

EVALUATING SPATIAL DATA ACQUISITION AND MANAGEMENT TECHNIQUES FOR MULTIPURPOSE CADASTRE IN ETHIOPIA AND RWANDA (PRELIMINARY RESULTS)

Didier Milindi Rugema (PhD candidate), Tadesse Amsalu Birhanu (PhD), Gebeyehu Belay Shibeshi (PhD)

Bahir Dar University/Institute of Land Administration

July 2019

ABSTRACT

Following various demands emerging from evolving societal changes of humankind relationship to land, cadastral systems have progressively evolved from fiscal and/or legal purposes to multipurpose. The effective process for the transition to modern cadastral systems resulting from technological developments in geo-information and communication technologies (Geo-ICT) needs a particular attention. However, there is insufficiently developed framework to compare experiences of different cadastral systems. In this regard, the concept of fit for purpose and the ongoing debate for cadastre 2034 are used for comparisons. This paper therefore aims to evaluate spatial data acquisition and management techniques for multipurpose cadastre in Ethiopia and Rwanda. Using a qualitative research method, a review of existing literature on spatial data acquisition and management techniques for cadastral purposes is carried out with a particular focus to Ethiopia and Rwanda. The preliminary empirical data have been collected in Rwanda. The preliminary results show that using techniques that are not standard based, not focusing on accurate survey, Ethiopia and Rwanda have carried out large-scale mapping under participatory approach for re-engineering their cadastral systems in short time. However, the question comes on quality of cadastral geodatabase implying reliability of land information, not mentioning the maintenance of the established infrastructure within available resources for the case of Rwanda given the manner by which the processes have been undertaken. The question also comes on covering all land types for the case of Ethiopia.

Keywords: *Multipurpose cadastre, Spatial data acquisition and management techniques, Efficient process, Ethiopia and Rwanda*

1. INTRODUCTION

1.1. BACKGROUND AND RATIONALE OF THE STUDY

Land being a scarce resource, it is affected by competing uses (GIZ, 2012), it should be carefully managed for the benefit of future generations (United Nations Economic Commission for Europe, 2004). This necessitates collecting detailed information on land not only limited to determination of boundaries of parcels and associated maps (Williamson, 1985). In this framework, cadastral systems being an engine to know who owns land on which the activities occur, while serving for legal protection and investment purposes (Bogaerts & Zevenbergen, 2001), they have progressively played a multipurpose role including social justice, environmental management and sustainable development due to evolutionary societal needs (Ting & Williamson, 1999). Modern cadastres focus on detailed georeferenced information at individual parcel level (United Nations Economic Commission for Europe, 2005), not only for legal and/or fiscal purposes, but also for other purposes including base mapping, facilities management, value assessment, land use planning and environmental impact assessment within a framework of multipurpose cadastre (Kaufmann & Steudler, 1998). However, in many African countries, contrary to traditional land tenure systems, cadastre was introduced following colonial administration of European law tradition, and this has led to the failures of the systems (Österberg, 2001). Across Africa, the developments of formal land administration systems are out of date, expensive to maintain and inefficient due to lack of the financial, human and technical resources (Burns & Dalrymple, 2006).

Together with non-spatial data associated with a parcel, a map describes a parcel spatially to form a cadastre (Konecny, 2009). Using spatial data acquisition techniques that are not standard based, mainly ortho-images, Ethiopia and Rwanda have carried out large-scale mapping for land certification to enhance land tenure security and proper land management (Deininger, et al., 2008; Rwanda Natural Resources Authority, 2016). The benefits have been evidenced (Holden & Tefera, 2008; Deininger, et al., 2011; Ali, et al., 2014; Mukahigiro, et al., 2015). However, there is knowledge gap on how efficiently spatial data acquisition and management techniques are undertaken in the back-end for the development of cadastral systems serving for multipurpose. Therefore, this research aims to investigate how efficiently techniques of acquiring and managing spatial data for multipurpose cadastre are selected, designed and implemented in the back-end to serve the public in the front-end. Given the similarities in re-engineering their cadastral systems, the empirical assessment is undertaken using the cases of Ethiopia and Rwanda when implementing land policies.

1.2. OVERVIEW ON LAND POLICIES

In Ethiopia, rights to property are stipulated in the constitution of the Federal Democratic Republic of Ethiopia Proclamation No. 1/1995. The rights to ownership of rural

and urban land, as well as of all natural resources, are exclusively vested in the State and in the peoples of Ethiopia. Also all land is a common property of the Nations, Nationalities and Peoples of Ethiopia and shall not be subject to sale or to other means of exchange (Federal Democratic Republic of Ethiopia, 1995). Land can be transferred, through inheritance, by a landholder to members of his family. In addition, peasant farmers, semi pastoralists and pastoralists with holding certificates can lease land to other farmers or investors from their holding of a size sufficient for the intended development in such way that shall not displace them. Also a landholder using his land use right may undertake development activity jointly with an investor (Federal Democratic Republic of Ethiopia, 2005). To realize the common interest and development of the people, no person may acquire urban land other than the lease holding system (Federal Democratic Republic of Ethiopia, 2011).

In Rwanda, the lack of reliable land registration system was among the factors that was hindering an efficient land management. In order to bring a rational and planned use of land while ensuring a sound land management and an efficient land administration, a national land policy was established in 2004 to guarantee a safe and stable form of land tenure (Republic of Rwanda, 2004). It is an obligation for a person to registering his owned land as stipulated in the enacted 2005 organic land law, amended in 2013 (Republic of Rwanda, 2005; Republic of Rwanda, 2013). This law stipulates that land is public for all Rwandans, and the State has supreme powers to manage all national land. The right to land is granted by the State in the form of emphyteutic lease, not less than three years or more than ninety-nine years. Through succession, gift, inheritance, ascending sharing, rent, sale, sublease, exchange, servitude, mortgage, and any other transaction within the boundaries of the laws and regulations, rights to land may be transferred between persons. For the sake of land reserved for agriculture and animal resources, land rights may be transferred, without prejudice to the provisions of law governing land in Rwanda relating to the area of the land that cannot be subdivided.

The two countries systems differ mainly in holding right based system for the case of Ethiopia while Rwanda's system is emphyteutic lease based.

2. RESEARCH METHODS

To investigate the processes in acquisition of spatial data and development of effective land information system, the research is undertaken using a qualitative research method. A review of existing literature on spatial data acquisition and management techniques for cadastral purposes is carried out with a particular focus to Ethiopia and Rwanda. The selection of the two countries in Africa is that they have carried out large-scale mapping for cadastral purposes using cadastral procedures that are not based on classical accurate ground surveys. In addition to that, the researcher is familiar with the two countries, and this facilitates data collection and analysis.

The comparative study allows to see better the implicit foundation of practices and phenomena and to improve the efficiency by revealing and challenging the less evident assumptions and conceptions about the World (Azarian, 2011), and in one way or another, the case study collects and analyses empirical evidence (Yin, 2002). Using a purposive sampling, primary data was gathered from the key informants. This approach is suitable for evaluation research and policy analysis by identifying who are involved in designing, giving, or administering the program or service in question and receivers of the service (Palys, 2008). In qualitative research, the idea is to select purposefully participants or sites that best help the researcher to realize the research problem and question (Creswell, 2014). The preliminary empirical data have been collected in Rwanda through correspondences with staff working for cadastral office, specifically from staff responsible for geographic information system (GIS) for cadastre and staff responsible for information and communication technology (ICT).

The measurement criteria for analysis are based on the fit-for-purpose land administration concept (Enemark, et al., 2014) and the ongoing debate on Cadastre 2034 (Lemmens, 2010), the two in the same line. The latter is about making differences between geographical areas and their respective needs, rather than one size fitting all. This includes cadastral systems for developing countries developed using light tools to generate exact data rather than accurate data to respond to the primary need of building land rights infrastructure. The former includes cadastral systems for developing countries developed using affordable spatial data capture methods for establishment and operations, being inclusive to cover all land types, participatory, achieved in short time within available resources, with reliable land information and upgradable over time.

3. FIT-FOR-PURPOSE LAND ADMINISTRATION FRAMEWORK AND VISION FOR FUTURE CADASTRE

This section aims to investigate at what extent needs to be the fit-for-purpose land administration framework and the vision for future cadastre given various contexts.

Most cadastral systems tend to be computer-based system to allow not only the integration of maps and registers but also integration with other land information databases (Kaufmann & Steudler, 1998). Considering a wide-range of humankind to land relations, there is a need of low cost rapid processes of recording land rights to serve in dealing with rapid urbanization, informality, and climate change and food insecurity. Such processes need secure and updating mechanisms to safeguard the sustainability (Molen, 2014).

Modernization being a process and response of social change to achieve intended goals (Tipps, 1973) as a result of technological progress (Inglehart & Welzel, 2007), the third world countries in a situation of lacking productive investments have to reside on aid,

including capital, technology and expertise from the Western World (Reyes, 2001; Mergel, 2012). The developments in geo-information and communication technology (Geo-ICT) have an influence on developments of cadastral systems and surrounding geo-spatial data infrastructure (Lemmen & Oosterom, 2002). However, the re-engineering of cadastral and land registration systems using Geo-ICT infrastructure to support in various demands encounters challenges including financial, technical, legal and organizational (Tuladhar, 2003). What is important is the debate on appropriate cadastral system for individual country conforming to circumstances and needs, rather than debate on whether cadastral systems are important (Williamson, 1997).

While the concept of fit for purpose land administration (Enemark, et al., 2014) is rooted to geo-referenced framework with the idea of responding to local needs in developing countries, the acquired spatial data need Geo-ICT infrastructure for the management. Being important to ease the tasks in cadastral services, Geo-ICT developments need appropriate applications depending on each country's context capabilities to assimilate the developed technologies. This calls to rethink on the fit-for-purpose land administration concept. Should this concept be limited to geo-referenced framework and with due focus to developing countries or less developed countries? This leads to question where the first-phase land certification in Ethiopia using traditional land measurements techniques could be classified; that is fitting-for-purpose at the time it was needed within its geographical context. This signals the need for comprehensively reframing the concept for different contexts in space and time. What is important as fit-for-purpose land administration is a cadastral system developed in such way that responds to the context needs given the location and period, using available resource capacities, whether being for developing or developed countries.

In the vision of Cadastre 2034 (Lemmens, 2010), it is discussed that developing countries need object survey (3 dimensions) in urban areas and general boundaries in rural areas, whereby in both areas what is most important is societal needs, and the technology to come next. The argument in this research is that taking into account the comprehensive fit-for-purpose land administration; the vision of Cadastre 2034 needs reconsideration. The object survey would not be the focus for urban areas in developing countries given that its implementation would need advanced technologies while different contexts may not be able to assimilate. Being important, the object survey would not necessarily focus on standard survey technologies to represent different strata of land rights.

4. TECHNIQUES OF SPATIAL DATA ACQUISITION AND MANAGEMENT FOR MULTIPURPOSE CADASTRE IN ETHIOPIA AND RWANDA

Given that empirical data are not yet collected for Ethiopian case, the discussion part talks little about Ethiopia.

4.1. METHODS AND TECHNIQUES OF ACQUIRING SPATIAL DATA AND DEVELOPMENT OF LAND INFORMATION SYSTEM

In Ethiopia and Rwanda, land registration was undertaken in participatory process with involvement of local people in identification and demarcation of parcel boundaries in the presence of owner of the parcel, owners of neighboring parcels and local land committees. Accordingly, the latter consists of the land use and administration committees (LACs) in Ethiopia and the land adjudication committees (LACs) in Rwanda (Deininger, et al., 2008; Rugema, 2011).

In Ethiopia, land measurements for land certification was undertaken in two phases with due focus to rural areas, and not covering all regions (Deininger, et al., 2008; Bezu & Holden, 2014). The first phase rural land certification was introduced in 1998 in one of the regional states of Ethiopian and the same practice was introduced in other three regions in subsequent years to enhance land tenure security and land use productivity (Muchomba, 2017). With rapid and low costs methods, more than 20 millions rural lands were registered over the period of 2 to 3 years. To do so, land measurement techniques consisted of rope or tape, and traditional measurement techniques known as *timad*, an area of land a pair of oxen can plow per day (Deininger, et al., 2008; Sida-Amhara Rural Development Program & Bureau of Environment Protection Land Administration and Use, 2010).

To address measurement limitations, the second phase land certification was introduced to complement the first phase. Pilot programs were carried out to add geographical locations and sizes of individual farm plots using modern technologies including Global Navigation Satellite System (GNSS), satellite imagery or orthophoto (Bezu & Holden, 2014) within a framework of progressive land administration system (Shibeshi, 2018). The computerized system in the second level certification is expected to make easier the updating and management of land records (Persha, et al., 2017).

In Rwanda, under land tenure regularization (LTR) program, land registration was undertaken systematically using ortho-images (Nkurunziza, 2015; Rwanda Natural Resources Authority, 2016). The Land Tenure Regularization Support System (LTRSS) was developed to support the LTR program by containing the textual information while Geographic Information System (GIS) was supporting spatial information of land parcels; the two systems linked by the unique parcel identifier (UPI). In the names of their land

holders, all national land parcels have been mapped and formally registered. During the maintenance phase, information contained in LTRSS was migrated to a web based Land Administration Information System (LAIS) that was developed to support mainly in the maintenance of land certification, while also supporting land administration and management. The system connects the central office and district offices (Rwanda Natural Resources Authority, 2016).

Initially, a hired consultant from abroad developed the first version of the LAIS as textual database on PostgreSQL (Postgres). This version had issues of duplication of parcel numbers and/or missing parcels due to the lack of integration with spatial part and automatic generation of UPI. A hired GIS developer consultant also from abroad and the previous consultant on the textual part developed another version of the system to connect the spatial database to textual database. The spatial component platform developed on SQLServer with SDE requires pushing, through web services, spatial information to textual component platform developed on Postgres. However, malfunctions of spatial transaction processes between the two platforms compromise the system. Different efforts have been made to upgrade the system and solve technical issues; however, by solving some issues, other issues come up and they keep circling. From the start, the system developed by outsourced consultants was deployed on production without a deep analysis on its stability, and it was not fully tested to see if it responds to all needs of the users.

4.2. PROCESS OF SELECTING AND DESIGNING SPATIAL DATA ACQUISITION TECHNIQUES

Following the completion of the LTR trial phase in Rwanda, a strategic road map (SRM) was prepared. This included the analysis of process and results, and calculations of the requirements including, but not limited to, work rates and costs (Sagashya & English, 2009; Nkurunziza, 2015). The outcome from the trial phase showed that countrywide implementation could run at the highest speed in more than 10 years for the estimated 7.9 million parcels using ortho-images (Republic of Rwanda, 2007). However, at a later stage the implementation plan was changed and fixed within 5 years (Government of Rwanda, 2008) and on ground more than 10 million parcels were mapped and registered (Sagashya, 2013).

To respond to the urgency of land tenure challenges, the government insisted on the necessity of accelerating the nationwide LTR program by registering 50% of plots by the end of the first year. This required reviewing the initial draft of the SRM, which was proposed to start with hotspots and to gradually extending the program nationwide over the period of 15 to 20 years (Nkurunziza, 2015). The SRM was adjusted for one-off investment with optimum conditions to speed up and complete the LTR in shortest time as possible to avoid inequalities to citizens in accessing the new system (Sagashya & English, 2009). Having the LTR completed in a short time, the number of parcels registered was far greater than what was expected to be met in a longer period using the same methods and techniques. However, this brings the question on how efficiently the process was undertaken in the implementation phase.

4.3. PROCESS OF IMPLEMENTING SPATIAL DATA ACQUISITION TECHNIQUES

4.3.1. SPATIAL DATA ACQUISITION PROCESS

To undertake the acquisition of spatial data in Rwanda, ortho-image maps were prepared, printed and taken to the field. The boundaries of parcels were delineated on maps. The post-processing was undertaken in the office by scanning and geo-referencing field maps, and the boundaries of parcels were then vectorised. This resulted in generating geo-referenced cadastral data; however, the way the processes were undertaken present issues.

4.3.2. CAPACITY BUILDING FOR CADASTRAL SURVEYING

At the start of the LTR in Rwanda, local people were recruited as para-surveyors to carry out demarcation of parcel boundaries and they were given on-job training from two to four weeks depending on adaptability of the trainee to work independently. However, at a later stage, for countrywide implementation, the practice changed; in different areas, the training was carried out only within some few hours within one day and let the trainee to start working independently from the same day. In such situation, the trained para-surveyors were lacking capacity needed to carry out cadastral survey in their respective areas.

4.3.3. PERFORMANCE EVALUATION

The LTR in Rwanda was undertaken under tight deadlines and performance targets (Nkurunziza, 2015). However, this implied the change in quality assurance, behavior and attentiveness. The evaluation of work progress was focusing on numbers for both data collection in the field and post-processing in the office; that is parcels demarcated and vectorised per day. To save their retention on employment, the staff had to focus on quantity. In different cases, a para-surveyor was targeting to report a large number of parcels demarcated per day, and delineating parcels on map just to fulfil the number of landowners in place, instead of going around each parcel boundary and demarcate boundaries as shown by landowners in the presence of owners of neighboring parcels and LAC.

In post-processing for vectorization of the demarcated parcel boundaries, the smallest scale was supposed to be 1/500 in order to visualize well the boundaries of parcels on a scanned-georeferenced map. However, due to performance evaluation criteria focusing mainly on quantity (number of parcels vectorised per day by one individual), the staff was vectorising parcel boundaries at a smaller scale, including 1/1000 and below, to reduce the time spent in post-processing to achieve as many parcels as possible.

The aim of the nationwide LTR was to maintain the quality of process used in pilot phase (Nkurunziza, 2015), however given the way the process was carried out, it diverts from proper land adjudication and demarcation process and post-processing while bringing the question on effects on quality of the acquired spatial data.

4.4. SPATIAL DATA CAPTURING OF PUBLIC LAND

During initial spatial data acquisition in Rwanda, the wetlands spatial layer that was previously acquired by the public agency responsible for environmental management in Rwanda was directly applied to cadastral geodatabase for the purpose of issuance of land certificates for implementing environmental policy. However, originally, the intention of generating this wetland layer was for the general protection of environment with the accuracy that was not focusing on cadastral use. This layer was generated by deskwork using remote sensing techniques with low-resolution image. In different places, the wetlands layer was inaccurate to cadastral use. To address the issues that were raised by owners of the affected parcels, other versions of wetlands were generated by deskwork using remote sensing techniques, and later on, other versions included field checking. Each version generated, in both initial data acquisition and maintenance of land register, was applied to the cadastral geodatabase; however, the problem of inaccuracy for cadastral use persisted. The correction of wetlands boundaries were demarcated on field maps according to the observations of field teams, and they were post-processed in the office for vectorization. Despite this field checking, the field teams did not go along and around of each wetland boundary.

Regarding public land for infrastructure, during initial spatial data acquisition, a number of parcels were demarcated by including road reserve like garden outside the parcel. The source of this issue was the lack of harmonized operations and monitoring. This has been gradually addressed during maintenance of land register.

4.5. MAINTENANCE OF LAND MEASUREMENTS

In support of Leica Geosystems, the Rwanda Geodetic Network (RGN) was established working in Continuous Operating Reference Stations (CORS). It provides real-time corrections/real time kinematic (RTK) to improve the positional accuracy of surveyed data and address issues encountered in the manual workflow from office to field and back to the office, whereas hand drawn fieldwork and digitisation in the office were depending on individual interpretation (Kendall, 2016). However, the maintenance of RGN encounters some problems. After the end of support project with Leica Geosystems, some stations have failed to operate while local resources capacity, specifically technical, are not sufficient for the maintenance. This requires waiting for external technical support. In addition to that, when the area surveyed does not have access to the internet connection, the RTK becomes impossible, while some users of the RGN have insufficient or no knowledge on post-processing corrections. Thereafter, to update the land register, they use raw data as surveyed on ground without RTK or post-processing corrections.

5. CONCLUSIONS

Spatial data acquisition for the development or re-engineering of cadastral system is important to nourish land information that serves for land administration and management. Using the cases of Ethiopia and Rwanda, this paper has assessed how efficiently spatial data for cadastral purposes have been acquired using techniques that are not standard based and their management. The use of the tools familiar and easy to use by local people allowed participatory large-scale mapping for land certification program to be undertaken at high speed. However, given the manner by which the processes have been undertaken in Rwanda, the question comes on the quality of the acquired data to represent boundaries of parcels and maintenance of the developed infrastructure for land information system. In the case of Ethiopia, a part from rural farming land certification undertaken in some areas, the problem comes on mapping and certification of other land holding types.

Given the issues raised in this study, further research could entail the impacts resulting from how the processes of acquiring spatial data and development of land information system have been undertaken.

6. REFERENCES

- Ali, D. A., Deininger, K. & Goldstein, M., 2014. Environmental and gender impacts of land tenure regularization in Africa: Pilot evidence from Rwanda. *Journal of Development Economics*, Volume 110, pp. 262-275.
- Azarian, R., 2011. Potentials and Limitations of Comparative Method in Social Science. *International Journal of Humanities and Social Science*, 1(4), pp. 113-125.
- Bezu, S. & Holden, S., 2014. Demand for second-stage land certification in Ethiopia: Evidence from household panel data. *Land Use Policy*, Volume 41, pp. 193-205.
- Bogaerts, T. & Zevenbergen, J., 2001. Cadastral systems – alternatives. *Computers, Environment and Urban Systems*, Volume 25, pp. 325-337.
- Burns, T. & Dalrymple, K., 2006. *Land Administration: Indicators of Success, Future Challenges*, Wollongong, NSW, Australia: Land Equity International Pty Ltd.
- Creswell, J. W., 2014. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 4 ed. Thousand Oaks, California: SAGE Publications, Inc..
- Deininger, K., Ali, D. A. & Alemu, T., 2011. Impacts of Land Certification on Tenure Security, Investment, and Land Market Participation: Evidence from Ethiopia. *Land Economics*, 87(2), pp. 312-334.

- Deininger, K., Ali, D. A., Holden, S. & Zevenbergen, J., 2008. Rural Land Certification in Ethiopia: Process, Initial Impact, and Implications for Other African Countries. *World Development*, 36(10), pp. 1786-1812.
- Enemark, S., Bell, K. C., Lemmen, C. & McLaren, R., 2014. *Fit-For-Purpose Land Administration*. Copenhagen, Denmark: The World Bank and the International Federation of Surveyors (FIG).
- Federal Democratic Republic of Ethiopia, 1995. *Proclamation No. 1/1995 of the Constitution of the Federal Democratic Republic of Ethiopia*. Addis Ababa: Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia: 1st Year No. 1, 21st August, 1995.
- Federal Democratic Republic of Ethiopia, 2005. *Proclamation No. 456/2005 Federal Democratic Republic of Ethiopia Rural Land Administration and Land Use*. Addis Ababa: Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia: 11th Year No. 44, 15th July, 2005.
- Federal Democratic Republic of Ethiopia, 2011. *Proclamation No. 721/2011 Urban Lands Lease Holding*. Addis Ababa: Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia: 18th Year No. 4, 28th November, 2011.
- GIZ, 2012. *Land Use Planning: Concept, Tools and Applications*. Eschborn, Germany: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.
- Government of Rwanda, 2008. *Strategic Road Map for Land Tenure Reform*. Kigali, Rwanda: Ministry of Natural Resources.
- Holden, S. & Tefera, T., 2008. *Land Registration in Ethiopia: Early Impacts on Women*, Nairobi, Kenya: United Nations Human Settlements Programme (UN-HABITAT).
- Inglehart, R. & Welzel, C., 2007. Modernization. In: G. Ritzer, ed. *The Blackwell Encyclopedia of Sociology*. Malden, MA, USA: Blackwell Publishing Ltd, pp. 3071-3078.
- Kaufmann, J. & Steudler, D., 1998. *Cadastrre 2014: A Vision for a Future Cadastral System*. Copenhagen, Denmark: International Federation of Surveyors (FIG).
- Kendall, J., 2016. *Improving Rwanda Land Administration Information Systems*. Ekurhuleni, Gauteng, South Africa: Geomatics Indaba 2016 – Stream 1.
- Konecny, G., 2009. Cadastral Mapping with Earth Observation Technology. In: D. Li, J. Shan & J. Gong, eds. *Geospatial Technology for Earth Observation*. New York, NY, USA: Springer Science + Business Media, LLC, pp. 397-409.
- Lemmen, C. & Oosterom, P. v., 2002. Cadastral Systems II. *Computers, Environment and Urban Systems*, Volume 26, pp. 355-360.
- Lemmens, M., 2010. *Towards Cadastrre 2034: Part II*. Lemmer, The Netherlands: GIM International.
- Mergel, T., 2012. Modernization. In: J. Paulmann & C. Müller, eds. *European History Online (EGO)*. Mainz: Leibniz Institute of European History (IEG), 2012-06-21. URL: <http://www.ieg-ego.eu/mergelt-2011-en> URN: urn:nbn:de:0159-2011050927 [2018-11-9].
- Molen, P. v. d., 2014. Cadastre 2014: A Beacon in Turbulent Times. In: D. Steudler, ed. *Cadastrre 2014 and Beyond*. Copenhagen, Denmark: International Federation of Surveyors (FIG), pp. 5-9.
- Muchomba, F. M., 2017. Women's Land Tenure Security and Household Human Capital: Evidence from Ethiopia's Land Certification. *World Development*, Volume 98, p. 310-324.

- Mukahigiro, A., Lengoiboni, M. & Groenendijk, L., 2015. *Land Tenure Regularization in Rwanda: Registration of land rights for women and its impacts on food security*. Utrecht, Netherlands: LANDac International Conference 2015.
- Nkurunziza, E., 2015. Implementing and Sustaining Land Tenure Regularization in Rwanda. In: T. Hilhorst & F. Meunier, eds. *How Innovations in Land Administration Reform Improve on Doing Business: Cases from Lithuania, the Republic of Korea, Rwanda and the United Kingdom*. Washington, DC, USA: International Bank for Reconstruction and Development / The World Bank, pp. 10-19.
- Österberg, T., 2001. *What is an Appropriate Cadastral System in Africa?*. Nairobi, Kenya : International Conference on Spatial Information for Sustainable Development, 2–5 October 2001.
- Palys, T., 2008. Purposive Sampling. In: L. M. Given, ed. *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand Oaks, California: SAGE Publications, Inc., pp. 697-698.
- Persha, L., Greif, A. & Huntington, H., 2017. *Assessing the Impact of Second-Level Land Certification in Ethiopia*. Washington D.C., USA: Annual World Bank Conference on Land and Poverty 2017: Responsible Land Governance—Towards an Evidence-Based Approach, March 20-24, 2017.
- Republic of Rwanda, 2004. *National Land Policy*. Kigali: Ministry of Lands, Environment, Forests, Water and Mines.
- Republic of Rwanda, 2005. *Organic Law N° 08/2005 of 14/07/2005 Determining the Use and Management of Land in Rwanda*. Kigali: Official Gazette of the Republic of Rwanda, Year 44 n° 18, 15th September 2005.
- Republic of Rwanda, 2007. *The Road Map to Land Reform*. Kigali: Ministry of Lands, Environment, Forests, Water and Mines.
- Republic of Rwanda, 2013. *Law N°43/2013 of 16/06/2013 Governing Land in Rwanda*. Kigali: Official Gazette no Special of 16/06/2013.
- Reyes, G. E., 2001. Four Main Theories of Development: Modernization, Dependency, World-System, and Globalization. *Nómadas. Revista Crítica de Ciencias Sociales y Jurídicas*, 04(2), pp. 109-124.
- Rugema, D. M., 2011. *Evaluation of Digital Pen in Data Capturing for Land Administration Purposes in Rwanda*. Enschede, The Netherlands: The Faculty of Geo-Information Science and Earth Observation of the University of Twente.
- Rwanda Natural Resources Authority, 2016. *Land Administration Procedure Manual. Second Edition*. Kigali: Rwanda Natural Resources Authority: Office of the Registrar of Land Titles.
- Sagashya, D. & English, C., 2009. *Designing and Establishing a Land Administration System for Rwanda: Technical and Economic Analysis*. Washington D.C., USA: Annual World Bank Conference on Land Governance in Support of the MDG's: Responding to New Challenges, 9-10 March 2009.
- Sagashya, D. G., 2013. *Land Reform in Rwanda: Building a Land Administration*. Musanze, Rwanda: Eastern Africa Land Administration Network Annual General Meeting, 14-18 July 2013.
- Shibeshi, G. B., 2018. Decision Premise for the Selection of Cadastral Surveying Methods in Progressive Land Administration Systems: the case of Amhara Region of Ethiopia. *Journal of Land Policy and Governance*, 1(1), pp. 10-35.
- Sida-Amhara Rural Development Program & Bureau of Environment Protection Land Administration and Use, 2010. *Land Registration and Certification: Experiences from the Amhara*

National Regional State in Ethiopia. Bahir Dar: Bureau of Environment Protection, Land Administration and Use (BoEPLAU).

Ting, L. & Williamson, I. P., 1999. Cadastral Trends: A Synthesis. *The Australian Surveyor*, 44(1), pp. 46-54.

Tipps, D. C., 1973. Modernization Theory and the Comparative Study of Societies: A Critical Perspective. *Comparative Studies in Society and History*, 15 (2), pp. 199-226.

Tuladhar, A. M., 2003. *Re-engineering Cadastre and Land Registration Systems and Business Opportunities*. Paris, France: FIG Working Week 2003, April 13-17, 2003.

United Nations Economic Commission for Europe, 2004. *Guidelines on Real Property Units and Identifiers*. Geneva, Switzerland: UNECE Information Service.

United Nations Economic Commission for Europe, 2005. *Land Administration in the UNECE Region: Development trends and main principles*. Geneva, Switzerland: UNECE Information Service.

Williamson, I. P., 1985. Cadastres and Land Information Systems in Common Law Jurisdictions. *Survey Review*, 28(217), pp. 114-129.

Williamson, I. P., 1997. The Justification of Cadastral Systems in Developing Countries. *Geomatica*, 51(1), pp. 21-36.

Yin, R. K., 2002. *Case Study Research: Design and Methods*. 3rd ed. Thousand Oaks, California: SAGE Publications, Inc..