Compiling a land audit in large rural areas: Results from the methodology applied in the non-urban areas of the Matzikama municipal area

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Abstract

To compile a comprehensive land audit in large, mainly rural-based municipalities such as the Matzikama Municipality in the Western Cape warrants an alternative methodology than that conventionally done through exhaustive property visits. This study attempts to showcase such an alternative methodology to compile the land audit for the municipality. The end result of the audit was a geographical information system (GIS) database that contains a wide variety of information required for spatial planning and land use management purposes. Each of these elements required a unique data-collection methodology that included spatial data collection; aerial photography and satellite image pre-processing; mapping of property boundaries; defining area of interest; determining land ownership through property valuation rolls; establishing the status of access roads and routes; mapping current land uses, and overlaying land use control measures in order to infer land uses and deriving potential land use zoning. The methodology applied succeeded in successfully linking land parcels as follows: valuation data: 3 731 out of 4 176 (89.3%) were linked; state land audit: 378 out of 4 176 (9.1%) were linked, and deeds data: 1 680 out of 4 176 (40.2%) were linked. The study found that creating and updating land audits require advanced skills in GIS and it is recommended that municipalities employ suitably qualified officials in this regard. Working with outdated planning scheme legislation/ policy can become a time-consuming and costly exercise for municipalities.

Keywords: Land audit, GIS, zoning, remote sensing, Matzikama

DIE SAAMSTEL VAN ‘N GROND-OUDIT IN GROOT PLATTELANDSE GEBIEDE: RESULTATE VAN DIE METODES TOEGEPAS IN DIE NIE-STEDELIKE GEBIEDE IN DIE MATZIKAMA MUNISIPALE AREA

Om ‘n omvattende grond-oudit in groot, hoofsaaklik landelike munisipaliteite, soos die Munisipaliteit Matzikama in die Wes-Kaap te doen, regverdig ‘n alternatiewe metode as die konvensionele een waar volledige eiendomsbesoeke gedoen word om die oudit saam te stel. Hierdie studie poog om so ‘n alternatiewe metode bekend te stel waarmee die grond-oudit vir die munisipaliteit opgestel kan word. Die eindresultaat van die oudit was ‘n geografiese inligtingstelsel (GIS) databasis wat ‘n wye verskeidenheid van inligting wat nodig is vir ruimtelike beplanning en bestuur vir grondgebruikdoeleindes bevat. Elkeen van hierdie elemente wat nodig is vereis ‘n unieke dataversamelingsmetode wat ruimtelike data-insameling, lugfoto’s en satellietbeeld pre-verwerking, kartering van eiendomsgrense, die definiering van areas van belang insluit; bepaal grondeienaarskap deur waardasierolle, bepaling van die status van die toegangspaaie en roetes; kartering van huidige grondgebruike en oortreksel grondgebruik beheermaatreëls om grondgebruike te kan aflei en potensiele grondgebruiksonering te kan bepaal. Die toegepaste metode het daarin geslaag om grondpakkies soos volg suksesvol te koppel: waardasie data: 3 731 uit 4 176 (89,3%) is gekoppel; staatsgrondoudit: 378 uit 4 176 (9,1%) is gekoppel, en akte data: 1 680 uit 4 176 (40,2%) is gekoppel. Die studie het bevind dat die skep en opdatering van grond-oudits gevorderde vaardighede in GIS vereis en dit word aanbeveel dat munisipaliteite toepaslik gekwalifiseerde beamptes in hierdie verband in diens neem. Om met verouderde dorpsbeplanningskema-wetgewing/beleid te werk kan ‘n tydrowende en duur oefening vir munisipaliteite word.

Sleutelwoorde: Grond-oudit, GIS, sonering, afstandswaarneming, Matzikama

HO ETSA LAND AUDIT LIBAKENG TSE KHOLO NTSA MAHAENG: LIPHETHO TSE TSOANG MEKHOENG E SEBELISITSOENG LIBAKENG TSE SENG TSA TEROPONG, MATZIKAMA MUNICIPAL AREA

Ho khona ho ets land audit e phethahetseng, haholo-holo ha masepala oa libakeng tsa mahaeng joalo ka Matzikama Municipality e Kapa Bophirimela, e tla ka mekhoa ea ona ea ho chakela libaka tseno khafetsa, khafetsa. Thuto ena e leka ho fumana mokhoa o mong oa ho etsa land audit masepaleng ona. Sepheto sa audit e ne e le geographical information system (e leng GIS ka bokhuts’oane) database e nang le tsebo e ngata e fapaneng e hlokahalang ho etsa merero ea libaka le mekhoa ea ho sebelisa lefatshe. E ngoe le e ngoe ea lintho tsena li hloka mekhoa ea pokello tse fapaneng tsa tsebo, tse kenyelletsang tsebo ea merero ea libaka mapeng, ho fumana libaka tse amehang, ho batlisisa meruo ea litsha ka property valuation, ho beha boemo ba ho kena hara litsla, hjo beha litshebeliso tsa libaka mapeng, le ho sheba tsamaiso ea tshebeliso ea libaka ka maihlo a fapanenghoo phethahatsa tshebeliso ea libaka, le bookamoso ba tshebeliso ea libaka. Mokhoa ona o atlehile ho kopanya lishobana tsa libaka ka mekhoa ena: valuation data: 3731 ho tsoa ho 4176 (89.3%) li kopane, State

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land audit: 378 ho tsoa ho 4176 (9.1%) li kopane, le deeds data: 1680 ho tsoa ho 4176 (40.2%) li kopane. Chebisiso ena e fumane hore ho bopa le ho hlahloba land audit khafetsa, ho hlokahala litsebo tse khethehileng tsa GIS, hape ho eletsoa hore ba masepala, ba hire batho ba [phethahetseng, ba nang le tsebo e nepahetseng tabeng tsena. Ho sebetsa ka melao ea khale/ tsamaiso tsa khale, ho senya nako le chelete ea masepala.

Keywords: Land audit, GIS, zoning, remote sensing, Matzikama

1. INTRODUCTION

Land use data is a central consideration in town and regional planning in South Africa (Harrison, Todes & Watson, 2008), especially for municipal planning purposes. South Africa's Spatial Planning and Land Use Management Act (SPLUMA) of 2013 identified municipal planning as consisting of three elements: integrated development plans, components of an integrated development plan falling within the competence of a municipality including spatial development frameworks and land use schemes, and the control and regulation of the use of land within the municipal area (RSA, 2013: 16). Section 24 of the Act specifically requires that a municipality must, after public consultation, adopt and approve a single land use scheme (LUS) for its entire municipal area within five years from the commencement of the Act. Such a land use scheme must include scheme regulations outlining conditions relating to the use of land within a specific zone, maps indicating the zoning of land, and a register of all amendments to the scheme (RSA, 2013: 35-37). However, large parts of the country have never been part of a land use scheme (*e.g.*, many areas under traditional leadership) and many municipalities do not have access to recent and accurate land use and other property-related information). The challenge facing many municipalities is thus well articulated by Cihlar and Jansen (2001: 275), stating that "there is a dearth of methodological knowledge … regarding the practical task of producing land use maps".

The absence of systematic land audits and its impact on the ability to undertake effective land use planning and management has also been noted internationally (Pethe, Gandhi, Tandel & Libeiro, 2010; Shaw, 1991) and locally (Ruhiiga, 2011). The purpose of land use information is to indicate how land resources are used. A great deal of emphasis in the rural literature is on land use management relating to environmental conditions and controls (*e.g.*, McIntyre & Marshall, 2010; Pattison & Lane, 2012; Schapper & Kington, 2001). It is, however, important for public institutions to have a clear understanding of current land uses before additional needs can be addressed. Land audits are viewed as useful in policy formulation and for land acquisition in land redistribution processes in post-reform countries (Bhatta, 2010). However, as is the case in many urban studies, Gordon, Nell and Bertoldi (2007: 6) state that there is "no single data source that can provide all the analytical dimensions on a national scale … [and that] a consolidated picture that addresses as many of the variables as possible therefore requires the construction of a consolidated database and a data model".

Matzikama Municipal area, located in the northern part of the Western Cape Province, is a vast, sparsely populated area (approximately 5.2 people/km²), with just more than 66 000 people living in the local municipal area. As of the last local government elections in May 2011, the previous district-managed area has been incorporated in the Matzikama Municipal area. As a result, the geographical area of the Municipality increased from roughly 8 000 km^2 to 14 000 km^2. In 2012, the agriculture sector was the largest economic contributor within Matzikama Municipality, accounting for 25.34% of the total Gross Value Added (GVA) (Matzikama Municipality, 2015: 49). Given the extent of the rural component of the municipality, the large number and inaccessibility of properties, as well as the very limited funds that were available for carrying out the audit, a conventional land auditing approach of exhaustive property visits (*e.g.*, Board, 1960) was not a viable option. It is the main aim of the paper to explain the methodology employed to compile a detailed land audit for the non-urban areas of Matzikama. The end result of the audit was a geographical information system (GIS) database that contains a wide variety of information required for spatial planning and land use management purposes. Each of these elements required a unique data-collection methodology, as discussed in the next section.

2. ROLE OF GIS IN MAPPING LAND AUDITS

Geographical information systems (GIS) are special computer systems that capture, store, query, analyse and display geographically referenced data (Chang, 2006; DeMers, 2005). GIS has been used for a range of applications relating to land audits. For instance, they are frequently used for land administration (Ali & Shakir, 2015; Chiemelu, 2014; Elia, Zevenbergen, Lemmen & Oosterom, 2012; Ibraheem, 2012); land suitability studies (Romano Dal Sasso, Trisorio Liuzzi & Gentile, 2015); land use planning (Wang, Shen, Tang, Skitmore & Harbour, 2013; Huang, Liu, Mao, Li & Chen, 2012; Porta, Parapar, Doallo, Rivera, Santé & Crecente, 2013; Campagna & Matta, 2014); land use mix and diversity analyses (Amin & Fazal, 2012; Musakwa & Van Niekerk, 2014b); land use change analyses (Musakwa & Van Niekerk, 2014a; Musakwa & Van Niekerk, 2013); land ownership management (Desmarais, Qualman, Magnan & Wiebe, 2015; Ivanova, 2014); land reform (Skaloš, Molnárová & Kottová, 2012), and land zoning (Bourgoin, Castella, Pullar, Lestrelin & Bouahom, 2012; Nackoney, Rybock, Dupain & Facheux, 2013).

GIS are ideal for carrying out land audits as most of the datasets are spatial in nature. It also allows for the combination of various datasets that do not necessarily have logical relations to each other, using location as the common denominator. The property that differentiates GIS from other information systems is their ability to analyse spatial data (Clarke, 2006). Longley, Goodchild, Maquire and Rhind (2002: 278) define spatial analysis as "the process by which we turn raw spatial data into useful information … [to] … add value, support decisions, and reveal patterns and anomalies that are not immediately obvious". In order to conduct spatial analysis, a spatial database is required. Geographical data is expensive to collect and capture and can be the most expensive component of GIS. Fortunately, GIS are maturing and more data is becoming available. Many governments, including that of South Africa, have made state-owned data freely accessible to the public since 2000. In spite of improved data accessibility policies, the establishment of spatial databases still impedes many GIS implementations, including land audits. Fortunately, new technologies such as remote sensing and global satellite navigation systems (GNNS), also known as global positioning systems (GPS), are available for rapid spatial data collection.

Remote sensing is the gathering of information from a distance. In the context of spatial analysis, remote sensing can be defined as the survey and analysis of electromagnetic radiation reflected or emitted from features on the surface of the earth (Campbell, 2006). Typically comprised of aerial photographs or satellite imagery, remotely sensed data has been used for over a century to catalogue and monitor a wide variety of geographic aspects. Digital remotely sensed data, combined with advancements in information technology, allows for the wide-scale analysis of the features, patterns and processes that occur on the earth's surface, in much higher detail and at a fraction of the cost than would be possible from ground surveys alone. This makes it ideal for the classification mapping of both land cover (the biophysical coverage resulting from natural and human processes) (Aplin, 2004; Friedl & Brodley, 1997; Gislason, Benediktsson & Sveinsson, 2006; Keuchel, Neumann, Heiler & Seigmund, 2003; Liu *et al.*, 2002; Steele, 2000; Yuan, Sawaya, Loeffelholz & Bauer, 2005) and land use (the human activity that occurs on the land which defines how it is used) (Erbek, Özkan & Taberner, 2004; Lackner & Conway, 2008; Myint, 2001; Rozenstein & Karnieli, 2011; Weng, 2002; Wu, Silvánhyphen-Cárdenas & Wang, 2007). While regular and accurate land use data is in high demand for a wide range of operational, legislative and regulatory needs generally in South Africa (Wessels, 2014), it is a valuable asset for land audits specifically, as it provides a detailed indication of the practices being undertaken by the population on the ground. Very high resolution imagery such as aerial photographs (0.5 m) or the French-owned satellite SPOT 5 (2.5 m) also allows for the classification and mapping of more specific landscape features such as roads and road networks (Valero Chanussot, Benediktsson, Talbot & Waske, 2010), buildings (Zhang, 1999), urban infrastructure and socio-economic attributes (Herold, Scepan & Clarke, 2002; Jensen & Cowen, 1999), agricultural field boundaries (Rydberg, Borgefors & Member, 2001), and cadastral boundaries (Rao, Sharma, Rajashekar, Arepalli, Arora, Kuldeep, Singh & Kanaparthi, 2014), all of which can be fed into the land audit process in GIS format.

3. METHODS AND MATERIAL

A combination of desktop analyses and fieldwork was used to carry out the audit. The main motivation for this approach was to save costs by collecting as much information as possible from existing databases and to limit field visits. The field survey was consequently mainly used for verifying the data collected during the desktop-analysis phase of the study. The project team included a GIS specialist, a remote-sensing specialist, a registered town planner, and a project manager (geographer). In addition, two fieldworkers did ground-truthing and a couple of GIS assistants helped identify land use from satellite imagery. Basic GIS training was provided to the municipality on how to update and maintain the land audit in GIS.

3.1 Spatial data collection

The project commenced with the identification and collection of a range of existing datasets[1] in support of the land audit. Table 1 lists each dataset along with its source and format.

Administrative boundaries were obtained in ESRI shapefile format from the Municipal Demarcation Board. Of particular interest were the local and district municipal boundaries, as these were used to define the area of interest. *Property*[2] *boundaries* were fundamental to the audit, because most of the other data related to it. Cadastral data was obtained in shapefile format from the Chief Surveyor General's Office (CSG). Two cadastral datasets, namely Erf and FPortion (short for farm portion), were used. *Cultivated and pasture field boundaries* were obtained from the Department of Agriculture, Forestry and Fisheries (DAFF) in shapefile format as polygons. These polygons describe the smallest unit of crop cultivation (fields) in South Africa, digitised at 1:10 000 scale from the 2.5 m mosaic of SPOT5 satellite imagery created annually for South Africa. Fields that are irrigated by centre pivot irrigation are labelled as irrigated fields; similarly, all permanent tree crops and orchards are labelled as horticulture. At the time of carrying out the audit, the latest field boundary dataset was dated 2007.[3] DAFF also provided the locations of existing wine cellars and silos. *Road data* was supplied by the provincial Department of Transport and Public Works in shapefile format. This comprehensive database includes

1 Not referenced in the reference list because they are in the form of electronic datasets

2 For the purposes of this study, the term *property* is equivalent to *land parcel*. A land parcel can be comprised of either an *erf* or a *farm portion*. This is derived from the CSG cadastral data classification, where an erf usually (but not always) lies within the urban edge of a town, and a farm portion falls outside the urban edge of a town.

3 This dataset was updated in 2014 using 2012 imagery.

road type, name, route number, and condition. The *location of existing tourism infrastructure* (*e.g.*, accommodation, information offices, attractions and activities in the Western Cape) was obtained from the Centre for Geographical Analysis (CGA) at Stellenbosch University. This database, developed in 2008 for Cape Town Routs Unlimited, consists of three-point datasets in shapefile format. The CGA also provided the Stellenbosch University Digital Elevation Model (SUDEM) for the purpose of this study. The SUDEM has a resolution of 5 m and was generated using a combination of spot heights, contours and Shuttle Radar Topography Mission (SRTM) data. *Land ownership data* of the rural properties was sourced from the Deeds Office (DO) in tabular (Excel) format. A second very useful source of ownership data was the most recent (2010/11) property valuation database. The valuation database consists of the assessment of the value of all the properties (erven and farms) within a municipality as determined by a property valuator. The valuations in Matzikama were based on a combination of CSG and deeds data, as well as field visits.

Over 1 000 very high-resolution (0.5 m) rectified and unrectified colour aerial photographs (dated 2010 and 2011, depending on the area) were obtained from the Chief Directorate: National Geospatial Information (CD:NGI). High-resolution panchromatic (2.5 m) and multispectral (10 m) SPOT5 satellite imagery (dated 2011) was obtained from the South African National Space Agency (SANSA).

3.2 Image preprocessing

Image pre-processing refers to any operations undertaken on imagery prior to analysis. Typically, this involves ensuring geometrical (positional) and radiometric (spectral) suitability of the imagery for the analysis at hand. Current aerial photography obtained from CD:NGI (since 2009) is usually very spatially accurate, but, in this instance, more than 700 of the aerial photographs obtained from CD:NGI were, at the time of the land audit, only available in raw (*i.e.*, unrectified) format. These images covered a large part of the study area and were critical for a number of the land audit processes. Consequently, the images were geometrically corrected (orthorectified), using PCI Geomatica OrthoEngine software. This process was complicated by the lack of accurate reference data in the study area at the time of the study (typically existing rectified aerials of older dates are used), though partial coverage of older rectified aerials (2003), combined with road data and farm portions, were found to be suitable replacements. The SUDEM was used as elevation data during the orthorectification process.

Pre-processing was also carried out on all the SPOT5 images to ensure comparability with the aerial photographs and property boundaries. Geometric correction was undertaken, using the rectified aerials and SUDEM as spatial and elevation reference data, respectively. Radiometric and atmospheric correction, the correction of satellite calibration effects and atmospheric interference, was undertaken, using the ATCOR2 algorithm in PCI Geomatica. The multispectral bands were then fused with the panchromatic band, using the PANSHARP algorithm in PCI Geomatica to produce multispectral images with a 2.5 m spatial resolution. This process improved the spatial and spectral quality of the images and allowed for better recognition of land features.

Table 1: Datasets collected

#	Description	Format	Source
1.	Administrative boundaries	Polygon shapefile (.shp)	Municipal Demarcation Board
2.	Cadastral data	Polygon shapefile (.shp)	Chief Surveyor General
3.	Agricultural field boundaries	Polygon shapefile (.shp)	Department of Agriculture, Forestry and Fisheries
4.	Wine cellars, silos and farm stalls	Point shapefile (.shp)	Department of Agriculture, Forestry and Fisheries
5.	Roads	Polyline shapefile (.shp)	Department of Transport and Public Works
6.	Tourism infrastructure, attractions and activities	Point shapefile (.shp)	Centre for Geographical Analysis, Stellenbosch University
7.	Digital elevation model	Raster (.tif)	Centre for Geographical Analysis, Stellenbosch University
8.	Deeds data	Excel spreadsheet	Deeds office
9.	Valuation database	Excel spreadsheet	??
10.	Internet-based spatial directories	Various	Internet
11.	Aerial photography	Raster (.tif)	Chief Directorate: National GeoSpatial Information
12.	SPOT5 satellite imagery	Raster (.tif)	South African National Space Agency
13.	State land audit of the Western Cape (2012)	Polygon shapefile (.shp)	Department of Rural Development and Land Redistribution (DRDLR)

3.3 Land audit procedure

The procedure for carrying out the land audit consisted of the following ten steps:

1. Define area of interest;
2. Map property boundaries and identify land parcels to be audited;
3. Determine land ownership;
4. Relate ownership information to property boundaries;
5. Establish status of access roads and routes;
6. Map current land uses;
7. Record current land use control measures;
8. Infer land use status;
9. Derive potential land use zoning, and
10. Carry out fieldwork.

Each of these steps is described in more detail in the following subsections.

3.3.1 Define area of interest

The first step in the land audit was to specify the area of interest. For the purposes of this study, this was defined as the Matzikama local municipality area (LMA) and the former separate district municipality area (DMA), excluding all areas defined as urban (see Figure 1). The study area is henceforth referred to as Matzikama.

3.3.2 Map property boundaries and identify rural land parcels

The *Erf* dataset includes all land parcels classified by the CSG as erven[4] (mostly land parcels within towns), while the *FPortion* (short for farm portion) dataset represents land parcels classified by the CSG as farms. The relevant attributes of these datasets are shown in Table 2. The CSG cadastral datasets provide a unique 21-digit identification number, called the 21DigitKey, for each property in South Africa. This key is a combination of four different numbers, namely a six-digit MAJ_CODE (specifying the administrative region of a property), a two-digit MIN_CODE (specifying a town number), an eight-digit PARCEL_NO (indicating the property's parcel number), and a five-digit PORTION_NO (indicating the property's portion number). All properties within the Matzikama LMA and DMA fall in the Vanrhynsdorp administrative area, which has a unique MAJ_CODE of "C07800". The MIN_CODE is only used for erven and is specified as "00" for all farms.

3.3.3 Determine land ownership

Land ownership data was obtained from two sources. First, the Deeds Office data (Table 3) for each property. The ERF NUMBER, PORTION and OWNER NAME items were the most relevant for the purposes of the land audit. Secondly, the municipal valuation database containing the formation outlined in Table 4.

As the Deeds Office is concerned with primarily private ownership, the Matzikama property valuation roll was used as primary source for identifying state-owned land. The 2012 State Land Audit of the Western Cape served as the secondary source to fill gaps in the municipal valuation roll data.

3.3.4 Relate ownership information to properties

The fourth step in the land audit procedure involved relating the valuation and deeds data to the property boundary database. This was done by using the information in the ownership records to generate a 21DigitKey that would correspond to the 21DigitKey of the cadastral data. The key was generated, using a series of concatenation functions in Microsoft Excel. ArcGIS 10 was used to join the valuation and deeds data to the cadastral data, using this field as common key. ArcGIS 10 was also used to calculate the extent of the property, using the Calculate Geometry tool. The extent calculated in this way often deviates from the registered extent. This is likely due to errors in the deeds data, but can also be due to spatial inaccuracies and/or topology errors in the cadastral data. For instance, there were many cases of overlapping polygons. Often these errors were caused by farm subdivisions which are recorded as new polygons. However, in many instances, the original polygons (parent farm) were left unchanged, which resulted in many small polygons overlapping larger polygons. The cadastral data also contained a

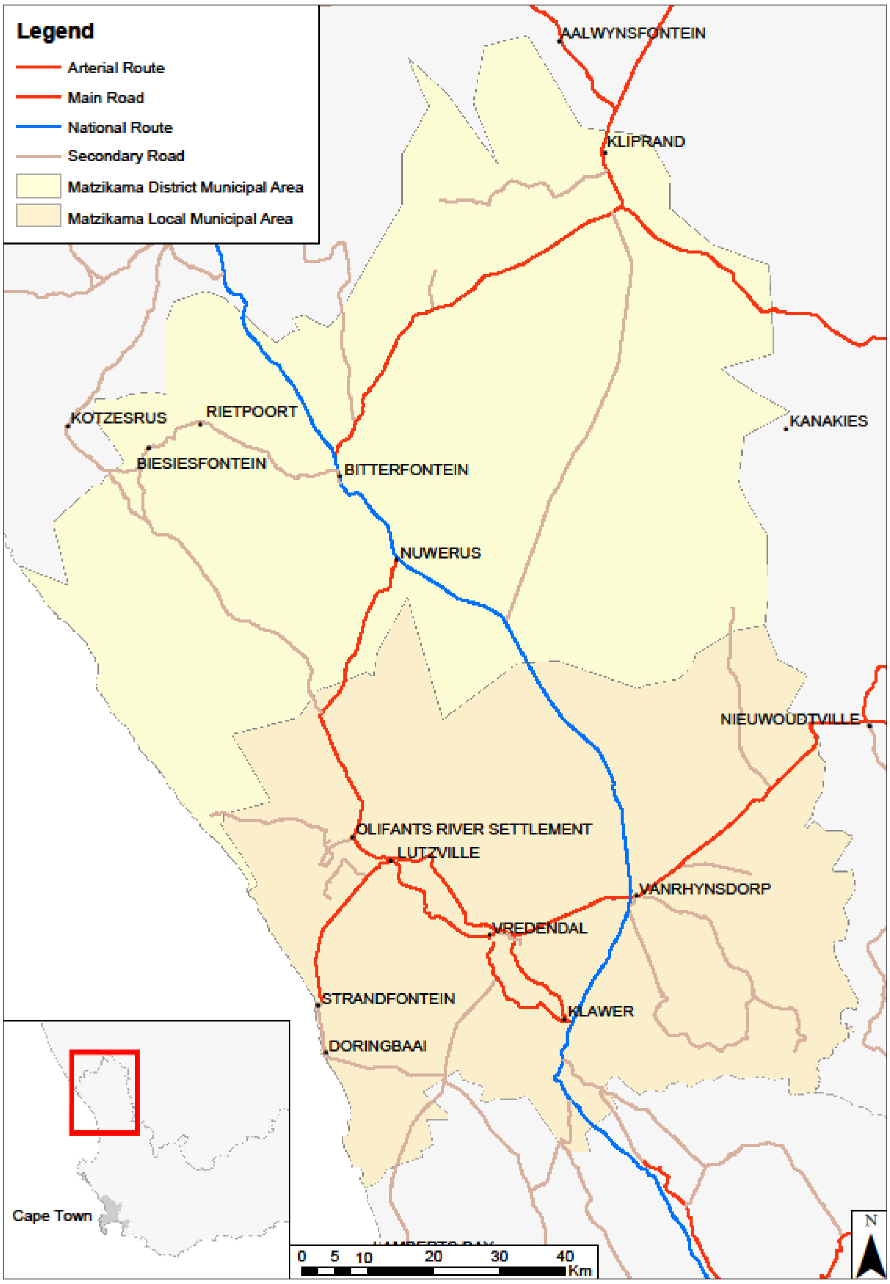

Figure 1: Study area: Map of location of Matzikama Local and the former District Municipal Area

4 In southern Africa, erf (plural *erven*) is a small parcel of land, as listed in a municipality's cadastre. In the CSG data, this term is usually used for urban properties.

number of gaps caused by missing properties or misalignment of property boundaries. These errors were reported to the CSG office and most were promptly rectified. Some of the remaining slivers caused by digitising errors were corrected by the authors. In spite of these corrections, a small number of polygons had duplicated 21-digit keys and could not be successfully related to the ownership information.

3.3.5 Establish status of access roads and routes

The nearest access road to each property was determined through a GIS operation. Each road name was included in the GIS database. The length of roads per property was also determined. These lengths were provided in the GIS database per road type: national, main, minor.

3.3.6 Determine current land uses

In the case of Matzikama, most of the land use is dominated by agriculture. The first step in determining the current land uses and development status of properties was thus to map agricultural land use. A combination of automated (*i.e.*, image processing) and manual (*i.e.*, visual interpretation) methods were used to update the 2007 agricultural fields data obtained from DAFF to match the 2011 imagery. It was difficult to automatically differentiate fields from natural vegetation, particularly in the northern parts of the Municipality, as many of the fields in this area are left fallow for long periods. All fields were consequently verified, using visual interpretation and, where necessary, the boundaries were manually edited. Any indication of disturbance due to cultivation was included in this category, even if it seemed that the field had been left fallow for a long period.

Buildings were manually digitised from the SPOT5 imagery and visually interpreted and classified, using high-resolution aerial photography. The resulting building database was used to determine land use and was also instrumental for determining the status of properties (see section 2.5.7).

The building database provides an indication of the number of structures on each property, according to all defined land uses within Land Use Planning Ordinance (LUPO) (Western Cape Government, 1985). A total of 29 zoning categories are defined in LUPO, and it includes 50 defined land uses that are permissible as either primary uses or consent uses in different combinations under each defined zoning. As a point of departure, the identified land uses present on each property (based on aerial photography interpretation, selected field verification and secondary sources) were interpreted based on these LUPO land use definitions.

Any item of interest consists of a number of features: shape, size, colour, texture, context, movement, and changes over time. The human brain, being highly practised in feature identification in everyday life, assesses these features unconsciously, compares the features to an existing dataset of prior knowledge, and assigns a label for what it is seeing. When using aerial photography for feature classification, the amount of information is limited to one viewpoint and usually one time frame. Feature classification, in this instance building type, is therefore reliant on only those features as captured by the camera: spectral tone, texture, shadow, geometry and context (Campbell, 2006). The classification of some of the building structures using aerial imagery alone was, however, challenging, and secondary sources were hence also often consulted for corroboration. The principles, upon which building types were determined by interpreting the aerial photography of the Matzikama region, are listed in the first column of Table 5, and the identification and verification methods in the other columns.

For any form of business to succeed, a reasonable amount of marketing has to be conducted. A range of marketing and advertising outlets were thus scanned for sites/businesses located within the study area. With the use of Google Earth, Google web searches, and information obtained from the Tourism Bureau and from the Department of Agriculture, specific businesses were identified, including wineries and farm stalls (“agricultural industry”); guest houses/cottages (“holiday accommodation”); mining/prospecting rights (“industrial III”), and schools (“place of instruction”). In addition, the Department of Agriculture was approached to provide information on farms with cellars, road stalls, cooling facilities, farm shops, nurseries and packaging stores.

Aerial photography was used for the identification of *Agricultural industry*, *Dwelling-house*, *Outbuilding* and *Reservoir*, while a combination of methods was used for the identification of other types of buildings. This included the use of aerial photograph interpretation, secondary sources, archival records (*e.g.*, building plans at the Matzikama Municipality), internet searches, as well as extensive field visits. The categories *Authority usage*, *Business premise or shop*, and *Service station* were identified during the fieldwork undertaken in the rural hamlets. The classes *Holiday accommodation* and *Places of worship* were identified using secondary sources, including spatial data directories (*e.g.*, OpenStreetMap, Tracks for Africa, GARMIN, Google Earth), websites, and telephone directories. The categories *Industry* (pertaining to industry near the large towns), *Places of entertainment*, *Places of instruction* and *Mining* were identified from aerial photographs and secondary sources.

Places of entertainment were defined as structures located in close proximity to sports grounds or golf courses (these were also verified by field visits). *Places of worship* were identified partially by aerial photograph interpretation, but mostly by using Google Earth and existing spatial databases. *Industry* was identified, using contextual information available to the interpreters of the aerial photographs.

Table 2: Attributes of the cadastral data received from the CSG

Item name	Description
26DIGITKEY	Unique 26-digit GIS key
21DIGITKEY	Unique 21-digit GIS key
PARCEL TYPE	Farm portion (FP) or erf (E)
PARCEL_NUM	Combined land parcel and portion number (*e.g.*, 124/5)
GEOMAREA	Area in square metres
PROVINCE	Province (Western Cape for all land parcels)
MAJ_REGION	Major region, equating to the registration division (Vanrhynsdorp for all land parcels)
MAJ_CODE	Major region code (C0780000 for all land parcels, as this is the code for the Vanrhynsdorp region)
MIN_REGION	Minor region, equating to the closest town (only applicable to erven)
MIN_CODE	Minor region code, combination of the major region code plus a unique town code (*e.g.*, Bitterfontein = 1; therefore, the minor region code for Bitterfontein = C0780001. Only applicable to erven)
PARCEL_NO	Land parcel number (either farm portion or erf)
PORTION	Portion number (only applicable to farms, 0 for all erven)

Table 3: Deeds data (May 2011)

Item name	Description
ERF NUMBER	Parcel number
TOWN NAME	Town to which the land parcel belongs (*e.g.*, Olifantsrivier Settlement)
PORTION	Portion number (only applicable to farms, “00000” is used for all erven)
EXTENT	Area in hectares
PROVINCE	Province (Western Cape for all land parcels)
REGISTRATION DIVISION	Division where registered (*e.g.*, Vanrhynsdorp RD)
OWNER NAME	Owner of land parcel
REGISTRATION DATE	Date of land parcel registration
PURCHASE DATE	Date of purchase
PRICE	Price on last purchase date (where available)
PREVIOUS TITLE	Title number before last sale
NEW TITLE	New (current) title number
PREVIOUS OWNER	Previous listed owner (where available/applicable)
PROPERTY TYPE	Erf or farm portion (where an erf is usually found inside, and a farm portion outside town boundaries)

Table 4: Valuation data (November 2011)

Item name	Description
ERF NO	Parcel number
PTN	Portion number (only applicable to farms, “0” is used for all erven)
REGISTRATION DIV	Division where registered (*e.g.*, Vanrhynsdorp RD)
OWNER	Owner name
ARTICLE	Article 8 classification, according to Local Government: Municipal Property Rates Act, 2004
PREV ARTICLE	Previous Article 8 zoning (where applicable)
ADDRESS	Owner postal address
EXTENT	Area in hectares
MARKET VALUE	Current market value
PREVIOUS MV	Previous market value
DIFF	Difference between current and previous market value

Typically, buildings related to industry were assumed to be located near towns, not obviously used for mining, not located on a working farm (*i.e.*, property that is clearly being used for cultivation), comprised of a number of large buildings (‘large’ is defined by a building footprint greater than 400 m^2), and often close to human-constructed/regulated standing water. These structures were verified during the field survey.

Mining activities are relatively easy to identify from aerial photographs, as they are often associated with significantly disturbed (bare) areas such as large open pits and quarries. Many small pits and quarries were also mapped on farms, although it was impossible to determine which of these features were still in use. Buildings located on the same property or in close proximity to mines were classified as being used for mining. Uncertain cases were verified by field visits. Some mines refused fieldworkers access and preferred to provide the audit information themselves if supplied with the aerial images.

The categories *Agricultural industry*, *Dwelling-house*, *Outbuilding* and *Reservoir* were identified primarily through the interpretation of aerial photography. The rules used to identify each of the categories are as follows:

- The locations of wineries were provided by the Department of Agriculture. In addition, buildings that are potentially used for *Agricultural industry* were defined as a group of large (>400 m^2) structures in close proximity to one another, or a single structure deemed too large to be an outbuilding, located on a farm. Greenhouses, intensive agriculture or human-constructed/regulated standing water were also included in this category. The identification of these structures erred on the side of caution (*i.e.*, *Outbuildings* were often classified as *Agricultural industry*, as the latter type of buildings were verified during the field survey).
- The *Dwelling-house* category comprises farmhouses and labour houses on farm portions, as well as residential structures within the hamlets of the district municipal area. Only farm and labour houses were identified, using aerial photography, as dwelling houses in urban areas were mapped during a field survey. A farmhouse was defined as a single complex structure (*i.e.*, not necessarily of a regular shape), with the presence of more than one of the following: a yard, lawn or garden; a verandah; trees planted for shade or aesthetics (in contrast to a windbreak or biofuel, for example); a swimming pool; a gable, cross-gable, hipped, cross-hipped or pyramidal roof; a non-grey roof (*i.e.*, tiled); a

water tank/reservoir on the roof or nearby; a paved driveway. Labour houses were also included in the *Dwelling-house* category and are typically less complex structures compared to farmhouses; usually a distance away from the main farmhouse; often arranged in a group, and generally have fewer trees in close proximity. They are characterised as having one or more of the following: a yard; a verandah; a flat or gabled roof; a network of footpaths leading to it from other farm structures, and lack of a clearly defined road leading to it (that would be necessary for farm vehicles).

- The *Outbuilding* class was defined as any building on a farm that is not used for residential purposes or for *Agricultural industry*. Such structures were typically simple (*i.e.*, rectangular); with a flat, shed, saltbox or gambrel roof; ranging in size; with a grey or brown roof colour. However, this class acted as a catchall class (to which buildings that could not be attributed to other classes were assigned), and these rules are consequently not exhaustive.

Many consider the interpretation of aerial photography to be an art. It is thus not an exact science and is open to subjectivity. To limit this subjectivity and to increase accuracy, several interpreters in the GIS laboratory were used. In addition to assigning the likely category of a building, the interpreters were required to rate their confidence that a particular classification was correct. In instances where the interpreter was not confident about a classification, a second (and, in some cases, a third) interpreter was employed to help identify structures. Instances where the confidence of a classification remained low, even after the third iteration, were referred to the fieldworkers for field verification. In addition, all farms with more than six buildings were automatically included in the list of farms to be visited by fieldworkers.

An ArcView script was developed to calculate the relative percentages of land use, number of buildings per land use category for each property. This script significantly reduced time spent on database development, as it allowed for rapid updates to the database as the underlying databases (*e.g.*, buildings, roads, land use) were updated.

3.3.7 Record current land use control measures

Existing land use control measures and land use rights that are currently applied were identified from the Municipal archives.

3.3.8 Infer land use status

The land use data generated in the previous step was used to differentiate between developed and vacant land in the study area. Roads extracted from the provincial roads database were also used in this step of the land audit. Essentially, all properties that intersect with buildings, reservoirs, cultivated areas, and roads were classified as being developed.

Table 5: Building types

#	Lupo categories	Identification method	Verification method
1	Agricultural industry	Aerial photographs	Fieldwork
2	Authority usage	Fieldwork	-
3	Business premises or shop	Fieldwork	-
4	Dwelling-house	Aerial photographs (outside towns)	Fieldwork (on farms)
5	Holiday accommodation	Secondary sources	Fieldwork
6	Places of worship	Secondary sources	Fieldwork
7	Industry	Aerial photographs, secondary sources	Fieldwork
8	Mining	Aerial photographs, secondary sources	Fieldwork
9	Outbuilding	Aerial photographs	Fieldwork
10	Place of entertainment	Aerial photographs, secondary sources	-
11	Place of instruction	Aerial photographs, secondary sources	-
12	Reservoir	Aerial photographs	Fieldwork
13	Service station	Fieldwork	-

3.3.8 Derive potential land use zoning

3.3.9.i Background

In the absence of any form of official zoning register, and given the fact that zoning can only be determined through a legal process (for which there seems to be no collective register of records at the Matzikama Municipality), the zoning component of the land audit was challenging. Figure 2 details the process followed to determine potential zoning. *Derived potential zoning* was interpreted from a combination of the following sources: official historical records; property valuation classification; land use data; secondary sources, and focused on-site verification.

3.3.9.ii Official archival records

Archival records on rezoning, subdivision, departure and consent applications for land parcels falling outside the urban edge were captured. The dates of the files ranged from 1990 to 2011. The Matzikama Municipality had no electronic records of applications and, therefore, archival information was incorporated into the GIS database. Data was captured for every farm for which information was available in the municipal archive, and includes the following information: current zoning; denied zoning application; reason for rejection; description of application; further conditions; consent use; subdivision; application dates; other parcel information, and reference number of municipal file. The information was captured in the language in which it was documented at the Municipality. In addition to the parcel records, the site plans and/ or location maps were identified for 62 structures on 17 land parcels. Information from historical records was obtained for a total of 362 of the 4 176 properties (*i.e.*, 8.7%). Specific zonings as well as the current land use control measures applied (where applicable) were determined for these.

3.3.9.iii Classification of property valuation

The Property Rates By-Law of the Matzikama Municipality was adopted in terms of section 156(2) of the Constitution (RSA, 1996: 76) and section 3 of the Local Government: Municipal Property Rates Act (RSA, 2004: 8). The by-law makes provision for a register to be kept by the Municipality in terms of section 23 of the Act. The Act makes provision for a municipality to have different rates for different categories of rateable property, and these categories may be determined according to the use of the property (land use); permitted use of the property (zoning), or geographical area in which the property is situated. It is on these three categories that the property valuators based their classification when they compiled the property valuation data roll. Section 8 of the Act makes provision for 24 categories of rateable properties.

These categories, however, do not correspond to LUPO's Article 8 zoning categories or the defined land uses (Western Cape Government, 1985). Despite these challenges, the Municipal Property Valuation Data Roll provides a valuable set of information (with a legal grounding) that can be applied to verify some land uses and assist in narrowing the focus for the identification of properties where physical surveys need to be conducted to confirm land use. Although the property valuators' database does not contain specific land use information, the classification of properties in terms of some of the valuation categories does provide some useful information that could be applied, together with other sources of data, as an indication of the land use on specific properties. Table 6 shows the categories within the Article 8 classification of the Local Government: Municipal Property Rates Act (RSA, 2004: 23-24) that could be used to provide an indication of land use.

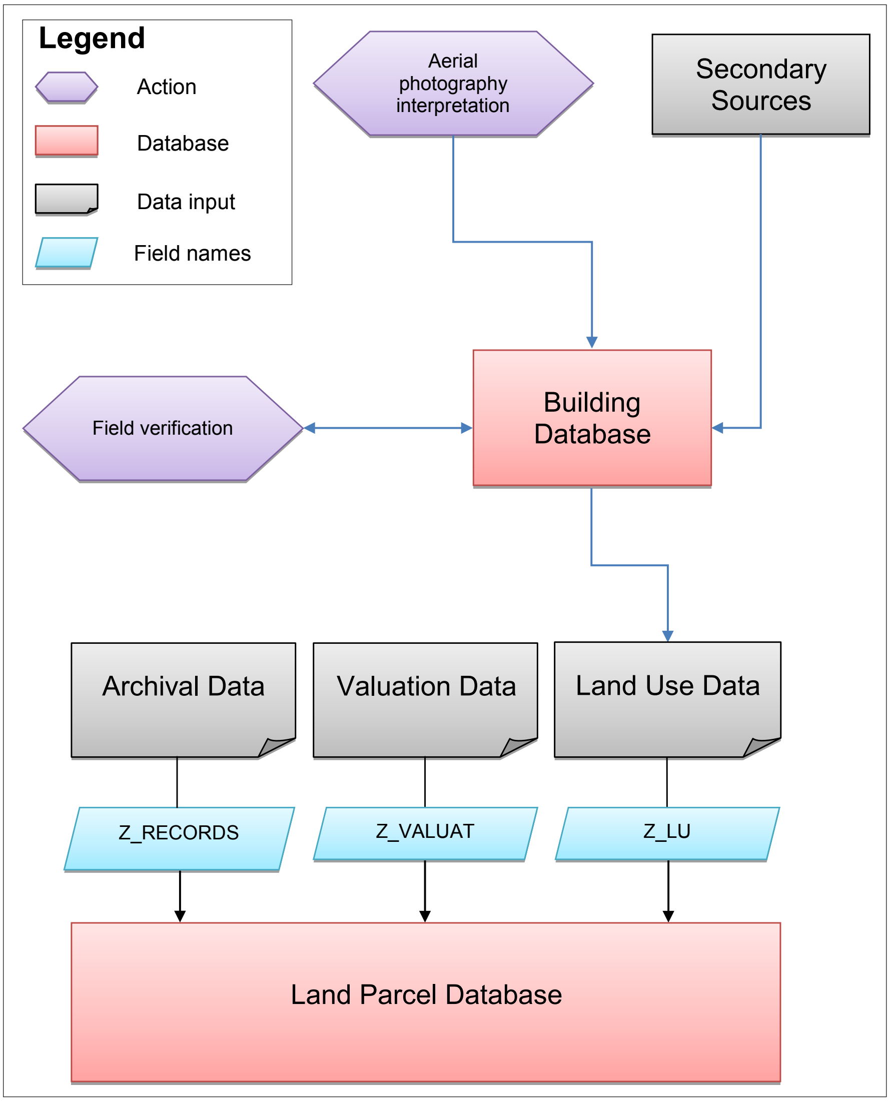

Figure 2: Process followed to derive potential zoning

The valuation database also contains a field referred to as "zoning", which only provides comments on the land use of some of the properties and does not signify any actual "zoning" of properties, as interpreted from a land use management perspective. This field can thus only be used as an indication of land uses on some properties. From the above, the following permutations could be observed:

1. Records with both a section 8 classification and a land use comment (referred to as "*zoning*" in database) = 1 285 records.
2. Records with either section 8 classification or land use comment = 2 475.
3. Records with neither section 8 classification nor land use comment = 416.

3.3.9.iv Deriving potential zoning

An initial potential zoning was derived from the information available from the four sources described earlier. The potential primary zoning of properties was interpreted as the primary land use activities covering the majority of the land area of the individual land parcel. Potential secondary land use was assigned in instances where additional land uses were identified on the property and that would not be permissible as either a primary use or a consent use in terms of the assigned potential primary zoning and occurs on a limited part of the property (mostly on farms). In some instances, these additional uses imply one secondary zoning, whereas, in other cases, multiple secondary zonings are implied to cover all land uses present on the property. These potential primary and secondary zonings were assigned through the application of a rule that was developed to interpret the data available from the combination of the available sources of data.

3.3.10 Carry out fieldwork

The fieldwork component could only start once the database creation had been completed. In total, there were 1 406 properties, of which 703 farms, that needed field verification. Nine land parcels were excluded, as access was not granted/available. The first phase of fieldwork entailed capturing land uses in all the small hamlets (*e.g.*, Rietpoort, Kliprand, Bitterfontein). The fieldworkers were provided with A3- to A1-sized aerial photographs of each settlement for orientation purposes. Because most of the erven were residential, it made sense to only focus on non-residential land uses such as businesses and government properties (schools, clinics), and record these uses on the aerial images. The second phase comprised the bulk of the fieldwork. Fieldworkers were provided with GIS data and hard copy A4 maps showing the property to be visited, access roads, and the buildings that were identified and classified during the database generation. Additional information included the farm/portion number and the owner's name (where available). The coordinates for each farm were also provided to enable fieldworkers to locate the farms using GPS navigation. The procedure was to drive to the farms and, upon arrival, ask the owner or manager for permission to verify the required structures.

4. RESULTS

Given the nature of the study, it was inevitable that there would be successes in some aspects and failures in others. This section highlights both and summarises the outcomes according to the following five sections: current ownership and title deed numbers; state-owned land ownership; land use zoning; fieldwork, and a general summary of results.

4.1 Current ownership of land parcels and title deed numbers

All 4 176 land parcels within the study area were joined in the GIS database, using three different sources (Figure 3), namely property valuation data roll; State Land Audit 2012 for the province, and deeds data. The property valuation roll provided 1 340 of the title deed numbers. From a visual inspection of the initial results from the valuation data on 4 June 2012, it was

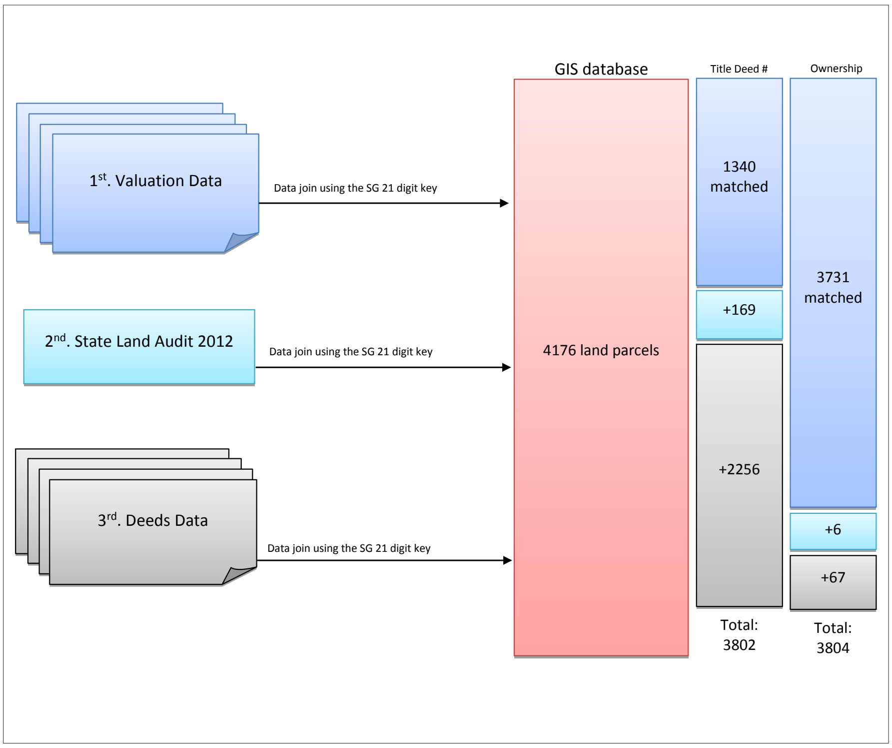

Figure 3: Property data source matching for title deed number and ownership

Table 6: Classes in the property valuation system that can be used to provide an indication of land use (Adapted from: RSA, 2004: 23-24)

Article 8 classification[1]	Description	Indication of potential land use
Section 8(2)(a)	Residential	Residential
Section 8(2)(b)	Industrial	Industrial
Section 8(2)(c)	Commercial/business	Business
Section 8(2)(d)(i)	Farm properties used for agricultural purposes	Agriculture
Section 8(2)(d)(ii)	Farm properties used for business or commercial purposes	Business
Section 8(2)(d)(iii)	Farm properties used for residential purposes	Agriculture (subject to number of residential structures)
Section 8(2)(d)(iv)	Farm properties used for purposes other than (i) to (iii)	Properties where land use needs to be verified
Section 8(2)(e)	Farm properties not used for any other purposes	Vacant
Section 8(2)(f)(i)	Smallholdings used for agricultural purposes	Agriculture
Section 8(2)(f)(ii)	Smallholdings used for residential purposes	Agriculture (subject to number of residential structures)
Section 8(2)(f)(iii)	Smallholdings used for industrial purposes	Industrial
Section 8(2)(f)(iv)	Smallholdings used for commercial or business purposes	Business
Section 8(2)(f)(v)	Smallholdings used for purposes other than (i) to (iv).	Properties where land use need to be verified
Section 8(2)(o)	Protected areas	Conservation/open space

NOTE 1: Only categories from which land use can *potentially* be derived

determined that many of the missing title deed numbers (and ownership) are state owned. An updated list of government-owned properties, the 2012 State Land Audit for the province, was obtained from the DRDLR in early August 2012 and matched with the database. The State Land Audit provided another 169 title deed numbers, leaving 2 630 still missing. Records for these missing land parcels were acquired from WINDEED and the Deeds Office. Figure 3 provides a breakdown of the total successfully matched title deed (3 802 out of 4 176) and ownership (3 804 out of 4 176) data from the various sources. Therefore, for this land audit, no title deed number and ownership details could be obtained from any source for 374 and 372 properties, respectively. According to the Deeds Office, these parcels either are in the process of being registered, or there simply are no records for these land parcels. It was recommended that the DRDLR, as a co-state institution, take this matter further with the CSG.

To summarise: the results from linking all of the available databases – valuation data, the State Land Audit, and deeds data from WINDEED and the Deeds Office – are as follows:

- Confirmed ownership: 3 803 out of 4 176 (91.1%), leaving 373 (8.9%) either unknown or with the statement ** *For Info Refer to Registrar of Deeds* ** (this line obtained from deeds data).
- Confirmed title deed numbers: 3 802 out of 4 176 (91%) confirmed, leaving 374 unknown (9%).
- Of the 374 parcels lacking title deed numbers, 373 coincide with those lacking ownership. Only one parcel had ownership without a title deed number.

Figure 4 shows the location of the land parcels where ownership and/or title deed numbers are still lacking.

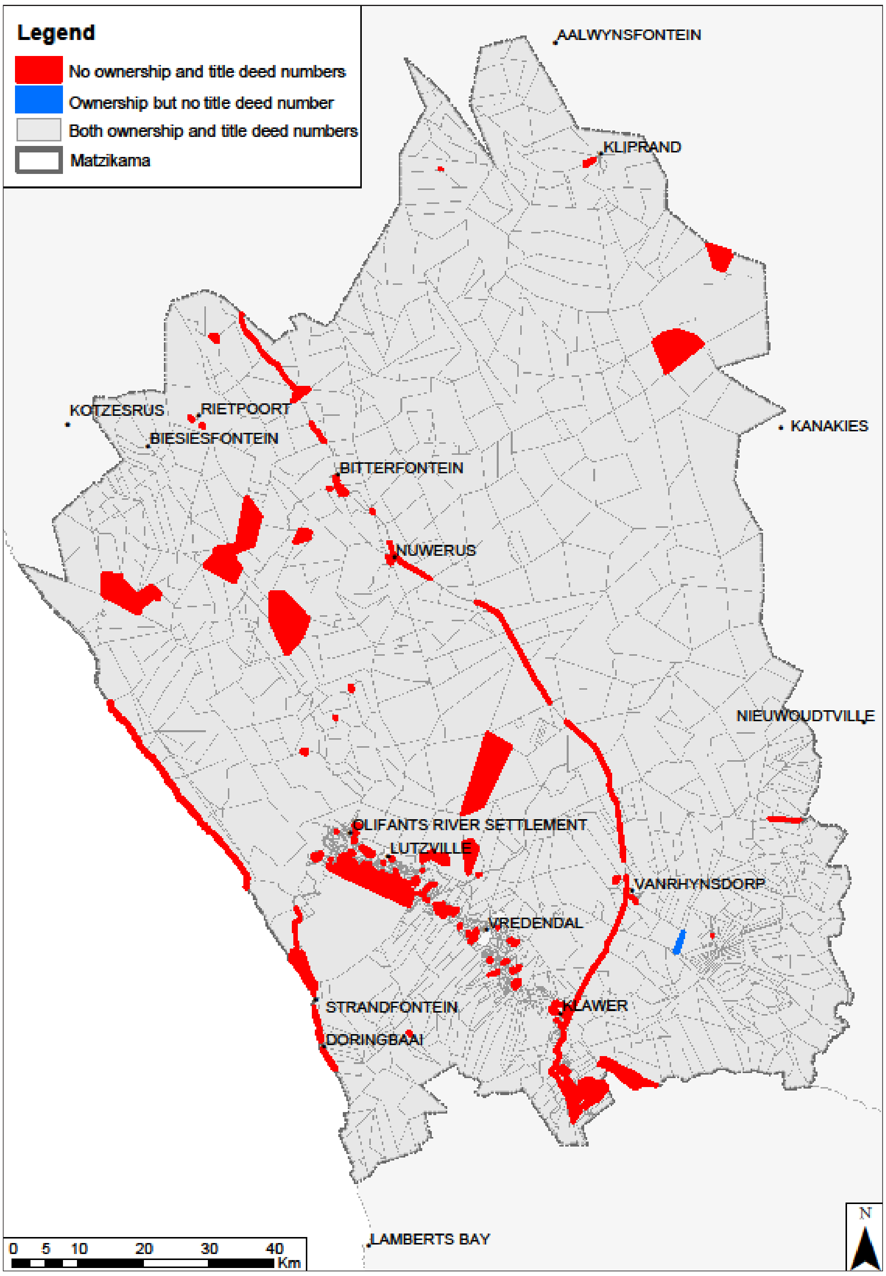

Figure 4: Land parcels without ownership and/or title deed numbers

4.2 State-owned land audit

Regarding the state-owned properties, 489 out of 4 176 land parcels (11.7%) were confirmed to be state owned (national, provincial and local). Caution should be taken regarding parcels designated as state owned. The State Land Audit (source: CSG) indicated 378 state-owned land parcels, and indicated owners classified under the state. Using this, it was possible to scan all the owners and assign state or private ownership. However, the State Land Audit is incomplete – indicated by the valuation data expressing state-owned land not covered by the State Land Audit, and parcels without owners which are probably state-owned (*e.g.*, road reserves). The distribution of state-owned property is shown in Figures 5 and 6.

The audit did not differentiate between exact ownership by government department and could, therefore, not be included in the GIS database as such. Instead, state ownership was listed according to the data obtained from the 2012 state land audit as is.

4.3 Potential zoning

A summary of these results are outlined in Tables 7 and 8. The information outlined in Table 7 indicates that 4 007 of the properties in the study area, representing 95.9% of all entities, were assigned only a potential primary zoning (without any potential secondary uses). A total of 145 properties (3.5% of the total) were assigned both a potential primary zoning as well as one the potential secondary use. A further 24 properties were assigned both a potential primary zoning together with potential multiple secondary uses.

Table 8 shows that the dominant categories are Agricultural I (3 053 properties, representing 73.1% of all entities) and Residential I (728 properties, representing 17.4% of the total). In the category where both a potential primary zoning as well as a secondary use were assigned, the dominant combinations were Agricultural I as potential primary zoning and Authority Zone as potential secondary use, as well as Agricultural I as potential primary zoning and Resort I as potential secondary use (a total of 29 properties for each of these categories). A total of 24 properties were assigned both a potential primary zoning together with potential multiple secondary uses. Properties that were assigned both a potential primary zoning together with potential multiple secondary uses in all cases consist of either Agricultural I or Agricultural II with multiple combinations of potential secondary users.

These derived potential primary zonings and secondary uses do not imply or infer any land use rights. It is merely an interpretation of what the potential zoning of a property should ideally be, based on the combination of land uses present on the property, as identified from the available data sources. In the absence of accurate information on the legal status of land use rights, the onus is on the Municipality to have these derived potential zoning classifications validated by the owners themselves. It was suggested, during the course of the study, that Matzikama Municipality has to embark on some form of public participation process to validate the information. Owners should be given a reasonable time period to verify the potential zoning classifications for their property. Verified data can be captured directly in the GIS database by the Matzikama Town Planning Department.

5. CONCLUSION

There is a small likelihood of getting a land audit of this magnitude in vast rural areas 100% accurate. The researchers, however, are of the opinion that the methodology that was devised and applied, and the results that were obtained, offer a valuable process for compiling land audits in large regions elsewhere in the country that may also soon be compelled to compile land audits. In much smaller municipal areas, a traditional site visit land use audit methodology would perhaps be less expensive to carry out, but, given the magnitude of remoteness of the study area covered in this study, we are convinced that a site visit study would potentially have cost up to three times more to do and would have taken much longer to complete.

There were, however, some missing information and data that were impossible to obtain. Table 9 summarises the main sources from which data was obtained for each of the land audit aspects.

Table 10 summarises the main data achievements.

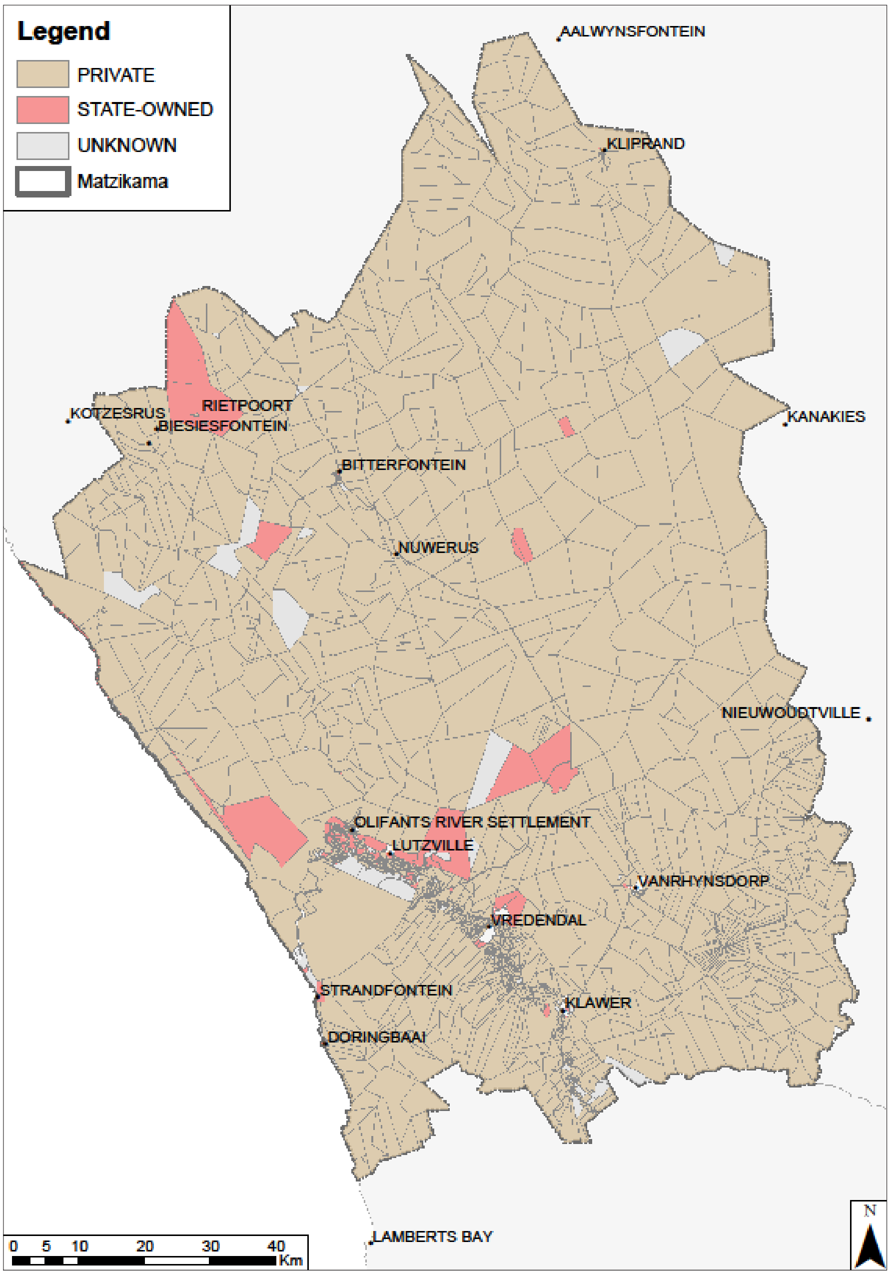

Figure 5: Location of state-owned property

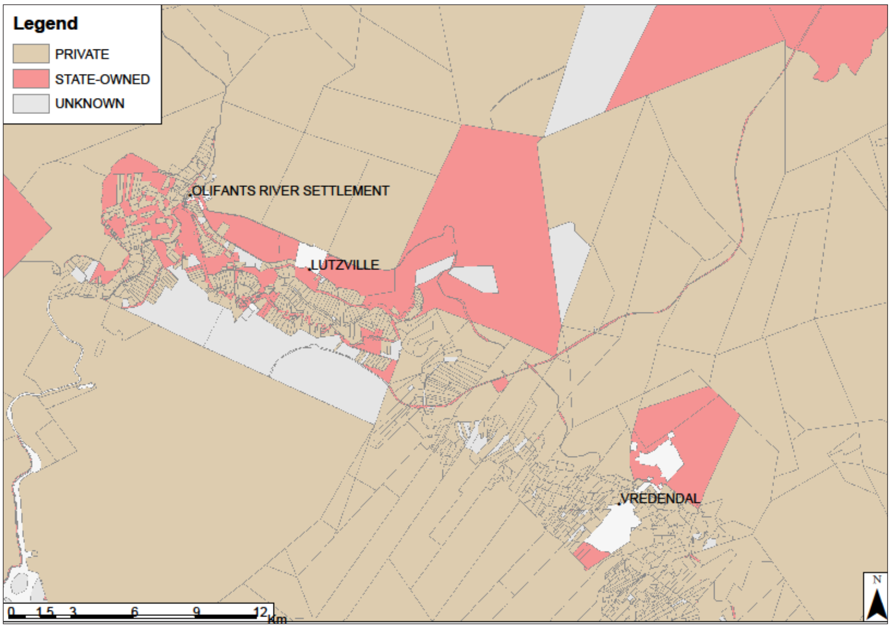

Figure 6: Location of state-owned property (Vredendal, Lutzville, Oranjerivier Settlement)

Table 7: Summary of assigned potential primary zonings and secondary use permutations

Category	Number of properties	Percentage
Potential primary zoning only	4007	95.9
Potential primary zoning with one potential secondary use	145	3.5
Potential primary zoning with multiple potential secondary uses	24	0.6

Table 8: Summary of assigned potential primary zonings and secondary uses according to category

Potential primary zoning	Potential secondary uses	Number of properties	Percentage
Agricultural I	None	3053	73.11
Agricultural I	Various	135	3.24
Agricultural II	None	38	0.91
Agricultural II	Various	5	0.12
Residential I	None	728	17.43
Residential I	Various	1	0.02
Residential V	None	2	0.05
Open Space I	None	3	0.07
Open Space III	None	54	1.29
Open Space III	Various	19	0.45
Authority	None	27	0.65
Authority	Various	1	0.02
Business I	None	20	0.48
Business I	Various	4	0.10
Business II	None	8	0.19
Business III	None	2	0.05
Business V	None	1	0.02
Business V	Various	1	0.02
Institutional I	None	21	0.50
Institutional I	Various	2	0.05
Institutional II	None	11	0.26
Industrial I	None	8	0.19
Industrial II	None	3	0.07
Industrial III	None	7	0.17
Industrial III	Various	1	0.02
Resort I	None	7	0.17
Transport I	None	6	0.14
Transport II	None	4	0.10
"Exceptions"		4	0.10

The following regarding the linking of land parcels was achieved:

- Valuation data: 3 731 out of 4 176 (89.3%) were linked.
- State Land Audit: 378 out of 4 176 (9.1%) were linked.
- Deeds data: 1 680 out of 4 176 (40.2%) were linked.

Obviously, there was overlap between these three sources, which were combined in this order of preference: first the valuation data; secondly, the State Land Audit and, thirdly, the deeds data. The combined results were as follows: Confirmed ownership: 3 803 out 4 176 (91.1%). Another 88 of the records read ** *For Info Refer to Registrar of Deeds* ** (2.1%). This leaves 285 records (6.8%) with ownership unknown. Confirmed title deeds numbers: 3 802 out of 4 176 (91%) confirmed, leaving 374 unknown (9%).

Several lessons were learnt in the process of conducting the land audit for Matzikama. It was found that, in the process of deriving zoning, general land cover mapping was of limited use. The CSG cadastral data contains many topological and spatial errors. Similarly, missing deeds data makes robust land audits challenging. The fieldwork component was very costly, time consuming and potentially dangerous, and should be limited. The status of municipal archives throughout the country varies. Not all necessarily contain all the expected data required for a study of this nature. We have noted that, by applying the appropriate methodology that integrates a variety of data sources, the extent of fieldwork and verification can be reduced significantly. Notwithstanding the advanced technologies available for land audit mapping exercises, internet connectivity in rural areas is generally insufficient for a fully digital approach (GPS, laptop, hand-held devices) in fieldwork verification (hence, the use of hardcopy maps and notebooks). If a municipality has the relevant qualified staff members (as in this project's team), they would be in a position to successfully replicate the methodology and application. However, creating and updating land audits require advanced skills in GIS, and it is recommended that municipalities

Table 9: Nine aspects of the land audit and main sources of information

Aspects pertaining to audit	Primary source(s)	Secondary source(s)
Current ownership of land parcels, including title deed numbers	Deeds Office; Matzikama Municipality Property Valuation Data	Windeeds
State-owned land audit	Surveyor General's land audit	Matzikama Municipal archive
Extent of the land parcels	Determined in the GIS database created for this study	
Current land use on the properties	Determined in the GIS database created for this study; Matzikama Municipal archive	Fieldwork verification
Current land use control measures applied	Matzikama Municipal archive	
Status of land use: vacant or developed (includes the extent and size of development)	Determined in the GIS database created for this study	Fieldwork verification
Land use zoning of property	Matzikama Municipal archive	Derived zoning based on combination of
Complying to rules that require special permission	Matzikama Municipal archive	Fieldwork verification and GIS database
Status of access roads and routes between farms	Surveyor General; PGWC	

employ suitably qualified officials in this regard. Working with outdated planning schemes/legislation/policy can become a time-consuming and costly exercise for municipalities. Large rural municipalities, unless legally required to do full land audits, may perhaps consider doing audits as a cost-saving measure and planning strategy only in areas where land use changes are expected to take place.

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Table 10: Summary of study data

Data type	Number	%
Properties for which there is no title deed	374	8.96
Properties verified in archive	362	8.67
Properties verified in field	1 337	32.02
Properties without potential primary zoning as Agriculture I or II	886	21.22

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