COMPONENT A: DISSERTATION

SPATIAL DESCRIPTION OF LEASED RURAL STATE LAND INCONSISTENT WITH THE CADASTRE

Its Capture and Maintenance on an Alphanumeric and Spatial Database

Paul C Schoeman

Mini-dissertation (LIMT890) submitted in partial fulfilment of the academic requirements for the degree of Master of Environment and Development (Land Information Management), in the Centre for Environment and Development, School of Applied Environmental Sciences, University of Natal.

Pietermaritzburg, 2003

ABSTRACT:

Leasing of state land under control of the Department of Land Affairs takes place, due to historical reasons, in a manner that is unconformable with the cadastre. The Department (and the State) is obliged to manage its assets efficiently and promote land reform. How can such leases be described spatially, and captured on a land information system?

The author argues that it is indeed possible to develop a method, system or convention of spatial description for leased areas unconformable with the cadastre by relating it to the cadastre and capture and maintain data on such areas on a spatially and text-based database.
In order to identify relevant best practices, available technology, a review was carried out on methodologies from other countries within the fields of land administration and land information systems, focussing on parcel-based cadastral systems.

Fieldwork consisted firstly of interviews with officials and specialists in these fields for more information on the management of leases in the Department and available technology. A full set of active leases (52) from a District Office was acquired for analysis on current spatial descriptions. In a second visit some of these leased areas were surveyed by GPS to construct maps to aid with the development of a convention.

Based on this work, the author developed a methodology/convention for indexing and spatial description of unconformable leases, with the current South African cadastre and embedded 21-character land parcel identifier as basis. It was demonstrated that basic technology could be used in the field, supported by an advanced land information system.

The value of the convention lies in the fact that it relates the unconformable leases back to the formal cadastre within a land information system.

Administration of leases will be more effective. Also that it could be applied to other spheres of land reform and non-parcel based geocoding of centroids indicating occupational or communal rights on land.

Disclaimer:

This is to certify that this study comprises only my original work except where due acknowledgement is made in the text.

(P C Schoeman)

(R. J. FINCHAM)

ACKNOWLEDGEMENTS

Jonathan Jackson – study supervisor, University of Natal.
Chris Schalkwyk and Floors Slabbert: Department of Land Affairs (Directorate Public Land Support Services) – for the opportunity to study and their support.
Daléne, Louis and Paul Schoeman – my family.

Soli Deo gloria

Table of contents

List of figures

List of tables

Glossary of abbreviations

DGPS	Differential GPS
DLA	Department of Land Affairs
EDM	Electronic Distance Measuring
FIG	International Federation of Surveyors
GIS	Geographic Information Systems
GNP	Gross National Product
GPS	Global Positioning Systems
ha	One hectare equals 10 000 square metres
HTML	Hypertext Mark-up Language
LIS	Land Information Systems
LPI	Land parcel identifier – unique 21-character code for property descriptions on South African digital cadastre
PLSS	DLA's Directorate: Public Land Support Services
PWD	Public Works Department
RD	Registration division – a South African deeds administrative area
SDTS	Sub-Directorate: System Development and Technical Support
SG	South African Surveyor-General
TBVC	Transkei, Bophuthatswana, Venda and Ciskei – pre-1994 'states'
UNCHS	United Nations Centre for Human Settlements
UPRN	Unique parcel reference number (internationally similar to LPI)
Web	World Wide Web

1. INTRODUCTION

Chapter 1 examines the background to the administration of rural leases on state land by the DLA. From this, study objectives and a hypothesis are formulated.

1.1 Problem analysis and description

1.1.1 Background

1.1.1.1 General

Dale and McLaughlin (1988) (cited in Dale and McLaughlin 1999:10) state that *'a land administration system provides a mechanism that supports the management of real property'*. They also regard the cadastral parcel as the basic building block in any land administration system.

Williamson (1997) further notes that cadastral systems in developing countries are important:

> *'in promoting increased investment in agriculture; for more effective husbandry of the land; for improved sustainable development; to support an increase in GNP through an increase in agricultural productivity; and*

> *providing significant social and political benefits leading to a more stable society, especially where land is scarce.'*

The cadastre is closely linked to land information systems, land registration and land management (FIG 1994). It is also an essential pre-requisite for land reform.

Leases on rural state land under control of the Department of Land Affairs (DLA) need to be issued and administered on a parcel-based computerised system. How is data on these leases to be carried on such a system if the leased areas do not conform to the cadastre?

1.1.1.2 South African cadastre

In South Africa, the Surveyor-General (SG) regulates cadastral surveys by *inter alia* examining and approving diagrams, general plans and sectional title plans prior to them being registered in a Deeds Registry, and preparing and keeping up to date cadastral maps and plans. Each individual land parcel depicted on these SG-diagrams has a unique land description.

During the 1990s the paper-based cadastral information was digitally captured on a multi-purpose cadastre in which each land parcel is assigned a unique 21-character key or land parcel identifier (LPI) (South Africa: Department of Land Affairs: Chief Surveyor-General 2003).

The LPI, which directly refers to the land description of each land parcel, is crucial for land administration as it makes it possible to link geocoded properties spatially in a Land Information System.

1.1.2 State land management in South Africa

In spite of the apparent tidiness of the cadastral system, a large number of real rights are managed outside of the South African central registry system. It is true to say that state land management in South Africa takes place in a complex and disjointed system, largely inherited from the previous regime.

The main elements of government that act as owners of state land in South Africa are the Department of Land Affairs (DLA), the Public Works Department (PWD), and the nine Provincial Governments. Other state departments utilising state land function only as holder or user departments, usually as clients of the PWD for state household purposes such as office space, training areas (Defence Force, Police Services), etc. The bulk of the state land that the DLA is responsible for consists of the areas of the former TBVC-states, self-governing territories and ex-South African Development Trust land. This study will focus on the administration of leases on state land of which the DLA is the owner.

1.1.2.1 Public land: Ownership and extent

Public land consists of state land (both provincial and national), parastatal land (state owned utilities, for example Transnet) and third sphere government land (municipal). *Figure 1.1* below depicts a simplified breakdown of ownership of public land into categories.

The public land inventory (a database established by the DLA's Directorate: Public Land Support Services) consists of around a million records while state land itself comprises of approximately 100 000 records.

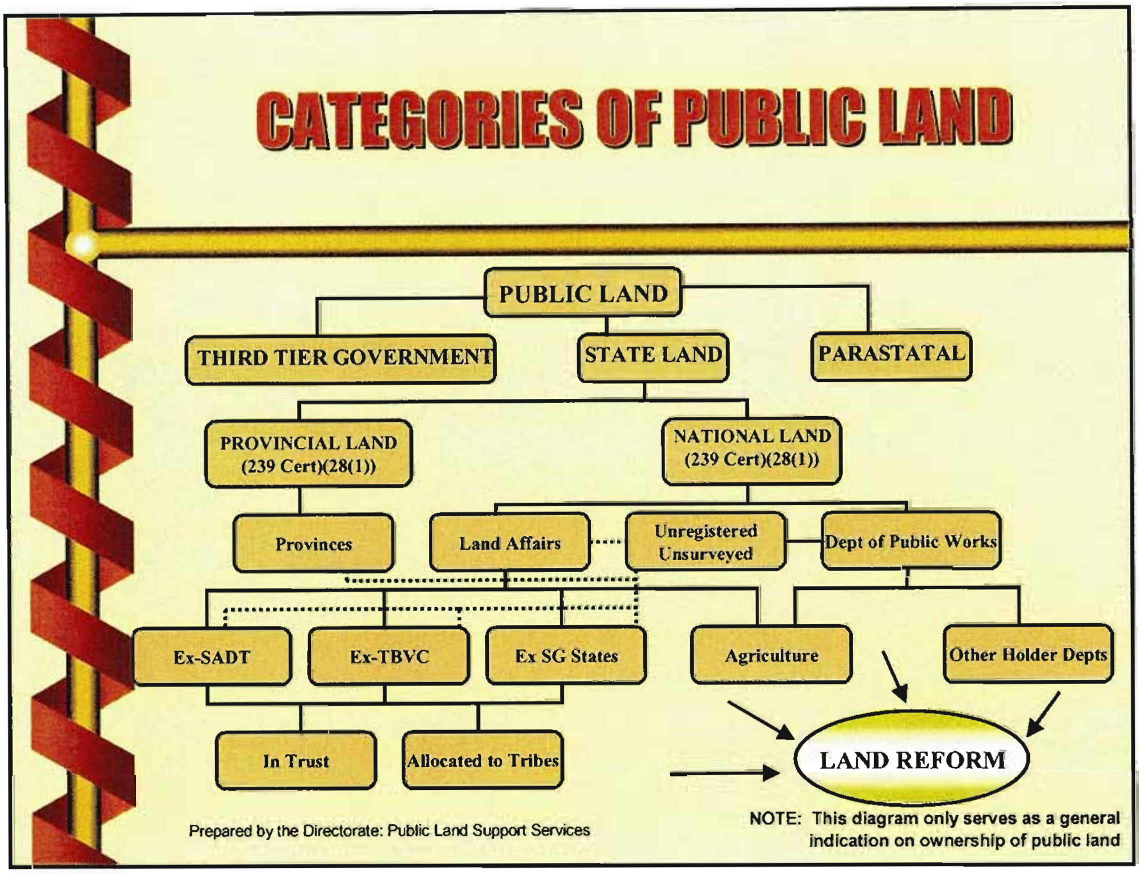


Figure 1.1: Ownership of state and public land *(South Africa: Department of Land Affairs, Directorate: Public Land Support Services, 2002)*

State land alone consists of approximately 24 million ha, of which the DLA is responsible for managing more than 13 million ha. *Table 1.1* indicates the ownership and extent of this state land.

Although the DLA is responsible for the managing and issuing of leases on the mostly rural agricultural land under its control, almost 600 000 ha of its agricultural land is fully administered by the Departments of Agriculture (national and provincial) under a power of attorney.

	THE EXTENT OF STATE LAND IN THE REPUBLIC OF SOUTH AFRICA (ha) *											
	NATIONAL STATE LAND PER PROVINCE									PROVINCIAL STATE LAND		
	National Department of Public Works							National Department of Land Affairs		(the nine provincial governments)		
PROVINCE	SANDF	SAPS	DCS	DWAF	AGRI-CULTURE (FALA-land) (1)	SOUTH AFRICAN NATIONAL PARKS	OTHER (2)	Ex-TBVC-STATES & SGT's	Ex- SADT (3)	NATURE RESERVES & PROTECTED AREAS	OTHER (4)	RSA - TOTAL
Eastern Cape	17 550	3 771	13 705	182 685	15 621	125 417	226 950	4 741 010	82 735	458 547	148 220	**6 016 211**
Northern Province	16 735	2 598	7 890	14 670	8 405	1 025 940	346 550	3 087 655	310 130	335 602	130 050	**5 286 225**
North West	34 134	1 712	2 422	3 592	6 390	0	214 750	3 118 090	90 300	240 119	157 090	**3 868 599**
Mpumalanga	10 251	2 370	3 275	81 589	1 936	955 670	174 800	643 345	119 478	209 878	172 500	**2 375 092**
KwaZulu-Natal	47 959	4 733	16 686	379 555	17 380	196 812	256 100	0	0	816 210	167 910	**1 903 345**
Western Cape	254 812	1 298	894	3 648	27 251	1 220 452	157 589	0	16 605	62 017	153 750	**1 898 316**
Northern Cape	7 690	4 487	17 445	67 960	8 029	0	301 870	0	457 674	769 772	199 600	**1 834 527**
Free State	31 325	875	2 818	1 020	1 682	11 633	96 640	159 384	63 754	198 292	64 250	**631 673**
Gauteng	14 176	3 865	11 407	3 777	0	4	130 420	0	36 762	42 191	80 650	**323 252**
TOTAL	**434 632**	**25 709**	**76 542**	**738 496**	**86 694**	**3 535 928**	**1 905 669**	**11 749 484**	**1 177 438**	**3 132 628**	**1 274 020**	**24 137 240**

Notes:

Figures as at 31 December 2001

* *Excluding* the following:

- unsurveyed, unregistered state land (e.g. coastal areas)
- foreign properties (e.g. SA embassies)
- offshore islands (e.g. Robben Island)
- land held in trust by the state (e.g. former Coloured Rural Areas)
- parastatal land (e.g. Transnet)
- former KwaZulu land (now Ingonyama Trust land - *2 902 056 ha*)
- land leased for state domestic or other national purposes (e.g. Richtersveld National Park)

(1) FALA-land refers to Financial Assistance Land (land bought in from insolvent farmers and PWD agricultural land administrated by the National Department of Agriculture.

(2) Includes unreserved PWD-land, and other smaller holder departments (e.g. Home Affairs, Justice, Mineral & Energy Affairs and experimental farms)

(3) Ex-SADT - refers to South-African Development Trust land *outside* the geographical boundaries of the former homelands and Self Governing Territories.

(4) Includes provincial agricultural land, as well as school and hospital land.

\# It is estimated that only between *5% - 7%* of state land is available for Redistribution; the other land is used for state domestic purposes or is already beneficially occupied.

Table 1.1: Extent and ownership of state land in the RSA *(South Africa: Department of Land Affairs, Directorate: Public Land Support Services, 2002)*

1.1.2.2 DLA: Directorate Public Land Support Services

The national Department of Land Affairs (DLA) is responsible for the administration of more than 54% of all state land in South Africa (*table 1.1*). The Directorate: Public Land Support Services (PLSS) has a primary administrative function in this regard, and its Sub-Directorate: System Development and Technical Support (SDTS) provides technical support as detailed below. The PLSS was created by the amalgamation of the Directorates: Public Land Inventory and State Land Management, with effect from June 2002.

In terms of the mission statement of the PLSS, its objectives are as follow:

- *'to obtain, gather and maintain relevant information on public land in order to identify superfluous land for land reform;*
- *to promote and oversee the administration of land under the control of the Minister of Land Affairs, including the acquisition, disposal and vesting thereof; and*
- *to supply relevant information and cartographical services to clients'.*

The Sub-Directorate SDTS is *inter alia* responsible for:

- the establishment and upkeep of an inventory of public land in terms of Section 39 of the Restitution of Land Rights Act, 1994 (Act No. 22 of 1994);
- the development of systems and technology to facilitate the administration of state land;
- the identification of superfluous public land; and
- the dissemination of such information.

1.1.2.3 Using the SA digital cadastre in land administration

The Sub-Directorate SDTS utilises current information technology at the Department of Land Affairs, in support of the above line functions, such as Geographic Information Systems (GIS), satellite and aerial imagery, Global

Positioning Systems (GPS), the Internet and advanced data administration linking information on land spatially to the cadastre. For example, an Internet-based inter-departmental administration system for the disposal of state land with integrated text and spatial components was developed and implemented by the Sub-Directorate.

Geocoded land parcels are spatially linked to the text data in a parcel-based land information system (the public land inventory) by using as key the unique 21 character land parcel identifier (LPI), provided by the Surveyor-General's Office *via* the digital cadastre.

Problems experienced with the linking process originate in the fact that the LPI does not apply in all circumstances: Sectional title properties, multi-apartment buildings, different lessees / owners of units in the same building, etc. The cadastre and the Deeds Register are also not perfectly synchronised, as a subdivision diagram may be approved at the SG, but not necessarily registered at the Deeds Office.

A daunting question therefore is how to link (alphanumerically and spatially) land administration data with the cadastre, as some leases were issued across cadastral units and parts thereof. Other examples in the land reform arena are restitution claims that were lodged quoting verbal boundary descriptions, people having different land rights in terms of the bundle of rights (in communal areas, and on state and private land), etc. Much of the tribal land and land held in trust for communities / tribes is also difficult to link spatially to the SG and Deeds data. Large tracts of state land have also not yet been surveyed and/or registered at the Deeds Office.

1.1.3 Administration of leases at the DLA

The inherited fragmented and disjointed administration of state land alluded to above also applies to the state of affairs in the administration of leases on state land under the control of the Minister of Land Affairs. Administrative shortcomings were primarily a result of the past government's policies: pre-1994 there were the four TBVC-'states', the five 'self-governing territories', the three chambers of Parliament with its administrations, the four provincial administrations, central government, all with different departments responsible for state land administration. In the changeover to the new dispensation much knowledge was lost, including records.

1.1.3.1 Background

The former Directorate: State Land Management was until recently (1999/2000) responsible for the leasing of the mostly rural agricultural land under the Minister of Land Affairs' control, involving also the Provincial and District Land Reform Offices (regional and sub-regional offices) of the national Department of Land Affairs. Since then, the administration of the above land has been assigned to the Departments of Agriculture (both National and Provincial at different stages) under a power of attorney. The affected land comprises of about 600 000 ha. However, the power of attorney does not include all DLA-controlled agricultural land and the Schedule thereto is amended from time-to-time as land is included and or excluded from it. The land excluded from the power of attorney is managed by the DLA itself.

During the process of amalgamation between the two Directorates (Public Land Inventory and State Land Management), it transpired that it would become necessary to investigate the development of a new centralised lease register due to the manifold problems associated with the current leasing system(s) as discussed in *paragraph 1.1.3.2* below.

Subsequently, the Sub-Directorate: System Development and Technical Support was officially tasked with investigating and developing a new computerised lease register in October 2001. This is in view of the fact that the Minister of Land Affairs is still ultimately responsible for all the state land under her control, including the agricultural land under power of attorney.

1.1.3.2 Leasing problems

Over a number of years the administration of leases on rural land placed under control of the DLA became fragmented, dissimilar, in various states of functioning/disrepair. Administration was mostly manually performed, and instances of corruption and gross inefficiency at collecting revenue occurred due to the lack of proper control and monitoring measures. It has even been alleged that paper records were destroyed on purpose.

Thus, problems currently encountered with leases are mostly the result of inadequate recording and control systems: For example fragmented manual record keeping systems, uncoordinated issuing of leases, systems difficult to control financially, and systems badly suited for financial reporting. This state of affairs makes proper management of the leases almost impossible. It is therefore advantageous and pertinent that a computerised leasing debtor system be developed for capturing, issuing and maintaining leases in order to address these problems.

The leased areas, which are almost exclusively in rural areas, must furthermore be spatially described on a land information system. As with freehold deeds, diagrams should be included in the lease documents to support the textual information. Spatial information is also needed as the leasing amounts are *inter alia* based on the area leased in most cases. Finally, spatial information is needed for proper land information and management. These requirements are easily met if leased land parcels have approved SG-diagrams, which are reflected on the digital cadastre with LPIs.

Unfortunately it is not possible to simply add the spatial component of the leasing debtor information to the existing cadastre, because as alluded to above not all leased areas correspond with approved cadastral parcels. For example, a leased area may only form part of a land parcel or it may lie across more than one land parcel owned by DLA. It can thus be described as being *unconformable* with the cadastre.

The term *unconformable* is derived from the field of geology where layers of rock are regarded as *conformable* when they have been deposited on top of each other without any interruption. *Unconformable* layers are then instances where various types of break in the rock layer record occur, such as a hiatus in deposition and/or a period of erosion indicating "missing time" or significant events (Hurtado 2002). In this context, *unconformable* is thus used to indicate instances where the boundaries of leases and that of cadastral parcels (although partially related) do not coincide, and are therefore two distinct discordant layers in the land administration system.

1.1.3.3 Unconformable leased areas

The Sub-Directorate: System Development and Technical Support received various requests for various types of assistance regarding adjudication and production of GIS and GPS generated sketch plans for the issuing of leases on state land. For example, in some instances leases were issued without the administration really knowing the precise location or land description or even the actual area leased (although the leasing price was based on Rand per hectare!). Many leases were also issued across more than one cadastral unit and portions of cadastral units. Furthermore, most leases include an option to purchase the leased land: If not properly described or if situated across cadastral boundaries, how can land be uniquely spatially described, especially if it is to be disposed of to a beneficiary?

In the course of this study, examination of current leases administered by the DLA's Brits District Provincial Land Reform Office in the North-West Province revealed the following: Only one lease of 52 administered by the District Office, coincides or is *conformable* with a surveyed land parcel. These 52 leases form only a fraction of land that could (and should!) be leased in that Office's service area. The said service area covers the Bojanala Platinum District Municipality (DC 37), which is comprised of four Local Municipalities, namely Moretele (NW371), Madibeng (NW372), Rustenburg (NW 373), and Kgetleng River (NW

374). This situation is regarded as indicative of what can be expected in most comparable District Offices (Venter 2003 *pers. comm.*).

Office policy dictates that areas for new leases must be surveyed by a land surveyor or technician to produce either accurate sketch plans or approved SG diagrams. However, this is proving costly while there are budgetary constraints and capacity problems (Venter 2003 *pers. comm.*). The backlog of existing leases issued unconformably across the cadastre, without proper spatial referencing, is also not addressed.

There is thus a need for a system or convention (in other words a method) for the spatial description of leased areas on state land *unconformable* with the cadastre in order to carry that information on a database in a leasing system. Relevant technology must also be used to spatially identify such leased areas. Such a method must build upon and strengthen the current cadastre and land registration system in South Africa to assist in integration of the leased areas into the classical cadastre in due course, especially in cases where it is known that ownership of a specific area will be transferred to a beneficiary in the form of freehold ownership. A simple flow diagram below illustrates the research problem (*figure 1.2*).

The last-mentioned problem regarding unconformable parcels associated with carrying spatial data on land in a cadastre-based database is similarly encountered in other land reform line functions, such as Restitution. A large percentage of the claimed areas or project areas for Restitution are not sufficiently spatially described in relation to the cadastre and are thus unconformable with it. It is therefore difficult to relate many claims to the cadastre and integrate the claims data with that of the parcel-based public land inventory to aid with the identification of available state and other public land suitably situated for possible land reform use. One should be able to extrapolate the developed methodology to other programmes of land reform, enabling the exchange of spatial data between different programme databases to bolster a more integrated approach to state land administration and land reform.

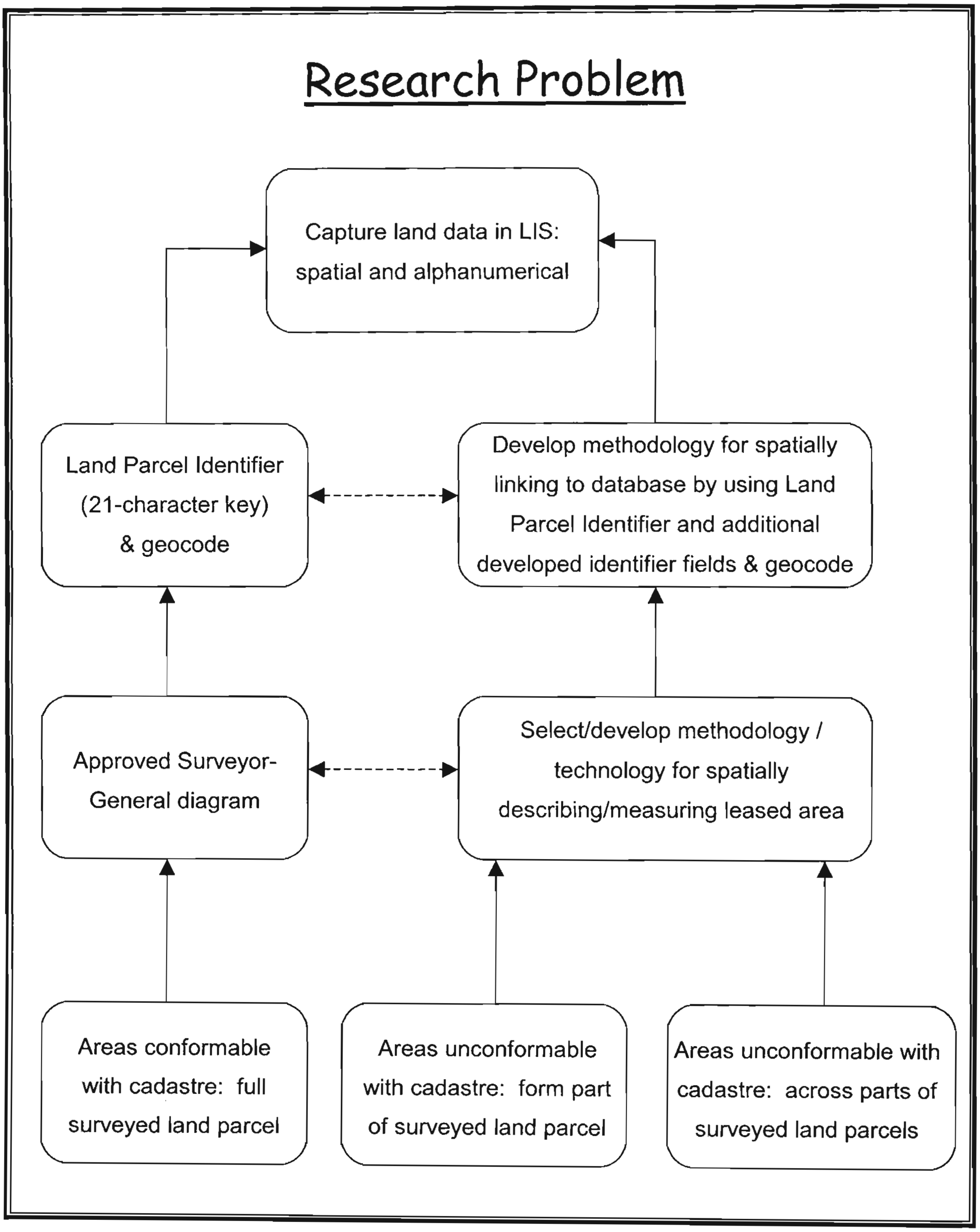


Figure 1.2: Research Problem

1.1.4 Relevant questions

One must remember that land administration (of which leasing is part and parcel) in the DLA takes place within a specific institutional setting (paradigm): on the one hand there is the existing parcel-based public land inventory LIS used as basis for land administration and on the other the fact that both the SG and Deeds Registry are part of the DLA. When focussing on the absence of a method of spatial description of leased areas that are unconformable with cadastral units, in order to capture and maintain it on a leasing database, the following questions can be asked:

- What is the necessity of efficient land administration and parcel-based LIS?
- How is a leased area that coincides with a surveyed land parcel, spatially described?
- How can a leased area on state land unconformable with the cadastre be spatially described, which either forms part of a surveyed land parcel or is situated across parts of surveyed land parcels?
- Must or can new methods be developed?
- Can such a method be used for capturing and maintaining spatial data on leased areas in an alphanumeric database?
- What appropriate technologies (e.g. GPS, sketches on 1:50 000 maps, digitising, aerial/orthophotos, and/or imagery) will be suitable or can be adapted for spatially identifying such unconformable leased areas?
- Can the method be applied to other parts of land reform and land management?
- Will it promote the exchange of spatial land data?
- Why not survey such unconformable areas in the first place?
- Will the current cadastre be compromised or strengthened?

1.2 Objectives

1.2.1 Main objective

To develop a system or convention (method) for the spatial description/linkage for leased areas on state land where the areas are unconformable with cadastral units, in order to capture and maintain the information on a spatial and textual database within a leasing system.

1.2.2 Specific objectives

- To identify if similar problems or areas of interest within the fields of land administration and parcel-based LIS exist in South Africa or other countries and analyse the common problem.
- To investigate the way in which a leased area on state land that does coincide with a surveyed land parcel, is spatially described by utilising existing LIS-related methods.
- To investigate and develop a convention/method for spatially describing leased areas on state land unconformable with the cadastre, which either forms part of a surveyed land parcel or is situated across parts of surveyed land parcels, in order to capture and maintain it on an alphanumeric database.
- To investigate what best practices are available and determine which will be suitable for spatially identifying leased areas on state land that lie unconformably over land parcels.
- To validate the methodologies adapted or developed for lease areas, in terms of their applicability (including other areas of land reform and/or land management).

1.3 Hypothesis

It is possible to develop a system or convention (method) of spatial description for leased areas unconformable with the cadastre by relating it to the cadastre and capture and maintain data on such areas on a spatially and text-based database.

2. LITERATURE REVIEW

Chapter 2 is a literature study examining the role of parcel-based LIS in land administration, techniques and technologies in LIS. Case studies of Botswana and Namibia are included, as some analogue lessons regarding their land administration in communal areas can be drawn to the situation in South Africa. This is to provide a basis for the development of a convention for the spatial description of unconformable leased areas.

2.1 Importance of land administration and management

In 1996, at the Habitat II Conference, many countries committed themselves to '*Promoting optimal use of productive land in urban and rural areas and protecting fragile ecosystems and environmentally vulnerable areas from the negative impacts of human settlements,* inter alia, *through developing and supporting the implementation of improved land management practises*' (UNCHS 1996 cited in Dale and McLaughlin 1999:1).

In addition to environmental aspects, access to land and security for credit are pivotal to sustainable development and good land management practice, necessitating that efficient and effective land administration mechanisms are put in place by the state. Dale and McLaughlin (1999:1) use the term *land administration* to refer to *'those public sector activities required to support the alienation, development, use, valuation, and transfer of land'*.

Two of the arguments offered by Dale and McLaughlin (1999:3) in favour of good land administration are:

- productivity (The factors of assurance, social stability, credit, and improvements to the land combine to ensure that land goes to its highest and best use); and
- resource management (*'Increased information about the land and property rights allows public agencies and private corporations to plan the management of resources more effectively and enables governments to enforce environmental and other regulations'*).

Thus, poor land administration is a constraint to economic growth.

2.2 Functions of land administration

Land administration systems provide mechanisms that support the management of real property. *'The processes of land administration include the regulating of land and property development, the use and conservation of the land, the gathering of revenues from the land through sales, leasing, and taxation; and the resolving of conflicts concerning the ownership and use of the land'* (Dale and McLaughlin 1999:10). They also regard the cadastral parcel as the basic building block in any land administration system.

Dale and McLaughlin (1999:11) divide land administration functions into four components: juridical, regulatory, fiscal, and information management. Information management is integral to and underpins the other three components in terms of land registration (juridical cadastre); valuation and taxation (fiscal cadastre); and planning and enforcement of regulations (zoning and other information systems).

McLaughlin (1975) (cited in Dale and McLaughlin 1999) ascribes the origin of the concept of the multi-purpose cadastre as a *'community-oriented, parcel-based system for integrating land related information collected and managed by different agencies'*, to the recognition that the above components share common information requirements. The idea of a multi-purpose cadastre is of course not new: For example, multiple uses of the cadastre were investigated as early as in the 1790s in France (the *ancien cadastre* was subsequently commissioned by Napoleon in 1807 focussing on cadastral needs such as fair land tax and ownership records) to construct a general map for possible use by civil and military engineers. Although individual parts of the cadastre were indeed used by public bodies, it was found not to be possible to construct such a general map by joining due to the different individual local triangulations. A general map (with topographical focus at a scale of 1:80 000) was constructed by the army after establishing a new geodetic grid between 1818 and 1827 (Kain & Baigent 1992). Many projects have been initiated in recent decades, in a number of countries, to develop information systems based on the cadastral parcel since it has been regarded as the basic spatial unit of human activity.

In short, thus, while the function of a land *administration* system is to support the management of real property, the function of a land *information* system is to underpin this process (Dale and McLaughlin 1999).

2.3 Land information systems

As discussed above, a key component of land administration is the management of land and property related data, increasingly within formal land information systems (Dale and McLaughlin 1999).

The concept / definition of LIS as adopted by FIG is as follows:
'A Land Information System is a tool for legal, administrative and economic decision-making and an 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 land information system is a uniform spatial referencing system for the data in the system, which also facilitates the linking of the data within the system with other land-related data' (cited in Larsson 1991:2).

Access to reliable information on land helps to further social and political objectives. Therefore, land information systems help to facilitate rural land reform and improve urban planning and infrastructure development. Most often land information systems are in the form of cadastres. Land related information is a valuable commodity that can be utilised in many ways, such as through its direct sale, or by adding value to service delivery and public decision-making processes (Dale and McLaughlin 1999).

This is especially important in view of the fact that the state is a major landowner, as illustrated in *table 1.1*, but the management of its land and buildings is not optimal. The management of leases on state land, as discussed in *paragraph 1.1.3* above, is a case in point.

The opportunities to develop land information systems have increased with advances in information technology, moves towards building national geospatial data infrastructures and the creation of national land information services (Groot and McLaughlin 2000).

A basic architecture for effective land information systems is sketched by the United Nations 1985 Ad Hoc Group of Experts on Cadastral Surveying and Land Information Systems cited in Larsson (1991:138):
'The most expensive and time consuming part of a computerised land information system is the collection and conversion of data. A trend towards decentralisation and deconcentration, with smaller dedicated systems linked together to form a larger overall system is seen. To provide that linkage, standards for the interchange of data must be established and a common spatial referencing system enforced. Effective cooperation and coordination among agencies is essential.'

Components of GIS assume a growing role in driving data processing within LIS. Although some people regard GIS as all-embracing institutional arrangements of which the technology is only part, in this discussion GIS is narrowly seen in terms of computer technology as sets of hardware, software, and data. In contrast, the term 'land information systems' is used in this study to cover the technology, the applications and the institutional framework within which the technology is operated. LIS *'are concerned with detailed information* *recorded at the local level so that they may be mapped at large scales'* (Dale and McLaughlin 1999:94).

2.4 The cadastral parcel and cadastre

Henssen and McLaughlin (1986) define the cadastral parcel as follows:
'A cadastral parcel is a continuous tract of land within which unique tenure interests are recognized. The cadastral parcel must envelop a continuous area of land and a continuous interest in land. On the map a cadastral parcel is formed by a, in itself closed, line which encloses the map, and has a unique identification' (cited in Larsson 1991:15).

Dale and McLaughlin's (1999:10) definition of cadastral parcel is much more compact, but virtually identical to that of Henssen and McLaughlin cited above:
'The cadastral parcel is a uniquely delimited tract of land within which a coherent set of definable property interests is recognised.' In most instances when I refer to 'land parcel' in South African context, it is identical in meaning to that of 'cadastral parcel'.

Of course, the bounded cadastral parcel is not necessarily ideal under all circumstances, as argued by Jackson (2000, 2002): The *single point method* where a (single) geocode is attached to a land right or centroid of an area can be a more effective method than parcelling, especially with regard to the 'visual confusion' when two unconformable parcel layouts are superimposed. This will also find application under communal conditions where a mixture of exclusive and overlapping communal use areas is found. However, land administration in the DLA takes place within a parcel-based paradigm.

The UN Ad Hoc Group of Experts on Cadastral Surveying and Land Information Systems (1985), cited in Larsson (1991:16), define *cadastre* as follows:
'The Cadastre is a methodically arranged public inventory of data on the properties within a certain country or district based on a survey of their boundaries; such properties are systematically identified by means of some

separate designation. The outlines of the property and the parcel identifier are normally shown on large-scale maps.' In addition, Williamson (1997) states that the key processes within (one could also say the purpose of) a cadastral system are the adjudication, transfer and sub-division/consolidation of land rights.

Various types and combinations of cadastre abound, such as the fiscal cadastre aimed at taxation, and the juridical cadastre which is more aimed at land registration. For the purposes of this document, a cadastre is therefore a systematic description (mapping included) of the land units (and associated rights) within an area. Information, in addition to the traditional identifier/land description, area, owner, land classes, land values or taxes, such as building plans may also be found in cadastres. Then the extended cadastre is known as a multi-purpose cadastre (Larsson 1991).

2.5 Role of the cadastre in land information systems

According to Dale and McLaughlin (1999) there are at least four different types of land information systems: environmental systems, infrastructure systems, cadastral systems, and socio-economic systems. Many possible types of data can be recorded in a LIS and applied to many different activities. From a land administration viewpoint, systems that focus on the cadastral parcel, such as the multi-purpose cadastre, are the most important. This ties in with the type of land administration at the DLA, as facilities management in an urban environment is not part of the equation.

Because many land data elements are parcel-based it can theoretically be collected and collated by a single cadastral agency. Such data can be used in asset management, development control, environmental impact, land-ownership, etc. However, in most instances it is not practical for all the gathering of data to be that centralised, since the various databases have historically been compiled separately by different agencies. Computer networking facilitates integration of these datasets into an apparently seamless whole. 'Hub-systems' at the different line function organisations carry separate files for groups of topics linked by using as key a *'unique parcel reference number (UPRN)'* to identify each land unit. This is similar to the South African land parcel identifier (LPI) using the cadastral reference of land parcels. The sum of information on one parcel can then be '*compiled by a series of inquiries to the different organisations gathering the data*' ('data custodians') rather than by carrying all the information on one massive database (Dale and McLaughlin 1999:96).

Advantages of operating in such a way is seen by Dale and McLaughlin (1999) on the one hand as avoiding a system that is too big and complex which tends to generate unique data management problems. On the other hand they are also administrative in that line function specialists can be responsible for the collection, collation, and updating of data within their functional areas without interfering with others. This allows land data administrators to act in an overarching coordinating fashion without having responsibility for each data item in the LIS.

It is generally accepted that a strategic way to promote development (in both urban and rural context) in Third World countries is to strengthen the usually weak institutional structures and systems such as the cadastre and land register. According to Larsson (1991:58) such an efficient system can help in the following ways:

- *'Better information base for planning and administration.*
- *Better specification of rights and more security.*
- *Better possibilities to finance development.*
- *Easier implementation of policy measures.*
- *Better steering and control.'*

Some further benefits of cadastral and land registration systems amongst others mentioned by Larsson (1991) are the following:

- *Administrative benefits*: Unique description of cadastral parcels can be used for other datasets such as population data (multi-purpose use). It promotes planning. There is less duplication of effort and better coordination of different datasets.

- *Improving map production*: Mapping at different scales and with different information layers (content) is possible when register maps (known as 'compilation sheets' in South Africa) are digitised, which enables automation.
- *Easier transactions in land*: Obviously, land transactions are difficult without reliable land registers.
- *Making agrarian reform possible*.

Some of the benefits of land formalisation and land titling applicable to this study, amongst many others listed by Dale and McLaughlin (1999), are:

- the facilitation of land reform (e.g. land redistribution and consolidation for development and redevelopment); and
- the management of state land so that the state can properly take control of its own resources and ensure the efficient administration of leases on state land.

2.6 Features of cadastres and Vision Cadastre 2014

Larsson (1991:134) records the following basic features seen as necessary in a well-functioning cadastre/land register system:

- *'One organisation is given primary responsibility for working out rules governing the new system and coordinating the work of various offices involved in monitoring the project.*
- *All duplication is avoided. It is clearly stipulated who is responsible for what information. Well-defined channels of communication are established as are fixed routines for the exchange of data among different departments and records.*
- *All data are designed for multipurpose use rather than for use within one department.*

- *Land units are assigned one identification code which is used in all public and private records. In case of automation, this code can be used as a key for integrating different records.*
- *The structure is user friendly and stimulates the flow of relevant data into the system. This means that service offices are decentralised in cases where direct contacts are necessary between citizens and authorities.*
- *Other factors, such as those influenced and driven by new technology, are the need to provide user training, development of corporate data sharing infrastructure, budget for funding, redefine traditional responsibilities, and to overcome historical encumbrances'.*

Also important as an indicator of the direction in which future development of the cadastre is headed, is the 'Vision Cadastre 2014': Working Group 7.1 was tasked by the FIG Commission 7 in 1994 to study the automation of cadastres and the increasing importance of the cadastre as part of a larger land information system. Based on the analysed trends of 31 jurisdictions, the working group produced a 20-year vision of where cadastral systems are headed with emphasis on the technology used to implement this vision. Vision Cadastre 2014 gained wide acceptance.

The six statements constituting the vision are as follow (Kaufmann and Steudler 1998):

'*One:* *Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions!*

Two: *The separation between* 'maps' *and* 'registers' *will be abolished!*

Three:'Cadastral mapping' *will be dead! Long live modelling!*

Four: 'Paper and pencil cadastre' *will be gone!*

Five: *Cadastre 2014 will be highly privatised! Public and private sector are working closely together!*

Six: *The cost of Cadastre 2014 will be recoverable!'*

2.7 Processes in compiling cadastres/land ownership records

According to the United Nations Centre for Human Settlements (Habitat) (1990), four basic operations take place in the compilation of cadastres/land ownership records:

- o Adjudication;
- o Demarcation (also called *monumentation*);
- o Survey; and
- o Documentation (registers and maps).

2.7.1 Adjudication

Lawrance (1985), as cited in Larsson (1991), describes the concept of adjudication as follows:

'Adjudication is the word now used in many English-speaking countries to describe the process whereby all existing rights in a particular parcel of land are finally, and authoritatively ascertained. ...... This specialized use of the word 'adjudication' is of recent origin. It was first introduced in the 1950s to replace 'settlement', the word previously used to describe systematic ascertainment of rights in land'.

According to Haldrup (1996), adjudication is a *'formal procedure for the resolution of a dispute by the application of pre-existing rules'.* Adjudication establishes <u>what</u> rights exist, by <u>whom</u> they are exercised and <u>what</u> limitations, if any, they are subject to. Linked to this, he sees the fundamental purpose of the cadastre as to establish and maintain certainty (in order to ensure tenure security) in three questions: <u>what</u> rights, <u>who</u> holds them, and <u>where</u> can these rights be exercised.

The United Nations Centre for Human Settlements (Habitat) (1990) defines adjudication as the process whereby *'existing rights in parcels of land are finally and authoritatively ascertained'.* They see adjudication as the first stage in titling already settled land where the ownership of the land is officially unknown.

It is also regarded as a prerequisite for land consolidation and redistribution ensuring equitable treatment of existing owners. Through adjudication the extent of affected land is also determined.

Dale and McLaughlin (1999) see the function of property adjudication as to resolve disputes and uncertainties regarding who owns what property. It may be used to resolve problems experienced with the inception of titling, but sometimes also in problems that arise after formalisation.

The adjudication process can be sporadic or systematic, and the proceedings may be of juridical or administrative nature (Larsson 1991).

2.7.2 Demarcation

Demarcation can, according to Larsson (1991), be done in two basic ways:

- By fixing the exact position of the boundaries on the ground in the presence of the parties. Boundary disputes can be referred to court. After fixing, the positions are monumented (with pipes, stones, concrete beacons, etc.) if existing topographical features such as fences and hedges are not regarded sufficient for demarcation. This method is usual when new boundaries are being established.
- By recognising the boundaries on the ground. When necessary, they may be surveyed or photogrammetrically identified, but they are neither legally fixed nor permanently demarcated if not specifically so requested by the parties. This method is cheaper to use for maps over large areas, especially where the boundaries are visible on aerial photos.

2.7.3 Cadastral survey

'Cadastral surveying is the term generally used to describe the gathering and recording of data about land parcels, even where the records do not form part of an official cadastre' (Dale and McLaughlin 1999:48).

A bit more simply, Larsson (1991:88) defines a cadastral survey as a survey of boundaries of land units (or land/cadastral parcels). He expands further: *'Boundaries'* (either fixed or general) *'are the main object of cadastral surveying. Other features, such as roads, watercourses, land-use boundaries, buildings, etc., are regularly included, but the primary purpose is to define the land unit – on the ground and in the cadastre and land register'*. All cadastral surveying should be connected to a national system of control.

There are two broad categories of surveying technique, which will later be discussed in more detail, namely field survey and photogrammetry, as well as two categories of output: graphical and digital (Dale and McLaughlin 1999).

2.7.4 Land register: documentation and maps

According to the International Federation of Surveyors (1994), *land registration* is the official recording of legally recognised interests in land. FIG also confirms that from a legal viewpoint there are two basic types of system:

- *deed registration*: documents filed in the registry are the evidence of title; and
- *registration* of title: the register itself serves as the primary evidence.

Variations abound: some deed registration systems include a number of critical elements of title registration, such as cadastral mapping, parcel-based indices, and examination of documents. Due to modern LIS and computerisation, the distinctions between systems are becoming less important (FIG 1994). The South African deeds registry combines elements of both systems.

Available resources are usually limited in developing countries for establishing different kinds of land information systems/land registers. Similarly, there are examples in Europe during the nineteenth century of cadastres/land registers that were started in a very simple way, and then were gradually upgraded in a progressive manner (incrementally) into effective systems. This is called a *progressive* cadastre, starting on a sound but simple, inexpensive basis, and developing further when resources and technology permit. In support of this progressive approach is the equally important objective to make the particular system flexible in order to adapt to new developments and new aims in the future (Larsson 1991).

2.8 Methods/techniques for cadastral surveying

As mentioned in *paragraph 2.7.3* above, there are two broad categories of surveying technique – field survey and photogrammetry, as well as two categories of output – graphical and digital (Dale and McLaughlin 1999).

Whether the approach is sporadic or systematic, according to Larsson (1991) the goal will eventually be to establish a cadastral map providing a total view of all the land units in an area, to enable the creation of an efficient parcel-based LIS. On the one hand, such plans can be compiled from existing topographic maps, cadastral surveys, aerial pictures, orthophoto maps, etc. If the national and the local system can be connected, computer-aided support can be used to transform the coordinates and plot the map. Digitizing coordinates from old cadastral maps can also be performed, as was done in South Africa during the 1990s from index plans ('compilation sheets'). On the other hand, should new cadastral surveys be needed, these can be made with either *photogrammetric* methods or *ground survey* methods. Modern instruments used are the total station and GPS.

Photogrammetric surveys involve a number of different methods with varying degrees of accuracy and expense. Images can be used as is, used in conjunction with ground reference points at a specific scale, rectified for scale (distortion from tilt), differentially rectified (distortions from tilt and height) to produce orthophoto maps, and used with employing high-precision instruments in conjunction with pre-marking of boundaries on the ground (Larsson 1991). However, photogrammetry is to a large extent dependent on existing boundaries that are visible from the air, which is a similar constraint to the use of high-resolution satellite imagery and remote sensing (Dale and McLaughlin 1999).

On the other hand, cadastral surveys have generally been undertaken in the field using theodolites, steel tapes, or Electronic Distance Measuring (EDM) Systems, and total stations. GPS technology are increasingly used that can provide coordinate values to a high level of precision down to centimetre level. GPS can also be used in conjunction with photogrammetric surveys. The unit cost of fixing any individual boundary point declines as the price of GPS equipment and support services fall. Traditionally, boundary surveying involved the measurement of the bearings and distances between adjoining boundary beacons. EDM and GPS technology makes it cost effective to measure the coordinates of boundary points, which are easily handled by computers (Dale and McLaughlin 1999).

Existing cadastral maps are increasingly being *digitized*, providing the ability to use the same database for producing maps at different scales and with different combinations of information layers. Simultaneously, manual production methods can be automated (Larsson 1991).

Larsson (1991) admits that, when considering the degree of accuracy required, most of the benefits of cadastre/land registration systems can be achieved even with relatively low mapping standards. In Sweden, simple maps on a scale of 1:10 000 have been used successfully in rural areas for the unique identification of all properties and as the basis for a register of title. This has also been the case in Kenya, where the title register is based mainly on photo-interpretation of enlarged aerial photos on a scale of 1:2 500, resulting in incontrovertible titles based on general boundaries. In support of this, Van der Molen (2001) says that mapping (by fixing a kind of geo-reference to an object where rights in land exist) only has to provide *sufficient specification* on the location of the object. According to him it is a fallacy that this could only be done by defining a cadastral parcel through a precise boundary survey, as any sort of spatial referencing (of the object) that is recognised by a community will be sufficient.

2.9 Technologies in cadastral surveying and LIS

Recent advances in main technologies have affected cadastral surveying to a large extent. These include GPS, digital mapping, GIS, and increasingly, high-resolution remote sensing. These technologies are influencing the way that data are gathered and the types of data being collected (Dale and McLaughlin 1999).

Significantly, Dale and McLaughlin (1999) feel that although GPS technology is playing an increasingly important role in the measurement of parcel boundaries and the construction of maps, the greatest impact on land administration has come from information-handling technologies rather than from surveying itself. However, one must be careful though not to computerise the mistakes and errors of the past just for the sake of computerisation. There may be quite serious underlying flaws preventing the efficient functioning of existing systems – computerisation won't fix that. Data integrity and quality is also important and every line functionary must take responsibility for his/her data as mentioned elsewhere, otherwise the old principle of 'garbage-in' equating to 'garbage-out' kicks in.

When referring to automation of the cadastre and land registers, Larsson (1991:135) quotes Simpson (1976):
'The operation of a land registry is basically an exercise in filing the indexing and storing of particulars in such a way that they can be amended, retrieved, and presented without delay or mistake. It seems inevitable, therefore, that sooner or later the computer, the miraculous device which has been developed for this sort of purpose, will be used'.

As an example, Larsson (1991) describes the Swedish cadastre/land register system as having a land data bank, which is integrated with other national registers by using the parcel number or address as identification key. Because the land data bank carries the central coordinate ('geocode') for every cadastral unit, all register information on persons, buildings, households, real estate, development plans, etc., can be positioned and mapped automatically.

In the past decade the Internet, in combination with standardised graphical user interface software, has come to the fore to address the requirements of access, viewing, and distribution of land data. Dale and McLaughlin (1999:99) describe the following example:

'In August 1996 Service New Brunswick (SNB) implemented one of the first commercially available on-line land registry systems in the world, a service that provides province-wide access to a series of integrated land data sets .... (This) .... *Real Property Information Internet Service (RPIIS), allows clients to access non-confidential, parcel based information residing at a password protected SNB Internet site. The service supports browsing and viewing of maps and map related information over the Internet. Users of this service may search for a property by specifying either a textual or graphical attribute such as a place name or coordinate reference. The software allow users to view and query maps and attributes, select display layers, perform 'point in polygon' analysis, and undertake many more core GIS-type operations. Additional textual and multi-media information can be associated with features on the map'.*

Another similar example in South Africa, although with controlled access through usernames and passwords, is the Internet based state land administration system ('Provincial State Land Disposal Committee Application') implemented in 2000 by the Directorate PLSS.

Although Barnes and Eckl (1996), cited in Dale and McLaughlin 1999:118, mainly refer to the field of cadastral surveying, the following statement is also generically applicable to LIS – they suggest that all new technologies should be justifiable in terms of:

- *'speed (they must significantly outperform current approaches);*
- *cost (they must significantly reduce current unit survey costs);*
- *suitability (they must be within the financial reach of local surveyors and within their range of skills to operate);*

- *appropriate accuracy (they must match real needs);*
- *simplicity of field operations (the data collection must be simple enough to allow for many field conditions)'.*

2.10 Indexing of cadastres/land registers

Larsson (1991) notes the trend in Western countries that their cadastres/land registers are increasingly being indexed according to the more enduring entity of the land unit itself, identified by maps and unit number, rather than on land owners. This (unique) land unit description also serves as a key for integrating other records into the system. *'Land records should be based on defined land units, not on persons'* (Larsson 1991:38). Therefore, he is of the opinion that data from databases will form a land information system not because they are combined in one single record or managed by one authority, but because they use the same identification keys, especially the land unit number.

From the above it is thus clear that the primary basis for even a simple land record system is a systematic division into land units. Larsson (1991:146) suggests that this division should be:

- *hierarchical*, namely, *'structured on different levels and go from district to block and to unit designation within the sub-block'*;
- *flexible*, namely, use *'logical and simple rules for making changes of designation when a unit is subdivided, amalgamated, or otherwise changed'*;
- *unique*, namely, *'no two units shall ever have the same designation'*;
- *multipurpose*, namely, be suitable for use – on its own *'or in combination with other units – in all types of land records and tasks irrespective of the purpose'*.

Dale and McLaughlin (1999:56) agree with the above in that they also see a register of titles containing these two elements: a *'record of the attributes associated with each parcel and a description of the land to which these attributes refer'*. Usually the identifying description of each land parcel is based on a (cadastral) plan or map, and is linked to either verbal or numerical data in the written parts of the register.

Dale and McLaughlin (1999:57-8) further specify a number of desired features for a parcel description. It should contain additional attributes such as the size of the property and the approximate location of its boundaries (by referring to boundary monuments such as pegs). It should further indicate the location of the property relative to adjoining parcels and relevant topographical features such as buildings and fences. Although parcel descriptions may be verbal, graphical methods are seen to be the most effective way to indicate boundaries. Due to the fact that descriptive elements such as coordinates (associated with newer technology such as GPS) are easily computerised and listed, property descriptions are increasingly based on numerical information.

Most importantly, it is further necessary to have a parcel reference number that uniquely identifies the parcel (e.g. the LPI) so allowing for cross-referencing within land registers and other related databases. Using just the parcel reference number as primary key, it is then possible to access all the details on a parcel. Various referencing methods have been developed, most notably those based on utilising grid coordinates or geo-codes (Dale and McLaughlin 1999).

One must be careful when integrating data sets, however, as two organisations may use the same parcel identifier, e.g. land description or street address, but they may not adhere to the same format or standard for denoting it. In my experience South African organisations are (as in many instances elsewhere) a shining example of non-conformity, making integration difficult.

2.10.1 Land unit identifier

Every unit (land parcel) in a parcel-based reference system must be uniquely identifiable. Larsson (1991) reiterates that this is of special importance in a land information system where the parcel identifier is the common key, linking and integrating different land databases.

It appears that the simplest identifier is a parcel designation, which indicates the sequential order of registration (e.g. as used in Zambia and Mozambique). However, no indication of location is provided, which is impractical with increasing numbers of parcels and subdivisions. The same deficiency applies to the grantor/grantee index (used in parts of the USA and Canada) but which also does not give a unique lasting identifying designation. Other methods are therefore applied in most countries (Larsson 1991).

According to Dale and McLaughlin (1999:59) it is easier to obtain consistency between different agencies addressing the same parcel if the reference system has the following features:

'1. *easy to understand, for thereby less confusion and mistakes are likely;*
2. *easy to remember so that landowners can recall their parcel references;*
3. *easy to use by both the general public and administrators and in computers;*
4. *permanent so that for instance the parcel reference does not change with the sale of the property;*
5. *capable of being updated when there is a subdivision or amalgamation of two adjoining properties;*
6. *unique so that no two parcels have the same reference and there is a one-to-one correspondence between what is on the ground and what is referred to in the registers;*
7. *accurate and unlikely to be transcribed in error;*
8. *flexible so that it can be used for a variety of purposes from registration of title through to all forms of land administration; and*
9. *economic to introduce and to maintain.'*

Larsson (1991:158-60) cites, in his opinion, the most important types of land unit identifiers from the work of Ziemann (1976), and Dale and McLaughlin (1988):

‘1. Hierarchical identification systems’

‘(a) *Volume and folio. Vol.45 Fol.175 means that the unit is described on the 175th page of the 45th volume…’*

‘(b) *Plan number and unit number*’. This can be a survey plan number reflecting the date of survey, plus the land units numbered in some consecutive order on the plan. Alternatively, the number of each topographical map-sheet can be used in conjunction with assigning numbers to the units within that sheet in a certain order.

‘(c) *Municipal unit – block – sub-block – land unit number. A municipal unit such as a county, city, town, township or municipality is subdivided into blocks and sub-blocks, within which land units are numbered in some consecutive order. The divisions are often based on existing sub-units such as town blocks or on administrative-historical boundaries such as those of a parish or village’*. Parish/village names or numbers can be used.

‘(d) *Municipality and street address.*’ A serial number can be used in place of the name of the street. Although street addresses probably are the most generally understood of all identifiers, not all land units are located alongside or are linked to a road. Streets and roads are also not always permanent. Nevertheless, the street address is often used concomitantly with other land unit designations.

‘2. Grid identification systems’

A grid is basically defined as *‘a set of mutually perpendicular and horizontal lines forming equal squares on a map, used as a reference for locating points and areas. Grid co-ordinates are a pair of numbers which locate a point in terms of its distance from two given axes’.*

Latitude and longitude can be used for the grid. In most instances a coordinate system based on a map projection is used, such as a national grid mapping system. If coordinates of the boundary points are so referenced, the land unit is spatially located. However, for it to be used as land unit identifiers, only one coordinate point must be chosen. Usually the parcel centroid is used, which is an example of a *geocode*.

As reiterated in *paragraph 2.10.2* below, grid coordinates or geocodes are very useful for locating parcel-based information in an automated system. However, they are impractical as identifiers because of their many digits making them awkward for the general user.

'3. <u>Hybrid hierarchical/grid identifiers'</u>

Hybrid hierarchical/grid identifiers can also be used, for example, *'the province and the county could be identified by name or number, while further identification of the land unit could follow a grid method'*.

Larsson (1991:160) cites Ziemann (1976) when looking into the advantages and disadvantages of the different systems: a hierarchical identifier consisting of the components (state) – county – tract – group – source parcel – affix is recommended. *'The source parcel is here the original land unit, while affix is the number given at subdivision. With this method, the source parcel number can be retained even after subdivision or other changes. County – tract – group can be designated by number or by names'*. Ziemann further explains that within this system, several affix solutions are possible: numerical or alphabetical, single or multiple. He recommends numerals, as they are more convenient than alphabetical characters. A single affix is also preferable, as multiple affixes would create a growing string of additional digits with each boundary change. In Sweden such a hierarchical system is used for determining parcel identifiers. The South African LPI can be compared to this system.

2.10.2 Geocodes

Larsson (1991) reminds the reader that parcel numbers do not directly express the geographical location of a property. Some kind of *geocode* is needed for that. They normally are the coordinates of boundary points (stemming from a grid identification system as discussed above) or of a certain point on the parcel such as the centroid or main building. Geocodes allow a direct relationship between the data and its spatial location. In this way all data in a system can automatically be mapped. Parcel-based systems thus have great flexibility because the information is no longer tied to a certain administrative area, but can be geographically linked to any selected area.

To enable automation, the geocoding system used by Sweden includes the centroid of the land parcel as well as the coordinate of the principal building in the cadastral records. Similarly, the inclusion of the coordinates of all boundary points would result in a comparable spatial determination of information (Larsson 1991:36). Related to this, existing cadastral maps are increasingly digitized, further enabling automation and scalable integration with other layers of data.

2.10.3 South African cadastre and parcel identifier

In this section the main sources of information were: *South Africa: Department of Land Affairs: Directorate Public Land Support Services (2001)*, and *South Africa: Department of Land Affairs (2003)*.

In South Africa, the Deeds Office is responsible *inter alia* for the registration of deeds, linked to a cadastre (depicting the relevant registered real rights) under the responsibility of the SG. The process is therefore basically two-fold: Firstly, a survey is carried out by a cadastral land surveyor to determine or demarcate the boundaries of a land parcel, lease or servitude. The second stage is that, once the survey has been examined and the diagram has been approved by the SG, the person or body who intends to benefit from that right over the land can register the right in the Deeds Office.

It must be noted that the fact that a land parcel has been surveyed, does not necessarily mean that it has also been registered at the Deeds Office. In practise this means that the cadastre and the deeds records are not always synchronised, because for example an owner may decide to subdivide now (with an approved cadastral diagram) in order to sell off or bequeath that subdivision in future. There also still are tracts of land, which, due to a number of reasons, have not been surveyed and are therefore not reflected on the cadastre. Some tracts simply were never granted via a deed of grant by the state and subsequently not surveyed. These areas often were remote or impractical for commercial farming purposes, or have been set aside for environmental reasons or conservation purposes. In certain instances, areas of unsurveyed state land were merely proclaimed as tribal areas held in trust for communities.

At present the documents lodged by the land surveyor are paper documents, although they are generally drawn by computer using data held in a digital database. The Surveyor-General's Office is advanced with investigating and developing systems for the electronic submission of documentation for examination, as is the Deeds Office. All is aimed at abolishing the present separation of cadastral maps and plans from the land registers, in order to facilitate the management of the national cadastre as one digital entity. Within this, a unique parcel identifier is of prime importance.

2.10.3.1 Assigning parcel descriptions

The property description indicated on the cadastral diagram and used in the 'property clause' of the deed is a unique description assigned to the land parcel by the Surveyor-General. The basic method to denote the parcel description is similar to that of the hierarchical identifier consisting of the elements (state) – county – tract – group – source parcel – affix cited above. The source parcel is the original land unit, while affix is the number given at subdivision.

Broadly, the parcel description consists of the following elements:

- For a *rural* land parcel, the land parcel (farm) is given a sequential number within a deeds administrative area called a *registration division* (RD) by one of the Surveyors-General in one of the areas historically coinciding with the four pre-1994 provinces. Some registration divisions in specific areas are based on a grid with one-degree squares and denoted as JQ, IQ, FU, etc. – for example, 'I' refers to 26° of latitude, and 'Q' refers to 27° of longitude. In the rest of the country, until finally converted to the above notation, RDs are geographic areas closely resembling magistrate districts. A farm registry book is opened at the SG Office to record all future surveys (subdivisions, consolidations, leases, servitudes, etc.) on this parcel of land (the 'source' or 'parent' parcel), the boundaries of which are indicated on a diagram framed by a surveyor, and examined and approved by the SG. In most instances, apart from the farm number, the farm was also named.

When *subdividing* the farm through further survey, the subdivisions are sequentially numbered ('affix') starting at one – the first is referred to as *Portion 1* of the farm, the second as *Portion 2* of the farm, and so forth. The piece of land left after subdivision, is referred to as the *Remainder*. Obviously, the original diagram would be endorsed to indicate that an area was deducted from the parcel (farm or subdivision). If an existing subdivision is re-subdivided, the new subdivision is allocated the next sequential portion number as determined from the register maintained by the SG. The original subdivision is referred to as the *Remainder of Portion (original farm number)*. The same principle applies to the original *remaining extent* of the farm.

Consolidation of two or more adjoining land parcels into one land parcel can also be done after preparation of a new survey-diagram. A *new* portion number is assigned to the consolidated land parcel by the Surveyor-General. Existing component diagrams are endorsed to indicate that they have been incorporated into the new land parcel. Where two adjoining land parcels situated on *separate* farms are consolidated then a new farm number is defined and a new farm register is opened. All future subdivisions of this farm will refer to the new farm number.

An example of such a property description could be: *Portion 3 of the Farm Rustfontein 502 in the Registration Division of KS.*

- For creating *urban* land parcels it is necessary to proclaim a township on an existing farm/rural land parcel (or subdivide / consolidate). In the process a *General Plan* depicting all the surveyed parcels (known as *erven*) is drawn up and submitted to the SG for approval.

  Exactly the same procedure is followed as with rural land parcels in assigning a number to an individual *erf* within a specific township. Numbers for consolidation and subdivision are also assigned in a similar way. The first subdivision on an erf would be identified as Portion 1 of Erf (original erf number), and so forth.

  An example of such a property description could be: *Portion 2 of Erf 554 in the Township of Pretoria in the Registration Division of JR.*

2.10.3.2 Unique parcel identifier

Each individual land parcel depicted on a SG-diagram has a unique land description as discussed above. The paper-based cadastre was digitally captured by the Surveyor-General's Office during the nineties on a multi-purpose cadastre in which each land parcel, based on its description, is assigned a unique alphanumeric 21-character key/code or land parcel identifier (LPI).

The 21-character key comprises five elements as follows:

- *First character refers to:*
  historically, the four pre-1994 provinces in which the offices of the four Surveyor's General are situated:
  T – Pretoria office (former Transvaal Province)
  F – Free State (Bloemfontein office)
  C – Cape Town office (former Cape Province)
  N – KwaZulu-Natal (Pietermaritzburg office)

- *Next three characters refer to:*
  the Registration Division (in the old Transvaal and in KwaZulu-Natal) or, the Administrative District in the Free State and old Cape Province. This is also referred to as the *major* region code.
  Example 1: 0IQ, 0JR, etc. This is a coded map reference used for Registration Divisions each comprising a Degree Square with its origin at 3411 = AA
  Latitude 33 = B, 32 = C, etc. with I = 26 degrees of latitude
  Longitude 12 = B, 13 = C, etc. with Q = 27 degrees of longitude
  Example 2: 001, 013, 003, etc. These are the numeric codes for computerisation purposes sequentially assigned by the SG to Administrative Districts, such as Cape, Caledon, Bloemfontein, etc.

- *Next four characters refer to:*
  the numeric code for townships / holdings at the Pretoria, Bloemfontein, and Pietermaritzburg SG offices, and to an allotment area at the Cape Town SG office. This is also referred to as the *minor* region code.
  Examples: 0099 is the numeric code for Eldorado Agricultural Holdings; 0014 is the code for the Kleinmond Allotment Area in Cape Town.
  A code of 0000 (4 zeros) indicates that the land parcel is rural or farm land.

- *Next eight characters refer to:*
  the land parcel number of an erf, holding or farm (source parcel).
  Example: 00001234 would be the code for Erf 1234, Holding 1234 or Farm 1234. The specific identification would be determined by referring to the *major* region code.

- *Last five characters refer to:*
  the portion of the erf, holding or farm. Subdivision numbers are not allocated to erf subdivisions in the Cape Town SG Office – they are given a new erf number.
  Example: 00015 is the code for Portion 15.

Combining these elements into a single key produces a unique description of a land parcel. Thus, the key N0FT02580000246400001, for example, uniquely identifies Portion 1 of Erf 2464 in the Township of Pietermaritzburg in the Registration Division of FT, Province of KwaZulu-Natal. The components are:

N	KwaZulu-Natal Province (area of Pietermaritzburg SG office)
0FT	Major region code (Registration Division FT)
0258	Minor region code assigned to Pietermaritzburg
00002464	Erf number
0001	Portion number

2.10.3.3 Geocode and parcel identifier

The linking of the datasets obtained from the Surveyor-General's Office and the Deeds Office is performed by the Sub-Directorate: System Development and Technical Support (SDTS) through using the above unique 21-character land parcel identifier (LPI) indicated on the SG's digital cadastre and generating a 21-character key from the Deeds Registry's alphanumeric land description of each individual land parcel. A geocode (based on latitude/longitude) for the centroid of each land parcel on the digital cadastre is then generated by the Sub-Directorate, thus enabling the spatial link to the digital cadastre within a GIS or LIS.

2.11 Case studies: Botswana and Namibia

In an endeavour to learn lessons from and draw parallels with land administration systems developed in neighbouring countries, two situations are reviewed, namely that of Botswana and Namibia. In both countries vast unsurveyed/unregistered tracts of land are still found, in many cases on tribal land, as in South Africa.

2.11.1 Botswana: Land information management on customary land

According to Manisa and Maphale (1999) land in Botswana is classified into three main types of tenure namely customary, state, and freehold. Customary land is known as communal or tribal land.

Urban villages on tribal land are expanding rapidly, creating unprecedented land problems. Customary land in Botswana is administered by Land Boards. The core functions of the Land Boards are land administration, surveying and registration. In their paper Tembo, Manisa and Maphale (2001:1) investigate avenues for improving *'land administration in these areas with special emphasis on the role that spatial information can play to improve the effectiveness of Land Boards'*.

According to Tembo, Manisa and Maphale (2001), land holding on tribal land takes place in the following manner: In settled tribal areas tenure can take the form of customary law tenure and common law leases. After an applicant applied for land, the Land Board will (if found suitable for the particular use) issue a *Certificate of Customary Grant* based on a *sketch plan* drawn by a technical officer of the Board. If an applicant wants to obtain a *Title Deed* in accordance with common law, the land must be formally *surveyed.* There are thus two routes for registering tribal land. These sketch plans are not easily retrievable, as they are normally not linked to a database. Only when a formal cadastral survey is done, the parcels can be linked to the other surveyed parcels. Because the graphical information of Certificates of Customary Grant is not properly captured, there are potential problems land management in these areas.

In their project, Tembo, Manisa and Maphale (2001:6-8) captured information on existing plots in a specific district by GPS and a land inventory questionnaire. They linked the graphical data and text-based land inventory in a GIS, providing the ability to perform spatial and non-spatial queries to aid decision makers. They further state that while the small GIS worked well, it was not used in day-to-day business of the Land Board, illustrating the need for institutional issues to be tackled if an effective system is to be put in place. *'Indeed there is need to link the technologies in surveying, mapping and IT to the planning and management process'.* A problem identified by them is that the sketch plans and survey diagrams tend to be an end in itself, while it has to be recognised that they are part of the spatial cadastre. A spin-off from the project was that some measure of systematic adjudication took place.

Tembo, Manisa and Maphale (2001:10) conclude by stating that it will be important to ensure that the collectors of data on land realise that the information is to be used in a greater system. Human resource development should also take place in tandem with the introduction of technology to ensure sustainability.

2.11.2 Namibia: Progressive title registration and land measuring

According to Juma and Christensen (2001), land in Namibia broadly falls into two categories: registered and unregistered land. Approximately half of the area is held under registerable freehold title, while the remainder is communal land with various types of land tenure associated with it. There is frustration at the slow pace of the land surveying and registration system requiring high and complex expertise in Namibia, which covers only part of the country. Tenure security is especially affected and eroded by rapidly expanding urban settlements in communal areas. It is said that it might take the existing freehold system up to 20 years to cover these settlements. In order to address these problems Namibia opted for a *parallel interchangeable property registration system* wherein the initial secure right is simple and affordable but may be upgraded according to what the residents and the government need and can afford at any given time. (*Parallel* indicating a system with different levels of tenure and *interchangeable* indicating the possibility to move from one level to the other.) This system, called the *Flexible Land Tenure System*, was piloted over two years, and put forward as a proposal in 1997.

Juma and Christensen (2001) and De Vries (2002) report that the system consists of three statutory types of tenure:

Firstly, a *starter title* (also referred to as an *initial title*) which provides a holder with the following rights:

- to perpetual occupation of a site within a block or in a similar block. The parcel boundaries are undefined, but the block's (outer) boundary is formally surveyed and registered in the (Windhoek) Deeds Office. The starter title is to be recorded at a local office.
- to transfer, or to otherwise dispose of, the occupation right subject to custom or a constitution restricting transfers drawn up by the group occupying the site. The registration of servitudes or mortgages is not possible, as the individual parcels are not yet defined.

Secondly, a *landhold title* which provides the owner with these rights:

- to occupy a defined site in perpetuity. The parcel boundaries are measured / registered in a local office, and the block's boundary is formally surveyed / registered in the Deeds Office.
- to transfer or dispose of this right. The right is thus mortgageable.

Thirdly, *freehold title* will provide the owner of the rights historically associated with it:

- the block's boundary will be cancelled.
- the parcel boundaries will be formally surveyed and registered in the Deeds Office.

Starter title can be upgraded to landhold title or, as is the case with landhold title, to freehold title. Registration of the two new types of title will be parallel to the existing registration system: the same land parcel will be registered in both the relevant local registry and the Deeds Office. However, in contrast with the local registry office, the Deeds Office will only show the ownership of the whole block of land and that a starter or landhold title exists. A conveyancer or legal practitioner need not prepare starter and landhold title documents, as a registration officer will be trained to process the transactions at the local office.

A land measurer, also based in a local office, will prepare a cadastral map indicating a landhold parcel (Juma and Christensen 2001).

Juma and Christensen (2001) state that due to a number of institutional, technical, legal and financial issues, the implementation of the new Flexible Land Tenure System has not yet proceeded as anticipated.

De Vries (2002:593) is of the opinion that, on the one hand, a flexible land registration system provides the advantage of flexibility to the end beneficiary, in terms of type of rights and simplified surveys as described above. On the other hand, such a flexible system is, from an information production and provision point of view, more complicated due to the additional levels of tenure registered and integrated at different physical locations. The consistency and redundancy of spatial and non-spatial databases at the different levels and offices may be problematic if not aptly handled.

2.12 Chapter conclusion

This chapter covers a wide range of topics from land administration to parcel-based LIS, to the cadastre, to relevant technologies and techniques, to case studies on neighbouring countries. In doing so, it tries to provide a firm foundation for basing the research into capturing unconformable leases in *Chapter 3* and the development of a convention for carrying such leases in a computerised lease register in *Chapter 4*.

3. RESEARCH & RESEARCH RESULTS

Chapter 3, based on the foundation provided by *Chapter 2*, reflects the results of research on existing leases at the DLA, shedding some light on the obstacles and methodology used to capture and carry data on unconformable leases in a computerised lease register.

3.1 Current leases at Brits District Office

One of the Department of Land Affairs' District offices was chosen to obtain lease information, namely the Brits District Provincial Land Reform Office in the North-West Province. It was deemed to be representative of the situation regarding the management of leases at a sizeable proportion of DLA's offices.

Examination of the 52 current leases (as on 11 July 2003) administered by the DLA's Brits District Provincial Land Reform Office in the North-West Province revealed the following:

- One lease out of 52 coincides or is *conformable* with a surveyed land parcel, making it suitable for capture in a spatial database using the 21-character key and a geocode.
- 17 leases, unconformable with the cadastre (mostly portions of land parcels), have some form of paper-based sketch plans. Some plans are hand-drawn maps (various formats) indicating 'farming/agricultural units'

mostly determined in the pre-1994 dispensation by extension officers of government departments such as Agriculture, and also more recent sketch plans (not approved cadastral diagrams) indicating coordinates framed by land surveyors/ land surveying technicians for the express purpose of describing the leased areas. Two examples of such sketch plans are respectively shown as *Figures 3.1 and 3.2* below. These leases cannot be identified and spatially linked by using the 21-character key, as they only form part of one surveyed land parcel.

- 34 leases, unconformable with the cadastre, have no sketch plans and are situated on one or across more than one cadastral parcel. Due to the fact that these lease areas do not coincide with the cadastre, they also cannot be identified and spatially linked by using the 21-character land parcel identifier.

These 52 leases form only a fraction of rural agricultural land that could (and should!) be leased in that Office's service area. The said service area covers the Bojanala Platinum District Municipality (DC 37), which is comprised of four Local Municipalities, namely Moretele (NW371), Madibeng (NW372), Rustenburg (NW 373), and Kgetleng River (NW 374).

Office policy dictates that areas for new leases must be surveyed by a land surveyor or technician to produce either accurate sketch plans or approved SG diagrams. However, this is proving costly and time-consuming (*inter alia* red tape) while there are budgetary constraints and capacity problems. The backlog of existing leases issued unconformably across the cadastre, without proper spatial referencing, is not addressed. This situation is regarded as indicative of what can be expected in many comparable District Offices of DLA (Venter 2003 *pers. comm.*).

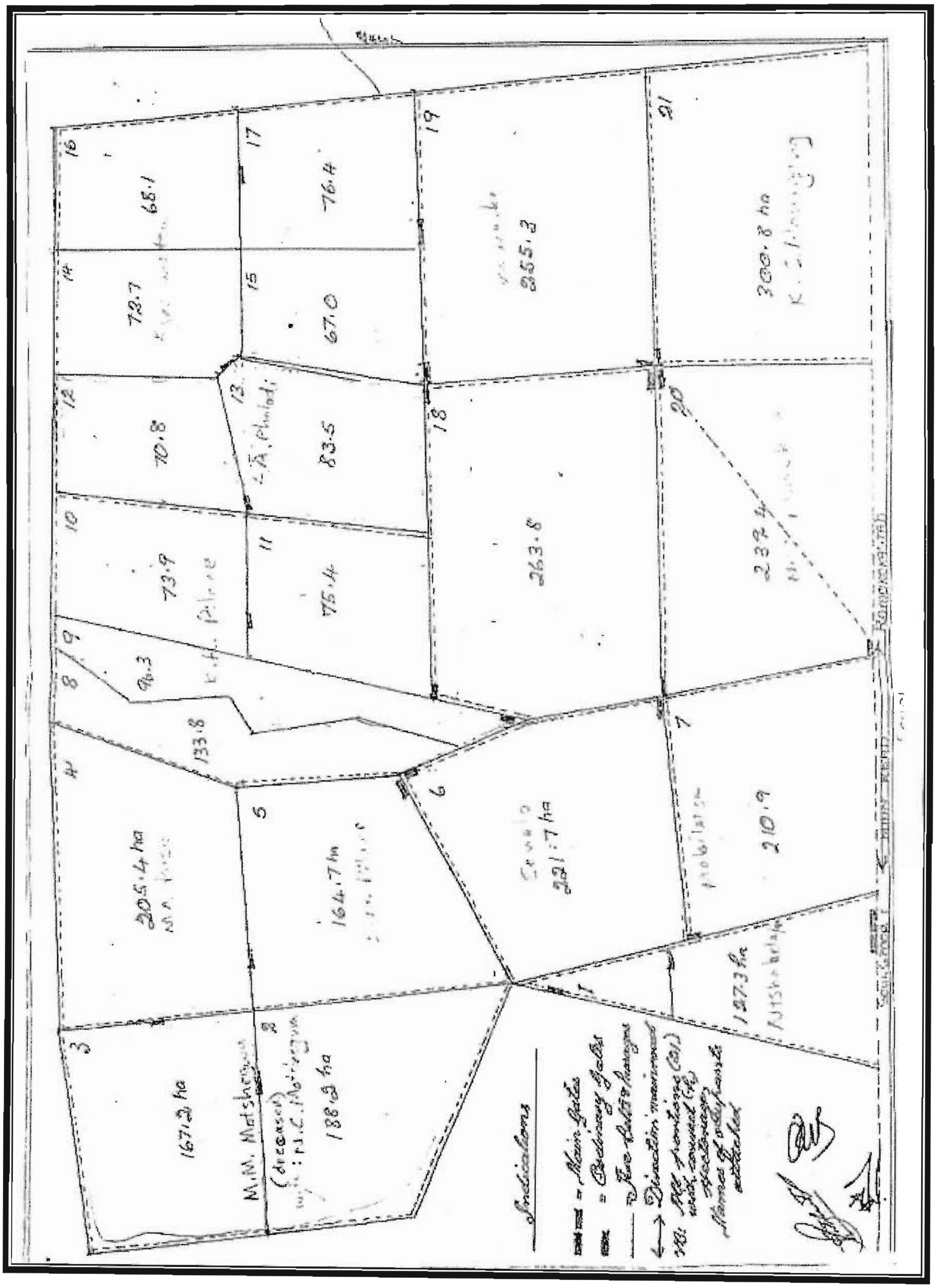


Figure 3.1: Hand-drawn sketch map *(South Africa: Department of Land Affairs, from departmental files 2003)*

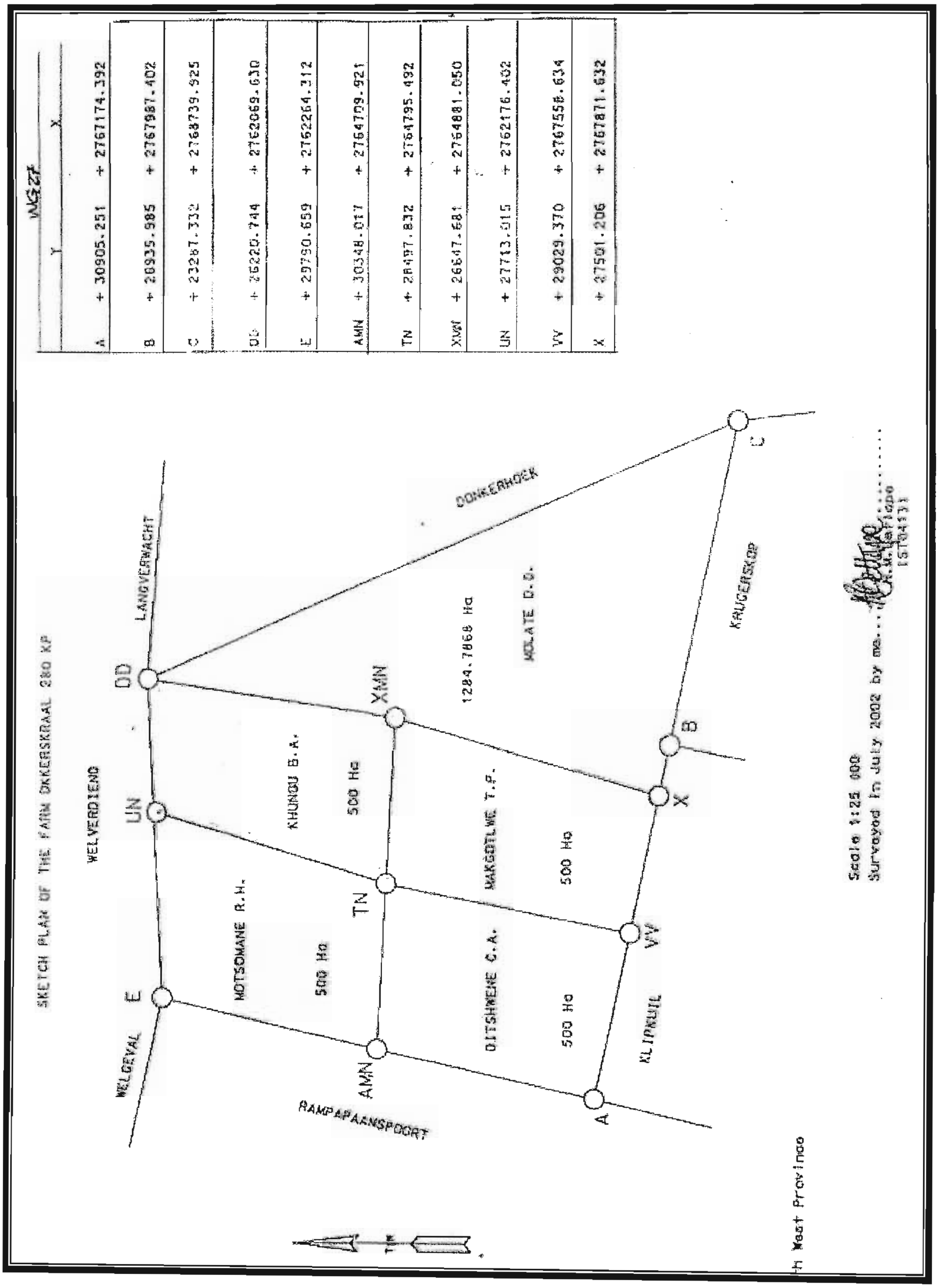


Figure 3.2: **Sketch map with coordinates** *(South Africa: Department of Land Affairs, from departmental files 2003)*

3.2 Information technology/tools used

As indicated in *paragraph 1.1.2.3* above, in order to perform its functions, the Sub-Directorate: System Development and Technical Support utilises information technology and tools, such as GIS, satellite and aerial imagery, GPS, the Internet and data administration. Chief base data providers (Deeds Office and Surveyor-General's Office) and software used (ReGis, ArcGis, Maptitude, AutoDesk MapGuide, SQL Server, MS Access, etc.) dictate to a large extent the format of the data.

3.2.1 GPS

Real-time differential GPS (DGPS) equipment is used (OmniSTAR) in conjunction with a pen-computer. Although the equipment is relatively expensive (R84 000 and a yearly signal fee of R14 000), DGPS is needed for its real-time capabilities to perform adjudication on state land, such as before leases are to be finalised and in boundary disputes between lessees. TrigNet, an active control survey network provided by the Chief Directorate: Surveys and Mapping is unfortunately currently only available as a post-processing facility (South Africa: Department of Land Affairs: Chief Directorate: Surveys and Mapping 2003) and is currently not regarded as a viable alternative to the OmniSTAR service.

On the pen-computer the real-time position in relation to the digital cadastre and topography is indicated, while point and line coordinates with individual remarks and land use categories contained in the data dictionary are logged on the Psion 'Workabout' data logger. The sub-metre horizontal accuracy of the system is a bonus, but arguably not absolutely necessary in rural land.

After returning from the field, the data from the GPS and pen-computer is downloaded and processed to produce relevant maps and update data on the inventory of public land. The GIS software (Maptitude) on the pen-computer allows basic maps to be produced of areas investigated/surveyed, and spatial data to be imported to the other software platforms referred to above.

3.2.2 Digitizing

All the GIS-packages used by the Sub-Directorate allow on-screen digitizing. If sketch plans are available, boundaries/corner points are digitized with the aid of topographical features on the sketches and a backdrop consisting of the digital cadastre and topographical-sheets, and where available aerial photography, satellite imagery and/or ortho-photos.

Those sketch plans indicating coordinates of leased areas can of course be imported into the GIS by simply inputting the coordinates of corner points.

Photogrammetry and satellite imagery is currently seen as complementary to map making and not primarily used for the determination of lease boundaries, due to a number of reasons such as availability and cost of data covering the vast rural areas and lack of distinguishing features visible from above to use as 'general boundaries'.

3.2.3 Data administration

Without proper data administration, including cleaning and regular updates of the data, it would not be possible to link information on land spatially to the cadastre. In depth knowledge is needed of the functioning of the deeds register, the map cadastre, land administration (also legal requirements), the data sets themselves, and the peculiarities associated with them. For example, the computerised deeds registry and also the digital cadastre contain many errors (such as incorrect 21-character land parcel identifiers). In PLSS' experience, due to various historical reasons large areas have simply been omitted from the digital cadastre where approved paper-based SG diagrams do indeed exist. (Sometimes different areas are affected, as big as magisterial districts or parts thereof, in different versions of the digital cadastre resulting in so-called 'holes' in the digital cadastre – mostly in the former TBVC-states.) Large tracts of state land have also not yet been surveyed and/or registered at the Deeds Office, including substantial parts of tribal land, land allocated to tribes and land held in trust for communities / tribes. Deficiencies such as these clearly require long-term efforts to create a complete, consistent and correct database. This study is focused at resolving one of the problems associated with this aim.

As a crucial part of data administration, geocodes are generated for the centroids of all land parcels in the digital cadastre, allowing them to be linked to the alphanumeric land parcel data (the public land inventory) by using the unique 21-character LPI as key.

An Internet-based inter-departmental administration system for the disposal of state land with integrated text and spatial components was developed and implemented by the Sub-Directorate in 2001. By using the geocodes and LPIs, it is possible to disseminate the state land data via the Web, employing HTML pages in conjunction with AutoDesk MapGuide (a thin-client desktop viewer with elementary GIS functionalities). The core of the system is the public land inventory database, which can be queried from either the spatial side by selecting a land parcel on the map, or via specifying the land description in a drill-down fashion. As the system is focused on the administration of state land, and the sensitivity of state land data, the system is accessed by using a username and password.

3.3 Fieldwork: GPS measurements and map generated

As a pilot exercise, three of the abovementioned unconformable 34 leases without any sketch plans were measured, including some additional areas for possible future leasing. The DGPS equipment described above was used in conjunction with all available information (digital and paper-based) on the state land in the study area, such as 1:50 000 topographical maps, cadastral parcel data, and deeds data.

On the field visit the researcher was accompanied by a representative from the District Office and the respective lessees. Boundaries and corner points were measured as indicated by the District Office official and the lessees. It was possible to adjudicate any conflicting claims on the spot because the GPS point coordinates along lease boundaries were constantly related in real time to the parcel descriptions/boundaries of the cadastral layer on the pen-computer. If a GPS-coordinate is close to an identifiable cadastral beacon or corner point, the GPS-reading is *deemed* to be that of the cadastral point, i.e. the cadastre takes precedence. Most boundaries measured in this exercise were along existing boundary and camp fences of barbed wire.

Figure 3.3 below indicates the results of the GPS measurements after mapping it with Maptitude:

- the first leased area (A) consists of (1) a portion of Portion 2 of the Farm Legkraal 54 JR, measuring approximately 78ha; (2) a portion of Portion 7 of the Farm Legkraal 54 JR, measuring approximately 76ha; and (3) a portion of Portion 2 of the Farm Legkraal 54 JR, measuring approximately 74ha. The total area leased is approximately 228ha;
- the second leased area (B) consists of a portion of Portion 2 of the Farm Legkraal 54 JR, measuring approximately 170ha; and
- the third leased area (C) covers (1) a portion of Portion 6 of the Farm Legkraal 54 JR, measuring approximately 185ha; and (2) a portion of Portion 4 of the Farm Legkraal 54 JR, measuring approximately 30ha.

The occurrence of leases unconformable with the cadastre is graphically illustrated by these measured examples.

(Assigning the lease unit numbers indicated in brown on *Figure 3.3* is discussed in *paragraph 4.2* below.)

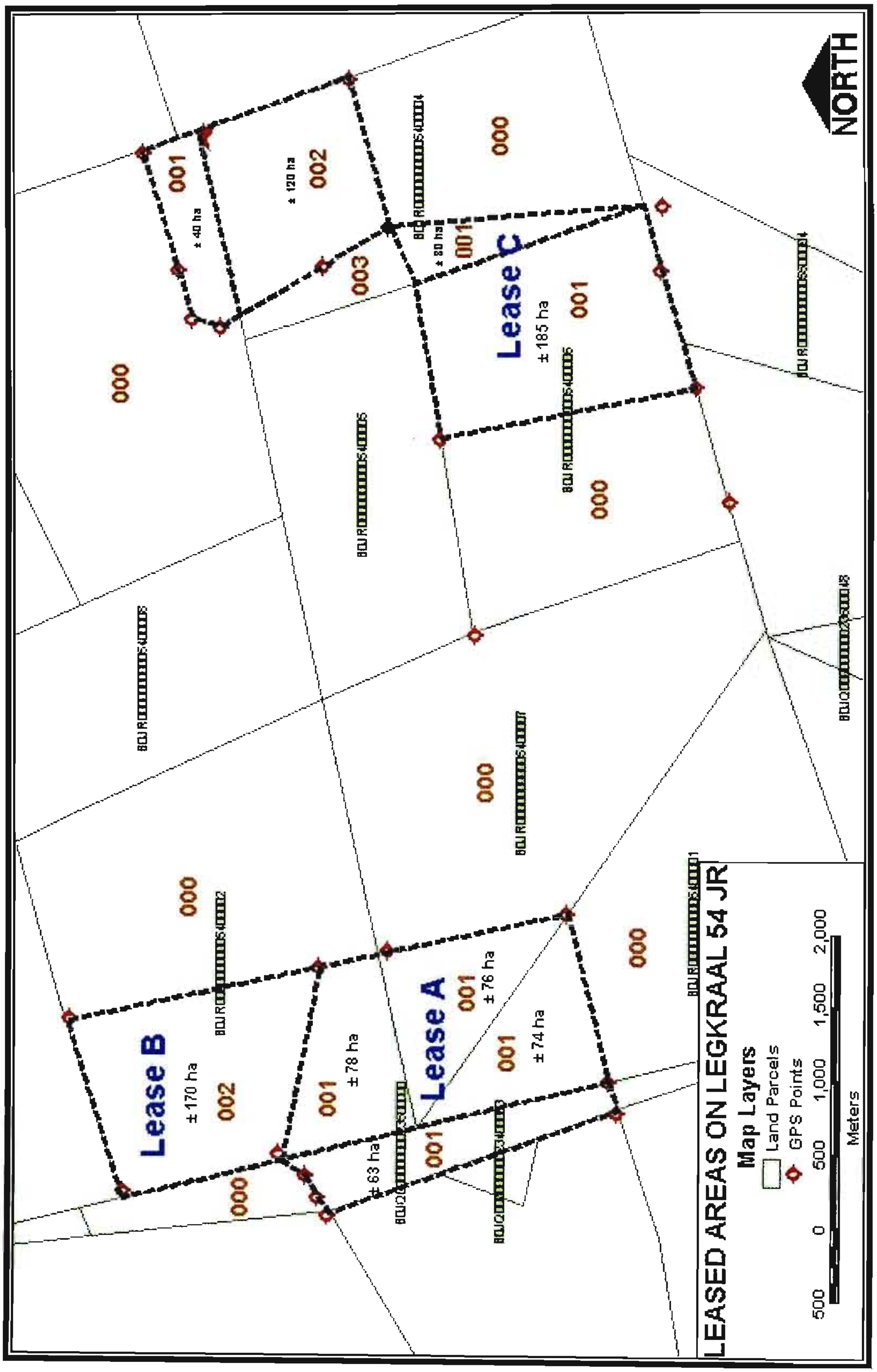


Figure 3.3: Unconformable leases measured by GPS *(own construction)*

4. PROPOSED CONVENTION FOR UNCONFORMABLE LEASE AREAS

Chapter 4 describes the proposed convention for spatial description of unconformable lease areas as developed on the basis provided in the previous chapters.

4.1 Founding principles

As previously discussed the South African cadastre uses, in line with international standards, a hierarchical convention to uniquely describe parcels. Based on this convention, a 21-character land parcel identifier has been derived for each land parcel on the digital cadastre.

It is sensible to build upon this logical, well-developed and entrenched system. Therefore the suggested convention for describing leases unconformable with the cadastre uses the cadastral descriptions (21-character code) of the underlying cadastral land parcels as foundation.

Apart from the data that is sourced from official data suppliers such as the Deeds Office and the Surveyor-General's Office, some form of measurements identifying the shape, size and location of leased areas must also be obtained or captured in some way. Both Larsson (1991) and Van der Molen (2001) strongly support the principle that a relatively low degree of mapping accuracy will provide sufficient specification on the location of the object, especially in rural settings.

This principle opens up various alternatives for measuring and describing rural leased areas on state land: by GPS (equipment range from cheap to expensive), by cadastral survey, by digitising existing maps found in various formats, by using photogrammetry and remote sensing where conditions permit. A main feature of the lease descriptions will be the fact that they are mapped *in relation to* the existing legal cadastre, although the leased areas may be captured less accurately in comparison with the South African cadastral surveying standards. The problem is simply that in many instances no spatial descriptions of leased areas exist. Most important, the data so captured will be in a format that can be carried on spatial and alphanumerical databases, enabling automation.

4.2 Assigning identifiers to lease units (convention)

Two basic types of *unconformable* leases have been encountered: (1) those forming part of a cadastral parcel, and (2) those across more than one cadastral parcel. The convention for uniquely describing these leases is founded in the existing cadastral descriptions (21-character code) underlying the units making up leased areas:

- the 21-character cadastral key forms the first part of the lease identifier;
- three additional digits forms the second part, denoting the individual *lease unit*. (It is not envisaged that more than 999 agricultural lease units will be allocated per cadastral parcel.);
- lease units are demarcated within each cadastral parcel;
- units are not assigned across land parcels, to be able to use one 21-character code for each unit. (This enables queries to specific cadastral parcels encumbered with leases.);
- leases can consist of one, or more than one unit which can be across cadastral parcels; and
- unit numbers are assigned to the individual demarcated lease units in accordance with the same convention as Portion numbers of cadastral parcels (described in *paragraphs 2.10.3.1 and 2.10.3.2*), starting at 000, 001, 002, etc.

Figure 4.1 schematically illustrates lease units (indicated in brown on map) with their assigned three-digit numbers on top of cadastral parcels (21-character code indicated in green on map). Leases may consist of a single lease unit, or more than one unit within a land parcel or across land parcels. This is also indicated on *Figure 4.1* with *Lease A* and *Lease B* (schematically indicated in blue on map). See also *Figure 3.3* above for GPS-measured leases in the Brits District Office area.

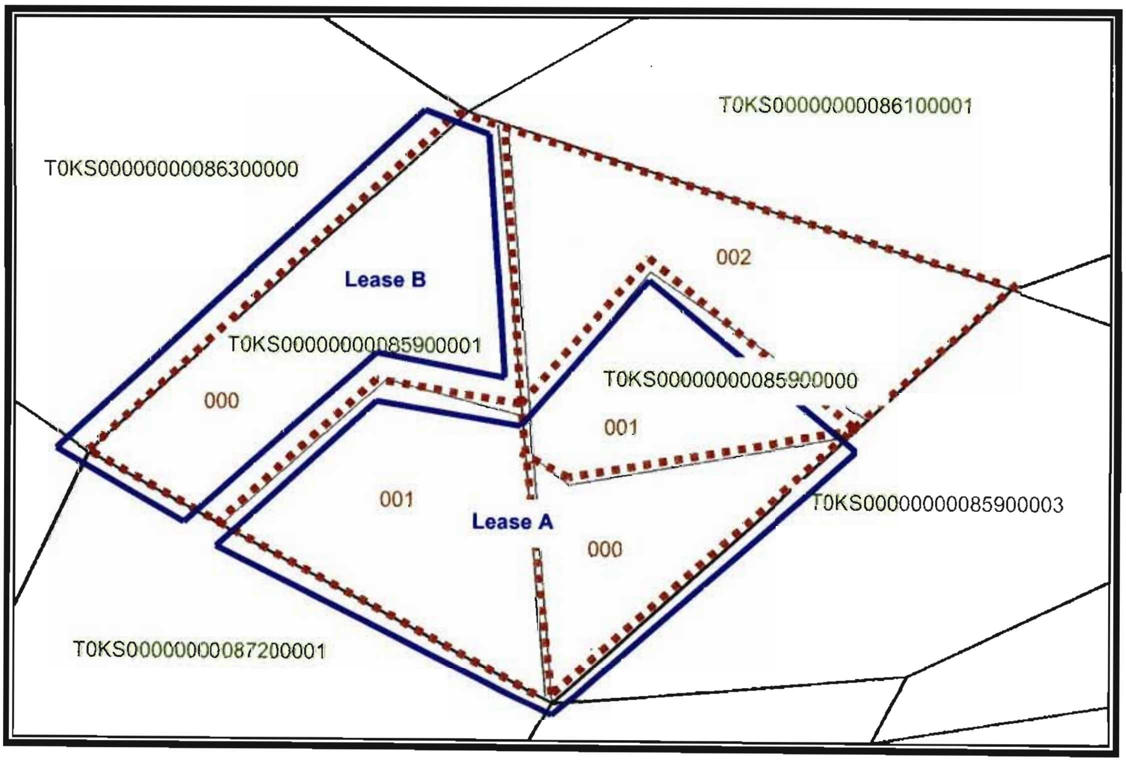


Figure 4.1: Lease units on top of cadastral parcels *(Own construction)*

Geocodes are generated for each lease unit and carried on a separate lease layer than the digital cadastre in the GIS. However, the two layers can be related to each other by using the 21-character key.

4.3 Information system architecture

The above convention is already being put to use in finalising development of a leasing system for administration of the Department of Land Affairs' leases. Spatial data on leases and land parcels will be contained in the public land inventory database on the Internet as described in *paragraph 3.2.3*. A second mainframe financial administration system known as the DLA's 'State Land Leasing System' (registration of lessees, receipt of payments, interest calculations, invoicing, etc.) will be linked to this database. All alphanumeric data on leased areas (21-digit codes, unit numbers, extents, etc.) will be populated into the leasing system via the Web. Lessee particulars will be populated back from the leasing system to the public land inventory database.

5. DISCUSSION

Chapter 5 concludes by providing some recommendations, and by commenting on possible applications of the proposed convention and perceived benefits thereof.

Statement one on the charter known as Cadastre 2014 hopefully states that in future cadastres will show the complete legal situation of land, including public rights and restrictions, which also means that the principle of *legal independence* must be respected. Different legal land objects (not only properties) are to be arranged in layers, according to the different 'laws' defining them (Kaufmann 1999, 2003). In keeping with the concept of a multi-purpose cadastre, the various line-function authorities and organisations are responsible for the respective layers. Kaufmann (1999, 2003) advocates the use of polygon overlaying techniques to create links between *land objects* where the different layers cut, such as a land parcel and the building on it. The links are only created when needed.

Linking of leases and cadastral land parcels is embedded in the proposed method /convention through the consistent use of the 21-character land parcel identifier. This is in line with the legal independence principle, but the linking mechanism is different to that of polygon overlaying, in the sense that the links are 'permanently' there and not just created when needed. Main reason for this is the express need to specifically relate lease units back to parcel descriptions in the cadastre to facilitate later formalisation of ownership. (One must not forget that the DLA is primarily responsible for administrating the land under its control within the current legal framework, which includes the cadastre.)

A most important spin-off is that although the convention is applied in a cadastral and parcel-based context for leases, it can easily accommodate a geocoded single-point register of rights such as communal/occupational rights. It is a known fact that various difficulties are also experienced in spatially describing and linking land claims data. Single-point cadastres and their merits have been discussed by Jackson (2000, 2002). Instead of indicating lease units, the extra affix (which needn't be limited to three digits) to the LPI can represent a numbered geocoded right occurring at a point within a parcel. The method can thus provide a vehicle for progressive recognition of rights towards full legal ownership analogue to progressive title registration and land measuring in Namibia. This could have many applications within land reform programmes.

Key to the successful functioning of the State Land Leasing System will be that of balancing the technical matters of a LIS with the needs in the field. Jackson (2002) articulated this by proposing a dumb-bell shaped information system with the data manager on the one end and the field worker on the other. A digital flow of information between the two forms the handle. He also sees the office being placed in the field. Therefore the proposed system is envisaged to function on a centralised technological level (data administration, base data, system development and maintenance, etc. by DLA National Office), with decentralized implementation/data gathering (DLA District and Provincial Land Reform officers responsible for restitution, redistribution and tenure reform) and two-way communication/feed of data. Providing a facilitating institutional framework is paramount, in which appropriate training plays no small part. For example, some District Office incumbents have indeed been involved in independently taking GPS-measurements with basic hand-held equipment. Thereafter the data was e-mailed to the Sub-Directorate: System Development and Technical Support and mapped by the GIS-operator for use by the District Office. Should it be necessary, the Sub-Directorate: SDTS can still be involved with specific matters such as adjudication, because of the available high-level technology, knowledge and expertise.

The question can be asked why not survey the leased areas upfront? Why the need for such a convention and spatial capturing of unconformable leased areas? Indeed, in some instances it is desirable and feasible to survey immediately. However, in many cases the individual lease areas can change over time before conversion to ownership takes place; funds and capacity are lacking to formally survey as the sheer magnitude of land for which only the Department of Land Affairs is responsible is mind-boggling – 13 million ha. Seeing that the district officer has to visit and monitor the leased land in any case, it would be efficient to use a basic GPS and palm-top connected to the leasing system. Many leases (especially those contained within a single cadastral parcel) can also be sufficiently digitised from existing hand-drawn maps.

Finally, it is hoped that the method proposed by this study will benefit state land administration at the Department by facilitating the capturing of unconformable lease data on a spatial and text database. The availability of better data on leases should promote more effective integration of data with the corporate systems of the DLA, needed to support land reform programmes. This should lead to more efficient financial reporting to the Auditor-General on the DLA's assets. More efficient administration of leases on DLA-land by enabling better capacity at District and Provincial Land Reform Offices (through the availability of systems and procedures) should lead to better services rendered to clients (specifically land reform beneficiaries). By using the convention, it is possible to better manage leasehold as an interim step before finalisation of individual freehold. Relating the unconformable areas to the cadastre should strengthen the formal cadastre, not replacing or detracting from it. It should lead to more precise instructions to surveyors in formalising individual ownership with less confusion. Updating of the cadastre will take place through formal surveys as needed in tenure upgrading of beneficiaries.

To conclude, let's start with the beginning – due to the need for a method of description of unconformable leases, a convention was developed that has strong links with the formal cadastre. (The formal cadastre is pivotal to the country's economy, especially in a classic commercial environment.) Relevant technologies and examples were examined. The proposals were tested and are feasible. They even appear to be suitable for other applications in the land reform arena, such as a geocoded single-point register of rights. It might even have some potential for application in the Communal Land Rights Bill. However, nothing will come of this methodology if it is not integrated into the business procedures of the DLA. For that, the support of management is crucial.

REFERENCES

Books, papers, articles and Internet URL

Dale, P. F. and J. D. McLaughlin (1999): *Land Administration.* Oxford University Press, New York.

Groot, R. and J. D. McLaughlin (2000): *Geospatial data infrastructure – Concepts, cases and good practice.* Oxford University Press, New York.

Haldrup, N. O. (1996): Adjudication – A way of coping with incomplete information in developing countries, *Survey Review, Vol. 33, No. 262, October 1996.*

Hurtado, J. M. Jr. (2002): *University of Texas at El Paso: Geology 1301, Lecture 3* [online].
Available at: http://www.geo.utep.edu/pub/hurtado/1301/index.html [Accessed 2 May 2003].

International Federation of Surveyors (FIG) (1994): FIG Statement on the Cadastre, adopted by Commission 7. *South African Journal of Surveying and Mapping, Vol. 22, Part 6, December 1994, pp.415-426.*

Jackson, J. (2000): *The relationship between the graphical elements of a colonial cadastre and the conception of land ownership that it supports.* Proceedings, Commonwealth Association of Surveying and Land Economy conference, Kuala Lumpur, 21 – 24 June 2000.

Jackson, J. (2002): *Technology as a problem in South African land tenure reform. Coming to terms with De Soto's criticism of "technicians".* Proceedings, FIG symposium on land redistribution in Southern Africa, Pretoria, 6 – 7 November 2002.

Juma, S. Y. and S. F. Christensen (2001): *Bringing the informal settlers under the register – the Namibian challenge.* Proceedings, International Conference on Spatial Information for Sustainable Development, Nairobi, Kenya, 2 – 5 October 2001.

Kain, R. J. P. and E. Baigent (1992): *The cadastral map in the service of the state: a history of property mapping.* University of Chicago Press, Chicago.

Kaufmann, J. (1999): *Cadastre 2014: A tool to make land administration more effective?* Proceedings, FIG working week and survey 1999.

Kaufmann, J. (2003): *Cadastre as the basic tool for land administration – need for a big leap forward.* Proceedings, FIG working week, Paris, France, 13 – 17 April 2003.

Kaufmann, J. and D. Steudler (1998): *'Cadastre 2014' – Report of Commission 7 Working Group 7.1, Modern Cadastres.* FIG (International Federation of Surveyors), Switzerland.

Larsson, G. (1991): *Land registration and cadastral systems: Tools for land information and management.* Longman Scientific and Technical, Essex.

Manisa, M. B. and L. Maphale (1999): *Spatial information management for sustainable rural development.* Proceedings, FIG working week and survey 1999.

South Africa: Department of Land Affairs (2003): *Chief Surveyor-General* [online].
Available at: http://www.csg.dla.gov.za/ [Accessed 2 May 2003].

South Africa: Department of Land Affairs: Chief Directorate: Surveys and Mapping (2003): *The South African network of active GPS base stations* [online].

Available at: http://w3sli.wcape.gov.za/surveys/mapping/gps-base.htm [Accessed 23 July 2003].

Tembo, E., M. Manisa and L. Maphale (2001): *Land information management in customary land in Botswana.* Proceedings, International Conference on Spatial Information for Sustainable Development, Nairobi, Kenya, 2 – 5 October 2001.

United Nations Centre for Human Settlements (Habitat) (1990): *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), Nairobi.*

Van der Molen, P. (2001): *The importance of the institutional context for sound cadastral information management for sustainable land policy.* Proceedings, International Conference on Spatial Information for Sustainable Development, Nairobi, Kenya, 2 – 5 October 2001.

Vries, W. T. de (2002): Implications of progressive title registration for cadastral information production: case study of Namibia. *Survey Review, Vol. 36, No. 286, pp. 591-601.*

Williamson, I. P. (1997): The Justification of Cadastral Systems in Developing Countries. *Geomatica, Vol. 1, No. 1, pp.21-36.*

Government Publications

South Africa: Department of Land Affairs: Directorate Public Land Support Services (2001): *Division and registration of land – From unsurveyed and unalienated state land to registered deed and the procedure of state land disposal.* Unpublished manual.

South Africa: Department of Land Affairs: Directorate Public Land Support Services (2002): *Categories of public land.* Unpublished figure.

South Africa: Department of Land Affairs: Directorate Public Land Support Services (2002): *The extent of state land in the Republic of South Africa (ha).* Unpublished table.

Statutes

South Africa: *Restitution of Land Rights Act, 1994 (Act No. 22 of 1994).*

Personal Communications

Venter, P. (2003): Chief Planner, Department of Land Affairs: *Personal communication during visit on 11 July 2003 to Department of Land Affairs' District Provincial Land Reform Office situated in Brits, North-West Province.*

COMPONENT B: ARTICLE

Untangling state records of agricultural leases in a LIS

Paul C Schoeman

Leasing of rural state land by the Department of Land Affairs takes place in a manner that ignores existing property boundaries. How can such leases be captured and described spatially on a land information system? This article describes a system or convention (method) of spatial description for these areas whilst relating it to the cadastre, as well as capturing and maintaining the data on a LIS. Best practices were identified through a literature study on land administration, LIS and available technology while focussing on parcel-based systems. GPS measurements of typical unconformable leases were taken at a pilot locality and a map constructed. Based on this, a convention was developed for indexing and spatial description. Using this, administration of leases will be more effective. It could also be applied to other spheres of land reform and non-parcel based geocoding of centroids indicating occupational or communal rights on land.

1. INTRODUCTION

Cadastral systems in developing countries are important: 'in promoting increased investment in agriculture; for more effective husbandry of the land; for improved sustainable development; to support an increase in GNP through an increase in agricultural productivity; and providing significant social and political benefits leading to a more stable society, especially where land is scarce' (Williamson, 1997). The cadastre is closely linked to LIS, land registration and land management (FIG, 1994). It is also an essential pre-requisite for land reform.

In spite of the apparent tidiness of the South African central registry system or cadastre, a large number of real rights are managed outside of it. It is true to say that state land management in South Africa takes place in a complex and disjointed system, largely inherited from the previous regime. Main owner-departments of state land in the country currently are the DLA, the Public Works Department (PWD), and the nine Provincial Governments. The bulk of the state land that the DLA is responsible for consists of the areas of the former (pre-1994) TBVC-states, self-governing territories, and ex-South African Development Trust land. State land consists of approximately 24 million ha in total, of which the DLA is responsible for managing more than 13 million ha. Leases on rural state land under control of the DLA need to be issued and administered on a computerised system that is compatible with the parcel-based cadastral model used for the other parts of land administration and management.

As with freehold deeds, leasehold diagrams should be included in the leasehold documents to support the textual information. Spatial information is also needed as the leasing amounts are based partly on the area leased. Finally, spatial information is needed for proper land information and management. These requirements are easily met if leased land parcels have approved Surveyor-General (SG) diagrams. Unfortunately it is not possible to simply add the spatial component of the leasing debtor information to the existing cadastre, because not all leased areas correspond with approved cadastral parcels. There is thus a need for a system or convention (method) for the spatial description of leased areas on rural state land unconformable with the cadastre in order to carry that information on a database in a leasing system. One should be able to extrapolate the developed methodology to other programmes of land reform, enabling the exchange of spatial data between different programme databases to bolster a more integrated approach to state land administration and land reform.

2. LITERATURE REVIEW: CONCEPTS & 'BEST PRACTICES'

Why go to the trouble of basing the proposed convention on cadastral land parcels? One must remember that land administration (of which leasing is part of) in the DLA takes place within a specific institutional paradigm: on the one hand there is the existing parcel-based public land inventory LIS used as basis for land administration and on the other the fact that both the SG and Deeds Office are part of the DLA. Furthermore, if state land is to be transacted, it has to be effected through legally prescribed registration procedures.

2.1 Land administration

In 1996, at the Habitat II Conference, many countries committed themselves to 'Promoting optimal use of productive land in urban and rural areas .... through developing and supporting the implementation of improved land management practises' (UNCHS 1996 cited in Dale & McLaughlin 1999:1). In addition to environmental aspects, access to land and security for credit are pivotal to sustainable development and good land management practice, necessitating that efficient and effective land administration mechanisms are put in place by the state.

Dale & McLaughlin (1999:1) use the term land administration to refer to 'those public sector activities required to support the alienation, development, use, valuation, and transfer of land'. Land administration systems provide mechanisms that support the management of real property. 'The processes of land administration include the regulating of land and property development, the use and conservation of the land, the gathering of revenues from the land through sales, leasing, and taxation; and the resolving of conflicts concerning the ownership and use of the land' (Dale & McLaughlin, 1999:10). Land administration functions can be divided into four components: juridical, regulatory, fiscal, and information management. Information management is integral to and underpins the other three components in terms of land registration (juridical cadastre); valuation and taxation (fiscal cadastre); and planning and enforcement of regulations (zoning and other information systems). They further regard the cadastral parcel as the basic building block in any land administration system. In short, thus, while the function of a land administration system is to support the management of real property, the function of a land information system is to underpin this process (Dale & McLaughlin, 1999).

2.2 Land information systems

The definition of the LIS-concept as adopted by FIG (International Federation of Surveyors) is as follows:

> A Land Information System is a tool for legal, administrative and economic decision-making and an 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 land information system is a uniform spatial referencing system for the data in the system, which also facilitates the linking of the data within the system with other land-related data (cited in Larsson, 1991:2).

Through providing access to reliable information on land, land information systems *inter alia* help to facilitate rural land reform. This is especially important in view of the fact that the state is a major landowner, but the management of its land is not optimal as discussed above.

GIS assume a growing role in driving data processing within LIS. In this article GIS is narrowly seen in terms of computer technology (sets of hardware, software and data). In contrast, the term *land information systems* is used in this study to cover the technology, the applications and the institutional framework within which the technology is operated. Further, LIS 'are concerned with detailed information recorded at the local level so that they may be mapped at large scales' (Dale & McLaughlin, 1999:94).

2.3 Role of the cadastre in LIS

Henssen & McLaughlin (1986, cited in Larsson, 1991:15) define the cadastral parcel as follows:

> A cadastral parcel is a continuous tract of land within which unique tenure interests are recognized. The cadastral parcel must envelop a continuous area of land and a continuous interest in land. On the map a cadastral parcel is formed by a, in itself closed, line which encloses the map, and has a unique identification.

The United Nations 1985 Ad Hoc Group of Experts on Cadastral Surveying and Land Information Systems, cited in Larsson (1991:16), define the cadastre as follows:

> The *Cadastre* is a methodically arranged public inventory of data on the properties within a certain country or district based on a survey of their boundaries; such properties are systematically identified by means of some separate designation. The outlines of the property and the parcel identifier are normally shown on large-scale maps.

For the purposes of this article, a cadastre is therefore a systematic description (mapping included) of the land units (and associated rights) within an area. Information, in addition to the traditional identifier/land description, area, owner, land classes, land values or taxes, such as building plans may also be found in cadastres. Then the extended cadastre is known as a multi-purpose cadastre (Larsson, 1991).

Of course, the bounded cadastral parcel is not necessarily ideal under all circumstances, as argued by Jackson (2000, 2002): The single point method where a (single) geocode is attached to a land right or centroid of an area can be a more effective method than parcelling, especially with regard to the 'visual confusion' when two unconformable parcel layouts are superimposed. This will also find application under communal conditions where a mixture of exclusive and overlapping communal use areas is found.

Because many land data elements are parcel-based it can theoretically be collected and collated by a single cadastral agency. Such data can be used in asset management, development control, environmental impact, land-ownership, etc. However, in most instances it is not practical for all the gathering of data to be so centralised, since the various databases have historically been compiled separately by different agencies. Computer networking facilitates integration of these datasets into an apparently seamless whole by using as key a 'unique parcel reference number (UPRN)' to identify each land unit. This is similar to the SG-generated South African land parcel identifier (LPI) derived from the cadastral reference of land parcels. The sum of information on one parcel can then be 'compiled by a series of inquiries to the different organisations gathering the data' ('data custodians') rather than by carrying all the information on one massive database (Dale & McLaughlin 1999:96).

2.4 Processes in compiling cadastres/land ownership records

According to the United Nations Centre for Human Settlements (Habitat) (1990), four basic operations take place in the compilation of cadastres/land ownership records: adjudication, demarcation (also called monumentation), survey, and documentation (registers and maps). These are similar to the processes needed to compile a lease register at the DLA.

2.4.1 Adjudication

Lawrance (1985), as cited in Larsson (1991), describes the concept of adjudication as follows:

> Adjudication is the word now used in many English-speaking countries to describe the process whereby all existing rights in a particular parcel of land are finally, and authoritatively ascertained.

According to Haldrup (1996), adjudication is a 'formal procedure for the resolution of a dispute by the application of pre-existing rules'. Adjudication establishes what rights exist, by whom and where they are exercised, and what limitations, if any, they are subject to.

2.4.2 Demarcation

Demarcation can, according to Larsson (1991), be done in two basic ways:

- By fixing the exact position of the boundaries on the ground in the presence of the parties. Boundary disputes can be referred to court. After fixing, the positions are monumented (with pipes, stones, concrete beacons, etc.) if existing topographical features such as fences and hedges are not regarded sufficient for demarcation. This method is usual when new boundaries are being established.
- By recognising the boundaries on the ground. When necessary, they may be surveyed or photogrammetrically identified, but they are neither legally fixed nor permanently demarcated (if not specifically so requested). This method is cheaper to use for maps over large areas, especially where the boundaries are visible on aerial photos.

2.4.3 Cadastral survey

According to Dale & McLaughlin (1999:48):

> Cadastral surveying is the term generally used to describe the gathering and recording of data about land parcels, even where the records do not form part of an official cadastre.

A bit more simply, Larsson (1991:88) defines a cadastral survey as a survey of boundaries of land parcels. He expands further: 'Boundaries' (either fixed or general) 'are the main object of cadastral surveying. Other features, such as roads, watercourses, land-use boundaries, buildings, etc., are regularly included, but the primary purpose is to define the land unit – on the ground and in the cadastre and land register'. All cadastral surveying should be connected to a national system of control.

2.4.4 Land register: documentation and maps

According to FIG (1994), land registration is the official recording of legally recognised interests in land. FIG also confirms that from a legal viewpoint there are two basic types of system:

- deed registration: documents filed in the registry are the evidence of title; and
- registration of title: the register itself serves as the primary evidence.

Variations abound: some deed registration systems include a number of critical elements of title registration, such as cadastral mapping, parcel-based indices, and examination of documents. Due to modern LIS and computerisation, the distinctions between systems are becoming less important (FIG 1994). The South African deeds registry combines elements of both systems.

2.5 Techniques and technologies in cadastral surveying and LIS

Broadly speaking, there are two categories of surveying technique – field survey and photogrammetry, as well as two categories of output – graphical and digital (Dale & McLaughlin, 1999). Whether the approach is sporadic or systematic, according to Larsson (1991) the goal will eventually be to establish a cadastral map providing a total view of all the land units in an area, to enable the creation of an efficient parcel-based LIS.

On the one hand, such plans can be compiled from existing topographic maps, cadastral surveys, aerial pictures, orthophoto maps, etc. If the national and the local system can be connected, computer-aided support can be used to transform the coordinates and plot the map (Larsson, 1991). Digitizing coordinates from old cadastral maps can also be performed, as was done in South Africa during the 1990s from cadastral index plans ('compilation sheets'). On the other hand, should new cadastral surveys be needed, these can be made with either photogrammetric methods or ground survey methods (Larsson, 1991).

Photogrammetric surveys involve a number of different methods with varying degrees of accuracy and expense (Larsson, 1991). However, photogrammetry is to a large extent dependent on existing boundaries that are visible from the air, which is a similar constraint to the use of high-resolution satellite imagery and remote sensing (Dale & McLaughlin, 1999).

Cadastral surveys have generally been undertaken in the field using theodolites, steel tapes, or electronic distance measuring (EDM) systems, and total stations. GPS technology is increasingly used to provide coordinate values (which are easily handled by computers) to various levels of precision from metre down to centimetre level. The unit cost of fixing any individual boundary point declines as the price of GPS equipment and support services fall (Dale & McLaughlin, 1999).

Significantly, Dale & McLaughlin (1999) feel that although GPS technology is playing an increasingly important role in the measurement of parcel boundaries and the construction of maps, the greatest impact on land administration has come from information-handling technologies rather than from surveying itself.

As an example of automation, Larsson (1991) describes the Swedish cadastre/land register system as having a land data bank, which is integrated with other national registers by using the parcel number or address as identification key. Because the land data bank carries the central coordinate ('geocode') for every cadastral unit, all register information on persons, buildings, households, real estate, development plans, etc., can be positioned and mapped automatically.

In the past decade the Internet, in combination with standardised graphical user interface software, has come to the fore to address the requirements of access, viewing, and distribution of land data (Dale & McLaughlin, 1999:99). An example is the Internet-based state land administration system implemented in 2000 by the Directorate Public Land Support Services (PLSS) and briefly discussed later.

2.6 Indexing of cadastres/land registers

Larsson (1991) notes the trend in Western countries that their cadastres/land registers are increasingly being indexed according to the more lasting entity of the land unit (parcel) itself, identified by maps and unit number, rather than on landowners. It is thus clear that the primary basis for even a simple land record system is a systematic division into land units. Larsson (1991:146) suggests that this division should be:

- hierarchical, namely, 'structured on different levels and go from district to block and to unit designation within the sub-block';
- flexible, namely, use 'logical and simple rules for making changes of designation when a unit is subdivided, amalgamated, or otherwise changed';
- unique, namely, 'no two units shall ever have the same designation';
- multipurpose, namely, be suitable for use – on its own 'or in combination with other units – in all types of land records and tasks irrespective of the purpose'.

2.6.1 Land unit identifier

According to Dale & McLaughlin (1999:59) it is easier to obtain consistency between different agencies addressing the same parcel if the reference system has the following features:

1. easy to understand, for thereby less confusion and mistakes are likely;

2. easy to remember so that landowners can recall their parcel references;
3. easy to use by both the general public and administrators and in computers;
4. permanent so that for instance the parcel reference does not change with the sale of the property;
5. capable of being updated when there is a subdivision or amalgamation of two adjoining properties;
6. unique so that no two parcels have the same reference and there is a one-to-one correspondence between what is on the ground and what is referred to in the registers;
7. accurate and unlikely to be transcribed in error;
8. flexible so that it can be used for a variety of purposes from registration of title through to all forms of land administration; and
9. economic to introduce and to maintain.

Larsson (1991:158-60) lists, in his opinion, the most important types of land unit identifiers as:

- o hierarchical identification systems (frequently in the form of 'municipal unit – block – sub-block – land unit number' or document numbering);
- o grid identification systems (using grid coordinates); and
- o hybrid hierarchical/grid identifiers.

Larsson (1991:160) cites Ziemann (1976) when looking into the advantages and disadvantages of the different systems: a hierarchical identifier consisting of the components (state) – county – tract – group – source parcel – affix is recommended. 'The source parcel is here the original land unit, while affix is the number given at subdivision. With this method, the source parcel number can be retained even after subdivision or other changes. County – tract – group can be designated by number or by names'. Ziemann recommends numerals as affix, as they are more convenient than alphabetical characters. A single affix is also preferable, as multiple affixes would create a growing string of additional digits with each boundary change. In Sweden such a hierarchical system is used for determining parcel identifiers. The recently introduced South African LPI (land parcel identifier) can be compared to this system.

2.6.2 Geocodes

Larsson (1991) reminds the reader that parcel numbers do not directly express the geographical location of a property. Some kind of geocode is needed for that. They normally are the coordinates of boundary points (stemming from a grid identification system as discussed above) or of a certain point on the parcel such as the centroid or main building. Geocodes allow a direct relationship between the data and its spatial location. In this way all data in a system can automatically be mapped. Parcel-based systems thus have great flexibility because the information is no longer tied to a certain administrative area, but can be geographically linked to any selected area. To enable automation, the geocoding system used by Sweden includes the centroid of the land parcel as well as the coordinate of the principal building in the cadastral records.

2.6.3 South African cadastre and parcel identifier

In South Africa, the Deeds Office is responsible *inter alia* for the registration of deeds, linked to a cadastre (depicting the relevant registered real rights) under the responsibility of the SG. The process is therefore basically two-fold: Firstly, a survey is carried out by a cadastral land surveyor to determine or demarcate the boundaries of a land parcel, lease or servitude. The second stage is that, once the survey has been examined and the diagram has been approved by the SG, the person or body who intends to benefit from that right over the land can register the right in the Deeds Office (South Africa: DLA: PLSS, 2001).

2.6.3.1 Assigning parcel descriptions

The property description indicated on the cadastral diagram and used in the 'property clause' of the deed is a unique description assigned to the land parcel by the Surveyor-General. The basic method to denote the parcel description is similar to that of the hierarchical identifier consisting of the elements (state) –

county – tract – group – source parcel – affix cited above. The source parcel is the original land unit, while affix is the number given at subdivision.

Broadly, the parcel description consists of the following elements (South Africa: DLA: PLSS, 2001):

- For a rural land parcel, the land parcel (farm) is given a sequential number within a deeds administrative area called a registration division (RD) by one of the Surveyors-General in one of the areas historically coinciding with the four pre-1994 provinces. Some registration divisions in specific areas are based on a grid with one-degree squares and denoted as JQ, IQ, FU, etc. – for example, 'I' refers to 26° of latitude, and 'Q' refers to 27° of longitude. In the rest of the country, until finally converted to the above notation, RDs (there referred to as administrative districts) are geographic areas closely resembling magistrate districts. A farm registry book is opened at the SG Office to record all future surveys (subdivisions, consolidations, leases, servitudes, etc.) on this parcel of land (the 'source' or 'parent' parcel), the boundaries of which are indicated on a diagram framed by a surveyor, and examined and approved by the SG. In most instances, apart from the farm number, the farm was also named.

  When subdividing the farm through further survey, the subdivisions are sequentially numbered ('affix') starting at one – the first is referred to as Portion 1 of the farm, the second as Portion 2 of the farm, and so forth. The piece of land left after subdivision, is referred to as the Remainder. Obviously, the original diagram would be endorsed to indicate that an area was deducted from the parcel (farm or subdivision). If an existing subdivision is re-subdivided, the new subdivision is allocated the next sequential portion number as determined from the register maintained by the SG. The original subdivision is referred to as the Remainder of Portion (original farm number). The same principle applies to the original remaining extent of the farm.

Consolidation of two or more adjoining land parcels into one land parcel can also be done after preparation of a new survey-diagram. A new portion number is assigned to the consolidated land parcel by the Surveyor-General. Existing component diagrams are endorsed to indicate that they have been incorporated into the new land parcel. Where two adjoining land parcels situated on separate farms are consolidated then a new farm number is defined and a new farm register is opened. All future subdivisions of this farm will refer to the new farm number.

An example of such a property description could be: Portion 3 of the Farm Rustfontein 502 in the Registration Division of KS.

- For creating urban land parcels it is necessary to proclaim a township on an existing farm/rural land parcel (or subdivide / consolidate). In the process a General Plan depicting all the surveyed parcels (known as erven) is drawn up and submitted to the SG for approval.

  Exactly the same procedure is followed as with rural land parcels in assigning a number to an individual erf within a specific township. Numbers for consolidation and subdivision are also assigned in a similar way. The first subdivision on an erf would be identified as Portion 1 of Erf (original erf number), and so forth.

  An example of such a property description could be: Portion 2 of Erf 554 in the Township of Pretoria in the Registration Division of JR.

2.6.3.2 Unique parcel identifier

Each individual land parcel depicted on a SG-diagram has a unique land description as discussed above. The paper-based cadastre was digitally captured by the SG Office during the nineties on a multi-purpose cadastre in which each land parcel, based on its description, is assigned a unique alphanumeric 21-character key/code or land parcel identifier.

The 21-character key comprises five elements as follows (South Africa: DLA, 2003):

- First character refers to:

  historically, the four pre-1994 provinces in which the offices of the four Surveyor's General are situated:

  T – Pretoria office (former Transvaal Province)

  F – Free State (Bloemfontein office)

  C – Cape Town office (former Cape Province)

  N – KwaZulu-Natal (Pietermaritzburg office)

- Next three characters ('major region code') refer to:

  the Registration Division (in the old Transvaal and in KwaZulu-Natal) or, the Administrative District in the Free State and old Cape Province.

  Example 1: 0IQ, 0JR, etc. This is a coded map reference used for Registration Divisions each comprising a Degree Square with its origin at 3411 = AA

  Latitude 33 = B, 32 = C, etc. with I = 26 degrees of latitude

  Longitude 12 = B, 13 = C, etc. with Q = 27 degrees of longitude

  Example 2: 001, 013, 003, etc. These are the numeric codes for computerisation purposes sequentially assigned by the SG to Administrative Districts, such as Cape, Caledon, Bloemfontein, etc.

- Next four characters ('minor region code') refer to:

  the numeric code for townships / holdings at the Pretoria, Bloemfontein, and Pietermaritzburg SG offices, and to an allotment area at the Cape Town SG office.

  Examples: 0099 is the numeric code for Eldorado Agricultural Holdings; 0014 is the code for the Kleinmond Allotment Area in Cape Town.

  A code of 0000 (4 zeros) indicates that the land parcel is rural or farm land.

- Next eight characters refer to:

  the land parcel number of an erf, holding or farm (source parcel).

  Example: 00001234 would be the code for Erf 1234, Holding 1234 or Farm 1234. The specific identification would be determined by referring to the minor region code.

- o Last five characters refer to:

  the portion of the erf, holding or farm. Subdivision numbers are not allocated to erf subdivisions in the Cape Town SG Office – they are given a new erf number.

  Example: 00015 is the code for Portion 15.

Combining these elements into a single key produces a unique description of a land parcel. Thus, the key N0FT02580000246400001, for example, uniquely identifies Portion 1 of Erf 2464 in the Township of Pietermaritzburg in the Registration Division of FT, Province of KwaZulu-Natal. The components are:

N	KwaZulu-Natal Province (area of Pietermaritzburg SG office)
0FT	Major region code (Registration Division FT)
0258	Minor region code assigned to Pietermaritzburg
00002464	Erf number
0001	Portion number (South Africa: DLA, 2003).

2.6.3.3 Geocode and parcel identifier

The linking of the datasets obtained from the Surveyor-General's Office and the Deeds Office is performed by the Sub-Directorate: System Development and Technical Support (SDTS) through using the above LPI of the SG's digital cadastre and generating a 21-character key from the Deeds Office's land descriptions. A geocode (based on latitude/longitude) for the centroid of each land parcel on the digital cadastre is then generated by the Sub-Directorate, thus enabling the spatial link to the digital cadastre within a GIS or LIS.

2.7 Case studies: Botswana and Namibia

In South Africa, agricultural lease areas were established in the course of development projects that in some respects paralleled administrative projects in neighbouring counties. Lessons might be drawn from our neighbours' experiences, unaffected as they were by apartheid. Two situations are reviewed, namely that of Botswana and Namibia.

2.7.1 Botswana: Land information management on customary land

According to Manisa & Maphale (1999) land in Botswana is classified into three main types of tenure namely customary, state, and freehold. Customary land is known as communal or tribal land. Urban villages on tribal land are expanding rapidly, creating unprecedented land problems.

According to Tembo et al (2001), land holding on tribal land takes place in the following manner: In settled tribal areas tenure can take the form of customary law tenure and common law leases. After an applicant applied for land, the Land Board will issue a Certificate of Customary Grant based on a sketch plan drawn by a technical officer of the Board. If an applicant wants to obtain a Title Deed in accordance with common law, the land must be formally surveyed. These sketch plans are not easily retrievable, as they are normally not linked to a database. Only when a formal cadastral survey is done, the parcels can be linked to the other surveyed parcels. Because the graphical information of Certificates of Customary Grant is not properly captured, there are potential problems land management in these areas.

In their project, Tembo et al (2001:6-8) captured information on existing plots in a specific district by GPS and a land inventory questionnaire. They linked the graphical data and text-based land inventory in a GIS, providing the ability to perform spatial and non-spatial queries to aid decision makers. They further state that while the small GIS worked well, it was not used in day-to-day business of the Land Board, illustrating the need for institutional issues to be tackled if an effective system is to be put in place. 'Indeed there is need to link the technologies in surveying, mapping and IT to the planning and management process'.

Tembo et al (2001:10) conclude by stating that it will be important to ensure that the collectors of data on land realise that the information is to be used in a greater system. Human resource development should also take place in tandem with the introduction of technology to ensure sustainability.

2.7.2 Namibia: Progressive title registration and land measuring

According to Juma & Christensen (2001), land in Namibia broadly falls into two categories: registered and unregistered land. Approximately half of the area is held under registerable freehold title, while the remainder is communal land with various types of land tenure associated with it. Tenure security is especially affected and eroded by rapidly expanding urban settlements in communal areas. In order to address these problems Namibia opted for a parallel interchangeable property registration system wherein the initial secure right is simple and affordable but may be upgraded according to what the residents and the government need and can afford at any given time. (Parallel indicating a system with different levels of tenure and interchangeable indicating the possibility to move from one level to the other.) This system, called the Flexible Land Tenure System, was piloted over two years, and put forward as a proposal in 1997.

Juma & Christensen (2001) and De Vries (2002) report that the system consists of three statutory types of tenure:
Firstly, a starter title which provides a holder with the following rights:

- to perpetual occupation of an (undefined) site within a block or in a similar block.
- to transfer, or to otherwise dispose of, the occupation right subject to custom or a constitution restricting transfers.

Secondly, a landhold title which provides the owner with these rights:

- to occupy a defined site in perpetuity.
- to transfer or dispose of this right. The right is thus mortgageable.

Thirdly, freehold title will provide the owner of these rights:

- the block's boundary will be cancelled.

- the parcel boundaries will be formally surveyed and registered in the Deeds Office.

Starter title can be upgraded to landhold title or, as is the case with landhold title, to freehold title. Registration of the two new types of title will be parallel to the existing registration system: the same land parcel will be registered in both the relevant local registry and the Deeds Office (Juma & Christensen, 2001).

Juma & Christensen (2001) state that due to a number of institutional, technical, legal and financial issues, the implementation of the new Flexible Land Tenure System has not yet proceeded as anticipated.

3. RESEARCH & RESEARCH RESULTS

I have tried to show that it is necessary to integrate leasehold records into the existing state cadastre, that the rules for such a land-information system are well-understood internationally and that the South African state has a well-developed system which however has not been applied uniformly to record leasehold rights. A field project was used to shed some light on the existing methodology for leasehold records and the obstacles for its adaptation to computerised lease register that would integrate well with the state's existing system.

3.1 Current leases at Brits District Office

One of the Department of Land Affairs' District offices was chosen to obtain lease information, namely the Brits District Provincial Land Reform Office in the North-West Province. It was deemed to be representative of the situation regarding the management of leases at a sizeable proportion of DLA's offices.

Examination of the 52 current leases (in July 2003) administered by the DLA's Brits District Provincial Land Reform Office in the North-West Province revealed the following:

- One lease out of 52 coincides or is conformable with a surveyed land parcel, making it suitable for capture in a spatial database using the 21-character key and a geocode.
- 17 leases, unconformable with the cadastre (mostly portions of land parcels), have some form of paper-based sketch plans. Some plans are hand-drawn maps (various formats) indicating 'farming/agricultural units' mostly determined in the pre-1994 dispensation by extension officers of government departments such as Agriculture, and also more recent sketch plans (not approved cadastral diagrams) indicating coordinates framed by land surveyors/ land surveying technicians for the express purpose of describing the leased areas. Two examples of such sketch plans are respectively shown as Figures 1 and 2 below. These leases cannot be identified and spatially linked by using the 21-character key, as they only form part of a surveyed land parcel.
- 34 leases, unconformable with the cadastre, have no sketch plans and are situated on one or across more than one cadastral parcel. Due to the fact that these lease areas do not coincide with the cadastre, they also cannot be identified and spatially linked by using the 21-character land parcel identifier.

These 52 leases form only a fraction of rural agricultural land that could be leased in that Office's service area. Office policy dictates that areas for new leases must be surveyed by a land surveyor or technician to produce either accurate sketch plans or approved SG diagrams. However, this is proving costly and time-consuming (*inter alia* red tape) while there are budgetary constraints and capacity problems. The backlog of existing leases issued unconformably across the cadastre, without proper spatial referencing, is not addressed. This situation is regarded as indicative of what can be expected in many comparable District Offices of DLA (Venter 2003 *pers. comm.*).

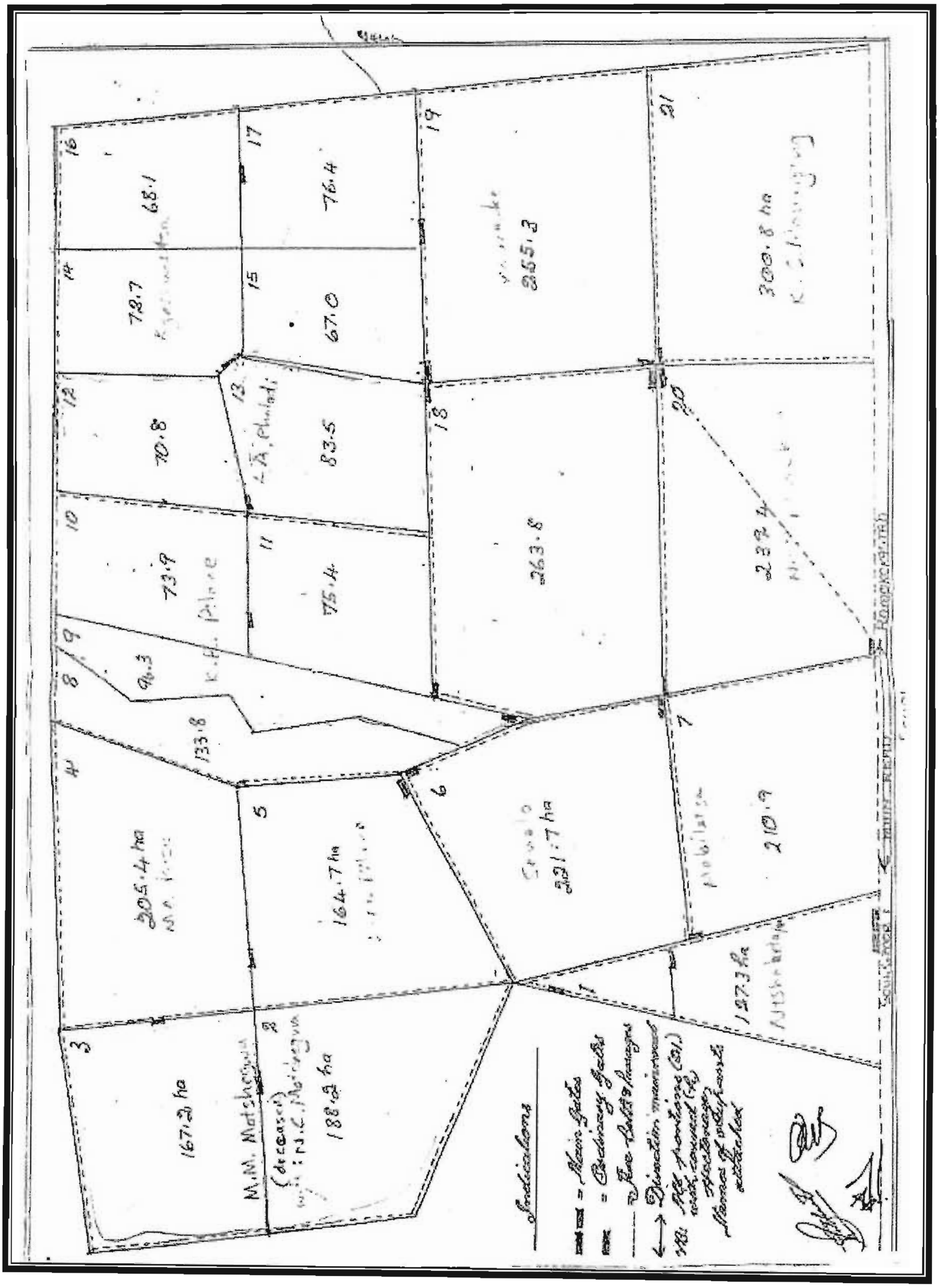
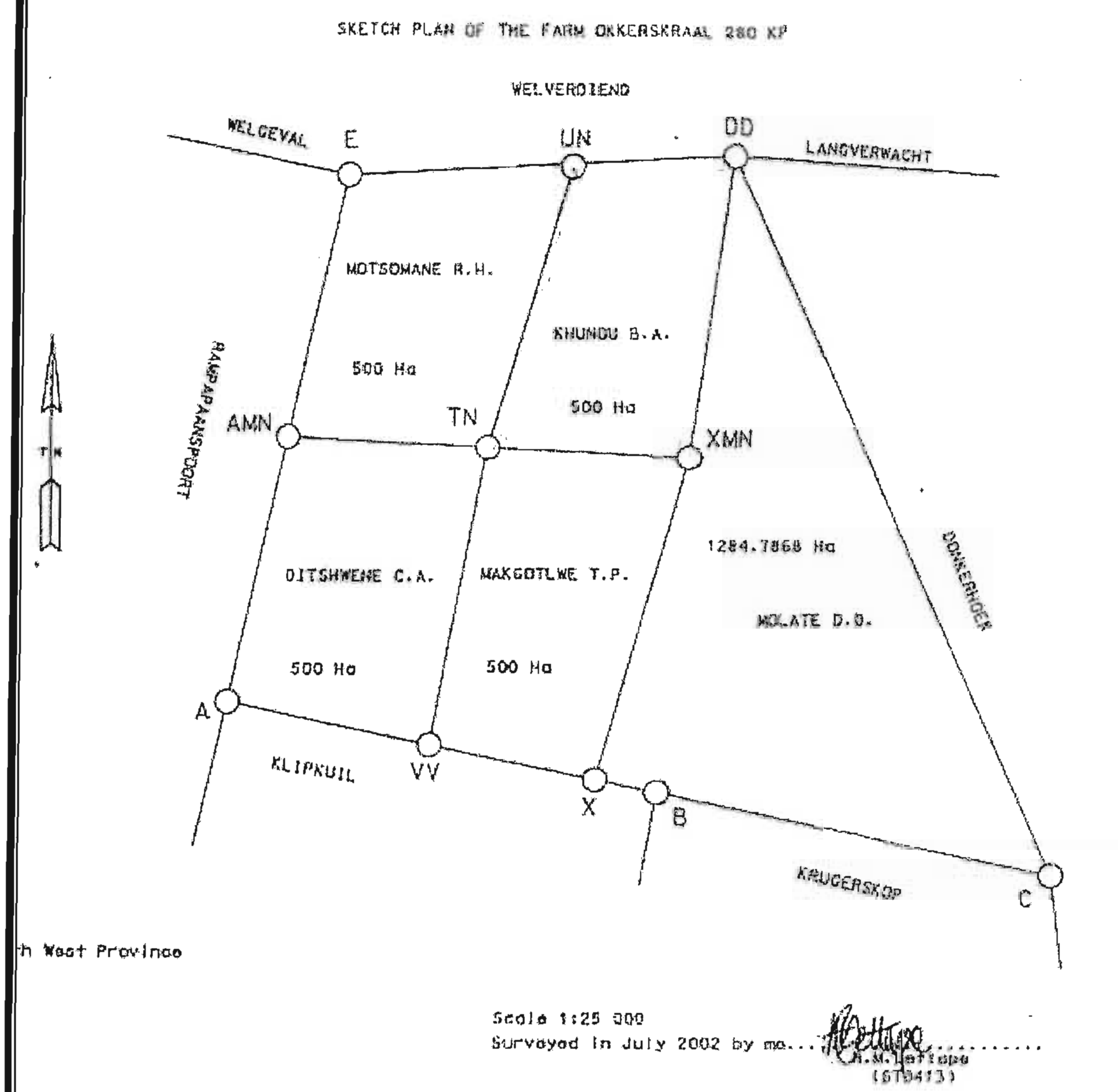


Figure 1: **Hand-drawn sketch map** *(South Africa: Department of Land Affairs, from departmental files 2003)*



WG27

	Y	X
A	+ 30905.251	+ 2767174.392
B	+ 26935.985	+ 2767987.402
C	+ 23287.332	+ 2768739.925
DD	+ 26220.744	+ 2762069.630
E	+ 29790.659	+ 2762264.312
AMN	+ 30348.017	+ 2764709.921
TN	+ 28497.832	+ 2764795.492
XMN	+ 26647.681	+ 2764881.050
UN	+ 27713.015	+ 2762176.402
VV	+ 29029.370	+ 2767558.634
X	+ 27501.206	+ 2767871.632

Figure 2: Sketch map with coordinates *(South Africa: Department of Land Affairs, from departmental files 2003)*

3.2 Information technology/tools used

The Sub-Directorate: System Development and Technical Support utilises information technology and tools, such as GIS, satellite and aerial imagery, GPS, the Internet and data administration, in order to perform its functions. Chief base data providers (Deeds Office and Surveyor-General's Office) and software used (ReGis, ArcGis, Maptitude, AutoDesk MapGuide, SQL Server, MS Access, etc.) dictate to a large extent the format of the data.

3.2.1 GPS

Real-time differential GPS (DGPS) equipment is used (OmniSTAR) in conjunction with a pen-computer. Although the equipment is relatively expensive, DGPS is needed for its real-time capabilities to perform adjudication on state land, such as before leases are to be finalised and in boundary disputes between lessees. On the pen-computer the real-time position in relation to the digital cadastre and topography is indicated, while point and line coordinates with individual remarks and land use categories contained in the data dictionary are logged on the Psion 'Workabout' data logger. The sub-metre horizontal accuracy of the system is a bonus, but arguably not absolutely necessary in rural conditions.

After returning from the field, the data from the GPS and pen-computer is downloaded and processed to produce relevant maps and update data on the inventory of public land. The GIS software (Maptitude) on the pen-computer allows basic maps to be produced of areas investigated/surveyed, and spatial data to be imported to the other software platforms referred to above.

3.2.2 Digitizing

All the GIS-packages used by the Sub-Directorate allow on-screen digitizing. If sketch plans are available, boundaries/corner points are digitized with the aid of topographical features on the sketches and a backdrop consisting of the digital cadastre and topographical-sheets, and where available aerial photography, satellite imagery and/or ortho-photos. Those sketch plans indicating coordinates of leased areas can of course be imported into the GIS by simply inputting the coordinates of corner points.

Photogrammetry and satellite imagery is currently seen as complementary to map making and not primarily used for the determination of lease boundaries, due to a number of reasons such as availability and cost of data covering the vast rural areas and lack of distinguishing features visible from above to use as 'general boundaries'.

3.2.3 Data administration

Without proper data administration, including cleaning and regular updates of the data, it would not be possible to link information on land spatially to the cadastre. In depth knowledge is needed of the functioning of the deeds register, the map cadastre, land administration (also legal requirements), the data sets themselves, and the peculiarities associated with them.

As a crucial part of data administration, geocodes are generated for the centroids of all land parcels in the digital cadastre, allowing them to be linked to the alphanumeric land parcel data (the public land inventory) by using the unique 21-character LPI as key.

An Internet-based inter-departmental administration system ('Provincial State Land Disposal Committee Application') for the disposal of state land with integrated text and spatial components was developed and implemented by the Sub-Directorate in 2001. By using the geocodes and LPIs, it is possible to disseminate the state land data via the Web, employing HTML pages in conjunction with AutoDesk MapGuide (a thin-client desktop viewer with elementary GIS functionalities). The core of the system is the public land inventory database, which can be queried from either the spatial side by selecting a land parcel on the map, or via specifying the land description in a drill-down fashion. As the system is focused on the administration of state land,

and the sensitivity of state land data, the system is accessed by employing a username and password.

3.3 Fieldwork: GPS measurements and map generated

As a pilot exercise, three of the abovementioned unconformable 34 leases lacking sketch plans were measured, including some additional areas for possible future leasing. The DGPS equipment described above was used in conjunction with all available information (digital and paper-based) on the state land in the study area.

On the field visit the researcher was accompanied by a representative from the District Office and the respective lessees. Boundaries and corner points were measured as indicated by the District Office official and the lessees. It was possible to adjudicate any conflicting claims on the spot because the GPS point coordinates along lease boundaries were constantly related in real time to the parcel descriptions/boundaries of the cadastral layer on the pen-computer. If a GPS-coordinate is close to an identifiable cadastral beacon or corner point, the GPS-reading is deemed to be that of the cadastral point, i.e. the cadastre takes precedence.

Figure 3 indicates the results of the GPS measurements after mapping it with Maptitude:

- leased area A consists of (1) a portion of Portion 2 of the Farm Legkraal 54 JR, measuring approximately 78ha; (2) a portion of Portion 7 of the Farm Legkraal 54 JR, measuring approximately 76ha; and (3) a portion of Portion 2 of the Farm Legkraal 54 JR, measuring approximately 74ha. The total area leased is approximately 228ha;
- leased area B consists of a portion of Portion 2 of the Farm Legkraal 54 JR, measuring approximately 170ha; and
- leased area C covers (1) a portion of Portion 6 of the Farm Legkraal 54 JR, measuring approximately 185ha; and (2) a portion of Portion 4 of the Farm Legkraal 54 JR, measuring approximately 30ha.

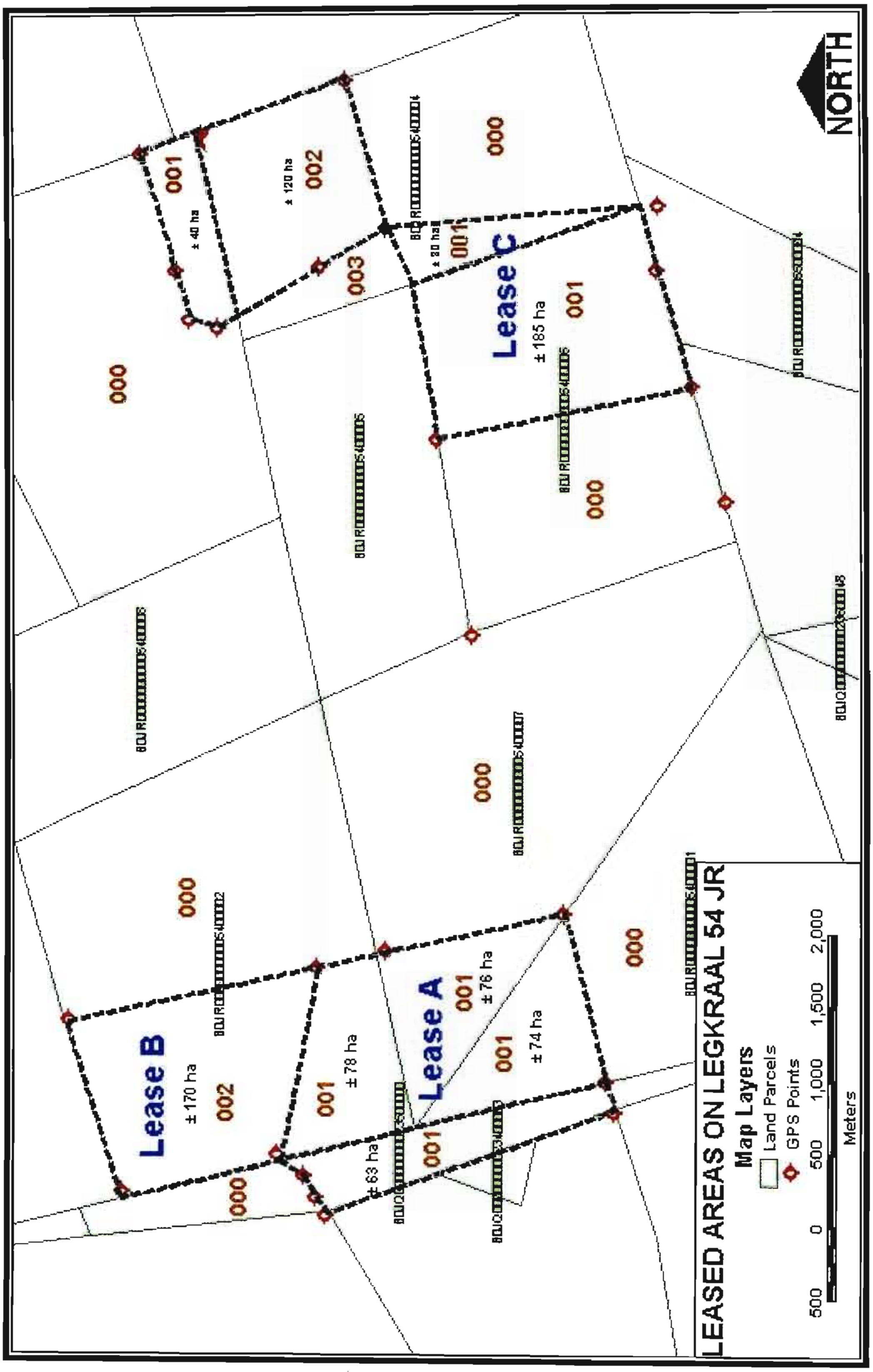


Figure 3: **Unconformable leases measured by GPS** *(own construction)*

The occurrence of leases unconformable with the cadastre is graphically illustrated by these measured examples. (Assigning the lease unit numbers indicated in brown on Figure 3 is discussed in paragraph 4.2 below.)

4. PROPOSED CONVENTION FOR UNCONFORMABLE LEASE AREAS

This section describes the proposed convention for spatial description of unconformable lease areas as developed on the basis provided in the previous sections.

4.1 Founding principles

As previously discussed the South African cadastre uses, in line with international standards, a hierarchical convention to uniquely describe parcels. Based on this convention, a 21-character land parcel identifier has been derived for each land parcel on the digital cadastre. It is sensible to build upon this logical, well-developed and entrenched system. Therefore the suggested convention for describing leases unconformable with the cadastre uses the cadastral descriptions (21-character code) of the underlying cadastral land parcels as foundation.

Apart from the data that is sourced from official data suppliers such as the Deeds Office and the Surveyor-General's Office, some form of measurements identifying the shape, size and location of leased areas must also be obtained or captured in some way. Both Larsson (1991) and Van der Molen (2001) strongly support the principle that a relatively low degree of mapping accuracy will provide sufficient specification on the location of the object, especially in rural settings. I agree.

This principle opens up various alternatives for measuring and describing rural leased areas on state land: by GPS (equipment range from cheap to expensive), by cadastral survey, by digitising existing maps found in various formats, by using photogrammetry and remote sensing where conditions permit. A main feature of the lease descriptions will be the fact that they are mapped in relation to the existing legal cadastre, although the leased areas may be captured less accurately in comparison with the South African cadastral surveying standards. The problem is simply that in many instances no spatial descriptions of leased areas exist. Most important, the data so captured will be in a format that can be carried on spatial and alphanumerical databases, enabling automation.

4.2 The convention: assigning identifiers to lease units

Two basic types of unconformable leases have been encountered: (1) those forming part of a cadastral parcel, and (2) those across more than one cadastral parcel. The convention for uniquely describing these leases is founded in the existing cadastral descriptions (21-character code) underlying the units making up leased areas:

- the 21-character LPI forms the first part of the lease identifier;
- three additional digits forms the second part, denoting the individual lease unit. (It is not envisaged that more than 999 agricultural lease units will be allocated per cadastral parcel.);
- lease units are demarcated within each cadastral parcel;
- units are not assigned across land parcels, to be able to use one 21-character code for each unit. (This enables queries to specific cadastral parcels encumbered with leases.);
- leases can consist of one, or more than one unit which can be across cadastral parcels; and
- unit numbers are assigned to the individual demarcated lease units in accordance with the same convention as portion numbers of cadastral parcels / LPIs (described above), starting at 000, 001, 002, etc.

Figure 4 schematically illustrates lease units (indicated in brown on map) with their assigned three-digit numbers on top of cadastral parcels (21-character code indicated in green on map). Leases may consist of a single lease unit, or more than one unit within a land parcel or across land parcels. This is also indicated on Figure 4 with Lease A and Lease B (schematically indicated in blue on map). See also Figure 3 above for GPS-measured leases in the Brits District Office area.

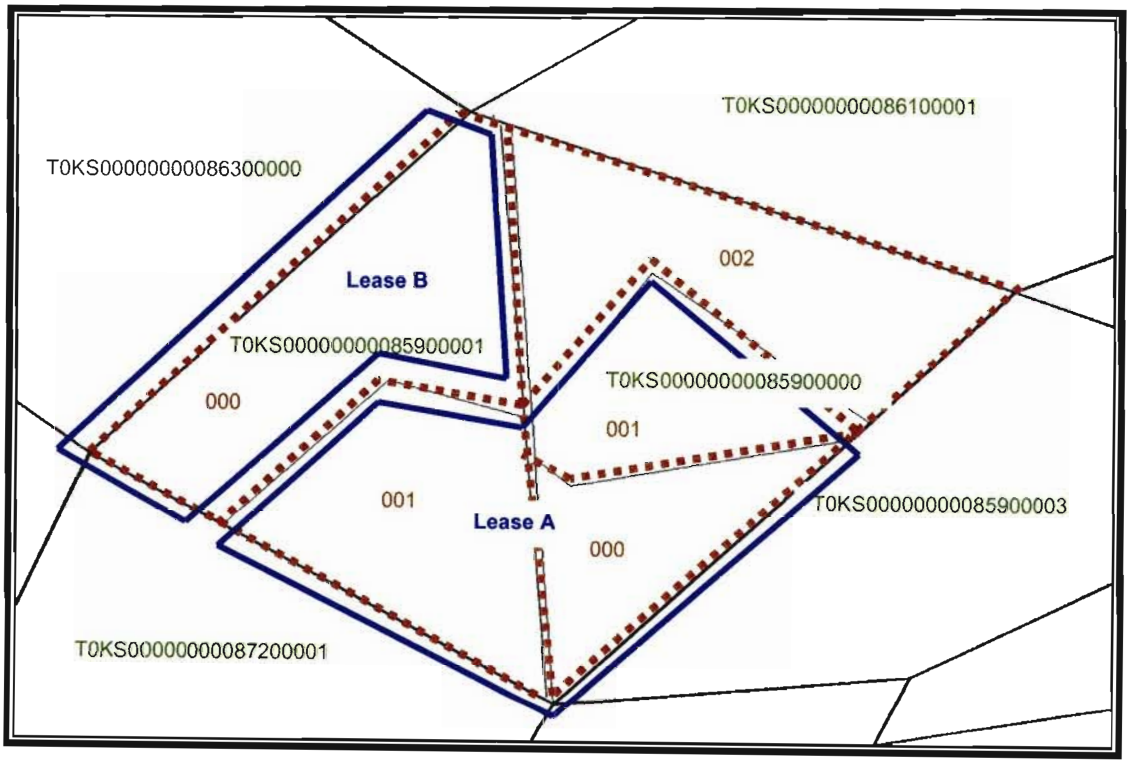


Figure 4: Lease units on top of cadastral parcels *(Own construction)*

Geocodes are generated for each lease unit and carried on a separate lease layer than the digital cadastre in the GIS. However, the two layers can be related to each other by using the 21-character key.

4.3 Information system architecture

The above convention is already being put to use in finalising development of a leasing system for administration of the Department of Land Affairs' leases. Spatial data on leases and land parcels will be contained in the public land inventory database on the Internet system described earlier. A second mainframe financial administration system (development being finalised), known as the DLA's 'State Land Leasing System' (registration of lessees, receipt of payments, interest calculations, invoicing, etc.), will be linked to this database. All alphanumeric data on leased areas (21-digit codes, unit numbers, extents, etc.) will be populated into the leasing system via the Web. Lessee particulars will be populated back from the leasing system to the public land inventory database.

5. DISCUSSION

Statement one on the charter known as Cadastre 2014 hopefully states that in future cadastres will show the complete legal situation of land, including public rights and restrictions, which also means that the principle of 'legal independence' must be respected. Different legal land objects (not only properties) are to be arranged in layers, according to the different 'laws' defining them (Kaufmann, 1999, 2003). In keeping with the concept of a multi-purpose cadastre, the various line-function authorities and organisations are responsible for the respective layers. Kaufmann (1999, 2003) advocates the use of polygon overlaying techniques to create links between land objects where the different layers cut, such as a land parcel and the building on it. The links are only created when needed.

Linking of leases and cadastral land parcels is embedded in the proposed method/convention through the consistent use of the LPI. This is in line with the legal independence principle, but the linking mechanism is different to that of polygon overlaying, in the sense that the links are 'permanently' there and not just created when needed. Main reason for this is the express need to specifically relate lease units back to parcel descriptions in the cadastre to facilitate later formalisation of ownership. (One must not forget that the DLA is primarily responsible for administrating the land under its control within the current legal framework, which includes the cadastre.)

A most important spin-off is that although the convention is applied in a cadastral and parcel-based context for leases, it can easily accommodate a geocoded single-point register of rights such as communal/occupational rights. It is a known fact that various difficulties are also experienced in spatially describing and linking land claims data. Single-point cadastres and their merits have been discussed by Jackson (2000, 2002). Instead of indicating lease units, the extra affix (which needn't be limited to three digits) to the LPI can represent a numbered geocoded right occurring at a point within a parcel. The method can thus provide a vehicle for progressive recognition of rights towards full legal ownership analogue to progressive title registration and land measuring in Namibia. This could have many applications within land reform programmes.

Key to the successful functioning of the State Land Leasing System will be that of balancing the technical matters of a LIS with the needs in the field. Jackson (2002) articulated this by proposing a dumb-bell shaped information system with the data manager on the one end and the field worker on the other. A digital flow of information between the two forms the handle. He also sees the office being placed in the field. Therefore the proposed system is envisaged to function on a centralised technological level (data administration, base data, system development and maintenance, etc by DLA National Office), with decentralized implementation/data gathering (DLA District and Provincial Land Reform officers responsible for restitution, redistribution and tenure reform) and two-way communication/feed of data. Providing a facilitating institutional framework is paramount, in which appropriate training plays no small part. Should it be necessary, the Sub-Directorate: SDTS can still be involved with specific matters such as adjudication, because of the available high-level technology, knowledge and expertise.

The question can be asked why not survey the leased areas upfront? Why the need for such a convention and spatial capturing of unconformable leased areas? Indeed, in some instances it is desirable and feasible to survey immediately. However, in many cases the individual lease areas can change over time before conversion to ownership takes place; funds and capacity are lacking to formally survey as the sheer magnitude of land for which only the Department of Land Affairs is responsible is mind-boggling – 13 million ha. Seeing that district officers have to visit and monitor the leased land in any case, it would be efficient to use a basic GPS and palm-top connected to the leasing system. Many leases (especially those contained within a single cadastral parcel) can also be sufficiently digitised from existing hand-drawn maps.

Finally, it is hoped that the method proposed by this study will benefit state land administration at the Department by facilitating the capturing of unconformable lease data on a spatial and text database. The availability of better data on leases should promote more effective integration of data with the corporate systems of the DLA, needed to support land reform programmes. This should lead to more efficient financial reporting to the Auditor-General on the DLA's assets. More efficient administration of leases on DLA-land by enabling better capacity at District and Provincial Land Reform Offices (through the availability of systems and procedures) should lead to better services rendered to clients (specifically land reform beneficiaries). By using the convention, it is possible to better manage leasehold as an interim step before finalisation of individual freehold. Relating the unconformable areas to the cadastre should strengthen the formal cadastre, not replacing or detracting from it. It should lead to more precise instructions to surveyors in formalising individual ownership with less confusion. Updating of the cadastre will take place through formal surveys as needed in tenure upgrading of beneficiaries.

To conclude, let's start with the beginning – due to the need for a method of description of unconformable leases, a convention was developed that has strong links with the formal cadastre. (The formal cadastre is pivotal to the country's economy, especially in a classic commercial environment.) Relevant technologies and examples were examined. The proposals were tested and are feasible. They even appear to be suitable for other applications in the land reform arena, such as a geocoded single-point register of rights. It might even have some potential for application in the Communal Land Rights Bill. However, nothing will come of this methodology if it is not integrated into the business procedures of the DLA. For that, the support of management is crucial.

REFERENCES

Dale, PF & JD McLaughlin (1999): *Land Administration.* Oxford University Press, New York.

Haldrup, NO (1996): Adjudication – A way of coping with incomplete information in developing countries, *Survey Review, Vol. 33, No. 262, October 1996.*

International Federation of Surveyors (FIG) (1994): FIG Statement on the Cadastre, adopted by Commission 7. *South African Journal of Surveying and Mapping, Vol. 22, Part 6, December 1994, pp.415-426.*

Jackson, J (2000): *The relationship between the graphical elements of a colonial cadastre and the conception of land ownership that it supports.* Proceedings, Commonwealth Association of Surveying and Land Economy conference, Kuala Lumpur, 21 – 24 June 2000.

Jackson, J (2002): *Technology as a problem in South African land tenure reform. Coming to terms with De Soto's criticism of 'technicians'.* Proceedings, FIG symposium on land redistribution in Southern Africa, Pretoria, 6 – 7 November 2002.

Juma, SY & SF Christensen (2001): *Bringing the informal settlers under the register – the Namibian challenge.* Proceedings, International Conference on Spatial Information for Sustainable Development, Nairobi, Kenya, 2 – 5 October 2001.

Kaufmann, J (1999): *Cadastre 2014: A tool to make land administration more effective?* Proceedings, FIG working week and survey 1999.

Kaufmann, J (2003): *Cadastre as the basic tool for land administration – need for a big leap forward.* Proceedings, FIG working week, Paris, France, 13 – 17 April 2003.

Larsson, G (1991): *Land registration and cadastral systems: Tools for land information and management.* Longman Scientific and Technical, Essex.

Manisa, MB & L Maphale (1999): *Spatial information management for sustainable rural development.* Proceedings, FIG working week and survey 1999.

South Africa: Department of Land Affairs (DLA) (2003): *Chief Surveyor-General* [online].
Available at: http://www.csg.dla.gov.za/ [Accessed 2 May 2003].

South Africa: Department of Land Affairs (DLA): Directorate Public Land Support Services (PLSS) (2001): *Division and registration of land – From unsurveyed and unalienated state land to registered deed and the procedure of state land disposal.* Unpublished manual.

Tembo, E, M Manisa & L Maphale (2001): *Land information management in customary land in Botswana.* Proceedings, International Conference on Spatial Information for Sustainable Development, Nairobi, Kenya, 2 – 5 October 2001.

United Nations Centre for Human Settlements (Habitat) (1990): *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), Nairobi.*

Van der Molen, P (2001): *The importance of the institutional context for sound cadastral information management for sustainable land policy.* Proceedings, International Conference on Spatial Information for Sustainable Development, Nairobi, Kenya, 2 – 5 October 2001.

Venter, P (2003): Chief Planner. *Personal communication during visit on 11 July 2003 to Department of Land Affairs' District Provincial Land Reform Office situated in Brits, North-West Province.*

Vries, WT de (2002): Implications of progressive title registration for cadastral information production: case study of Namibia. *Survey Review, Vol. 36, No. 286, pp. 591-601.*

Williamson, IP (1997): The Justification of Cadastral Systems in Developing Countries. *Geomatica, Vol. 1, No. 1, pp.21-36.*