DIGITAL INTEGRATION OF LAND RECORDS THROUGH THE LADM AND STDM

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Key words: Land Records Management System, Digital Cadastre, Land Administration Domain Model, Free Libre Open Source Software

SUMMARY

Cadastral information in many cadastral systems is comprised of various datasets held in different locations. This results in duplication of effort, and inaccessibility to comprehensive and complete land records. Integrating the varied datasets is affected by their differing precisions and resolutions, different tenure regimes - formal, informal, customary, and communal; differing formats - analogue and digital; differing supportive legislative framework - titles and deeds and systematic and sporadic adjudication; differing boundary systems - fixed and general; and differing institutional structures - fiscal and legal foundations, and centralised and decentralised operational framework. All this lack of cohesion results in ineffective land management, which stymies economic development, and leads to high cost and inaccuracy in land registration – duplication in registration of land; inappropriate development approval; weak land administration and management; and poor disaster risk reduction and management. Developing countries such as those in the Caribbean are particularly affected and made more vulnerable to economic, social and environmental shock in the presence of such inadequate cadastral systems.

This paper describes a strategy for the development of an integrated digital land records management system, through the adoption, modification and application of the International Standards Organization certified ISO 19152: Geographic Information – Land Administration Domain Model (LADM) and the Social Tenure Domain Model (STDM). The paper demonstrates how the LADM and the STDM may be incorporated using generic Free Libre Open Source Software (FLOSS) technology, to support the solution to the problem of inefficient land records management in developing countries.

The result is presented in the form of a new conceptual data model and tested using a prototype created with open source software. It establishes links and relationships between data created by various departments and agencies of the state, which currently, proves cumbersome to access, due to the physical distribution of the data and the multiple formats and models of its structure.

The outcome is a strategic fit-for-purpose implementation of a hybrid of the LADM and STDM named LSTDM.

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1. INTRODUCTION

Land records have traditionally been analogue in nature. However, with the advent of Information & Communication Technology (ICT), the management of land information has been significantly revolutionised. Various attempts and solutions using ICT have emerged. Different models have been explored, yet there has not been a universal one size fits all solution. This is almost impossible to achieve, given the differences in the culture, socio-economics, politics, customs, and practices of each country. The International Federation of Surveyors (FIG), and the constituents of its member states have been very active in pursuing a best practice or universal model upon which any jurisdiction may develop a system for managing land records. This research examines the many options that are available, in particular, the Land Administration Domain Model (LADM), as a solution to effective and efficient land records management. Ineffective cadastral mapping, distributed storage of paper records, dual registration of land, and lost records are just a few of the problems that confront users of land records in, for example, Jamaica.

2. BACKGROUND

Within the Caribbean, a number of territories have only been able to realise a partial solution to automating their land records. In most cases, this is confined to the use of Geographic Information Systems (GIS) to capture, store, retrieve, query, manipulate and update cadastral parcel information. Examples of these can be seen in Trinidad & Tobago's "LISTT Land Parcel Viewer" (http://200.1.109.94/parcelviewer3/) and Jamaica's "iMap Jamaica" (http://www.nla.gov.jm/map.asp). These options offer very limited scope in terms of data that is made available to the user. This is because much of the records of land information is either still in analogue form, or those that are digital, are kept as independent datasets. In Jamaica for example, of the 836,749 parcels that exist as at 1 February, 2018, only 498,870 or 60% (Campbell 2008; Pickersgill 2014; National Land Agency 2018), are titled in their voluntary system of registration, and lodged in the Land Registry's database. Some 337,879 parcels still remain outside of the legal register, for reasons including: high cost of entry; lack of education on benefits; lack of awareness of the procedure; and duration and rigidity of the process (McCook 2013). Yet, there are thousands of parcels for which there are survey plans, which have not been brought under the operation of the Registration of Titles Act. Jamaica's Land Valuation Division has captured the unimproved value and approximate area of all of the 836,749 parcels. This data is not linked to survey plans, but to a very approximate digital cadastral index. This gap in the register leads to challenges in researching the records to ascertain ownership. Without a comprehensive cadastral map, integrated with the fiscal data,

the office of titles lacks the necessary support to avoid dual registration of parcels of land. This results in poor management of land records (Tuladhar 2002) and instances of fraud (DaCosta 2003; Stanfield, Barthel, and Williams 2003). The record of state lands which accounts for approximately 22% of the lands in Jamaica (DaCosta 2003), much of which is leased to private individuals, is now being entered into a digital database.

Land use planning is a significant activity which facilitates the effective and efficient use of land. Effective decision-making on land allocation and use requires comprehensive and integrated land information. A country cannot realise its full development potential without a system which facilitates proper planning and management of land resources. Many central and local and government institutions as well as private sector companies are in urgent need of a fully operational, accurate, and up-to-date Digital Land Records Management System (DLRMS) to facilitate their land business processes. When supported by a digital cadastral map, effective land policies regarding zoning, land use, taxation and divestment can be executed seamlessly through the integration with a GIS.

2.1 **Cadastre 2014**

Cadastre 2014 was conceptualised in 1994 by a FIG Working Group of Commission 7 (Cadastre and Land Management), which described the form cadastres should take in another 20 years (2014) (Steudler and Kaufmann 1998). It called for the registration of all private and public rights, restrictions and responsibilities (RRR) relating to land in the form of "land objects" in cadastral systems (Inan and Cete 2007). As a result, the core Cadastral Domain was developed by Oosterom et.al.(2006b), which was designed to include not only register object (objects subject to registration), but also Person and RRR. The concept is articulated through six (6) statements: 1) show the complete legal situation of land, including public rights and restrictions; 2) the separation between 'maps' and 'registers' will be abolished; 3) Cadastral mapping will be dead! Long live modelling; 4) paper and pencil – cadastre, will have gone!; 5) Cadastre 2014 will be highly privatised! Public and private sector are working closely together; and 6) Cadastre 2014 will be cost recovery!, These statements provided a framework within which cadastres were to be reformed by 2014 (Steudler and Kaufmann 1998; Kaufmann 2002; ESRI and Kaufmann 2004).

Although Cadastre 2014 has enjoyed a long shelf life compared to that of the customary strategic plan, which is five (5) years, it continues to be relevant as a benchmark for the global reform of land administration systems. More recently 'fit for purpose' and the 'continuum of land rights', approaches are gaining momentum (Bennett 2014). Proposals such as those for future cadastre approaches from an Australian perspective: 1) eventually upgraded to survey accuracy; 2) incorporation of unbundled property rights, restrictions and responsibilities through the object-oriented approach; 3) incorporation of 3D storage and visualisation; 4) real-time updates; 5) national and international interoperability through more standardisation; and 6) inclusion of green property rights (Bennett 2014), are more than worthy of consideration.

2.2 Current situation

The National Land Agency (NLA), with four hundred and ninety-nine (499) staff members, is the primary source of land information in Jamaica. It is the umbrella body for four (4) real estate and property oriented divisions: Surveys & Mapping, Land Titles, Estate Management, and Land Valuation; as well as Business Services, Information & Communication Technology, Corporate Legal Services and Corporate Services Divisions.

An Island Records Office (IRO) records and stores land deeds. All records are held in paper form only.

2.2.1 Surveys and Mapping Division

The Surveys & Mapping Division builds and maintains the national geodetic infrastructure. The Division also surveys government lands, checks survey plans submitted by both private and government surveyors, to be used in connection with the application for registered titles, and produces cadastral maps. It uses a Parcel Data Management System (PDMS) developed on an ArcGIS 9.3 platform, by International Land System (ILS) now Thompson Reuters. PDMS is a customised standardised application, used by the Division's Regional Mapping Unit (RMU), for the creation and maintenance of tabular parcel information, including creation and assignment of a unique Parcel Identification (PiD) number for each parcel to be registered under the Registration of Titles Act (Samuels 2008). The PDMS is used to create parcels that are to be added to the tax roll, which is the Land Valuation database. The spatial parcel must be created in PDMS before a new Volume and Folio number is assigned. Likewise, the spatial parcel fabric must be updated prior to the assignment of a new valuation number. The PDMS records: Object ID; PiD; Volume and Folio number; Land Valuation number; Plan Examination number; Lot number; Civic number; Street name; Map, Grid, Enclosure and Parcel numbers; Parcel Status – Active/Inactive, Pending,Suspended; and Survey Status; Shape; Area; and Perimeter. The PiD tool is used to create a table to store such entities, as: Parcel Type; PiD; Strata Extension; Volume and Folio number; Land Valuation number; Plan Examination number; Record Index number; Deposited Plan number; Lot number; Unit number; Legal Area; Property name; Postal Location; Address; Modified by; and Date. In addition, there is a whole host of paper records, which indexes survey plans stored on microfilm.

2.2.2 Land Titles

The Land Titles Division provides state guaranteed land titles, as well as registers dealings (mortgagees, transfers, leases, caveats, transmissions, and marriages) on the certificates of title. The Division's business processes are run on a Commercial off-The-Shelf (COTS) software called Lands Registration System (LRS), which is used to track all transactions that are effected on documents submitted for processing. It is hosted by a dedicated application server, and is custom-built by International Land Systems now Thompson Reuters. The functionalities of the LRS are: Workflow Management, Automated Registry Tasks, Automated Reporting, Integration with Cadastral Systems, Full Security logging in with access rights, Cashiering, Integrated Point of Sale functionality for fee based transactions, Integrated Document Imaging System, Secure Web Access Module for improved customer service, and Legacy Data

Conversion tools (Samuels 2008; Rabley and Falk 2004). LRS is complemented by an ILS developed Property Finder and a Digital Scanning System (DSS), which has as its graphic user interface, a scanning client, hosted on its own application server and stores attribute data and pdf's of certificates of title in a RDBMS, on a dedicated data server. DSS produces a version of a Certificate of Title created by the LRS, once the certificate is sent by the LRS to be printed. Other documents such as Deposited Plans, Enclosure Maps, Survey Plans, Strata Plans, Cadastral Maps, approved Subdivision Plans/Blue Prints, and Caveats, are stored on the system. It is a multi-user imagery and public access system, configured for scanning, storing and retrieving documents and textual data (Samuels 2008).

2.2.3 Estate Management

The Estate Management Division's (EMD) manages government owned lands, for optimal use of the asset. The Division divests government's real estate in accordance with a Land Divestment Policy. The division leases and sells government property in single parcel blocks and lots from land subdivided into what is called land settlement schemes. There are about three hundred and thirty-seven (337) land settlement schemes in Jamaica, for which the Division has to apply for certificates of title, and then lease or sell the lots. One hundred and thirty-nine (139) schemes comprising 18,412 lots are in the process of being titled (Pickersgill 2014). The Division is also responsible for renting government property.

Except for pockets of computerisation within the EMD, the process, up to recently, was largely manual and paper based, with some 35,000 files created, one for each case. However, since then, a Government Revenue Management (GRM) system called the Jamaica Estate Management System (Jamaica - EMS), was implemented under a contract awarded to Thompson Reuters. It features a 4GB RAM application server and a data server for its own RDBMS. All the data in these paper files are being loaded into the system through a combination of keyboard entry and scanning. Access to LVS and DSS is also available to the EMD. The entities stored on the system are: EMD file reference number; Property number; Property Class; PiD; Parcel SUID; Land valuation number; Examination number; Parent property name; Property name; Settlement; Volume and Folio; Lot number; Street number; Street name; Postal location; P.O. Box; District; Parish; Plan number; Plan type; Plan deposit date; Held in Trust; Property subdivided, Subdivision approved; Reserved Lot, Vacant; and Area, Area units.

2.2.4 Land Valuation

The Land Valuation Division manages the financial fortunes of the government of Jamaica, as far as property tax collections are concerned. It provides the Ministry of Finance with the unimproved value of land parcels for which property tax is required to be paid, for the property tax computation by the Ministry and collections by the Inland Revenue Department.

This division of the agency maintains a valuation roll to support the taxation of all properties, appraise all privately owned properties in Jamaica for the purposes of property taxation, as well as properties owned, leased or to be acquired by government, and records changes in property information, in a computerised Land Valuation System (LVS), which operates in a Disk Operating System (DOS) environment, while the data in a RDBMS is on a separate data server running in an INFORMIX environment. The Land Valuation Roll (database) comprises: Land Valuation number; Premises name; Lot Number; Street number; Street name; Scheme name; Postal Location; District; Survey Code; Plan number; Survey number; Liber Series; Volume and Folio; Area; Value (Current); Value (Previous); Date of Valuation; Issue Date; and Tax Payable.

2.2.5 Island Records Office

The Island Records Office (IRO), is an arm of the Registrar General's Department (of Births, Deaths, Marriages etc.). The IRO operates under the aegis of: Record of Deeds, Wills, Letters and Patent Act 1681, Probate Deeds Act 1863, Records Office Act 1879 and the Conveyancing Act 1889. Common law land transaction deeds, prepared and submitted by, for example, parties to an Indenture/Conveyance, Attorneys, The National Housing Trust, The Peoples' Cooperative Bank and the LAMP, are being recorded and stored since 1663, for safekeeping, in hard copy only. Prior to recording, the requisite Stamp Duties must be paid at the Government Stamp Office. Storage is in the form of in a Libre (folder) and Folio (pages) system. The Libres are file folders, the documents are kept in such folders for up to four to five (4-5) years before they are transferred into acid free sealed box folders. There is no attempt on the part of the IRO to verify with Land Titles as to whether a transaction is being recorded against registered property, as there is no such legal requirement.

3. DATA MODELLING

Based on the foregoing, Land Records data is managed by various divisions within the NLA and at the IRO in a distributed and heterogeneous manner, so users have to visit the various divisions of the NLA as well as the IRO to obtain complete data, despite the advanced computerised systems within the NLA. There is a high level of redundancy in the storage of land records data, as some entities are recorded in as many as three (3) different databases across the NLA. Data models provide a representation of data structures, for example, how land parcel data is to be stored, the characteristics of the data, the relationship between various datasets for the same parcel constraints and transformation routines (Rob and Coronel 2007), for the consistent development, application and management of the data in a database management

system, by the various users and organisations that have an interest in the data. Data models provide the framework for the migration of data expediently and inexpensively from existing database designs to a geodatabase environment (ESRI 2012). Two (2) existing forms of data modelling are briefly discussed below:

3.1. LAND ADMINISTRATION DATA MODEL (LADM)

The LADM is a conceptual model (Figure 1), which is divided into three (3) packages: Party, Administrative (RRR and BAUnit) and SpatialUnit, divided into four (4) classes, which has a sub-package in Surveying and Representation (Lemmen 2012):

1. Parties (people and organisations)
2. Basic Administrative Units and RRR (ownership rights)
3. Spatial Units (parcels, legal space of buildings and utility networks)
4. Spatial Sources (surveying), and spatial representations (topology and geometry)

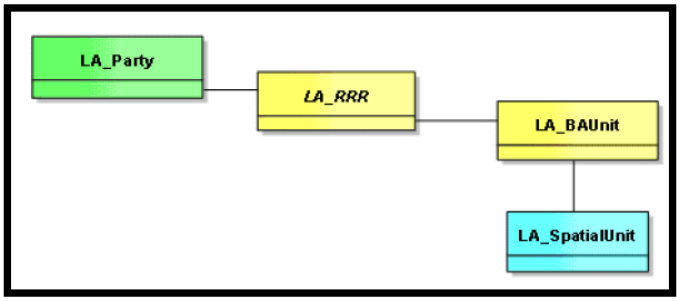

Figure 1: The LADM Conceptual Model

Source: ISO (2012)

The LADM makes provision for modifications to suit specific country needs. Attributes or even new classes may be added, while at the same time parts of the model may not be used (International Standards Organization 2012). The LADM has so far seen implementations in such countries as: Portugal (Hespanha 2012; International Standards Organization 2012), Israel (Felus et al. 2014), Australia (Quensland) (Karki, Thompson, and McDougall 2013; Karki, Thompson, McDougall et al. n.d.; International Standards Organization 2012), Indonesia (International Standards Organization 2012; Sari 2010), Cyprus (Elia et al. 2013), Japan (International Standards Organization 2012) , Hungary (Ivan 2013; International Standards Organization 2012), The Netherlands (International Standards Organization 2012), Malaysia (Zulkifli, Rahman, and Hassan et al. 2015; Zulkifli, Rahman, and Jamil et al. 2014), China (Zhuo 2013), South Africa (Tjia and Coetzee 2013; Tjia and Coetzee 2012), Russian Federation (International Standards Organization 2012), Republic of Korea (Shin and Byung-Yong 2013; (International Standards Organization 2012), and the exploration of its applicability to large scale customary tenured land acquisition in African states (Hespanha et al. 2014). Cost can be

a factor, especially for developing countries. The growth of these economies largely depends on the successful implementation of a cadastral system (DeSoto 2000). it is therefore more desirable to look to GIS technologies incorporating standard data models such as Land Administration Data Model (LADM), ISO International Standard 19152, rather than the more costly customised systems (Jones and Land 2012).

3.2 SOCIAL TENURE DOMAIN MODEL (STDM)

Not all land rights or claims can be accommodated into a formal or conventional, parcel-based system such as the LADM, as some rights or claims are based on social tenures, such as: customary, mailo, freehold, leasehold, land use, land allocation, tribal land, land grant rights (Arora 2011), and therefore needs special modelling such as that developed by the Global Land Tools Network (GLTN), and named the Social Tenure Domain Model (STDM) (International Federation of Surveyors 2014; Global Land Tool Network 2014). This is a specialisation (Augustinus, Lemmen, and van Oosterom 2006) or refinement and a more flexible version of the LADM, to be used in circumstances where the LADM is not applicable, for example, in countries whose Land Administration System has a colonial flavour, so that customary, informal and communal tenure, such as family land, are not supported (Griffith-Charles 2011; Augustinus, Lemmen, and van Oosterom 2006). The STDM is a representation of the social relationship between people and land (Augustinus and Lemmen 2011; Lemmen, Oosterom, and Uitermark et al. 2009; Augustinus, Lemmen, and van Oosterom 2006), and is based on version A of the LADM (Lemmen 2012), accounting for such tenures as personal, customary, informal, slum dwellers, pastoralists and indigenous (Augustinus and Lemmen 2011). Here the RRR class in the LADM is replaced by Social Tenure Relation.

This change, effected by adding look up tables and key words, allows for the inclusion of informal tenure situations into the STDM, so that common law rights may be added, to Social Tenure Relation, whereas this would not be allowed in RRR. Also, the spatial unit includes an object id and name (Molero, Barry et al. 2010). The STDM would therefore accommodate informal rights, including: occupancy, adverse possession, tenancy and use rights, which are documented or undocumented, individual or group, pastoralist, slums, legal or illegal, utilizing a number of innovative concepts: 1) a range of spatial units to depict a parcel of land (a dot in a polygon, high/low accuracy coordinates, a set of lines, as a 3D volume); 2) recording of holders of rights (individuals, couples, groups with defined and non-defined memberships, group of groups, company, municipality, government department; evidence (imprecise and ambiguous evidence), may be accommodated by the STDM to close the technical gap that would otherwise be left in an LADM (Augustinus 2010; Lemmen, Oosterom, and Uitermark et al. 2009). Although simple in its design, it may very well not be able to handle the complexity of the various land tenure circumstances on the ground (Barry, Molero, and Muhsen 2013). There are efforts however to test its applicability to complex circumstances of land tenure

(family land, squatting, community land trust systems) as obtains in Eastern Caribbean States, using software developed by UNHabitat (Griffith-Charles, Lalloo, and Browne 2013).

The Conceptual Model for the Social Tenure Relation shown in Figure 2 represents the "Person-Land" relationships, whereby Social Tenures such as: use rights, informal occupation, customary tenure, tenancy, rent, ownership, lease, permit, etc., in a Spatial Unit (land, property, structure, natural resources, objects, etc.), is claimed by a Person/Party which can be: tribes, people, groups, villages, co-operations, organisations and governments, and is supported or portrayed in a: sketch, video, scanned documents, and audio, etc. (International Federation of Surveyors 2010; Global Land Tool Network 2014). Social Tenures replaces the RRR in the LADM.

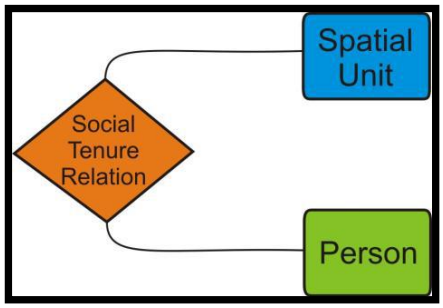

Figure 2: The STDM Conceptual Model

Source: Barry, Molero, and Mushen (2013)

STDM has been modelled in Free Libre Open Source Software (FLOSS), where fingerprints and photos are used to identify the Person, while a single point can represent the spatial unit, the two being related by some social tenure relation (Lemmen 2010). The STDM is considered to be affordable, flexible, simple, inclusive and represents good governance principles (participation, responsiveness and transparency), and should be considered for integration into formal Land Administration Systems (International Federation of Surveyors 2014).

4. NEW MODEL – LEGAL AND SOCIAL TENURE DOMAIN MODEL (LSTDM)

Only 60% of the parcels on the island are registered in the formal system, which could be represented by the LADM In order to represent the complete situation on the ground, provision is made in the model for social tenures, hence a hybrid system of the LADM and the STDM called the Legal and Social Tenure Domain Model (LSTDM) shown in Figure 3, where Social Tenure Relationships are included in the Administrative Package. This would ensure that all land objects, titled in the formal system or untiled can be accommodated, thereby leaving no gap in the records, and therefore representing the true situation on the ground.

All of the entities across the two institutions (NLA and IRO) that record cadastral data were identified. The data on land parcels that are stored by these entities were collected and sorted among four (4) packages: Party, Administrative, Spatial Unit, and a sub-package of Spatial Unit called Surveying and Representation. The Party Package stores pertinent information on a party, including unique identification number and address, as well as groups of parties and the amount of shares owned by a party in a spatial unit. The contents of the classes of RRR, BAUnits, and Points in the Surveying and Spatial Representation Sub-package, were not evident among the data collected. Notwithstanding, in this attempt to improve the existing system, all of these and their associated classes such as Level are implemented in the new model, so as to take advantage of grouping parcels according to RRR, BAUnits, and to be able to reference those spatial units represented by weak descriptions, using coordinates. Social Tenures can now be added into this comprehensive integrated system, which is realised through FLOSS tools such as: Quantum GIS, PostgreSQL PostGIS and PGModeler.

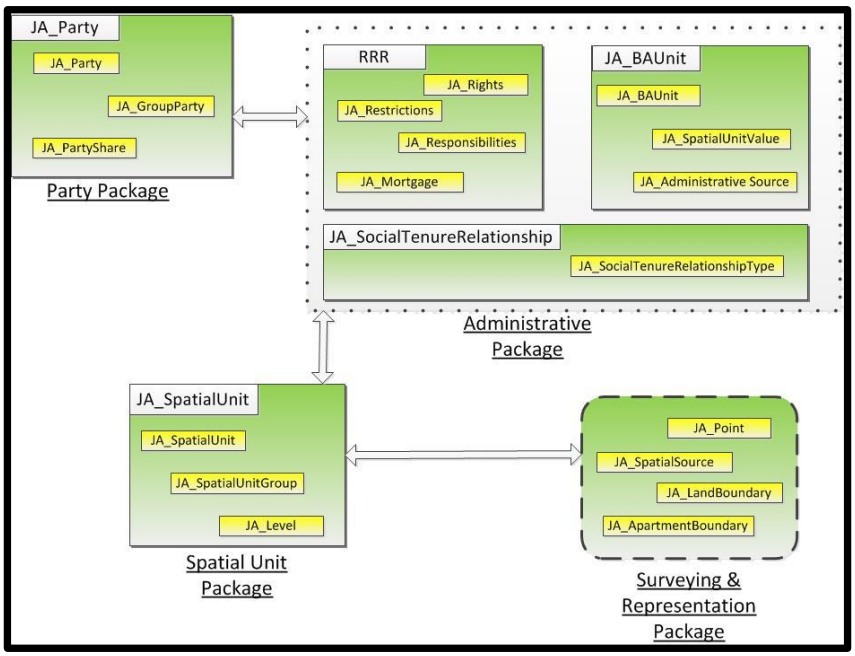

Figure 3: Packages and Classes of the Jamaica Country Profile

5. APPLICATION OF THE MODEL

The application of the model to Jamaica and other Small Island Developing States (SIDS) is discussed below:

5.1 Application to Jamaica

The application of the new model to Jamaica takes into account the features of the cadastral system, which is comprised of five (5) components, namely: Land (Titles) Registry, Surveys & Mapping, Land Valuation, Estates Management, and an Island Records (Deeds) Office. Both the Registration of Titles Act of 1889 and the Record of Deeds, Wills and Letters Patent Act of 1681, makes provision for the registration and recording of property and transactions in property to be made in the name of a company, syndicate (Joint Tenants or Tenants-in-Common), or individual. The design of the model for Jamaica takes these into account and therefore treats these as the constituents of the Party Package.

The land registry issues certificates of titles in the name(s) of parties, setting out the rights of the party(s). Restrictive covenants are also noted on the certificate, and includes both restrictions on the party(s) use of the property, as well as their responsibilities associated with the use and enjoyment of the land object. Deeds are recorded at the Islands Records Office in respect of transactions between parties that are executed on land objects. These are encapsulated under the Administrative Package, where they form: the Administrative Source class; and the Rights, Restrictions, Responsibilities classes. The Jamaica Cadastral System has its origin in a Fiscal Cadastre, which remains a very strong component of the overall system, to the extent that it is this cadastre which is used to drive the modernisation efforts through the digitisation of the fiscal cadastral index maps, showing registered, un-registered, surveyed and un-surveyed parcels, and the adoption of its textual records, the only one that was available in digital form, on which to build its spatial database, through a merger with land registry records. It is on this basis why the design of this new model for Jamaica, retains land valuation records, which forms part of the Administrative Package.

The land parcel is the basic unit of the Cadastral System, and is accounted for, either as a single object or as a group of objects. This accounts for the inclusion of the Spatial Unit and the Spatial Unit Group classes of the Spatial Unit Package, which identifies each land object and groups of land objects, respectively.

The Acts also allow for the use of either survey plans or metes and bounds descriptions, which are either included in the documents (Title and Deed) or annexed, as the means of describing legal land objects, and therefore the Surveying and Representation Sub-package of the Spatial Unit Package makes provisions for these two forms of descriptions in the Spatial Source class. Provisions are also made in the model for plans and metes and bounds descriptions of un-

registered land objects, where these are available. Also in this package are plans representing groups of land parcels called Deposited Plans which represents subdivisions.

However, apartments or condominiums, the subject of the Registration (Strata Titles) Act of 1969, are represented by a strata plan, in analogue form. Because there is no spatial representation of the strata development in the digital environment (iMap), a query executed on a condominium, yields only the land parcel on which the strata building(s) is located. This is as a result of the database not being configured to accommodate data at the level of each condominium unit. It is therefore not in accordance with statement 1 of cadastre 2014, which requires that the complete legal situation on the ground must be reflected by the national cadastre. In the new model, developed in this research, all textual attributes and the associated spatial representation of condominium units are accounted for in the Basic Administrative Units Class. A query on a condominium unit will therefore return the name of the owner and all other textual attributes as well as the spatial representation of the unit itself.

In cases where there is a graphic representation of the parcel, the approach taken by Jamaica was to convert the paper plans to digital form through raster scanning and raster-to-vector conversion (as was the case with the land valuation cadastral index map), heads-up digitizing (single parcels plans) and coordinate geometry (group of land parcels or deposited plans). The cadastral index map is relied upon for graphic support in the case of registered titles that describe land parcels by metes and bounds, as well as un-surveyed parcels. The new model makes provision for the position of a spatial unit through "originalLocation", which allows the entry of a Northing Easting coordinate value, to identify, the start, end, or centroid of a land parcel, which will assist in averting the effects of the spatial deficiencies of the cadastral index map in the case of un-surveyed land parcels. These coordinates can be acquired through crowd sourcing or during systematic adjudication of parcel rights, an exercise which is long overdue for the purpose of improving on the up-to-datedness of the Jamaica land records.

Thirty-two (32) of the attributes in this DLRMS are newly introduced, based on the application of the LADM, while in excess of forty (40) attributes are brought into the system, based on the analogue (index cards and logbooks) records which are kept at the NLA and to a lesser extent the IRO. All of the packages from the LADM are utilised in the JA_LSTDM. However not all classes are included, and not all attributes of the classes included, are used. Both LA_Source and RRR are abstract super-classes, with two (LA_Administrative and LA_SpatialSource) and three (LA_Rights, LA_Restrictions and LA_Responsibility) sub-classes, respectively. Since the sub-classes would override the super-classes, there is no need to implement the super-classes, which would merely act like placeholders for features that would eventually be defined in the sub-classes. All five sub-classes are implemented in JADM.

The other classes that are not implemented are: LA_RequiredRelationshipBAUnit and LA_RequiredRelationshipSpatialUnit. LA_RequiredRelationshipSpatialUnit and LA_RequiredRelationshipBAUnit are excluded since it is neither required nor of necessity in the Jamaica Cadastre to model the relationship between spatial units and basic administrative units, respectively. On the other hand a class JA_SpatialUnitValue has been included to cater

to the need for retaining land valuation information in this cadastre, which has a fiscal foundation, and is still heavily relied upon to support property tax administration.

The Party Role attribute is also omitted from the Party class, as the cadastral databases in Jamaica only stores land owners' information and surveyors' names. The latter is provided for in the spatial unit group class as it is more likely that users will query the database through owner name and/or surveyor name. This does not preclude other professionals such as valuers and attorneys from being added, depending on the needs of the jurisdiction in which the system is implemented.

The results satisfy the stated aim of the research i.e. to develop a digital land records management system which will improve access to land records. This has been accomplished through: the engagement of ICT; the adoption of a recognised ontology in the LADM and STDM, which is in line with the goals of Cadastre 2014 vision; and features ease of use, robustness, and scalability. The cost associated with software is minimal, given that FLOSS tools are used. This is in line with the current trend for land administration systems to be pro-poor. The system is freely accessible and customisable for local needs, unlike proprietary software. Hardware, ICT skills in setting up and maintaining the system is of necessity and will come at a cost, but more affordable than COTS systems.

5.2 Application to other sids

Cadastral systems vary as a function of whether: parcel boundaries are fixed or general in definition; the system is centralised or decentralised; land registration is by deed or title; rights adjudication is systematic or sporadic; and whether the system is based on a fiscal or legal cadastre. The versatility of the DLRMS is such that any system in any SIDS developed on any combination of these features, can adapt the DLRMS as part of its modernization efforts.

Most Caribbean islands do not have in place a digital cadastral database. In fact, only Antigua & Barbuda which among many others, have scanned and vectorised their cadastral maps, have this data stored in a digital form along with tenure information from their Land Registry, as part of the attributes available to users in a Landfolio system. Many others which have also scanned and vectorised their cadastral maps, only store and view this data in ArcGIS or AutoCAD, while their tenure information is stored in Microsoft Access. The model will therefore be attractive to those developing countries which have resource constraints and want to make land records storage and retrieval more efficient.

6. DISCUSSION

Features such as, low cost and full integration, are made possible by FLOSS and the two established domain models, respectively. The development of a LSTDM ensures that the full and complete situation of man to land relation is accurately represented. The growth of the FLOSS community of developers and users, and the advent of conferences and workshops, are very encouraging signs that this concept is sustainable, and therefore systems such as the DLRMS will serve organizations long into the future. Given the current less than acceptable state of affairs with the management of cadastral data in most Caribbean countries, there is extremely great potential for the application of the DLRMS, as they are all stymied by financial constraints, although they are slowly preparing for the establishment of a fully integrated digital cadastral database, by digitising analogue data.

The DLRMS provides a generalised solution for land records management in other Caribbean countries, and would create an atmosphere of shared growth and development of member states, each benefitting from the others' experiences with the system, while at the same time satisfying the unique needs of each jurisdiction. Ultimately, such a cooperation could evolve into a Caribbean cadastre, one akin to the INSPIRE initiative, especially in light of the fact that neither significant ICT nor technical high level technical expertise is required to grow the systems across the region. The LADM is based on the well-established man to land relations of rights, restrictions and responsibilities, and was designed to support stable land administration systems. The STDM on the other hand was developed based on the fact that not all land rights or claims can be accommodated into a formal or conventional, parcel-based system such as the LADM, as some rights or claims are based on social tenures: communal, informal and customary, and therefore needs special modelling. The combination of the two therefore complement each other to satisfy the recordation of 100% of the man to land relations in any jurisdiction. Given that there is a mix of both situations in most under-developed and developing territories, makes for trouble-free implementation of DLRMS in those countries.

7. CONCLUSION

The extent to which the system adheres to the principles of the FIG Statement 1995, Cadastre 2014 and implements users' needs, through the development of a LSTDM makes it very relevant to the needs of SIDS. The high cost for the acquisition and maintenance of software licences is circumvented, and given their relatively small scale, computer hardware, office space and staffing will be minimised, rendering it very feasible for them to implement provided the necessary policy, legal and regulatory support is in place, and will allow for phased implementation as their respective governments' budget dictate. In SIDS where social tenures are very evident, co-existing with legal tenures, a system built on a LSTDM, will be seen as a vehicle by which social tenures can transition to the legal status within one system, therefore allowing greater transparency. This will be good for confidence in the Cadastral System, as many overlaps and gaps will be revealed and can be regularised. This will lead to an increase in transactions, and ultimately bolster the number of legal tenure relationships on the record.

As a result of the requirements of the FIG Statement 1995, Cadastre 2014 and the user needs survey, LADM and the STDM were adopted, modified and integrated in a fit-for-purpose approach, to create a LSTDM, resulting in the DLRMS. This system will cost much less than proprietary options to acquire and maintain, yet will facilitate the representation of the full and complete situation on the ground with regards to the man to land relationship. The system will result in substantial savings in time for both the Surveys and Mapping and Land Titles Divisions of the NLA to certify plans and process title applications, respectively, given that all land related information, including deeds, will be in one repository, and more readily accessible. Likewise, users of land records will that find their research time is significantly reduced. In the final analysis, this new model will increase the efficiency with which land transactions are completed.

The integrated system delivers a comprehensive view of all available land information, so significant improvement in support for land administration will be realized. Concomitantly, there will be reduced, if not zero occurrence of duplicate registration and therefore substantially fewer conflicts over land.

In the final analysis, the DLRMS, is the result of an innovative and seamless integration of several FLOSS tools (pgModeler, PostgreSQL, PostGIS, and QGIS) to form a simple, robust, accurate, easily updatable system, highly extensible, and scalable solution, adequate for the needs of small island Caribbean states.

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