7

Point Cadastre

Walter T. de Vries, Co Meijer, Susan Keuber, and Bert Raidt

CONTENTS

Introduction

Most land information systems rely on systematic records of property rights that are associated with parcels and parcel boundaries (Tuladhar et al. 2004). Parcels may however not always be the most appropriate spatial basis for maintaining land records. Not only does surveying parcels and parcel boundaries tend to be too expensive in low-income countries (de Vries et al. 2003), but it also tends to be bureaucratic in countries with weak governance systems (Hanstad 1997) and deferred when limited technical surveying resources are available (Enemark and Williamson 2004). In such cases, alternative organizational processes are required as a basis for developing and maintaining the land records. One such alternative is the point cadastre.

A point cadastre is stripped-down method for collecting and maintaining cadastral data (Hackman-Antwi et al. 2013). Geographic points, instead of boundaries or areas, are used as the key reference to represent land parcels in a cadastral database. One of the main requirements to recognize and distinguish these points is that they should be uniquely identified (Fourie 1994), so that they can be connected to tenure attributes, such as owner names or land rights. The concept *point cadastre* has many equivalents in literature, such as center-point cadastre (Fourie 1994), lots-by-dots (Burke 1995), single-point and midpoint cadastres (Home and Jackson 1997), or dots on plots (Davies and Fourie 2002). Experiments of point cadastres (lots-by-dots) designs date back to early 1990s to document rural parcels in Honduras, Indonesia, Pakistan, and the Philippines (Burke 1995) and of recording land rights in slum areas in South Africa (Home and Jackson 1997). The name suggests that technically one does not bother with the size, extent, or boundary of an area with homogeneous rights, yet relates the land information to a single surveyed or identified point—either centroid or midpoint. We use the term "point cadastre" for the remainder of this article.

Although the reference to points in the approach suggests that the added value refers to the physical shape of geospatial feature in the database, Keuber (2014) argues that the socio-institutional situation of land tenure is an intrinsic aspect of point cadastres as well. The point as such represents more than the *dot*. It represents a relation with rights and claims and offers a means to both recognize tenure and social relations, which would otherwise be hidden from administration. An additional advantage of point cadastres as compared to conventional cadastres concerns the potential of savings in cost and other resources. The cost savings are especially in the process of constructing and populating the spatial database. Instead of having to rely on individual land surveys and adjudication processes constructing the boundaries to be included in the databases, one populates the database with a point as basic geometric reference and connects other attributes to such a point. Hence, when searching for low-cost approaches to data acquisition in land administration, point cadastre can be seen as a very usable starting tool.

Conventional cadastral systems rely heavily on expert practitioners, extensive quality procedures, and sustained financial resources. The underlying assumption hereby is that such capacity is available and can directly be put to use to construct and maintain a cadastral database. Such an approach may of course often be the preferred option for governments who aim for the best quality—both in geometry and in content. However, if a government (including local governments) aims to improve or start-up their land administration system, and thereby rely on standards and rules set in Western countries, then it may take a long time before the system can actually be used. The professional stakeholders, such as surveyors and registrars who would act as basic actors to populate the database, would need to have the skills to do so and should also be available in sufficient numbers. Experience has shown that developing such capacity may however take various decades, which is not the time frame that governments have in mind. Consequently, alternative systems that can be used immediately, while being developed much quicker and being maintained with relative limited capacities and resources, are preferable in such cases.

Many countries need to improve their management of the land. What is described in this chapter can be a very good starting point to set up quick and simple first registrations. In this way, the system can be improved step by step later. This chapter deals with how to build a point cadastre, whereby it identifies the challenges needed to be overcome. These include both technical, organizational, management, and institutional challenges, as it is important that the design does not occur in isolation of the context but is done in a responsible way. It is shown that a point cadastre has to be clearly based on an identified need (to have a cadastre and cadastral info), a request by stakeholders and a validation process of discussions and feedback of stakeholders.

Theoretical Perspective

Conceptually, the point cadastre approach has both a historical and a geospatial or information technical root. Historically, it has especially been considered suitable and appropriate in locations where weak interests in land prevail, where informal tenure is not yet aligned with a formal registration system, or where connections to other registers are lacking (Deininger et al. 2010). This may in particular be true where there are gaps between the recognition of formal (registered) and informal (unregistered) tenure, or in areas of (post) conflict. Point cadastre may then be an alternative method based on relatively rapid data collection and registration.

From a geospatial and information technical perspective, the point cadastre is a cadastral system that uses points instead of parcels, or otherwise put, uses points to represent closed areas (either parcels or buildings). Point instead of parcel identifiers thus becomes the key. Technically, a point cadastre can serve as a multipurpose cadastre or land information infrastructure. As a basic register it can also be used as a starting point for a street name and house number register. It thus has the potential to be linked to other registers using these identifiers. It then serves a broader range of domains: not only to provide tenure security but also for basic management issues and can be used by local or central government, by health services, and by other service deliverers, such as water, electricity, as an instrument to support valuation and taxation and the execution of a census. Even transactions on objects related to the point can be handled.

Point cadastre may serve a different purpose and be designed differently for urban or rural areas. Furthermore, the practice of record keeping may be different in rural versus urban point cadastres. Although the records associated with point cadastres should provide easier access to land and security of tenure than before, in a rural setting the record related to the land is most crucial whereas in urban setting the record of the house/building providing the location of shelter may be more crucial. This has an influence on the design of the underlying (spatial) database model.

An appropriate reference to evaluate a design of a point cadastre is the framework of requirements engineering (van Vliet 2008). This framework starts from the assumption that technology cannot function in isolation from its environment and vice versa. A technical design therefore not only goes beyond translating technical requirements into technical possibilities, but also recognizes social and cognitive tacit knowledge in the design and implementation practice. Such tacit knowledge is often associated to experience with what works and what does not in a given local physical and institutional context. In short, the requirements analysis engineering includes three major aspects:

1. Evaluation of technical requirements. For point cadastres, Hackman-Antwi (2012) and Hackman-Antwi et al. (2013) differentiate three categories of main requirements for point cadastres: functional requirements (e.g., related to establishment of titles, boundaries or legal records, to maintenance and interoperability functions), quality requirements (related to ease of use, cost, flexibility, scalability, and accuracy), and architectural requirements (related to data collection, storage, maintenance editing tools, visualization, field infrastructure).
2. Adaptation and incorporation of physical conditions of the area. This primarily relates to the degree of stability and access to the area for which a point cadastre is made is required. In case of landslides or floods, for example, the physical shape may be subject to such changes that physical structures may no longer be recognizable and people may be forced to leave the area. In addition, when parcel boundaries already coincide with physical boundaries, representation of a point instead of an area may not provide any additional advantage.
3. Legal framework and stakeholder environment in which the new cadastre needs to be embedded. This relates to the degree to which a new type of cadastre can either be embedded in currently operational legislation or whether a new law or regulation needs to be made. The former strategy is easier to adopt but requires careful examination in legislation whether technical changes are legally valid. The latter requires introduction of new legislation and is thus more difficult to adopt. Yet, it would have the advantage that the administration of the law could be constructed directly alongside the technical system.

The collection of these requirements provides the framework for practitioners designing solutions of point cadastres. This theoretical framework needs however testing in a practical setting. This chapter does this.

Methodology

The requirements analysis engineering framework forms the basis to evaluate each of the designs of point cadastres in two specific cases. The comparison of the two cases is done qualitatively, with the aim to derive a set of a generic recommendation how and when point cadastres could be designed and used. The base data from the two cases partly draw on secondary sources and partly on direct communication and personal experience. Data are drawn from recent work on developing a point cadastre for Bugala Island in Uganda (Keuber 2014) and in Guinea-Bissau based on experiences of Kadaster International. Bugala Island is in the south of Uganda in Lake Victoria. It has approximately 10,000 ha of land developed for a vegetable oil palm plantation, out of which 3,500 ha are for small-hold farmers and 6,500 ha for the nuclear farm itself. It is a suitable location for developing a point cadastre given that smallholder farmers' land is not documented. Most of the smallholders are tenants on the land, and although the law provides the possibility to issue certificates of occupancy and guarantee some sort of tenure security, the landlords are reluctant to do so. A point cadastre can help in establishing a basic record of tenancy.

Guinea-Bissau is a country in Western Africa. The mayor and the council of the capital Bissau had challenges in managing their city. There was a lack of information to manage the city, because of a bad quality of paper-based administration, low capacity, computer illiteracy, and outdated registers based on several Microsoft (MS) Access databases. These were however not considered reliable any more. Furthermore, there was a lack of topographical maps on the basis of which planning and administration could be carried out. During a fact finding mission in 2011 on request of the Mayor of the city, the advice and first outline was given to establish a low-cost and simple-to-use registration, with a direct link to a geospatial reference. This paved the way to design an innovative multipurpose point cadastre.

The requirement specifications for Bugala Island were drawn from a collection of sources, including the technical point cadastre requirements as specified by Hackman-Antwi (2012), whereas the data on Bugala physical conditions and the Bugala stakeholders were drawn from the empirical work by Keuber (2014). She conducted interviews with stakeholders in the area and reported on needs and requirements, and also drew conclusions on how best to design an associated land information system. The development of the prototype relied on 9 personal interviews and 17 survey responses (Keuber 2014), and data modeling based on unified modeling language (UML) and land administration domain model (LADM) specifications, all supplemented by the architectural requirement for the underlying information and communication technology (ICT). The prototype was tested in a pilot area, Kasekulo village, with 57 parcels (represented by points). In addition, a thorough stakeholder requirement and feedback analysis was executed to capture social and cognitive aspects. Additional documentary evidence from Uganda and its legislation on land matters relied on formal and gray literature relating to the Ugandan Land Act of 1998.

The development of the Guinea-Bissau prototype relied on a fact-finding mission on invitation by the Camara Municipal de (City Council of) Bissau in July 2011 and subsequent discussions on design and functionality at Kadaster International in August/September 2011. The city needed advice on how to improve its administration. In Bissau field visits, meetings with municipal and governmental stakeholders, the tax department, and some ministries gave insight in the existing situation. Meetings with the mayor gave first insight in the questions and desired functionalities that were needed to start and improve the administration and management of the city. A workshop was organized to present and discuss the first ideas and advises with a broad audience from local and central governments.

Results

In the Bugala Island case, the exploratory interviews with stakeholders identified several basic current problems of tenants (Keuber 2014), including perceived bureaucracy when having to hire surveyors privately and communicating with the Ministry of Lands, no issuance of land tenure documentation, no available or accessible expertise or authority in handling land conflicts, and dependence on the goodwill of local political leaders. In addition, the regional office in Masaka indicated having problems with both squatters and absentee landlords, lack of occupancy information leading to incomplete local register, and hesitance to record rights at all. A point cadastre had to address these problems alongside establishing a new system of recording rights. Given these observed problems preparatory requirements were formulated before addressing the technical and legal requirements and crafting the prototype. Such preparatory requirements included the establishment of a permanent body that would eventually operate and maintain the point cadastre, attracting and training skilled personnel to operate the system and ensuring that the output of the new system would receive legal status (being a legal document related to land). It was agreed that with these requirements in place there would be a suitable ground for establishing the point cadastre. The strategy to do so addressed the specific elements of the requirements engineering methodology. Each of the elements was discussed in consultation with the stakeholders.

Technically, the stakeholders indicated that any geospatial information with the point cadastre should be georeferenced using GPS coordinates. Any data collection on points should be done relatively quickly to make a significant difference in comparison to conventional methods. Parcel boundaries were considered relevant for tenants, but they were satisfied with the option to link the points of a point cadastre to the parcel sketches. Photographs of owners and tenants should be included whenever possible. Finally, scalability of the system was considered crucial. Connections to other databases, both spatial and nonspatial, should be easy. Access to Internet server and mobile telephone networks would even increase this possibility.

The combination of these requirements resulted in the following preliminary technical design for the point cadastre in Bugala Island (Figure 7.1). The model is adapted yet based on the international standards captured in the LADM. The class of occupied parcel, which describes the geometry of the parcel with a point, can at the same time also be connecting sketch plans reflecting an area. Tenants are furthermore identified by pictures among others, which would make it easier and more transparent when recalling with whom the arrangement was made.

The physical conditions of the area were such that the area was relatively flat with good access to parcels. This is a crucial characteristic when relying on low-end global navigation satellite system (GNSS) receivers to acquire single, georeferenced points and aiming to make sketch plans by hand.

As far as using and/or adapting the legal framework is concerned, first observations showed that very limited occupancy was supported in some sort of register, which would be acknowledged by the current legal framework. Given that the only legal instruments to provide this framework were

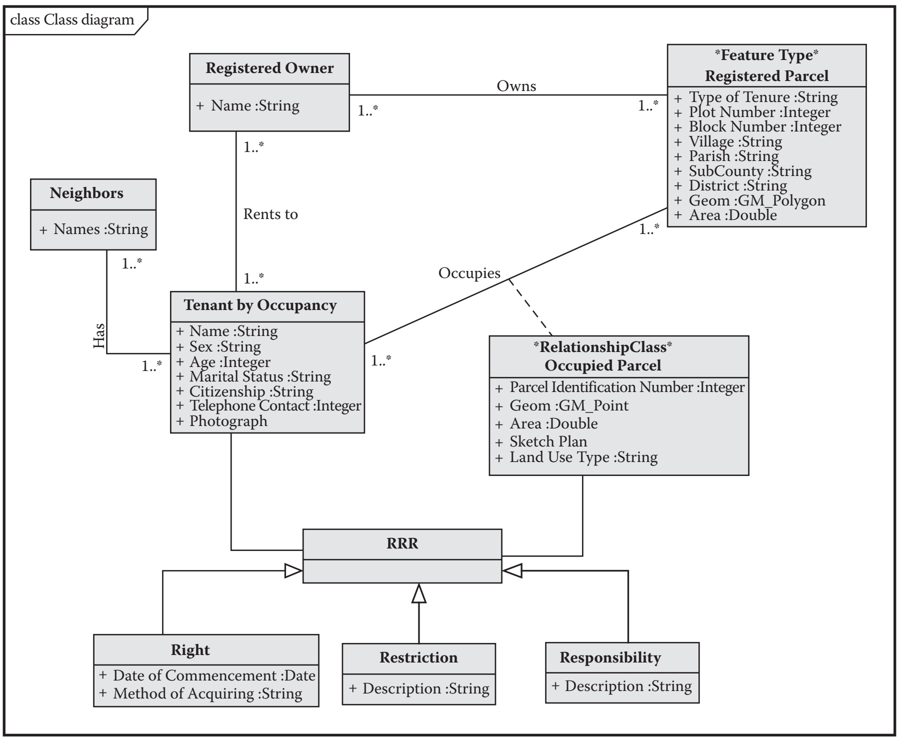

FIGURE 7.1
Preliminary conceptual data model of Bugala Island.

the land act of 1998 and its related regulations of 2004; any operational adjudication process leading to points should fit in these two legal instruments. Consequently, stakeholders were consulted about which information they would like to see recorded in the new point cadastre system, and these needs were compared and translated into the specific attributes described in the land act and the regulations. This included for example the determination of "who owns what and where," but also the spatial–legal relation between major landlords and land occupants needed to be recorded during an adjudication and demarcation process. Once the prototype containing the point cadastre records was completed all farmers were requested to validate the information that could be traced to them.

In the Guinea-Bissau case, the functional requirements were acquired through a visit and meeting with the stakeholders in Guinea-Bissau, after which the development of the Guinea Bissau prototype relied on a brainstorm session with land administration experts and geographic information system (GIS) experts and software developers in 2011. This session was organized to check and discuss and even pilot the ideas to find out if point cadastre and the management of it would be viable. This resulted even in a rough first pilot version that was tested and made available in the cloud in a cooperative action of the Netherlands Kadaster and GIS software giant ESRI.

The technical implementation of the prototype was executed by proposing the following procedure: each object (physical structure, house, etc.) had to be identified on an aerial photo and/or a Google Earth map—usually through the roof of the structure. These aerial photos were printed and provided with meta-information (name of city, neighborhood, and number of the photo) to identify and classify each photo. Inspectors—in the form of para surveyors and para legal practitioners—were identified to classify each element on the photos. This process was demonstrated through several examples, as depicted in Figure 7.2.

The procedure continued by identification of roofs on the ground and connection of points to a single roof. The combination of the unique number of the dot on the photo (representing a roof) with the unique identifier number of the photo itself provides a basic record of a multipurpose cadastre. This can also generate a link to existing administration of buildings, by connecting the dot to the building, or connecting the X and Y coordinates of the dot to that of the building. If there can be used a GIS system for the georeferencing and a digital administrative database on buildings, the connection between the administrative data and the unique dot number will have to be managed in the system. The above activities deliver a GIS database with the location of the dots, and an administrative database on for example buildings with the connection made by the unique dot number of the roof. This approach also makes it possible to register other essential sectors such as health, water, electricity, valuation, taxes, and real estate.

FIGURE 7.2
Prototype of point cadastre in Guinea-Bissau.

The physical conditions of the area are specific. The capital city of Bissau is a relatively flat and small area of approximately 10 × 10 km^2. Yet, the physical structures are closely and densely connected and usually contain only one floor. On the ground, people do not perceive clear boundaries of plots by physical structures or signs nor by verbal agreements. This physical situation and perception of stakeholders made the introduction of a point cadastre easier and more appropriate than having to measure individual boundaries.

With regard to the legal embedding of the new point cadastre stakeholders in Bissau explicitly called for the design and immediate implementation of a fit-for-purpose cadastre during the preparation phase. The specifications for Guinea-Bissau were collected during observations, discussions, and interviews with stakeholders in local and central government that had to deal with urban and rural migration, health issues, uncontrolled city development, land disputes, and underdeveloped valuation and taxation. The basis of these observations gave input to a first outline of what is realistically possible to develop in a step-by-step approach. From this the plans could be drawn for first steps in improving the land management functions within the government.

A brainstorm meeting was organized in the Netherlands to discuss the Bissau case. Discussions with IT experts and other advisors resulted in a first outline for solution to support a multipurpose point cadastre. Unfortunately, the actual construction of the point cadastre in Bissau could never materialize. Soon after the consultation and design process political unrest in the country and a failed coup attempt led to changes in the administration. Because of these circumstances, the process was immediately interrupted and the use of the system could never be tested.

Discussion

The experiences in the two cases provide insight in conditions under which a point cadastre may be useful, the technical model with which a point cadastre can be constructed, and the procedure that can populate and update point cadastre.

First of all, the physical conditions of the location requiring some sort of registration are significant when aiming to introduce a point cadastre. Although it is always possible to identify points on an aerial or satellite image, locating, recognizing, and connecting these points on the ground may be seriously hampered in rough areas and in areas with many overlapping buildings or structures. Still, both cases have shown that points were easily recognizable by stakeholders familiar with the location. Given that this issue came up in both cases it is valid to state that this condition applies for both rural and urban areas.

Second, both the role of stakeholder consultation and demand-driven approaches proved valuable. The tests reveal that the validation of requirements with local communities provides a better understanding among stakeholders of why the introduction of a new type of cadastre could be beneficial. It also acts as a vehicle to open up tenure and governance discussions. Connecting furthermore, the construction of the system as a way to overcome concrete organizational constraints of a ministry or of a local government in a given context is paramount: it forces the system designers to connect functional processes to societal roles and benefits of local communities.

Third, on the technical requirements the pilot of Guinea-Bissau showed that in the field para surveyors can execute their activities without any support by equipment. A pen and an aerial photo on print are sufficient for data gathering or updating. There is no need for technical tools that need technical skills, batteries, digital connection with the GIS system, maintenance and costs, and so on. In the office on a GIS system, the collected dots on the roofs can be georeferenced on the aerial photo in the GIS database. Little technical requirements are needed, and in this low cost and with less (technical) capacity the results can be achieved. The georeferenced aerial photo in the GIS system should be updated as much as possible to have the most actual situation on the screen. This paves the way for active maintenance of the database, and registers also the changes. GIS basic skills are needed.

The test in the Bugala case shows that the use of handheld GPS systems to validate points proves to be more cost-efficient than having to rely on conventional surveying methods. In connection with the use of publicly available satellite and/or aerial images, both the organization spatially referencing points seem relatively cheap. The basic georeference also allows for scaling up and linking to other basic registers, which shows improvements in the accessibility of the contained information. In addition, the use of visual images makes it easier to connect to stakeholders and to the public than when using conventional systems or cadastral parcel plans.

Technically, the preliminary conceptual data model for the Bugala case can be further explored. In cases where local utilities and technical infrastructure is insufficient, the database itself could be stored in the cloud. This would prevent the risk of failure in case of power cuts or insufficient storage capacity in local areas. The storage of geospatial elements with point still has the potential for upscaling and linking to other databases and/or registers. The tests have shown the potential for scale-up the small design to either a multipurpose cadastres or a system contained and maintained in a cyber-information infrastructure. Even without a GPS in the field, using a paper aerial or satellite image and a pen, it would be possible to register points and later transfer these points in a digital environment on completion of the fieldwork. In this case, no specific knowledge of GPS systems would even be necessary to build up and populate a reliable database.

Despite the moderately positive results obtained through the two cases there are still some limitations when constructing a point cadastre. An obvious one is that the full utilization still needs time before any benefits become visible. Though the development of a point cadastre may be a good start to enhance the explicitness of tenure, tenants, and claims on land, one would need to evaluate who will profit most from using this information after several years. This will largely depend on how activities are connected to the new system and whether the system becomes embedded in daily institutional routines. The discontinuation of the actual construction and testing of the next prototype in Bissau given the instability of government also shows the dependence on the sociopolitical environment in which land management can be executed, and a cadastre needs to be built.

With the emergence of social media, the ability to upload spatially referenced information via mobile-/smartphones adds another potential technical element in the development of point cadastres. Such tools can indeed contribute to *quick-and-dirty* registers, even when the data quality or completeness of attributes needs to be improved over time. The main lesson of building point cadastres is that geometric quality is not of utmost importance if no information is available at all. Instead, reasoning from uptake and usage of information and adaptability to local context is more relevant in such cases. The acceptance of reduced geometric quality does have consequences for the land surveying profession in the phase of setting up the basic register. However, once the basic system is in place, the main task becomes updating and maintenance. Given that in a country such as the Netherlands there are 120,000 geometric updates per year (on a total of 10 million parcels), there is still a lot of work to do for para land surveyors or fully accredited/licensed land surveyors. However, in a country such as Guinea-Bissau, where there is historically a limited number of professional surveyors, one is required to rely on para professionals, who can within a relatively limited time be trained in the basic acquisition and recording of points and attributes.

Conclusion

The main issue of this chapter is whether point cadastres could be an alternative in case of poor or incomplete land administration systems. The two cases and related prototypes have shown how to build a point cadastre and have identified several challenges to overcome in this process. In each case, it has been possible to construct a basic database and connect this with a georeference using an online base map. Regarding the challenges, these include technical challenges of fit-for-purpose data models and data acquisition procedures, organizational challenges of retrieving the data with paraprofessional human resources, institutional and legal challenges of either adapting or aligning with current legislations, and social challenges of ensuring the involvement and acceptance of local stakeholders. A technical challenge also still remains: the access to technology, basic utilities, and infrastructure and technical skills. In addition, it is important that the design does not occur in isolation of the sociopolitical and physical context. Within these boundaries, the conclusion is that it is possible to link sufficient and appropriate attribute information about a parcel and tenure via a point and that such a method may contribute to responsible land administration.

The two cases have also revealed some difference in the design for urban versus rural point cadastres. The technical specifications are probably easier to reach in rural areas as compared to urban areas. Objects and areas in rural are often easier to identify and pinpoint by a single point in case of limited overlapping structures or in case of obvious boundaries. At the same time, however, if there are no overlapping trees, the case of Guinea-Bissau has shown that even in densely populated urban areas it is relatively easy to pin-point roofs. A crucial difference is perhaps more related to its use. In an urban setting, the main interest and usage is likely activities such as tax collection, whereas in rural areas it mainly supports tenure security. Finally, the physical conditions may play a role. It works well in a city such as Bissau, where there are no high-rise buildings and the area is relatively flat. This make the construction of a point cadastre feasible and appropriate, even though technically one could opt for more than one dot per roof, if there were multiple rights to pinpoint. For this specific case however, there existed a culture where boundaries of areas were hardly contested. Similar conditions would apply for informal settlement areas or cities with similar physical characteristics or similar institutional practices. This would be much more complicated in densely populated cities with many high-rise buildings or large boundary conflicts. In such cases, a point cadastre would not facilitate data collection nor tenure security.

Unlike Western/Northern paradigms in land administration spatial quality receives perhaps less priority in the design of the cadastral system, thus favoring quality factors such as fit-for-purpose, equality of tenants, and complementarity and accountability of the system holders. Such an approach is especially suitable where interests in land are unequal or opaque, where undocumented tenure does not have the same weight as formal registration systems, or where connections to other basic registers, such as the tax and civil registers, are lacking.

With regard to the methodology of designing and applying technology, the tests have proven that the choice for requirements engineering seems appropriate in the design and implementation of *responsible* point cadastres. It not only develops the technical system based on certain requirements, but it also forces the system designers to systematically connect with stakeholders to collectively formulate design requirements, test and validate such requirements, and test and validate first prototypes before actually relying on such systems. In locations where there is limited capacity in surveying legal matters and ICT, the gradual design solution can thus be a responsible solution.

As the prototypes could not further be implemented it is recommended that the point cadastre approach could be further tested in other countries and contexts. This could include looking into linkage to other types of registers as well.

References

Burke, L. 1995. *Urban and Municipal GIS Applications in Developing Countries—The Problems and the Potential*. Paper presented at the ESRI user conference, Wyndham Hotel and Convention Center, Palm Springs, CA, May 22–26.

Davies, C., and C. Fourie. 2002. A land management approach for informal settlements in South Africa. In *Holding Their Ground: Secure Tenure for the Urban Poor in Developing Countries*, edited by A. Durand-Lasserve and L. Royston, pp. 218–230. London, United Kingdom: Earthscan Publications.

de Vries, W.T., J. Lewis, and Y. Georgiadou. 2003. The cost of land registration: A case study of cost efficiency in Namibia. *The Australian Surveyor* 48(1): 7–20.

Deininger, K., C. Augustinus, S. Enemark, and P. Munro-Faure. 2010. *Innovations in Land Rights Recognition, Administration, and Governance*. Washington, DC: World Bank Publications.

Enemark, S., and I. Williamson. 2004. Capacity building in land administration—A conceptual approach. *Survey Review* 37(294): 639–650.

Fourie, C. 1994. *Options for the Cadastre in the New South Africa: Report to the South African Council for Professional and Technical Surveyors*. KwaZulu-Natal, South Africa: Department Surveying and Mapping, University of Natal.

Hackman-Antwi, R. 2012. *Design and Assessment of a Procedure for Building and Maintaining Point Cadastres*. Enschede, The Netherlands: University of Twente, Faculty of Geo-Information and Earth Observation (ITC).

Hackman-Antwi, R., R.M. Bennett, W.T. de Vries, C.H.J. Lemmen, and C. Meijer. 2013. The point cadastre requirement revisited. *Survey Review* 45(331): 239–247. doi: 10.1179/1752270612y.0000000015.

Hanstad, T. 1998. Designing land registration systems for developing countries. *American University International Law Review* 13: 647.

Home, R., and J. Jackson. 1997. *Our Common Estate: Land Rights for Informal Settlements: Community Control and the Single Point Cadastre in South Africa*. London, United Kingdom: The Royal Institution of Chartered Surveyors.

Keuber, S. 2014. *Validation of Point Cadastre Requirements in Practice: The Case of Bugala Island, Uganda*. Enschede, The Netherlands: University of Twente, Faculty of Geo-Information and Earth Observation (ITC).

Tuladhar, A.M., M.J.M. Bogaerts, and P. van der Molen. 2004. *Parcel-Based Geo-Information System: Concepts and Guidelines*. PhD thesis, ITC Dissertation 115. Enschede, The Netherlands: ITC.

van Vliet, H. 2008. *Software Engineering: Principles and Practice*. 3rd ed. Chichester, West Sussex, England: John Wiley & Sons Ltd.