Scalable Land Tenure Record Systems

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Abstract
Land tenure information is vital for managing informal settlement upgrades. Multi-media data, such as video clips, have also been found to be useful in that information about rights and interests in land can be recorded and played back in a person's own language and the capture of the data is often a public record in itself.
The concept underlying the Talking Titler system of land records which incorporate a range of different data types, including multi-media data was developed in informal settlements in South Africa. Multi-media data hold an added advantage in that they may not require transcription to written form and the process is simple enough for a member of a community to capture the data.
Designing a land records system which is suitable to a particular set of circumstances, but which can be adapted as these circumstances change holds a number of challenges. In an informal settlement one may start off collecting information in an exercise book which may later be computerised and possibly provide the basis for registration. In this paper we describe the design of a system which allows a local office to start with a computer assisted hard copy (e.g. paper, photographs) and through an electronic evidence model move to a complex LIS in a series of stages. We also describe an alternative, but not incompatible model, using a word processor with hyperlinked files rather than a database.

1 INTRODUCTION

Land tenure records are of major importance in securing land tenure for people in a number of situations. After food and shelter, security of tenure is one of humankind's most basic needs.

More than 1 billion people live in slums (UN-Habitat 2003). Failure to address a range of basic needs of these people through a variety of interventions is likely to lead to social and political unrest. A sizeable proportion of slum dwellers live in informal settlements in peri-urban zones. People are prepared to break the law to gain access to these settlements, presumably in the hope of better long term opportunities in cities. In African informal settlements, land tenure practices and the associated conflict management processes and solutions to disputes often blend customary and western practices.

Rural situations are also requiring increasingly accurate land tenure information, especially in the area of aboriginal rights. A developed country such as Canada demonstrates the cost of resolving land restitution claims and claims pertaining to declarations of rights. A land rights court action can cost of the order of $10 million and the British Columbia Land Claims Commission has spent of the order of $300 million with little to show in the way of tangible results (Fairweather 2006). The courts have increasingly attempted to recognise the need to interpret customary law and practice equitably when the evidence is in conflict with written documents or there are no documents at all in deciding these cases.

The decision handed down in the Delgamuukw case is that oral evidence, stories and such like should be given considerable weight (Delgamuukw v British Columbia 1997). The challenge is to capture this evidence and store and retrieve it in an organised manner so that it is admissible in court. The recent decisions in favour of the Richtersvelders in South Africa and the San/Bushmen in the central Kalahari in Botswana suggests that the developing world is going to face an increasing number of these cases.

These problems are complex in that they tend to have enormous political, social and economic implications. Strategies to improve these situations are multifaceted. Having appropriate, accurate and current information which mirrors the tenure situation on the ground, and which does not exclude vulnerable groups such as women or ethnic minorities, is arguably an essential factor in successful strategy.

We note that land registration is often not an appropriate response in most of these situations. Some of the possible negative impacts of registration are that it can legalise rights which de facto did not exist prior to registration, it can extinguish a number of *de facto* rights, and in many situations it may not be appropriate at all. However, the courts tend to weight legally registered documents heavily in the event of a dispute.

Therefore, we are arguing that land tenure records should

be designed such that as they develop over time, they can ultimately be used for registration purposes, or be considered to be of equal quality, and therefore afforded equal weight to legally registered documents used within conflict management structures.

The challenge is to develop a system of records which closely resembles the complete state of affairs in a particular case. Records should be complete, current, and accurate, and the system of records should be designed to suit the human, financial, technical and communication resources available at a particular time. As technical managerial skills develop, and more of the other resources become available, the level of sophistication of the record system should increase, as should the level of integration of these records with other land information.

A further challenge when developing land records in uncertain situations such as informal settlements is that local social and political circumstances associated with development are not likely to change in a linear fashion. As development opportunities arise, competition for power and access to resources will likely emerge, and at times conflict over these can turn to violence. Gangs or "land mafias" may attempt to take control over allocating land. Social unrest over unfulfilled expectations can lead to buildings housing the land records being burned down. Thus progress towards improving livelihoods can proceed smoothly for a while, but then temporarily be stalled by conflict. In some cases it may be impossible to move forward at all. Furthermore, two nearby informal settlements may develop very differently as a result of conflicts. One development may proceed smoothly to the extent that the informal settlement is upgraded and people are provided with formal housing quickly. The other may stall for years while internal struggles are waged (Barry 1999, 2006).

Given the above, if the level of sophistication of the land record system is expected to increase as development progresses, this is well and fine, if the development project progresses smoothly. What then should occur if it does not? We posit that the record system should be designed so that it is possible to fall back on a less sophisticated system which is suited to the human and technical resources available due to the changed circumstances.

Thus one needs scalable solutions which allow for upgrading to different systems which have higher levels of functionality and integration with other records. These systems should also allow one to scale back to a lower level system if circumstances dictate this.

We begin by describing a rudimentary record system; a rent card system that can be used to describe use and occupation rights for an informal settlement. This is followed by a description of an integrated deeds system which can be operated using a word processor. We then examine the most basic database type, or title, system and explore increasing sophistication in these systems and what this involves.

2. TYPES OF LAND RECORD SYSTEMS

2.1 Rent Cards and Written Records

Generally records are only likely to be kept once upgrading of the settlement is envisaged or some form of taxation system is introduced by the local authority. The first part would involve adjudication of who should be a beneficiary of the upgrade. Community leadership structures tend to be involved in this process.

In Cape Town, South Africa, a rent card system was used for a number of years in a number of settlements. As an example, Brown's Farm was a site and service scheme which drew beneficiaries from three surrounding informal settlements in 1991. The beneficiary received the Allocation Card as per figure 1. This was their "ticket" to a site in Brown's Farm. Once they were in Brown's Farm, the rent card was their proof of a right of occupation until the land was registered several years later.
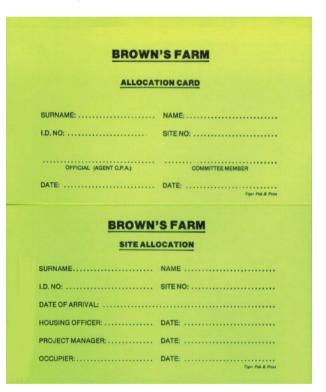

Figure 1. *Rent Card from Brown's Farm, Cape Town*

The Site Allocation record was kept on file in a local municipal office. When transactions (e.g. sale, inheritance) took place, community leaders and the parties to the transaction met in the council office and explained the transaction to an official and a new rent card was issued (Barry 1999).

A problem with issuing the card is that it is not dissimilar to a deed. Instead of following agreed procedures when

it came to transactions, some beneficiaries traded land rights through informal means, i.e. they transacted though private conveyances which were not officially sanctioned. They did not go to the municipal office and probably preferred to avoid letting community leaders know what they were doing.

In other settlements, such as Marconi Beam and Imizamo Yethu, a register was generated in a computerised database and allocation cards were not issued in the hope that this would discourage informal transactions. However, informal transactions still occurred. In Imizamo Yethu it was fortunate that an offsite computerised record was kept, as the administration office in the settlement was burned down in the early days of its development (Barry 2006).

In Marconi Beam, the computer record also soon became out of date. A rudimentary system was then implemented where transactions were noted in an exercise book. This is similar to systems introduced by colonial administrations. For example, in Somaliland the city of Hargeisa (pop. 400,000) still uses such a manuscript book to record land transactions (Barry and Bruyas 2007).

In many of these settlements in Cape Town, when it came to registration, a number of conflicts arose because a number of persons claiming to be entitled to registration were not those whose names appeared on the official records. Numerous conflicts arose, and in some cases they are still ongoing, and the upgrading projects were delayed for a number of years. Delays in turn caused more dissatisfaction and were professed by some of those involved in the administration of these settlements to be the cause of demonstrations and civil unrest in some settlements.

Similar off-record land dealings are common in Canada within some First Nation communities. The so called Buckshee lease is a private agreement, traditionally for agricultural land, between a First Nation or an individual member and a non-member. Buckshee leases are sometimes also referred to as customary allotments (Nyce 2003). While clearly not recognized under the Indian Act (R.S., 1985), and hence not enforceable in court, the practice of customary leases is sufficiently common that they receive mention in the Indian and Northern Affairs Canada Land Management Manual (Government of Canada, 2002), and a perusal of recent First Nations cases would indicate that the range of uses of these customary allotments is increasing, presumably to reflect contemporary life on Reserves (see Tsartlip Indian Band v. Canada [1999] for example).

Some of the lessons from these examples are that there would probably have been off record transactions, whatever the quality and sophistication of the record system. What has reduced this level of informal transaction and conflict in one informal settlement upgrading project was to generate publicity around land administration meetings. This involved continual communication through the public display of notices with minutes of meetings and notice of changes in occupation of certain shacks. Employing community mem-

bers to do frequent census surveys was also a successful strategy (Barry and Rüther 2005).

Multi-media data such as video and audio recordings of meetings and still photographs of shacks and the people in them can also reduce this level of conflict. One can also use these media as part of the adjudication record. In that way one diminishes the chances of weaker or vulnerable members of the community from being unfairly excluded.

2.2 Deeds Systems

There are numerous definitions of what constitutes a deeds registration system versus a title system. We do not concern ourselves with the semantics surrounding these, as the meanings tend to be country and even local jurisdiction specific. For our purposes a deed is a single document which contains as much information as possible about the legal rights, or expected legal rights and interests in a land object. A land object can include things such as a plot (parcel), dwelling, or a physical feature such as a tree or a power line. Historically deeds were kept as written records of land rights and could be either parcel or person based in their construction. In a scalable system, we envisage that the deed system can be managed as a set of word processor files kept in a local office. If not, written documents should be set up so that they can be migrated to a computer in the long term.

We present the ideal case of a highly detailed deed generated and maintained in a word processor file and a sample is included as Appendix A. Our sample is suited to a registration system, but the design can easily be adapted to an informal settlement land tenure information system where the settlement is to be upgraded to formal housing. We have adopted the notion of schedules used in a number of commonwealth countries to partition a deed. The first part of the deed includes the property or object description. It would include the object identifiers (e.g. parcel number and designation), possibly the tenure type (e.g. ownership, leasehold) and area, and links to other important documents such as an original deed which created the object and a survey diagram. It may include a sketch plan or an extract from a legal survey diagram.

Modern deeds systems can be developed as electronic linked file systems. Nowadays, mainstream word processors permit hyperlinks to other files, so if the survey diagram and the original deed are electronic files, hyperlinks to them can easily be created in this section.

The First Schedule includes the names of the current primary rights holders (e.g. owners, expected owners, long term leaseholders) and possibly the history of transactions. Hyperlinks can be created to the instrument identifiers (i.e. deeds) and the person identifiers in this section. Thus one can keep a word processing file on people and their addresses and other details, and call this information up from any deed via hyperlinks to the relevant file(s). If historical deeds or deeds defining other real

rights (e.g. a deed defining a servitude power line) are stored as word processor files, they too can be opened from this deed.

An important part of the deed is ensuring that there are witnesses to the transaction to reduce the incidence of fraud, or at least to allow for fraudulent transactions to be unravelled. Although the information is stored in a word processor file, the legal or legitimate copies should be the printed documents duly signed by the different parties and their witnesses. Copies should be held in an office and by the landholders or authorised agents.

The Second Schedule includes the identifiers (called memorandums in some registration systems), and possibly hyperlinks, to the relevant instruments and persons which define partial rights in the land object. Careful thought and design should go into these, so that the system can be migrated to a database later on if necessary.

The Third Schedule includes details of partial rights such as servitudes / easements and mortgages. If the right is cancelled or lapses, one changes the font to strike through text as shown in Appendix A. If there is a one to one relationship between the partial right in an object (e.g. an object could be a land parcel or a shack) and the object, then partial rights can be created in a deed such as this. For example a caveat (notice or warning) may apply to this land object only. Therefore we can create the caveat and the details of it in the third schedule of this deed when we create this deed. If the land is transferred and a new deed is created, the caveat is merely carried forward to the new deed. If, however, we have a many to many relationship such as a power line which crosses many parcels, then we need to create a separate instrument (i.e. deed) for this power line. We can then cut and paste relevant information from the power line's deed into our current document. In the case of a dispute, what is written in the original deed for the power line is what counts as legal evidence.

The Fourth Schedule provides hyperlinks and/or a description of the location of ancillary documentary evidence such as a historical description of a settlement, anthropologists' research reports of a community, multimedia evidence (e.g. video and audio clips) of people describing their land rights and such like. In uncertain situations, such as an informal settlement or an aboriginal land claim, this type of evidence is becoming more and more important.

The Fifth Schedule provides interested person details. This may be inter-family relationships or depict membership of a lineage group or clan, depending on the situation. This information is of particular relevance prior to registration taking place or during a quieting period after registration has occurred. To recap, a major problem with registration is that it can extinguish de facto rights, especially of extended family members, thus information about people who may be affected by registration should be included in the document.

Registration can have the effect of extinguishing a range of rights in land, and often concentrating land ownership in the hands of a few. Note that many title registration systems include all the details up to the end of the Second Schedule above on

the title. The title is then used to source the instruments which we have copied into the third schedule. The Fourth and Fifth Schedules provide information, or links to information, which may reduce the risk of this occurring. They also provide information which offers a more comprehensive picture of the land tenure system than a conventional title registration system does. This should diminish the risk of disputes. In the event of a dispute, there should be a great deal more circumstantial evidence which can be used in resolving the dispute. This increases the likelihood of the dispute being solved fairly and equitably.

The advantage of this type of deeds system is that it allows a fairly complex information system to be reflected in a single document. This document can be hyperlinked to other relevant documents relatively easily using off the shelf word processors. Thus there is a good chance of having a near complete and accurate document system. In uncertain situations, where there is a strong possibility of conflict over land rights, this holds major advantages in reducing the cost of resolving conflict as many of the relevant facts are contained in or linked to a single document. Of major advantage of this modern style deed system is that little IT maintenance is required. Operators need to be able to type and use a word processor and know how to back up files. With some training, they should know the file directory structure. What is important is that the identifiers for the different records, persons and objects are consistent and well designed. This will allow easy migration to a database system in the long term.

2.3 Database or Title System

We define a Title System as, ideally, a normalised database system where each data item is stored only once in a table or in a media item such as a paper document or map. Under this definition a Torrens system, where title is guaranteed by the State, an insurance fund exists, and the curtain principle applies, is a special form of title system.

There are four basic entities in this system, Persons (which includes *inter alia* juristic persons and lineage groups); Land Objects (e.g. parcels, dwellings, trees, trap lines); Reference Instruments (e.g. a title, a deed or a property file); and Media Items.

The four entities in figure 2 should cover most of the relationships and demands made on a land records system. To allow flexibility for the different requirements of cases where the system may be applied, each relationship between entities is a many-to-many relationship and each entity has a recursive many-to-many relationship. For example a person is related to other persons (e.g. parent-child, member of lineage group). A land parcel may have servitudal rights in another land parcel if the right is a real right. In addition a person may have a personal right in the parcel.
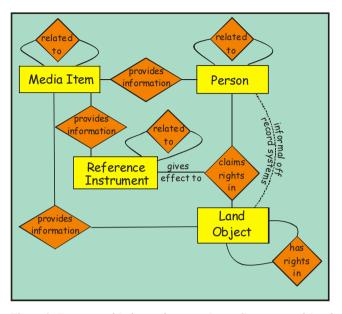
Figure 2. *Entities and Relationships in a Basic Computerised Land Records System*

The Reference Instrument may be a property administration reference file, a title or a deed. In a title or a deed the relationships should be similarly constructed to the way in which they are constructed in the example of a deed using a word processor. Again the reference instrument may be related to another reference instrument. For example, a title is superseded by a newer title, or a title includes a caveat as per the Second Schedule in the appendix.

Media items can be a range of instruments such as a survey plan, a video, a will, photographs and such like. They can be stored in electronic or analogue format.

The above structure will allow a range of different land record systems designs. The trick is to create a design for a particular application and then ensure that operators stick to the rules for the application. The less skill one requires of the people managing and using the system, the more entities and relationships one will require and one therefore has to scale the system up in terms of complexity, security and functionality. However, the bulk of these entities and relationships can be hidden from the operator, and the interface can be designed such that data entry conforms to the model described for the Deeds system above.

One should recognise that informal, off record, systems may exist which underlie a number of de facto claims to land. Hence the direct link between persons and land objects above. If the local social and political dynamics allow this, then implementers of the system should attempt to reflect as much information about these systems in the media items (e.g. reports and academic papers might be included in the system). These information items are in essence what might appear in schedules 3 and 4 in the deed system described earlier. Clearly, if documenting these relationships may result in a violent response then this should be avoided.

The objective of the structures outlined is to recognize the legitimacy of informal settlements, and to be able to cater to existing forms of land tenure. At the same time one should create a system that is sufficiently open and general such that it may also be able to cope with new formalised forms of tenure as they arise (Ballantyne *et al* 2001). Ideally, such a system must be able to deal with varying land tenure systems over the same land base. Under this condition the level of registration, and possibly survey, "improves" as the value and use of land increases.

CONCLUSIONS

We have described some different approaches to land records for situations such as informal settlement upgrades, rural or aboriginal land claim processes. These are intended as local level record systems where, in the long term, the records can be integrated into a municipal, regional or national system of land records. Word processor advances have made deeds type systems attractive, providing a good set of rules are established and people who run the system adhere to them.

One can make the system as comprehensive and complex as one chooses.Limiting a database ("title") system to four entities provides a simple, flexible data structure. However, careful design and management of the system is required. All of these can be scaled up to systems with more complex, specific entities, increased functionality and security.

What is required, and which extends beyond the scope of this paper, is a set of identifiers and media constructed in a manner which will allow downscaling in the event that the resources are no longer in place to run a complex system.

REFERENCES

Ballantyne B, Dobbin J and Hunter A J S 2001. Options for Land Registration and Survey Systems on Aboriginal Lands in Canada, *Geomatica*, 55(1), 23 - 38.

Barry M B 1999. *Evaluating Cadastral systems in Periods of Uncertainty: A Study of Cape Town's Xhosa-speaking Communities*. PhD thesis, University of Natal, Durban.

Barry M and Rüther H 2005. Data Collection and Management for Informal Settlement Upgrades. *URISA Journal 17(1), 43 -52*.

Barry M 2006. Formalising Informal Land Rights: the case of Marconi Beam and Joe Slovo Park. *Habitat International*. 30(2006), 628 – 644.

Barry M and Bruyas F 2007. *Land Administration Strategy Formulation in Post Conflict Situations: Case Hargeisa, Somaliland*. FIG Working Week, Hong Kong.

Delgamuukw v. *British Columbia* (1997), 3 S.C.R. 1010

Fairweather J G. 2006. *A Common Hunger. Land Rights in Canada and South Africa*. University of Calgary Press

Indian Act (Canada R.S., 1985, c. I-5)

Government of Canada, 2002. Land Management Manual: Directive 8-2. Administering Compensation, Indian and Northern Affairs.

Nyce C, 2003. *Masters In Our Own House: The Path To Prosperity - Report of the Think Tank on First Nations Wealth Creation*, Skeena Native Development Society, Terrace.
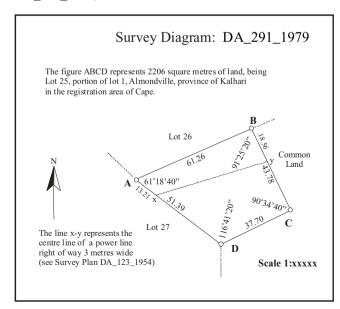
Tsartlip Indian Band v. Canada (Minister of Indian Affairs & Northern

Development) [1999] 1 C.N.L.R. 258, 1 C.N.L.R. 258, 163 D.L.R. (4th) 353, 148 F.T.R. 142.

UN-HABITAT 2003. The Challenge of Slums –new Global Report on Human Settlements. www.unhabitat.org

APPENDIX A
SAMPLE DEED: TALKING TITLER SYSTEM

PROPERTY DESCRIPTION

Lot 25, portion of lot 1, Almondville, province of Kalahari in the registration area of Cape bounded as shown on the sketch plan below.

Survey Diagram: DA_291_1979
Original Deed: TA_4562_1979
Tenure: Lifetime Lease
Area:2206 square metres more or less

Sketch Plan: Not to Scale (Extract from Survey Diagram DA_291_1979)

Survey Diagram: DA_291_1979

The figure ABCD represents 2206 square metres of land, being Lot 25, portion of lot 1, Almondville, province of Kalhari in the registration area of Cape.

The line x-y represents the centre line of a power line right of way 3 metres wide (see Survey Plan DA_123_1954)

Scale 1:xxxxx

FIRST SCHEDULE

A: Primary Rights Holder

This property lease was transferred for the sum of $50,000 from James Blog ID635478003 to Jane Beatrice Doe ID 576832008, represented by John David Brown who appeared before me.

James Blog:	ID 635478003
Signature:	
John David Brown	ID 772118009
Signature:	
James Louw	ID 772118009
Signature:	

Registrar of Deeds
Witness 1: James Peter Doe
ID 671231456   Signature:
Witness 2: John David Brown
ID 780817378   Signature:

HISTORY OF PRIMARY RIGHTS HOLDERS

Instrument	Holder	ID Number	Date	Comments
TA_452_1992_3	James Blog	635478003	13 Jan. 1992	Inherited by will W456/92
TA_876_1986_0	Joan Blog	228781008	13 Mar. 1986	
TA_4562_1979_2	Germaine Jones	345649008	29 Sep 1979	Created by subdivision from lot 1

SECOND SCHEDULE: PARTIAL RIGHTS

INSTRUMENT	DESCRIPTION	DATE	Notes / Endorsements
CA_123_2008	Caveat: Family rights	5 May 2008	Family rights reservation
MA_278_2008	Mortgage in favour of Greenland Bank	5 May 2008	
SA_452_1992	Right of Occupation (usus) in favour of Arthur Blog	13 Jan 1992	Cancelled 5 May 2008
SA_235_1954	Powerline right of way 3 metres wide in favour of electricity corporation	26 Feb 1954	Created over parent lot 1. Survey plan DA_123_1954

THIRD SCHEDULE: INSTRUMENTS

If the relationship is 1:1 then the instrument may be created in this document. It can be copied to a separate document in the database if necessary. If it is a Many-to-1 (e.g. powerline servitude) or Many-to-Many relationship, then the partial right document should be created separately. The text of that document should be copied into this document. I envisage that the legal document is the one which was first created to define the particular rights – copies of that are evidence of the rights.

CAVEAT file CA_123_2008

No transaction in rights in this land shall take place without the express, written consent of the interested parties listed under schedule 1 part B of this title deed.

MORTGAGE file MA_278_2008
(Copy method: direct by cut and paste)

Over property known as lot 25, portion of lot 1 Largeville, province of Kalhand in the registration district of Cape in the amount of $40,000 in favour of Greenland Bank to be repaid in monthly installments over twenty years at a rate of interest to be determined from time to time *etcetera*.
Date :

Cancelled on 5 May 2008 as per cancellation notice on original document.

Cancelled on 5 May 2008 in terms of death certificate DD1234/2008 by me

[signed]
James Louw
Registrar of Deeds

Cancelled in terms of TA_452_1992, 13 January 1992.

POWERLINE SERVITUDE in terms of Deed SA_235_1954; Survey Plan DA_123_1954
(Retyped from Deed SA_235_1954)

The line as represented on Survey Plan **DA_123_1954** represents the centre line of a power line servitude 3 metres wide over lot 1. Owner shall allow all reasonable access to the powerline at all times.

FOURTH SCHEDULE: MULTIMEDIA EVIDENCE

ITEM	TYPE	LAND AFFECTED	DESCRIPTION AND LOCATION
MMP1_2007 MMP1_2007.Doc	Photographs	Lot 25	Photographs of interested parties listed in First Schedule part B
MMv2_1994 MMv2_1994.doc	Video	Region	Video of nature and extent of pastoral over-rights of grazing, access and passage in the region
MMV1_1966 MMV1_1966.Doc	Video	Lots 1, 25, 26	Video of elder Howling Wolf Jones relating to floatable rights: collect bark for medicinal purposes over lots 1,25 and 26. Unextinguished yet insufficient corroboration to register caveat.
MMS1_1954 MMS1_1954.doc	Sound File	Lot 1	Recording of oral history of Grand Owl; power line crosses sacred site.

FIFTH SCHEDULE: INTERESTED PERSON DETAILS

Interested Parties

Name	ID	Relationship
John Doe		Husband
Jack Doe		Son
Erin Doe		Daughter
Ally Doe		Cousin

Description of Relationships

BIOGRAPHICAL DATA

Mike Barry is an Associate Professor in the Geomatics Engineering Department at the University of Calgary, where has been since the end of 2002. Prior to this, he was at the Department of Geomatics at the University of Cape Town. He has PhD, MBA and BSc(Survey) degrees. His research interests are in land tenure, analysing and managing change in implementing elements of cadastral systems, and spatial data analysis. He has worked in informal settlements for a number of years and was one of the authors of the Informal Settlements Handbook published by the Western Cape Provincial Government.

Mr. Hunter holds a Bachelor of Surveying from the University of Otago and an MSc in Geomatics Engineering from the University of Calgary. He is a Professional Registered Surveyor with the New Zealand Institute of Surveyors, and he has extensive research experience in land tenure, land information systems and geospatial information systems. Mr. Hunter's current research is focused on the acquisition, use, and analysis of dynamic spatial data within the domains of wildlife management, land use planning and Cadastres.

Abdel-Rahman Muhsen holds a BSc in Computer Science and Information Technology from University of Jordan. He is a MSc student in the Geomatics Engineering Department,

University of Calgary. His MSc research involves the design of data structures for multi-media data in land tenure records systems.

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