INTEGRATING CADASTRAL INFORMATION FROM STATE INSTITUTIONS INTO THE GUATEMALAN NATIONAL CADASTRE

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March, 2015

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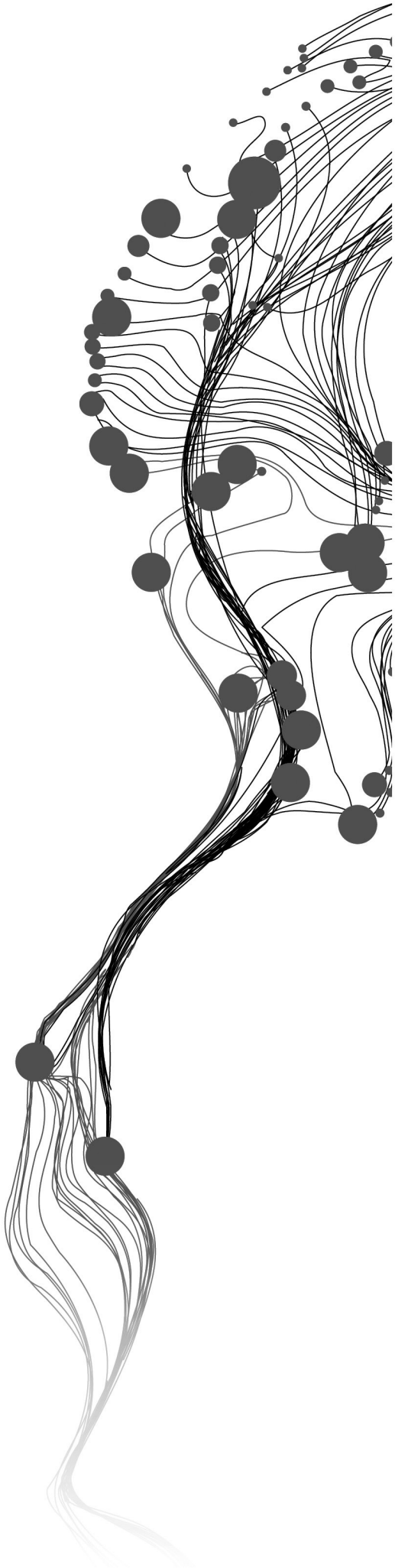

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ABSTRACT

Under the guidance and control of the Cadastral Information Registry (RIC), currently 68 out of 338 municipalities in Guatemala are in cadastral process. Nevertheless, prior to this, other cadastres were already being conducted in the country and most of them still are, some of them very modern and accurate and some not as much. The fact that these other cadastres are currently separated from the national cadastre and the fact that they are disconnected from each other produces a fragmented cadastre for which no integration procedure currently exists. The main objective was to determine how and to which extent cadastral information from Guatemalan State institutions can be integrated in the national cadastral information system. A comprehensive literature review was done using a combination of scientific literature on the issue of integration with a collection of contextual literature from the public sector in Guatemala first identifying the current views on cadastral information integration, analyzing the causes and effects behind cadastral fragmentation in Guatemala, learning from experiences that have taken place in the country in order to solve the issue of fragmentation and finally identifying the challenges for cadastre in the future. The analysis on the current views on cadastral information integration led to the development of an analytical tool which provides the five key aspects that integration must be based on: technical, institutional, legal, political and socio-economic. The results showed that fragmentation in Guatemala was mainly caused by a set of historically connected malpractices, that the effects that such integration produce have a mainly negative connotation and that the political aspect plays a major role in the success of integration. Three integration models were identified and compared in equal number of scenarios: centralized, supply chain and reciprocal. The three models were evaluated from two perspectives: first, by an analysis of purposes, limitations and outcomes and second by an evaluation of perceived impacts on the technical and non-technical aspects of integration; the result suggested that the model that is more likely to work in Guatemala is supply chain, which along with a set of key recommendations for RIC aims to contribute to a future development of sound cadastral information integration procedures in the country.

Keywords: Guatemala; Cadastre; Cadastral information; Integration

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To the NICHE project: An initiative by the International Cooperation that makes possible, among other things, that people like me coming from developing countries, have the opportunity to come into contact with different realities and improve our academic training in order to put it at the service of our respective societies.

To my supervisors: In whom I recognize their knowledge and experience in the research field. The time that they spent on providing answers to my inquiries, their prompt observations, suggested corrections and improvements are all things that I greatly appreciate since they helped me clarify the way of properly addressing each one of the aspects of the research process.

To the Cadastral Information Registry (RIC): Institution responsible for cadastre in Guatemala, which once gave me the opportunity to work for it and increase my experience. With the present research I look forward to contribute to the solution of one of the main problems relating to its domain which is cadastral information integration.

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ACRONYMS

CONAP	Consejo Nacional de Áreas Protegidas (National Council of Natural Reserves and Protected Areas)
CONRED	Coordinadora Nacional para la Reducción de Desastres (National Coordinating Office for Disaster Reduction)
DICABI	Dirección de Catastro y Avalúos de Bienes Inmuebles Cadastre and Real Estate Valuation Office
FONTIERRAS	Fondo de Tierras (Land Fund)
FYDEP	Empresa de Fomento y Desarrollo Económico del Petén (Enterprise of Economic Development of Petén)
IDAEH	Instituto de Antropología e Historia (Anthropology and History Institute)
IGN	Instituto Geográfico Nacional (National Geographic Institute)
INE	Instituto Nacional de Estadística (National Statistical Institute)
INFOM	Instituto de Fomento Municipal (Institute of Municipal Development)
INGUAT	Instituto Guatemalteco de Turismo (Guatemalan Tourism Institute)
INSIVUMEH	Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (Volcanology, Seismology Meteorology and Hydrology National Institute)
INTA	Instituto de Transformación Agraria (Agrarian Transformation Institute)
OCRET	Oficina de Control de Reservas Territoriales del Estado (State Territorial Reserves Control Office
RGP	Registro General de la Propiedad (General Property Registry)
RIC	Registro de Información Catastral (Cadastral Information Registry)
SAA	Secretaría de Asuntos Agrarios (Agrarian Affairs Secretariat)
SEGEPLAN	Secretaría de Planificación y Programación (Secretariat of Planning and Programming)
SINIT	Sistema Nacional de Información Territorial (Territorial Information National System)
SNIG	Sistema Nacional de Información Geográfica (Geographic Information National System)
UTJ	Unidad Técnico-Jurídica (Technical-Legal Unit)

1. INTRODUCTION

1.1. Background

Guatemala is a country with a complex agrarian structure where land tenure has been historically insecure for centuries mainly because of unreliable cadastral and legal information on land. It was in 1996 when the Peace Accords were finally signed, after 36 years of internal war, when it was identified as urgent to create a decentralized, efficient and modern cadastral system promoting development and helping on the elimination of all agrarian disparities such as land tenure insecurity, weak conflict resolution mechanisms and concentration of resources contrasting with the poverty of the majority (Permanent Mission of Guatemala to the United Nations, 1996).

In the past, several attempts were made to build a nationwide cadastre, amongst which the Multi-Purpose cadastral project of 1968 can be mentioned as the most relevant although it was only capable of covering one third of the country's total area before its discontinuation in 1978 (Erba, 2008). In addition, a number of municipalities have been sporadically implementing their own cadastres, using their own standards and tools, and each one of them for a different purpose, according to their own needs. All these events led to a considerable cadastral information fragmentation in the country where any institution with the need and capability to establish a cadastre, especially municipalities, did it under little or no supervision.

As a result of the Peace Accords, in 1997, an inter-institutional commission was created with the objective of addressing the aforementioned agrarian disparities and cadastral information fragmentation. The creation of that commission eventually led to the Land Administration Project, which implemented cadastral surveying and conflict resolution in a pilot area (around 33% of the country's total surface); this project was financed through a loan granted by the World Bank (World Bank, 2005).

The Land Administration Project unveiled the dire need for a legal and institutional framework for cadastral services in the country, and after years of discussion between several land-related sectors, the Guatemalan Congress finally issued the Legislative Decree 41-2005 (RIC Law), thus creating the Cadastral Information Registry (hereinafter referred to as RIC) as an autonomous public institution with the objective of establishing, maintaining, and updating the cadastre nationwide (World Bank, 2007).

In accordance with RIC's law, this institution is the responsible for establishing the national cadastre through a systematic implementation, declaring (in cadastral process) one by one all of the 338 municipalities in the country in order to proceed with cadastral surveying activities (as of February 2015, 68 have been already declared).

According to RIC's law Article 74, any State institution that might have cadastral information when this law comes into force must make it available for RIC, which will evaluate the possibility of integrating it into the National Cadastre (Congress of the Republic of Guatemala, 2005). However, neither Article 74 nor any RIC's regulations (Law Regulations, Technical Cadastral Regulations, Cadastral Procedural Guidelines, etc.) specify how that integration is going to be done, which instance will be held responsible, which aspects are to be considered and how to evaluate the existing information.

It is therefore necessary to investigate what land administration scientific literature says about fragmentation and integration problems, the reasons behind cadastral information fragmentation as well as the impact that it causes in Guatemala and which challenges does RIC have to face to get the most of the already existing cadastral information in the country.

Based on that, this research will provide a set of guidelines that will help in the future to the development of comprehensive regulations on how to integrate cadastral information from State institutions in order to build a National Cadastre in Guatemala.

1.2. Literature review

1.2.1. A National Cadastre

According to the International Federation of Surveyors (FIG) (1995) a cadastre is normally a parcel based, and up-to-date land information system containing a record of interests in land. It is often referred to as the engine of a Land Administration System (Wallace et al., 2010).

Williamson et al. (2007) claim that a national cadastre is of vital importance and that this applies for any approach taken for its design and management; however, the establishment of a national cadastre requires great efforts to put all the available information together because it is often scattered or fragmented in different institutions or agencies.

Moreover, a wide range of availability and quality of cadastral information is present across every country that makes the decision of carrying out the task of building a national cadastre. As stated by the U.S. National Research Council (2007), the challenge is still present in that country even after years of technological advances that now seem to be making it more feasible.

By the same year in Europe, the INSPIRE initiative also addressed the problem of spatial information sharing, recognizing that solving the problem would require important measures to overcome the problems related to availability, quality, organization and accessibility (European Parliament, 2007).

In order to build a national cadastre, there are two ways of obtaining information: by collecting or by sharing it (Aboagye-Kyei, 1999). While collection is necessary when there is no information on certain areas, sharing is critical because if it is well done, it will help saving time and resources (Godínez García, 2001).

1.2.2. Overview of relevant literature

The following table presents an overview of literature that is relevant for the research topic:

TITLE	CITATION
DATA SHARING	
Cadastral data sharing: A choice between standards and translators	(Aboagye-Kyei, P., 1999)
Data sharing issues in SDI implementation at National Land Administration for country multi-government	(Hamzah, A., Shariff, A., Mahmud, A., Yusof, N., Ali, H., 2010)
Geospatial Data Sharing in Pakistan: Possibilities and Problems	(Ali, M., Ahmad, A., 2013)
INTEGRATION/MERGING OF CADASTRAL OBJECTS	
Ontology - based geographic data set integration	(Uitermark, H., van Oosterom, P., Mars, N., Molenaar, 1999)
A Model for Integrating Multi-scale Spatial Data for e-Government and Public Service	(Jiang, J., Chen, J., Han, 2005)
Merging polygons with uncertain boundaries	(Klajnšek & Žalik, 2005)
Towards integration of 3D legal and physical objects in cadastral data models	(Aien, A., Kalantari, M., Rajabifard, A., Williamson, I., Wallace, 2013)
Managing Inaccurate Historical Survey Records in a Future Accurate Digital World	(Harper, 2014)
CADASTRE AND LAND REGISTRATION	
Land registration and cadastre in the Netherlands, and the role of cadastral boundaries: the application of GPS technology in the survey of cadastral boundaries	(Wakker, W., van der Molen, P., Lemmen, 2003)
A Systems Approach to Land Registration and Cadastre	(Zevenbergen, 2004)
Land Registration and Cadastre Systems: Principles and related issues	(Henssen, 2010)
A Domain Model for Land Administration	(Lemmen, 2012)
ORGANIZATIONAL ISSUES	
Cadastral Trends: A Synthesis	(Ting, L., Williamson, 1999)
Processes in a cadastre	(Navratil & Frank, 2004)
Awareness – a tool for investigating inter-organizational collaboration in land administration systems?	(Thellufsen, 2008)
Cooperation – a Key Factor for Sustainable Spatial Data Infrastructure (SDI)	(Olsson, 2009)
Taking land policy and administration in Indonesia to the next stage and National land agency's strategic plan	(Winoto, 2009)
Spatially Enabling Survey & Land Registration Bureau of Bahrain for Better Management of Property Transactions	(Kashram, A., Dixit, N., Hashim, 2010)
CADASTRE IN GUATEMALA	
Development of a cadastral infrastructure : case study "National Cadaster in Guatemala"	(Godínez García, 2001)
Integration of heterogeneous databases "National Cadastre in Guatemala"	(Aceituno Díaz, 2005)
Property and Cadastre general regime: a Cadastre-Registry Coordination Proposal	(Carrillo Castillo, 2005)

Table 1. Relevant literature for the research topic

1.3. Research problem

The key focus of this research is the cadastral information integration, its process and the regulations that make it possible.

Thus far in the Land Administration domain, research has mainly focused on databases integration, the problem of semantics in databases, design and implementation of normative data models and there is also a growing interest on business processes re-engineering and legislative reform. Nevertheless, little has been researched about the problem of integration as a whole, considering the legal, technical and organizational issues together.

The latter leads to the fact that there are no comprehensive guidelines on how to deal with the problem of integration in a way that on one hand, security and transparency in cadastre are guaranteed and on the other hand, the problem of fragmentation is gradually reduced such as in the case of Guatemala.

1.4. Research objectives

The main objective of this research is **to analyze how and to which extent cadastral information from Guatemalan State institutions can be integrated in the national cadastral information system**. This will be accomplished by carrying out three main phases, which at the same time are the research sub-objectives:

- To analyze the current land administration views on integration of cadastral information
- To determine the causes and effects of cadastral information fragmentation in Guatemala
- To develop approaches on the cadastral information integration process in Guatemala

1.5. Research questions

In order to achieve the sub-objectives, the following questions are formulated:

1.5.1. For sub-objective 1

- Which science-based views exist on cadastral information integration?
- How are these views different from each other?

1.5.2. For sub-objective 2

- What are the causes behind cadastral information fragmentation in Guatemala?
- What are the effects of fragmentation for the Guatemalan Cadastre?
- Which solutions have been tried so far to address the problem of fragmentation in Guatemala?

1.5.3. For sub-objective 3

- Which specific challenges have to be considered in the cadastral information integration process?
- What lessons can be learned from integration in other domains of the public sector in Guatemala?
- What are the main elements of a potential approach?

1.6. Research design

The present research is based on a qualitative approach and will be based upon literature; the literature to be used consists of primary and secondary sources.

1.6.1. Primary sources

For the purpose of this research, primary sources are case studies that have been conducted in Guatemala in the past, either from official or non-official sources; author Robert Yin's Case Study Evidence methodology (2003) will be applied, analyzing case study evidence. The information will be collected from different sources such as academic and official web sites and by email directly from institutions' civil servants which whom previous contact has already been set up. Four specific methods will be used for these sources:

- Cases analysis: The process of analyzing documents describing cases that have occurred in the past or are currently occurring in the study area.
- Cases results analysis: For the specific objective 3.2, this research will focus on specific cases' results in order to identify the good and bad results and therefore gain knowledge in the form of lessons, which later can be applied to the problem of integration.
- Relevant documentation review: It differs from literature review in the sense that this type of review is focused on documents that are more descriptive and less opinion-oriented e.g. reports, briefs, news, etc.
- Interpretative analysis: An interpretation of the similarities and differences found in the reviewed literature.

1.6.2. Secondary sources

Secondary sources, such as documents and historic data will be analyzed through adapting the Desk Study methodology proposed by WFP (2009) to the particular subject of this research; the method consists of a document review which purpose is to help build a good understanding of the situation and its evolution, while uncovering data gaps information will be collected from official and academic sources, in the same way as for primary sources. Two specific methods were used for these sources:

- Literature review: It is understood as the search, acquisition, classification and in-depth review of relevant writings each one of them dealing with their respective research question.
- Comparative and Interpretative analysis: The result from a comparison of the reviewed literature followed by an interpretation of the similarities and differences found.

For both primary and secondary sources, as WFP's Guidelines book states, information and findings of the desk study were integrated with the data and findings from the primary data collection and analysis.

1.6.3. Development of potential approach

For research question 3.3 (What are the main elements of a potential approach?), the main principles of Process Improvement methodology (University of Michigan, 2013) were applied. This methodology originally consisting of six main phases, was originally conceived for information and technology services, but it was applicable for this research because on one hand, what the approach aims to is developing an improvement in the process of cadastral information integration and on the other hand, most of the integration process will be done in the information and technology environment; hence the use of this

tool was justified. The potential approach was developed under the principle of applying the first three phases of Process Improvement Methodology to all the extents of the present research (Define scope, Document and Analyze, Redesign), with a final output of redesign in form of general recommendations.

The following table depicts the relationship between the research objectives and the employed methodology for each case, while Figure 1 shows the summarized methodology for each research question and how the expected results from the first two sub-objectives will be integrated into the third one.

SUB-OBJECTIVE		RESEARCH QUESTION		METHODOLOGY
1	To analyze the current land administration views on integration of cadastral information	1.1	Which science-based views exist on cadastral information integration?	DESK STUDY: LITERATURE REVIEW • SCIENTIFIC VIEWS ON INTEGRATION • LAND ADMINISTRATION LITERATURE
		1.2	How are these views different from each other?	DESK STUDY: COMPARATIVE AND INTERPRETATIVE ANALYSIS • COMPARATIVE ANALYSIS • INTERPRETATIVE ANALYSIS
2	To determine the causes and effects of cadastral information fragmentation in Guatemala	2.1	What are the causes behind cadastral information fragmentation in Guatemala?	DESK STUDY: LITERATURE REVIEW • HISTORICAL DOCUMENTATION • REPORTS, DOCUMENTS, PAPERS, ETC.
		2.2	What are the effects of fragmentation for the Guatemalan Cadastre?	CASE STUDY EVIDENCE:CASES ANALYSIS • FROM OFFICIAL SOURCES • FROM CASE STUDIES
		2.3	Which solutions have been tried so far to address the problem of fragmentation in Guatemala?	CASE STUDY EVIDENCE: RELEVANT DOCUMENTATION REVIEW • FROM OFFICIAL SOURCES • FROM REPORTS, DOCUMENTS, PAPERS, ETC. • FROM WEB SITES
3	To develop approaches on the cadastral information integration process in Guatemala	3.1	Which specific challenges have to be considered in the cadastral information integration process?	CASE STUDY EVIDENCE: INTERPRETATIVE ANALYSIS • COMPARATIVE ANALYSIS OF EXISTING STANDARDS AND AVAILABLE DATA
		3.2	What lessons can be learned from integration in other domains of the public sector in Guatemala?	CASE STUDY EVIDENCE: CASES RESULTS ANALYSIS • FROM OFFICIAL SOURCES • FROM CASE STUDIES
		3.3	What are the main elements of a potential approach?	PROCESS IMPROVEMENT METHODOLOGY • Define Scope • Document and analyze • Redesign • Implement

Table 2. Relation between sub-objectives, research questions and methodology

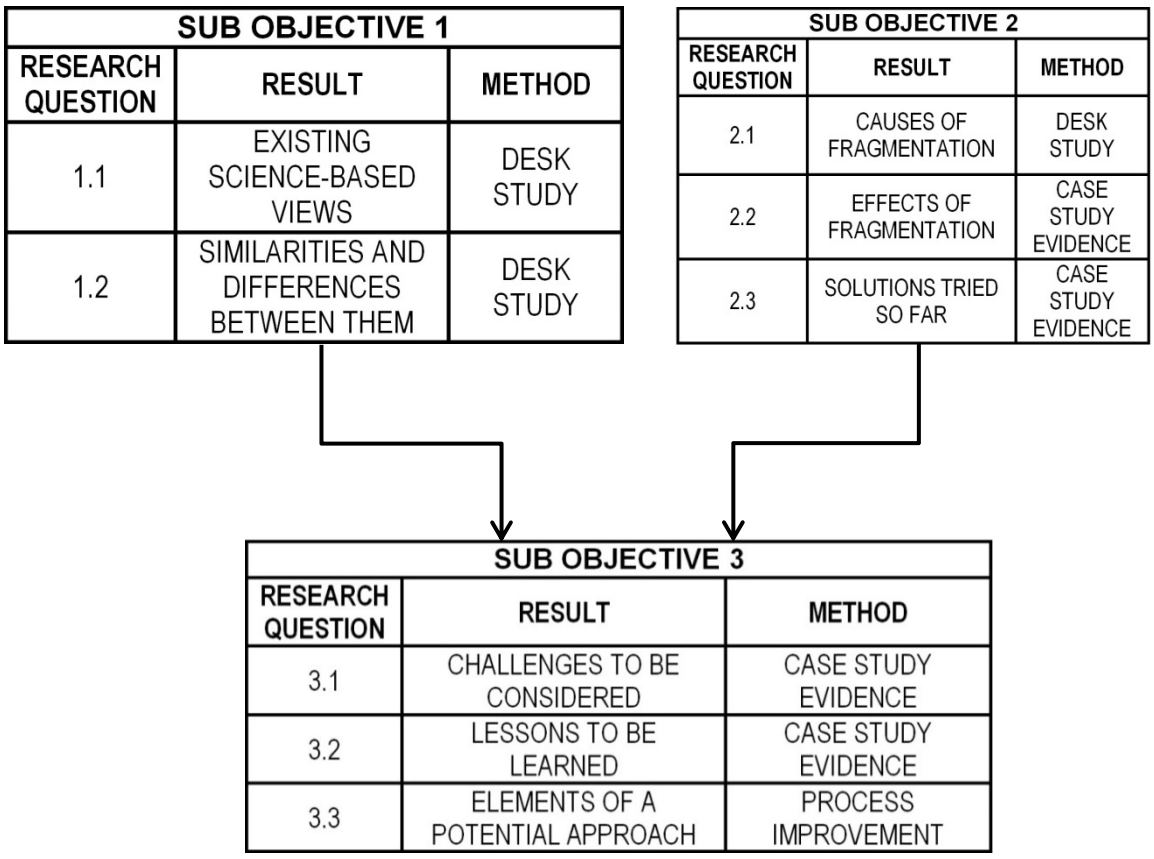


Figure 1. Expected results, workflow and methods employed.

1.7. Thesis structure

The present research consists of the following chapters:

Chapter 1: General Introduction

This introduction describes the current situation and background for the particular research problem, highlighting the study objectives.

Chapter 2. Scientific views on cadastral information integration

A description of the different science-based views that currently exist in the Land Administration domain related to the problem of cadastral information integration. It is based upon academic literature from diverse sectors in Land Administration around the world. It also contrasts the different views on cadastral information integration in order to appreciate the main similarities and differences between them.

Chapter 3. Causes of fragmentation in the Guatemalan cadastre

This chapter describes the causes of fragmentation based on a historical review of relevant documentation.

Chapter 4. Effects of fragmentation in the Guatemalan cadastre

In this chapter the focus is on the fragmentation effects and how they impact the public sector, the land administration main concerns and the country's development.

Chapter 5. Solutions that have been tried so far in Guatemala to solve the problem of fragmentation

This chapter summarizes the different attempts that have been tried in the past or that are currently been tried to solve the problem of cadastral information fragmentation. It is divided in two parts: the solutions that have been tried in the cadastral domain and the ones tried in the geo-information domain.

Chapter 6. Challenges to be considered to address the problem of cadastral information fragmentation in Guatemala

In this chapter, a combination of knowledge obtained from the previous chapters and an insight into potential integration models is used to identify the different challenges that the Guatemalan national cadastre faces in order to integrate cadastral information into its own database.

Chapter 7. Conclusions and recommendations

This chapter summarizes all the answers to the research questions and at the same time presents the most relevant findings from the research. In addition, it includes a set of recommendations or considerations that will help the development of further research in the cadastral domain, particularly in Guatemala.

2. CURRENT VIEWS ON CADASTRAL INFORMATION INTEGRATION

2.1. Introduction

In the present research, Cadastral Information Integration is defined as the act or process of incorporating as equals into an institutional cadastral database a set of information coming from another institution.

Cadastral Information Integration is not a new concept, in fact, the majority of countries that nowadays have a national cadastre have gone through that process sometime in their history; however, documentation describing cadastral information integration do not always use the same words for referring to the subject and especially in the most recent literature it is common to find concepts such as 'data sharing' (Aboagye-Kyei, 1999), 'semantic interoperability' (Lemmens, 2006) or 'fusion' (Samadzadegan, 2004).

After a systematic revision of these concepts and the literature describing them, two major schools of thought are identified in the form of perspectives: an Organizational perspective and an Information and Communication Technology (ICT) perspective. The Organizational perspective includes the different factors that are external to the problem of data sharing, such as economic, political or even of human resources (Williamson, 2001) while the ICT perspective is only focused on data modelling (Lenzerini, 2002) or semantic interoperability, standards and data sharing (Harvey, F., Kuhn, W., Pundt, H., Bishr, Y., Riedemann, 1999).

Considering that the present research was conceived with the idea of taking into account all the aspects involved in cadastral information integration –not only those related to ICT– the main concern in this research (and at the same time the necessary scope for developing the potential approach) is the organizational perspective, coinciding with the observations made by Bennett et al. (2012), who claim that the issue with the national approaches in Land administration organizations must transcend the boundaries of the technological aspect.

Cadastral information integration is in essence an organizational issue; problems related to use and management of that information as well as its interoperability are just part of that issue. According to Thompson (1967), there are three integration models for tackling these problems:

- 'Pooled' coupling: Administrative components integration through centralization
- Serial coupling: When the product of one organization is the primary resource for the next organization.
- Reciprocal coupling: When the product of one organization is the input for another organization and vice versa in a reciprocal way.

2.2. The constituent parts of Cadastral Information Integration are aspects

The analyzed documents in this section contain several different concepts regarding the constituent parts of cadastral information integration or in some cases, other forms of information integration. In order to identify a concept that describes the different phases that have to take place when integrating information is done, an overview of what the different authors discuss is presented:

Using the term 'aspects' Durán (2002) explains that EU activities on land administration made the importance of all aspects notorious; Vogel (2002) describes the aspects that are particularly relevant for the development of a geo-data infrastructure; Mohammadi et al. (2006) base their paper on the aspects that facilitate the data flow, access and integration; Sebake & Coetzee (2012) consider aspects, that in the form of motivators and barriers constitute either incentives or obstructions for data sharing initiatives.

Making use of the term 'issues' Aboagye-Kyei (1999) describes a number of issues that need to be settled for an efficient functioning of the integration system; the Global Spatial Data Infrastructure in their Cookbook (GSDI, 2009) describe how to resolve the issues related to interoperability complications while Ali & Ahmad (2013) define the issues that hamper sharing of geospatial data.

Other authors use the term 'steps' like the UK Digital National Framework (DNF, 2010) explains that to go beyond individual applications there are a number of steps that will need to be taken, while Godínez García (2001) suggests steps to achieve the implementation of a data exchange mechanism.

Referring to 'factors' Hamzah et al., (2010) highlight the several factors related to data or information sharing and Hadzilakosa et al. (2000) define a wide range of factors and criteria that prescribe the evaluation strategy for the adoption of a GI exchange standard.

In other cases, the authors use other terms: Bekkers (2007) explains that interoperability faces problems; the Geographic Information Strategy for Northern Ireland (2009) formulates strategic objectives that respond to conducted surveys among stakeholders in order to integrate geo-information; Hawerk (2006) mentions the major tasks for all stakeholders when implementing a national SDI; the US National Research Council (2007) says that numerous challenges must be overcome to develop nationwide digital parcel data; the International Federation of Surveyors (1996) gives options for the cadastre to serve the different needs of countries at different stages of development and SEDI/OAS (2005) focus on the evaluation of areas of interest for cadastre modernization.

It is then notorious that it really depends on the scope of each case but for the purposes of the present research, the term '**aspects**' has been chosen not only because it is the most frequently used term but because it is more meaningful for cadastral information integration. Therefore, an **aspect** is the constituent part: the particular way or phase in which cadastral data integration may be looked at or considered.

2.3. Analyzed views overview

The following is an extract of the main ideas described in the reviewed literature, consisting of 20 documents which are ordered by year from oldest to newest; the summarized overview of what their authors explain can be appreciated in Table 3 of the next sub-section.

FIG's Bogor Declaration (1996) suggests administrative and technical options for the cadastre to serve the different needs of countries at different stages of development also explaining that each one must consider economic and human resource issues:

a. Land Policy
b. Legal
c. Institutional
d. Technical

Aboagye-Kyei (1999) states that in order to address cadastral data sharing in Ghana, a number of key issues must be settled before data sharing and that they conform a suggested structure where he focuses on four major issues as follows:

- Standards development
  - Development of cadastral standards
  - Development of Information and Transfer Model
- Cost factor for standards development
  - Hardware and software cost
  - Manpower and training requirements
  - Operational cost
- Economic issues
- Institutional issues
  - Administrative organization and coordination
  - Political support
  - Supporting Policy and Legal issues
  - Access

For the Greek case, the article by Hadzilakosa et al. (2000) explains that the most suitable GI standardization schema for Greece needed to be based upon a wide range of factors and considerations that had direct influence on the implementation of standards. The factors are:

a. Political
   i. Compatibility with foreign policy and international status
   ii. Status of the supporting organization
b. Socio-Economical
   i. Status of the standard (completeness, stability)
   ii. How widespread it is
c. Technical-Scientific
   i. Context of transferred data
   ii. Sender-Recipient relations
   iii. Transfer method specification
   iv. Conceptual model

v. Transfer procedure
vi. Transferred file contents
vii. Quality data
viii. Spatial entity data
ix. Attribute data
x. Spatial relationships data
xi. Meta-data
xii. Suitability for cadastral data
xiii. Theoretical background
xiv. Existence of products
xv. Ability to transfer incomplete data
xvi. Availability and documentation
xvii. Platform independence

d. Practical
   i. "Simple vs. Complete" characterization
   ii. Acceptability in Greece
   iii. Cost and other consequences of adoption

Godínez García (2001) derived three basic steps for implementing a national cadastral infrastructure in Guatemala, according to the author these steps are to be taken one after each other:

a. Technological change
b. Organizational structure change
c. Organizational culture change

Durán, I. (2002) in his dissertation indicated that in order to harmonize cadastre in the European Union and at the same time foster the coordination between the European cadastral agencies it was necessary to consider the following four aspects:

a. Technological
b. Political
c. Regulatory
d. Growing demand for cadastral information

The Geo-data infrastructure (GDI) in Germany, as presented by Vogel, F. (2002), requires a coordinated phased implementation strategy between both public and private sector. He points out that it is necessary to cover the three crucial aspects of Standards (definition and implementation), Economic and Human and for that he states that it is necessary to consider the following main aspects:

a. Technological
b. Political
c. Institutional

SEDI/OAS in their report (2005) conducted three case studies in equal number of Latin American countries highlighting the modernization priority in cadastral and land registry systems (which might include integration as one of the main actions). The report focuses in the following areas of interest:

a. Legal Considerations

b. Institutional Framework
c. Financial Issues
d. Technology

According to Hawerk (2006), the German integration model AFIS-ALKIS-ATKIS (AAA) which consists of the information integration of control points (AFIS), cadastre (ALKIS®) and topographical data (ATKIS®) in one database was done in order to Germany's cadastre to follow the six statements of the FIG paper Cadastre 2014. It went through two major tasks:

a. Organizational, in terms of public and private coordination
b. Standards, regarding software, interfaces and core datasets

McLaren (2006) derives some conclusions for implementing National Spatial Data Infrastructures. By adapting these conclusions to the problem of cadastral integration the result in form of a series of steps is as follows:

a. Encourage effective partnerships and shared services among the involved institutions.
b. Sustain a strong communication strategy to ensure good understanding.
c. Create a robust business case that identifies a wide range of economic, social and environmental benefits.
d. Design an infrastructure that directly supports political initiatives and obtain joint funding wherever possible.
e. Introduce a capacity building program to ensure that sufficient and appropriate human resource capacity is available.
f. Clarify the proposed scope of the infrastructure over time and obtain funding and resources to support the implementation plan.
g. Provide clarity and transparency of the underlying business models to the institutions.

Mohammadi et al. (2006) present some findings and observations of some case studies, considering institutional, social, legal and policy requirements that are associated with the technical integration of datasets, they summarize the problem of integration in the technical, legal, institutional, policy and social aspects as follows:

a. Technical
    i. Computational heterogeneity
    ii. Vertical topology
    iii. Semantic
    iv. Reference system and scale
    v. Data quality
    vi. Data model
    vii. Metadata
    viii. Format
b. Legal
    i. Rights, restrictions and responsibilities
    ii. Copyright and intellectual property rights
    iii. Data access
    iv. Privacy
    v. Licensing

c. Institutional
    i. Collaboration models
    ii. Funding model
    iii. Linkage between data management units
    iv. Awareness of data existence
d. Policy
    i. Legislation issues
    ii. Priorities and policy drivers
    iii. Pricing
e. Social
    i. Cultural issues
    ii. Capacity building
    iii. Background of stakeholders

Bekkers (2007) in his back-office integration theory explains that along with the usual considerations that have to be considered in the integration domain, there are six interoperability problems that domain integration faces:

a. Administrative
b. Legal
c. Operational
d. Technical
e. Semantic
f. Cultural

The US National Research Council (2007) conducted an extensive research in the information integration domain for the development of a national land parcel infrastructure, in their effort they explain the integration in that country in terms of the following challenges:

a. Technical and data
    i. Dynamic nature of land records
    ii. External distribution of parcel data
    iii. Quality of data in existing digital parcel maps
    iv. Reconciling data at Administrative Boundaries
    v. Multiple Coordinate Systems
    vi. Definition of Street Addresses
    vii. Inconsistent practices for Complex parcels
    viii. Poor utilization of consistent standards for data quality
    ix. Existing legacy parcel systems
    x. Secure, reliable data storage and backup
b. Financial
c. Legal
    i. Data sharing restrictions
    ii. Liability for incorrect data
d. Organizational
    i. Federal Agency Coordination
    ii. State Coordination
    iii. Personnel

e. Political
    i. Return on Investment
    ii. Motivation from Local Government
    iii. Distrust of unfunded mandates
    iv. Private sector seen to benefit at expense of local governments
    v. Local political realities
f. Unique challenges for Indian country
    i. Legal and policy challenges
    ii. Political challenges
    iii. Social challenges
    iv. Juxtaposition of tribes and BIA

Mohammadi et al. (2008) discuss the technical and non-technical heterogeneities of multi-sourced spatial data and how they hinder effective data integration at different jurisdictional levels on spatial data coordination in Australia. They finally adapt the following structure for data sharing, focusing on the technical, legal, institutional, policy and social aspects:

a. Technical
    i. Standards
    ii. Semantic heterogeneity
    iii. Metadata quality
    iv. Data models consistency
    v. Bounding box
    vi. Projection system
b. Legal
    i. Definition of rights, restrictions and responsibilities
    ii. Consistency in copyright and intellectual property rights
    iii. Data access and privacy policies
c. Institutional
    i. Collaboration models consistency
    ii. Model differences
    iii. Awareness of data integration
d. Policy
    i. Supporting legislations
    ii. Policy drivers and priorities
    iii. Pricing
e. Social
    i. Capacity building activities
    ii. Stakeholders' backgrounds

Folger, P. (2009) explains that the complexity of creating a national infrastructure in the US is greater than the financial and technical aspects which can often be perceived as apparently more relevant. He explains that a coordinated and integrated national approach brings the following four major challenges:

a. Legal
b. Organizational
c. Political

The Geographic Information Strategy for Northern Ireland (2009) is a strategy to increase the use and exploitation of Geographic Information in Northern Ireland. Since one of the major goals in achieving that goal requires data integration as part of the necessary effort for building a sound data sharing infrastructure, it traces four strategic objectives:

a. To realize the business benefits
b. To create and improve skills
c. Data sharing process
    i. Search for existing data
    ii. Assess the data quality
    iii. Implement standards
    iv. Protect the data
    v. Overcome interoperability issues
    vi. Require the mandatory use of approved information
d. Data collection and project collaboration
    i. Governance and Leadership
    ii. Communication Plan
    iii. Monitoring of strategic implementation and risks
    iv. Resources
        1. Human
        2. Economic
        3. Implementation plan

The SDI Cookbook published by the GSDI (2009) explains that three factors will help on tackling the main issues that complicate data interoperability: technology, adoption of a common concept of 'core data' (sharing the core data sets between users in order to facilitate the development of GIS) and political support (a help to resource the necessary key implementations). These three factors must be considered in order to address the four types of levels of data interoperability complication:

a. cross-border : edge matching between different data sets
b. cross-sector : data sets created for different sector-based applications
c. cross-type : e.g. raster- vs. vector-data
d. overlap : same features coming from different sources and process

The Digital National Framework in the UK (DNF, 2010) has as a primary objective to enable integration, sharing and use of geographic information from multiple sources. It considers the following steps that will need to be taken to exploit the benefits of object referencing:

a. Agreement within a user community on the use of a Reference Base.
b. Specifying and defining what constitutes the Reference Base and the documenting of this in a feature catalogue.
c. Provision of access to the Reference Base and agreement on how it is to be maintained and who is to maintain it.
d. Agreement within a user community on the use of a common coordinate reference system.
e. Deciding on how Business Objects are going to be associated with the Reference Base i.e. directly or via existing Reference Objects.
f. The unique identification and life histories of the objects being associated.

g. The form of the cross-reference and how this is qualified (i.e. its attributes or properties).
h. The establishment and maintenance of cross-references.
i. Setting up mechanisms for the sharing and transfer of cross-references and any other information within user communities.

Hamzah et al. (2010) discuss the land administration infrastructure in Malaysia. They argue that the development of Land Information Delivery Services or LIDS and the achievement of a Spatially Enabled Government rely on properly addressing the following factors, which can be considered as a guide for decision-making:

a. Organizations, Legal and Policy Factor
    i. Institutional Framework
    ii. Partnership
    iii. Capacity Building
    iv. Data sharing
    v. Access Network
b. Technology Infrastructure Factor
    i. Fundamental datasets
    ii. Data and metadata
    iii. Technical Standards
c. People factor
    i. People

According to the motivators and barriers explained by Sebake & Coetzee (2012), the following issues should be considered when sharing address data in South Africa:

a. Economical
    i. Promote cost saving
    ii. Guarantee return on investment
    iii. Provide economic incentives
    iv. Ensure funding for coordination activities
b. Technical
    i. Ensure data quality
    ii. Guarantee the correct applying of standards
    iii. Improve human resources
c. Cultural
    i. Improve users' satisfaction
    ii. Consider the behavior of institutions
d. Institutional
    i. Overcome institutional barriers
    ii. Consider the different institutional interests

Ali & Ahmad (2013) describe geospatial data sharing in Pakistan based on the findings of a questionnaire that was distributed among various public and private sector organizations. As a result they divided the data sharing problem in Institutional issues and Technical issues:

a. Institutional:
    i. Data Policy and Legal Framework
    ii. Data management
    iii. Coordination
    iv. Data cost
b. Technical:
    i. Standards
    ii. Metadata
    iii. Technical arrangements
        4. Backbone network infrastructure
        5. Portal
        6. Security concerns
    iv. Data quality

2.4. Classification of science-based views on cadastral information integration

Inside the different points of view that were subject to analysis, some aspects of integration are particularly common. That is the particular case of the 20 documents that have been reviewed in the present chapter, which describe the different practices in the information integration field that have taken place in several countries around the world; almost all of these documents mention the aspects that headline Table 3.

Table 3 depicts what authors have to say about information integration. In some cases, those authors do not explicitly discuss the problem of cadastral information due to the fact that their points of view are more oriented to Spatial Data Infrastructures (SDI); however, their considerations are valid and perfectly applicable to our case since a cadastral data infrastructure is indeed quite similar to a SDI in general.

The use that authors make of the different identified aspects in table 3 also varies. In some cases, authors consider some of the aspects as a *Primary Concern* (in strong color), in other cases some aspects are viewed as less relevant, so they are seen as a *Secondary Concern* (in light color) and finally some of the aspects are not mentioned at all or *not considered* (blank). At the end of the table, the percentages show the frequency of times that the aspects appear in the analyzed literature.

No.	AUTHOR	YEAR	ASPECTS OF INTEGRATION						
			TECHNICAL	INSTITUTIONAL	POLICY	LEGAL	SOCIAL	ECONOMIC	STANDARDS
1	FIG	1996							
2	Aboagye-Kyei	1999							
3	Hadzilakosa et al.	2000							
4	Godínez, E.	2001							
5	Durán, I.	2002							
6	Vogel, F.	2002							
7	SEDI/OAS	2005							
8	Hawerk, W.	2006							
9	McLaren, R.	2006							
10	Mohammadi et al.	2006							
11	Bekkers	2007							
12	NRC	2007							
13	Mohammadi et al.	2008							
14	Folger, P.	2009							
15	GI N. Ireland Strategy	2009							
16	GSDI	2009							
17	DNF	2010							
18	Hamzah et al.	2010							
19	Sebake & Coetzee	2012							
20	Ali & Ahmad	2013							
Primary concern (%)			90	75	65	50	35	35	20
Secondary concern (%)			5	5	10	10	10	20	25
Not considered (%)			5	20	25	40	55	45	55

Table 3. Identified Information Integration aspects and their frequency of appearance in the analyzed documents

Not all the documents mention directly the aspects presented in Table 3, in some cases their authors mention them indirectly, meaning that the situations, circumstances and conditions that these authors describe implicitly contain one or more of those aspects.

The next graph (Figure 2) shows the summary for Table 3, where it is possible to appreciate a marked focus on the technical aspect, followed by the institutional and policy ones while legal, people (social), economic and standards aspects have received less attention because the majority of authors consider these as having an external influence to the integration process itself.

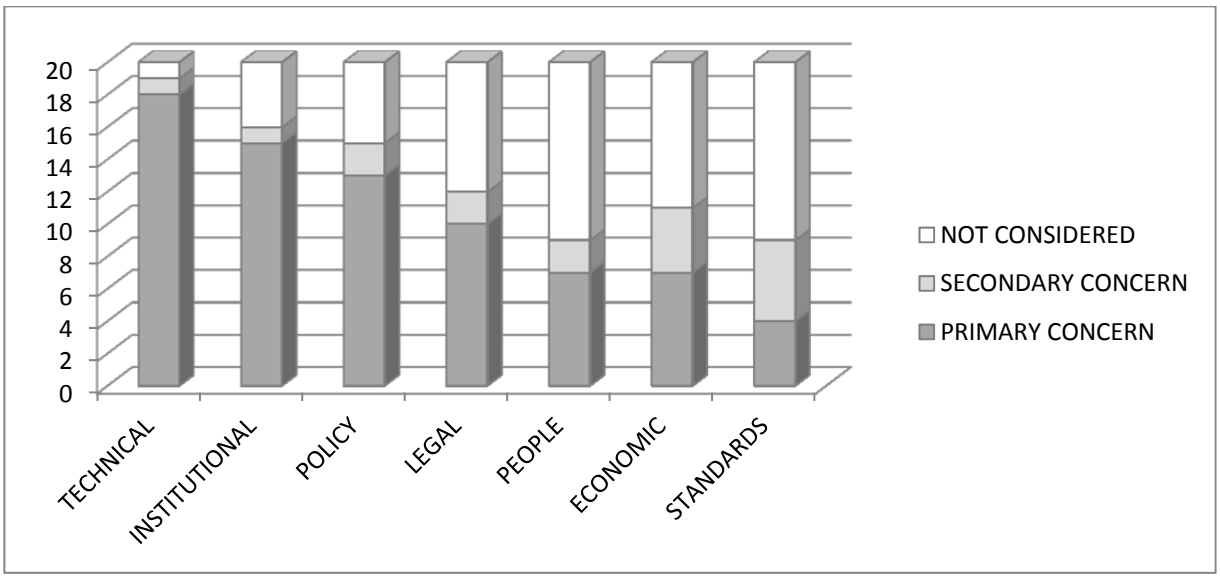


Figure 2. Aspects of integration and their citation frequency in the reviewed literature

2.5. Discussion on the aspects of integration

The technical aspect is in the first place the most frequent aspect in the reviewed literature. This responds to the fact that in the majority of cases the authors consider the technical aspect as the driver of the whole integration process, most of them describe for example that the other aspects, when properly considered and addressed, will support the different technical tasks that are necessary to be done.

The two major observed tendencies in the technical aspect are to identify standards as the starting point for the technical integration, which is true for the most recent literature as of 2007 and an increased discussion on security concerns because enabling data integration or data sharing poses a risk for all the involved actors.

In the reviewed literature, the discussion on standards is mainly based on the premise that a general technical standard (described by one of them as a set of common data definitions, formats, and models) must be defined across all involved actors before doing any integration procedure. In addition in the most recent literature it is observed that awareness about the importance of standards is rising because they are perceived to improve data quality, also some of the studies conducted in different countries reveal that a potential mandatory application of standards is perceived as positive.

It is also notorious that there has been an increase of social aspects been mentioned in the most recent years, however the arguments used by the authors that mention the social aspect do not seem to be influenced by a particular trend given the fact that they refer to specific concerns in the integration process such as users' satisfaction, the importance of considering cultural backgrounds and the need to make the integration processes more open to the public.

2.6. The 'lifesaver' and its importance in cadastral information integration

Based on the model presented by Mohammadi et al. (2009) and combining the economic aspect with the social one as considered by Hadzilakosa et al. (2000) and the Geographic Information Strategy for Northern Ireland (2009), thus creating a new aspect called Socio-Economic, cadastral information integration can be represented in the Figure 3 diagram into what hereinafter will be known as the 'Cadastral Information Integration Lifesaver' or simply, the Lifesaver.

Since a lifesaver is normally an inflated toroid that uniformly floats over water, containing in its center the person attempting to keep from drowning, the concept of the Cadastral Information Integration Lifesaver is supported by the analogy in which 'life' is the technical integration which, in order to 'be saved', must be supported by the four non-technical aspects: Socio-Economic, Policy, Legal and Institutional, as it is widely demonstrated by the consulted literature in the present chapter. In this context, 'saved' must be understood as achievement of success and satisfactory result.

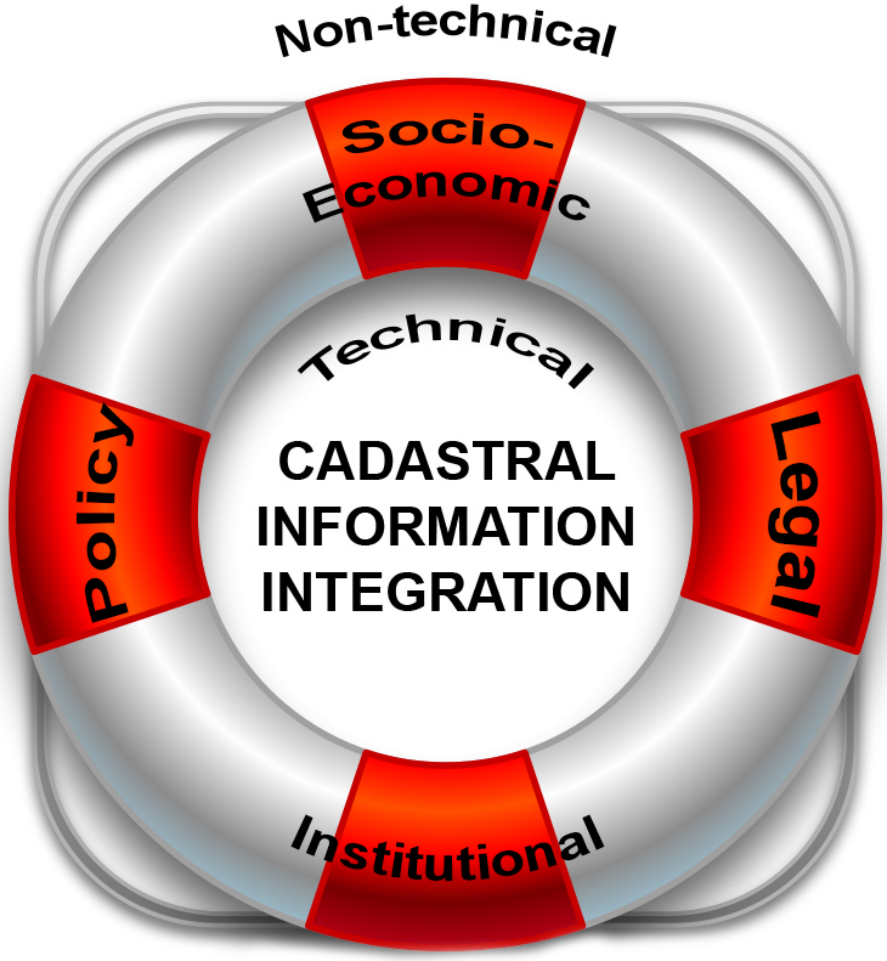


Figure 3. The Cadastral Information Integration Lifesaver (Adapted from Mohammadi et al. (2009))

In the upcoming chapters, this Lifesaver serves as an analytical tool that helps to classify and interpret the obtained results from the present research. It is used to classify the causes and to assess the effects of cadastral information fragmentation in Guatemala (Chapters 3 and 4 respectively) and as the analytical tool behind the assessment of integration models in Chapter 6.

2.7. Concluding remarks

Even though reviewed literature varies in several aspects such as geographic location or level of development of the projects described, the predominant and best described aspects of Cadastral Information Integration are the ones present in the Lifesaver, it is from here that it is recognized that Cadastral Information Integration cannot take place without considering them.

The political aspect is generally understood as an instrument for necessary legislation, a motivation and source of trust for supporting organizations behind integration; it determines the institution's capacity of convincing those other institutions from where it wants to obtain information, that sharing that data will be useful for both parties, not just for the central one.

The majority of reviewed documents consider the technical, institutional and political as the aspects that define integration, they demand more effort and the success of integration greatly depends on them. The other aspects (legal, social, economic and standards) are complementary and rather important in the integration process but demand less efforts and require less attention than the first ones.

Most of the mentions to the Standards aspect done by the consulted literature refer to it as part of the technical aspect; it comes from a line of thought that considers that the technical aspect must start from a standards definition.

3. CAUSES OF FRAGMENTATION IN THE GUATEMALAN CADASTRE

3.1. Introduction

In the present research, the term 'State Institutions' as part of the main title has been chosen to describe all those established organizations of public character devoted to the promotion of a particular cause in the State of Guatemala.

For the purposes of this research, cadastral fragmentation in a given country is understood as the state or condition in which there are two or more agencies, organizations or institutions either public or private carrying out cadastral activities at the same time but with poor or no collaboration at all between them. Such entities can have different scope, procedures, legal background, data collection technologies and data models for the management of their cadastres in a way that there might be overlapping of functions especially when their work is completely disconnected.

The main purpose of the present chapter is to find the causes of cadastral fragmentation in Guatemala while providing elements that help on documenting and analysing the problem of fragmentation. To provide an answer for this question, a literature review was conducted employing a desk study approach which consisted of a review of historical and contemporary documentation including official and non-official reports, documents and papers, especially those related to Guatemalan institutions and in a smaller scale, historical maps were also studied. The focus of this literature review was on the history of cadastre in Guatemala where past and current cadastral activities in Guatemala were reviewed in order to find the underlying causes of such a fragmented state which in the end were classified by the integration aspects found in the Cadastral Information Integration Lifesaver: technical, institutional, legal, political, economic and social.

3.2. History of Cadastre in Guatemala

The history of cadastre in Guatemala is a subject that has not been properly addressed by literature; there are so few documents that properly describe it. While the present research does not pretend to become the main historic reference material and considering that greater efforts should be made in the future to go in depth with that subject, this chapter presents a more detailed study than its predecessors in which three main historic stages of cadastre in Guatemala have been identified: its early years, the agrarian institutional development in the second half of the 20th century and the creation of the Cadastral Information Registry (RIC).

3.2.1. The early years of cadastre in Guatemala

Cadastre in Guatemala had its origins in the urban areas. Some of the first cadastral maps can be traced back at least to the 19th century depicting subdivisions of parcels in different urban centers and even when cadastre back then was not established in the same magnitude and formality as Napoleon did in

France (Zevenbergen, 2002), those maps show that the initial trend was about carrying out cadastral activities only in certain areas.

One of the first maps that contain information related to parcels and owners is the 1821 *Topographic Plan of Guatemala City and its common lands* (National Geographic Institute of Guatemala (IGN), 1972). The map carefully describes all Guatemala City's surrounding lands and their respective owners. The name of this map seems to suggest that a detailed study took place like the kind cadastre does, making it one of the first (if not the first) cadastral maps of Guatemala (lower left, Figure 4).

In 1877 the Property Registry is created (Registro General de la Propiedad, 2013), thus establishing the first institutional formalization with control over land property in the modern sense in Guatemala. Back then no cadastre was considered to support land registration procedures. It was until 1892 that as part of the extinct Development Secretariat (*Secretaría de Fomento*) an institution was created with that purpose, it was called Public Works, Agronomy, Cadastre and Geography Office (in Spanish: Dirección de Obras Públicas, Agronomía, Catastro y Geografía) and two years later surveying works started in order to compile a new national map (Erba, 2008).

Cadastral maps from those early years show that cadastral works in the country were focalized in areas of particular interest and not necessarily responding to the country's needs such as the case of *Karte der Alta Verapaz 1901* (upper right, Figure 4), showing a delimitation of land property and tenure in the Department of Alta Verapaz (American Geographical Society Library, 2012a).

In 1919, the U.S. American Geographical Society conducted an economic study called *Economical Survey*, with the objective of providing useful information to solve the territorial disagreement between Guatemala and Honduras that was taking place back then. The results of that study can be seen in the map below (lower right, Figure 4) called *Guatemala and Honduras 1919* (American Geographical Society Library, 2012b) and the results from that study also led to the compilation of the *Cadastral Map* of 1929, which is one of the oldest and finest cadastral maps that have survived to these days (Comisión de Límites, 1929).

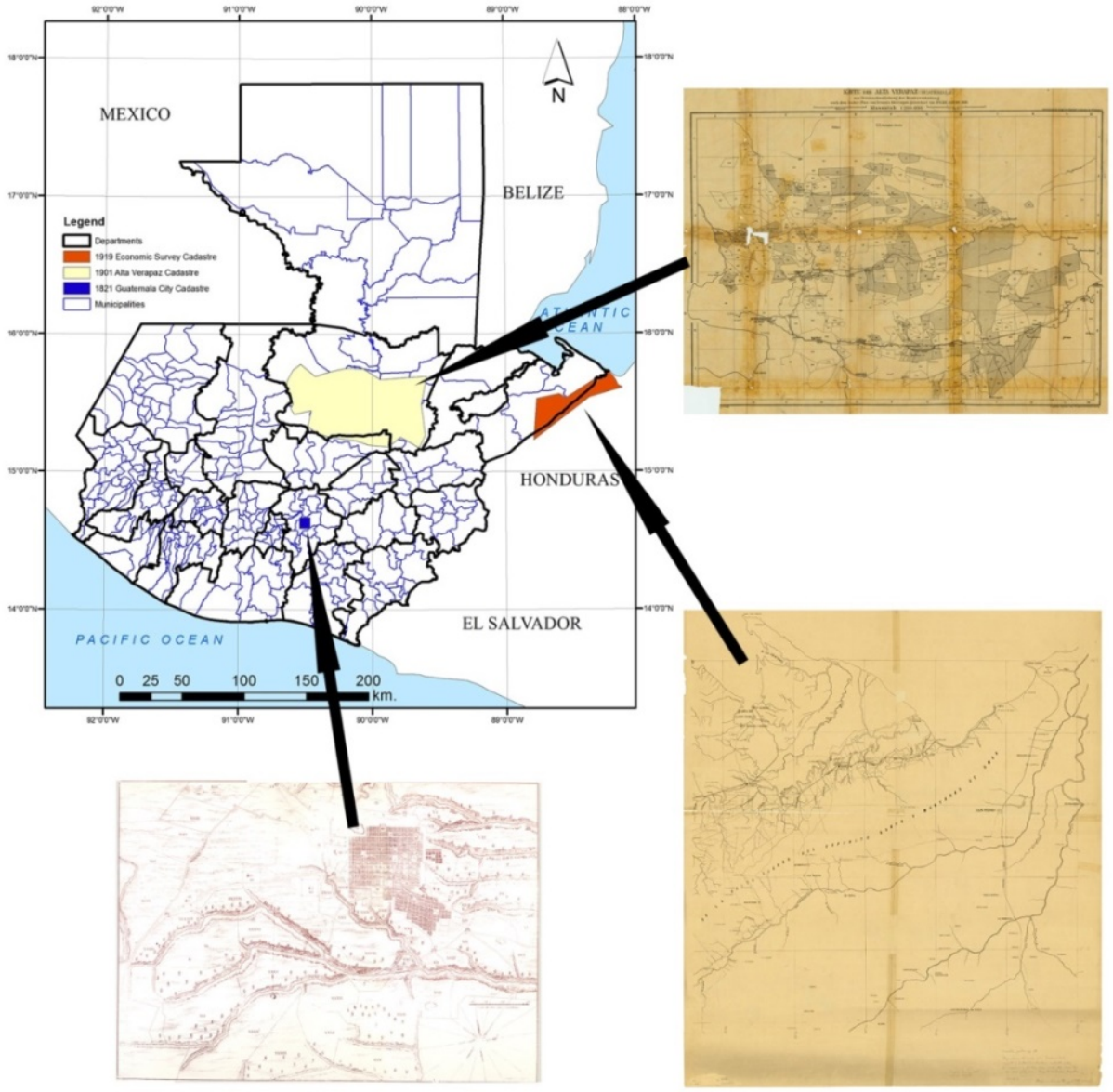


Figure 4. Cadastral coverage in the early days of cadastre in Guatemala. The center figure shows a digitalization of the areas covered by the cadastral projects that are represented in the respective surrounding historical maps (own work).

All the aforementioned studies and maps exhibit the state of Guatemalan cadastre on its early days which was the result of isolated efforts that took place in specific areas of interest; none of these projects was continued after they were finished.

3.2.2. Agrarian institutional development in the second half of the 20th century

After the political turmoil caused by the effects of the 1954 counterrevolution and the abolition of the 1952 Agrarian Reform, in 1959 the Guatemalan State decides to create the Enterprise of Economic Development of Petén –FYDEP– (In Spanish: *Empresa de Fomento y Desarrollo Económico de El Petén*) with the objective of promoting the installment of human settlements and farming cooperatives, negotiate timber industry concessions, chicle gum extraction and distribute State land, using for those purposes the

then vast land national reserves located in the Department of Petén to the north of the country (Grunberg, 2012).

FYDEP as an institution initiated an identification of the available lands thorough an own cadastre that allowed the location of fallow lands for the accomplishment of the institution's goals and subsequently control all concessions granted. After 28 years of operation in Petén the government decided to dissolve FYDEP due to alleged bad management and corruption within the institution. Map 1 shows the then geographic coverage of FYDEP's cadastre in 1987, when the institution was cancelled (northern region of Guatemala).

In 1962 the Agrarian Transformation Institute (INTA) was created with one of its purposes being the establishment of an agrological cadastre in order to clearly identify vacant or unused lands in the country (Congress of the Republic of Guatemala, 1962). According to Erba (2008), the lack of application of sound cadastral procedures caused several social and institutional problems, which hampered the correct implementation of such cadastre.

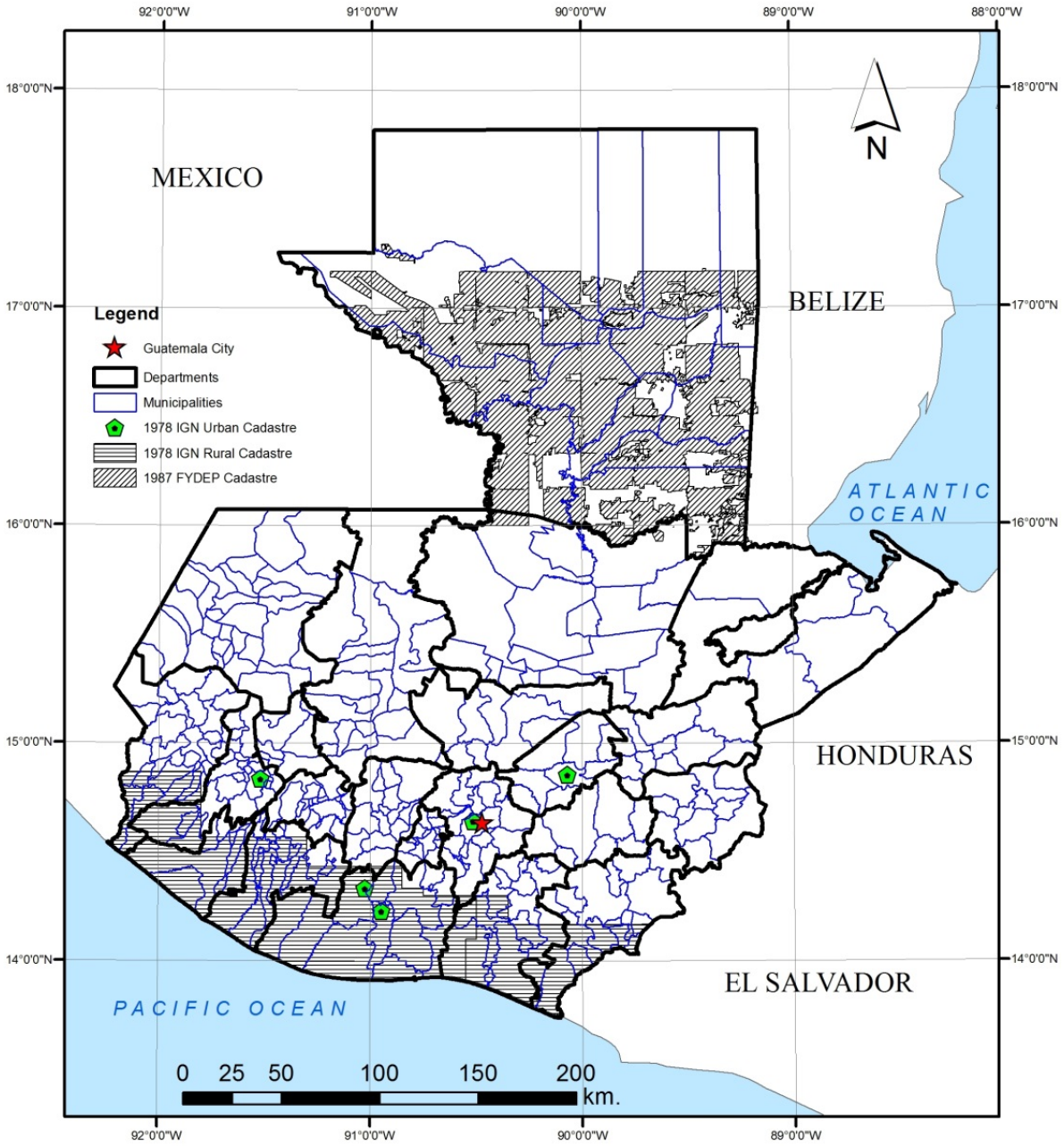
Three years later, in 1965, the Cadastre Division is created within the National Geographic Institute (IGN) as an effort to institutionalize the national cadastre by means of a competent agency with the sufficient technical capacity to carry out a project of such nature.

In 1968, a big and ambitious project starts within the IGN's Cadastre division aimed to install a Multi-purpose cadastre in the Departments of Guatemala south of 15º parallel with an estimated planned coverage of 33,000 km² (Pan American Institute of Geography and History, 1977). By 1977 the project had covered a total of 18,000 km² with rural 1:10,000 and urban 1:1,000 scale photomaps (map 1, southern area with horizontal hatching); that project lasted until 1978 when lack of a supporting law combined with several organizational and economic aspects (Erba, 2008) led to the suspension of most of the project's activities.

In 1978 the Cadastre and Real Estate Valuation Office (DICABI) was created with the purpose of building a cadastral database oriented to the improvement of tax collection related to real estate (Public Finances Ministry of Guatemala, 2004).

In 1982, due to the Civil War in Guatemala, the government decides to turn IGN into a military cartographic institute where, according to Valdés (2006) all cadastral activities were completely abandoned owing to the direction change taken by the institution.
Meanwhile, DICABI managed to build its initial cadastre taking advantage of IGN's cadastre and eventually focused on the management of real estate registries of the majority of municipalities so it could control the collection of the property tax known as IUSI (Valdés, 2006).

According to Erba (2008), the last effort of the Guatemalan government to establish a nationwide cadastre took place in 1987 when an integral cadastre project was established in cooperation with the government of France; however, once again due to lack of inter-institutional coordination and lack of economic and human resources the initial idea of a nationwide cadastre was abandoned a year later.



Map 1. Main cadastral works that existed in Guatemala in the second half of the 20th century. (Pan American Institute of Geography and History, 1977), (Grunberg, 2012).

In 1997, one year after the signing of the Peace Accords in Guatemala, the Inter-institutional Commission for the Strengthening and Development of Land Property Rights (known as PROTIERRA) was established with the objective of addressing the land tenure issues considered in the Peace Accords. Through this Commission the Technical-Legal Unit (UTJ) was created as a government agency responsible of performing cadastral and other activities oriented to the improvement of land tenure security.

It is under these conditions that the first Land administration project was implemented in Guatemala. It consisted of an effort to increase legal security of land tenure and strengthen the legal and institutional framework for land registry and cadastre (World Bank, 2007).

Land Administration project eventually led to the passage of Land Fund law (FONTIERRAS), the establishment of an integrated institutional structure between cadastre and registry, opening of registry offices in the Department of Petén, resolution of land conflicts and most important, the passage of RIC law in 2005.

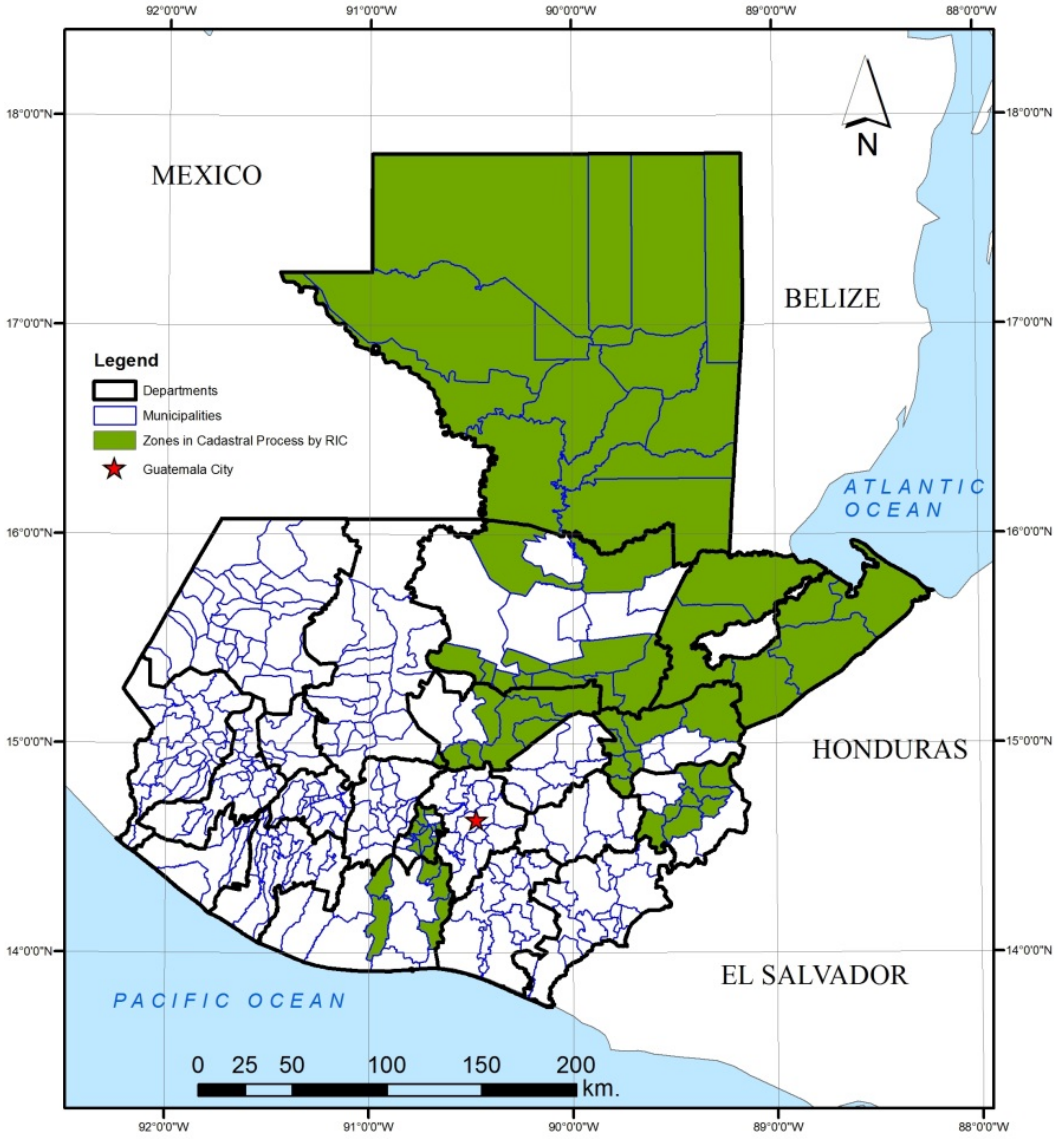
3.2.3. Creation of the Cadastral Information Registry (RIC)

RIC was created in 2005 according to the law of the same name (Congress of the Republic of Guatemala, 2005) which defines it as an autonomous State Institution with the objective of establishing, maintaining and updating the national cadastre and with its creation the biggest effort to implement a nationwide cadastre in Guatemala takes place.

RIC assumed all the responsibilities and assets of UTJ, thus becoming the implementing agency of Land Administration projects thenceforth. As one of its first measures, RIC started with the establishment of Zones in Cadastral Process first focusing on the municipalities that were attended by UTJ prior to RIC's creation.

With the necessary legal and institutional framework in place, cadastre in Guatemala was ready to move forward and in 2006 a second phase for the Land administration Project was approved. It was conceived to consolidate an integrated and financially sustainable cadastre and registry system to provide users in the project area with accurate information on urban and rural land parcels (World Bank, 2005); one of the goals of this project was to extend the original geographic coverage and as a result cadastral operations were established in 8 more departments of the country (World Bank, 2014).

RIC is currently working on a *Zone in Cadastral Process* declaration basis which means that cadastral operations conducted by RIC can only take place if such a zone is legally declared as such (the minimum zone area is an entire municipality). Guatemala has a total of 338 municipalities of which only 68 have been publicly declared as Zones in Cadastral Process (Registro de Información Catastral de Guatemala (RIC), 2014). Such municipalities or zones can be seen in green in the following map:



Map 2. Municipalities currently declared "Zones in Cadastral Process" by RIC. (Registro de Información Catastral de Guatemala (RIC), 2014).

3.2.4. Municipalities and their own cadastres.

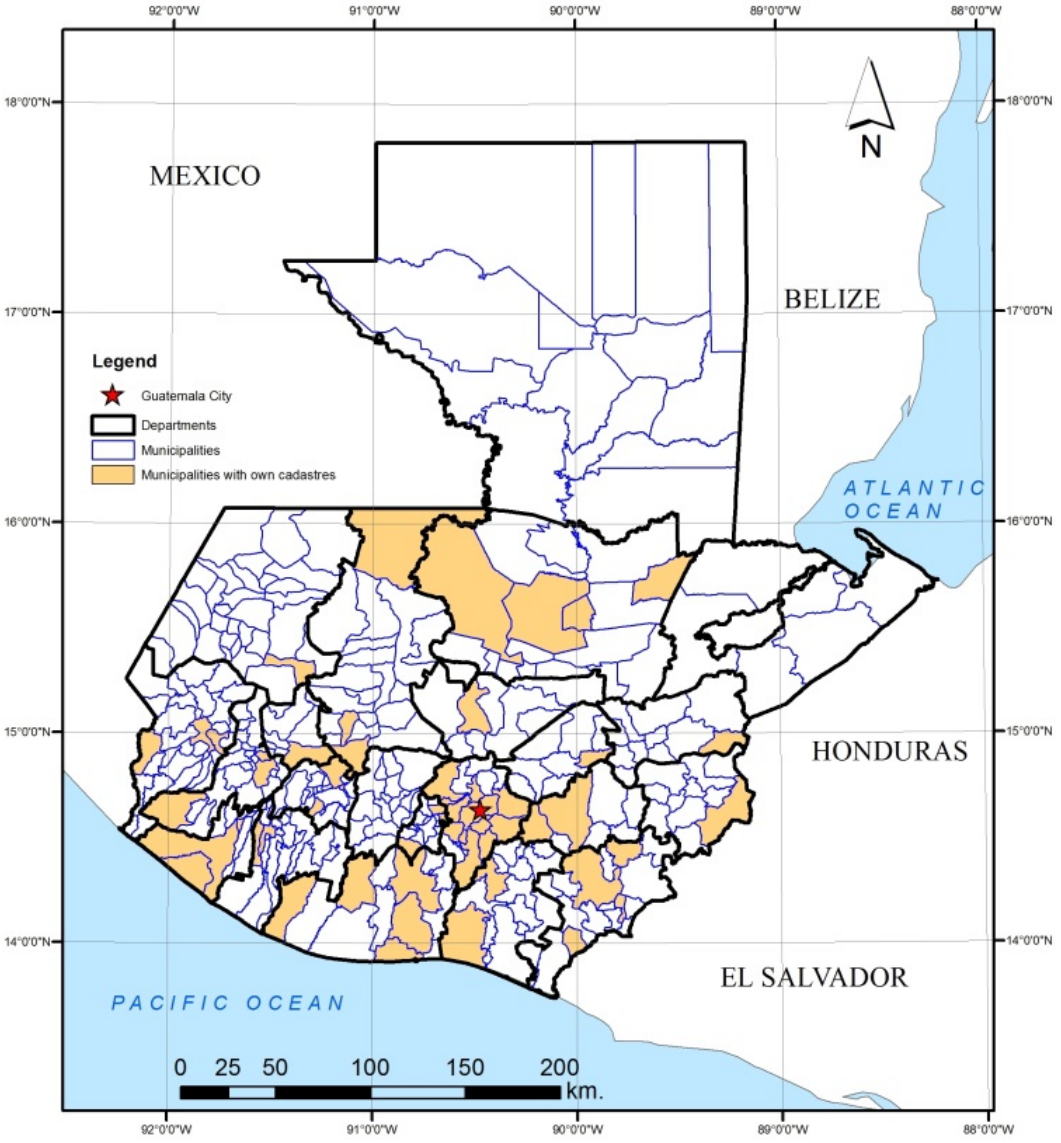
Municipal cadastres in Guatemala, understood as some form of parcel-based information have a very recent history with the only exception of Guatemala City, with the oldest municipal cadastral system in the country which can be traced back as far as the 19th century.

Although there are no reliable sources of information to confirm it other than the institutional archives or memories from past public servants it seems to be that the next municipal cadastres started in the 70's when IGN's Cadastre Division started different projects in urban areas (Pan American Institute of Geography and History, 1977); many of the municipalities that by virtue of IGN obtained a cadastral system decided to keep updating them.

The majority of the current municipal cadastres appeared in the beginning of the 20th century, this can be explained by the following three causes: 1) The signing of the Peace Accords in 1996, because it favoured

the demilitarization in the country allowing cadastral data collection to be a safe activity; 2) The issuance of the Real Estate Unique Tax law (IUSI) in 1998, which meant an opportunity for municipalities looking for an improvement in their revenue and 3) The issuance of the Municipal Code in 2002 which reorganized public administration in the municipal level including a mandate for the municipalities to take care of municipal and territorial planning, encouraging them to establish a municipal cadastral office in case they did not have one.

The National Statistical Institute –INE– (2012) states that there are 74 municipalities with their own cadastre. In order to confirm this figure, a web-based search was conducted in order to confirm INE's information, the search was done through the use of the keywords *cadastre* and the municipality name applied to all of the municipalities outside RIC cadastral zones over the web. The search resulted in the discovery of eight additional cadastres as well as the finding that some of the municipalities considered by INE are in fact part of RIC's cadastral zones thus leaving a final number of 55 municipal cadastres that are completely independent from RIC; their geographic distribution can be appreciated in Map 3.



Map 3. Municipalities with own cadastral systems in Guatemala as of 2014. (Guatemalan Statistical Institute (INE), 2012)

3.3. Current status of cadastre in Guatemala

Currently, two major institutions are carrying out cadastral activities: the Cadastral Information Registry (RIC); and municipalities, which according to the Guatemalan Municipal Code a municipality is an autonomous institution of public law, whose objective among others, is to establish and maintain the municipal cadastre (Congress of the Republic of Guatemala, 2002). The following diagram shows a summary of the cadastral institutional development in Guatemala across the years:

CENTURY	START YEAR	GUATEMALAN CADASTRE INSTITUTIONS								END YEAR
		DEVELOPMENT SECRETARIAT	FYDEP	INTA	IGN CADASTRE	DICABI	UTJ	RIC	MUNICIPALITIES	
XIX	1892									
XX										
										~1950
	1959									
	1962									
	1964									1964
	~1970									
	1978									
										1982
										1987
	1997									
XXI	2005									2005
	PRESENT (2014)									PRESENT (2014)

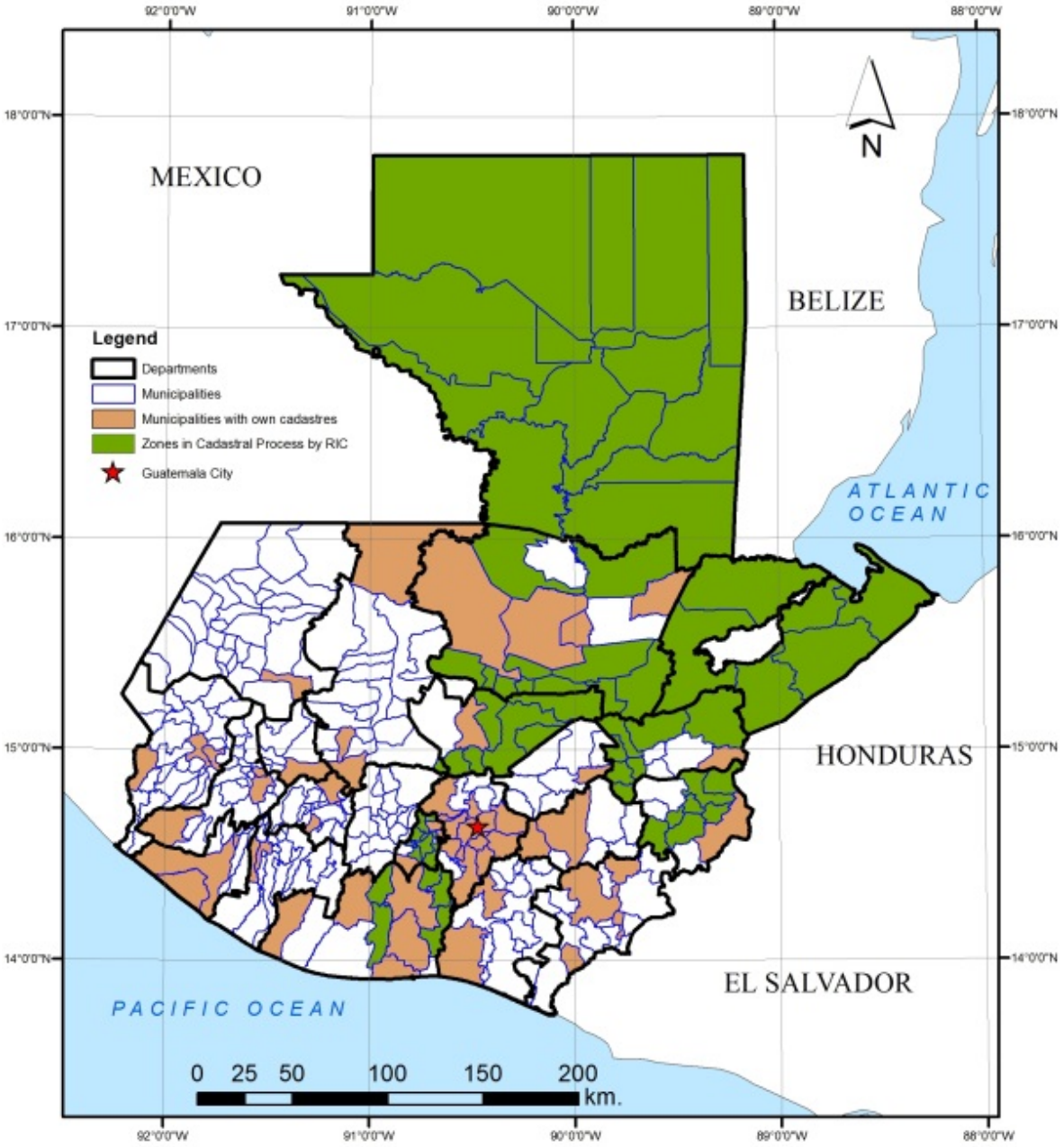
Table 4. Overview of Guatemalan institutions responsible of cadastre over time (own work).

Although DICABI initially was conceived with the objective of developing the national cadastre especially for real estate, it moved to a more passive role in cadastral activities especially because of RIC's presence in the country, its current activities are tax collection and decentralization, valuation system management and fiscal registry of real estate (Guatemala, 2004).

DICABI can still be considered as a third institution involved in the cadastral process in Guatemala, however, the fact that it is no longer performing cadastral operations in the country turns it into a potential source only for historical research. Basically, any type of user interested on looking for historical cadastral data can refer to DICABI's archives since it has been present in the country much longer than RIC and it therefore might have useful information, especially for some particular areas.

For the purposes of the present research, it must be understood that the fact that DICABI is not working on cadastre anymore, it cannot be considered as a potential source for integration since most of the cadastral data contained on its archives is probably outdated or even improper for the current requirements that RIC's nationwide cadastre need.

These last considerations finally leave us with the figure of only two major institutions in Guatemala at the present time: RIC and municipalities. Their current coverage in the country is shown in map 4, which also gives us an idea of how fragmented is the Guatemalan cadastre yet.



Map 4. Current geographic coverage of cadastre in Guatemala. RIC's coverage in green (northeast) (Registro de Información Catastral de Guatemala (RIC), 2014); municipalities in beige (center, south and west). Municipal cadastres according to the Guatemalan Statistical Institute (INE)(2012) and own research.

3.4. Concluding remarks

Across the present chapter it is possible to see that a very marked fragmentation tendency was present throughout most of Guatemalan's cadastral history. The tendency consisted of a continuous establishment of cadastral operations scattered in different areas across the country which could be in the form of:

- A standalone cadastral project for a specific purpose
- An institution with a specific mandate of implementing a cadastre

The first, standalone cadastres, were implemented in particular regions and aimed to discover or portray the land tenure situation in those regions in order to provide information for planning and development. The second, institutions, were created with a more solid foundation. Especially in the cases of IGN and FYDEP (as presented in section 3.2.2), at the beginning those institutions started in the middle of big expectations and considerable budgets, and although FYDEP was created to concentrate its efforts only in the Department of Petén, it is presumable that a final result would have been IGN's cadastre sweeping up north to Petén and finally completing the much desired dream of a nationwide cadastre (see Map 1).

Instead, the result in those two cases was the abandonment of cadastre due to different reasons: organizational problems related to corruption and the Civil War. While the first could have been avoided by implementing stricter auditing and transparency for instance, the second depended more on social security, which is more difficult to address. However, even in those circumstances the government was responsible of securing the already collected data since the investment done for acquiring it was huge.

It is notorious that all of the cases presented in the previous sections, either if they were just projects or institutional formal implementations, show that all cadastral operations always tended to be established in different areas instead of focusing only in one area, a fact that could possibly be explained by the choice of conducting pilot projects instead of nationwide projects, except for RIC's case which up to now has been the first one to be fully recognized as such. It is here where the fact of fragmentation becomes evident; it is the result of an unfinished historical development and the incapacity of the State to provide a prompt and sound cadastral legislation since the very beginning.

Based on what was reviewed in the present chapter and using the Cadastral Information Integration Lifesaver as the analytical tool, the causes of fragmentation in the Guatemalan cadastre can be summarized as follows:

- Technical
    - Different surveying and data acquisition methods used by the institutions
- Institutional
    - Frequent change of institutions responsible of cadastre.
    - Discontinuity of established cadastral projects
    - Freedom of choice for municipalities. Before 2005 there was no legal instrument to conduct municipal cadastres into an oriented path aimed to a nationwide vision.
    - RIC still does not have the sufficient capacity to ensure observance of the Technical Cadastral Regulations across the country; many municipalities are still technically deviated from them.
- Legal
    - Technical Cadastral Regulations passed until 2008. All cadastres prior to that date were formulated according to varying procedures provoking in some cases the abandonment

of cadastral projects due to difficulties found or inconsistencies presented in the expected results.
    - Lack of synchronization between different laws and law articles prior to RIC law led to freedom of action by the involved institutions.
    - Overlapping in functions and responsibilities caused by issuance of laws oriented to different purposes
- Political
    - Changing political will from the government in the second half of the 20th century responding to circumstantial factors typical of the time.
    - Diverse interests that have driven cadastres to be set up only in certain areas.
- Economic
    - Budget cuts for cadastre, leading to partial or total abandonment of cadastral activities
    - In the case of municipalities, economic inequality and priority changes over time have obliged them to abandon cadastres or kept them from establishing one.
- Social
    - Authorities in some cases have chosen to avoid the establishment of a cadastre in potential conflict areas because especially in rural areas, cadastre is perceived only as an instrument of taxation.
    - Population in general does not have a clear comprehension of cadastre and its benefits, this has kept civil society from historically demanding a solider cadastral infrastructure in the country.

4. EFFECTS OF FRAGMENTATION IN THE GUATEMALAN CADASTRE

4.1. Introduction

Land parcel databases or cadastres contain information related to graphic and descriptive information of land property and tenure; the fact that they depict the distribution of land in a given area is vital for government, society and private sector. When these cadastres are in a state of fragmentation, such as in the case of Guatemala, the nationwide benefits that cadastres represent are considerably minimized.

This chapter provides answers for the question "What are the effects of fragmentation for the Guatemalan Cadastre?", it portrays the different effects that such a state of fragmentation produce, based on the knowledge of the Guatemalan cadastral context acquired in the previous chapter as well as the primary concerns from the land administration perspective, as presented by some of its most significant current authors providing elements for documentation and analysis that helped on the development of a potential approach at the end of the research.

Official sources, actual examples of the existing situation and personal experience have been used in order to provide information for answering this question. The question is answered by first building a coherent structure, then examining the primary sources, and finally presenting the effects that can be inferred from what is seen happening in the country.

According to RIC's law, the National Cadastre consists of graphic and descriptive information i.e. spatial and non-spatial information (Congress of the Republic of Guatemala, 2005), its Article 74 states that such National Cadastre will contain cadastral information collected by RIC itself and cadastral information collected by other State institutions, effectively integrated into one and only database. We know from the previous chapter (Causes of fragmentation in the Guatemalan Cadastre) that the cadastral information collected by other State institutions is fragmented, meaning that up to date a number of State institutions still have cadastral information without any control by RIC and considering the mandate by Article 74 it is a primary concern to solve the problem of fragmentation by integrating all existing cadastral information into RIC's database.

The effects of fragmentation of cadastre in Guatemala were classified by the same aspects that are found in the Cadastral Information Integration Lifesaver as analytical tool: non-technical (institutional, legal, political, socio-economic) and technical.

Effects caused by cadastral information fragmentation can be positive or negative. A positive effect occurs when one of the involved parties either an institution, sector or a part of the civil society gets a direct benefit or is in a situation that produces opportunities for future benefits. A negative effect occurs when any of the involved parties has an obstacle for the accomplishment of its objectives, satisfaction of their needs or when its potential for development is halted in a particular way.

4.2. Institutional effects

This section describes the effects that cadastral information fragmentation produces in the Guatemalan institutions. For a better understanding, there are three major groups of institutions related to cadastre in Guatemala, and the effects are described for each one of these groups. The first group, which consists of the Core Cadastral Institutions, includes the institutions that are directly related to cadastre being they: RIC, the main cadastral institution; the municipalities, which currently have cadastral information but

without relation with RIC's cadastre; the Property Registry which holds land property and land tenure information and DICABI, which although officially is not considered part of the Land Administration Structure, holds historical cadastral data as well as land valuation information. The second group, the secondary land administration institutions are the ones that belong to the Guatemalan Land Administration Structure (Registro de Información Catastral de Guatemala (RIC), 2009a) and that often work with cadastral information but it is not their primary concern. The third group, the rest of State institutions is the group of Guatemalan public institutions that might eventually require cadastral information for a specific reason but in a less relevant way than the second group.

In the following table, the institutions that make use of cadastral information in Guatemala are presented; they were sorted by the relevance that cadastral information has in their activities.

GROUP	INSTITUTION'S NAME	KEY ROLE OR RELATION WITH THE CADASTRAL DOMAIN IN GUATEMALA
1. CORE CADASTRAL INSTITUTIONS	RIC	Institution responsible for the National Cadastre
	Municipalities	Institutions with own cadastres
	RGP	Holds land property and tenure information
	DICABI	Land valuation, holds historical cadastral information
2. SECONDARY LAND ADMINISTRATION INSTITUTIONS	SAA	Land conflict resolution
	CONAP	Demarcation of natural reserves and protected areas
	OCRET	Demarcation of State territorial reserves
	IGN	Geo-information production, management and updating
	IDAEH	Demarcation of archaeological and ceremonial sites
	FONTIERRAS	State land management, provision of access to land
3. REST OF STATE INSTITUTIONS	SEGEPLAN	Decision-making aid based on territorial knowledge
	INSIVUMEH	Weather forecasting, hydrology, volcanology, seismology
	CONRED	Natural disasters risk-reduction
	INE	Statistical studies
	Other State institutions	Eventual need for cadastral information

Table 5. Guatemalan institutions that make use of cadastral information. (Own work with information from RIC's report "Land Tenure Security" (2009))

4.2.1. Effects for the Core Institutions

4.2.1.1. For RIC

RIC, being the main cadastral institution in the country with its own law and regulations, considers the other existing cadastres as potential sources for valuable information which unless proven not useful will be eventually integrated into its own cadastral database.
The fact that there are currently 55 municipal cadastres away from RIC's direct control (map 4) constitutes a challenge that will be complicated because, as stated before, all of them are different in scope, nature, data quality and other important technical matters. Up to now, RIC still does not have an official methodology to address this challenge, which according to Doerr et al. (2006), should at least consider two major phases:

- Compilation (obtaining the information)
- Consolidation (analyzing and integrating the information)

However, as stated in Chapter 2 (Current Views on Cadastral Information Integration) and also by Mohammadi et al. (2006), an information integration process is much more than just the technical part, which would be relatively easy if the other non-technical components of the lifesaver are not considered.

It is then a clear effect for RIC the challenge of paying attention to this process from a wider non-technical perspective in order to cover the necessary non-technical aspects of integration (Mohammadi, H., Rajabifard, A., Williamson, 2009). In addition, another effect for RIC is not having absolute control over cadastral operations in the country. RIC is by law the main authority in cadastral information management, and as such, it must have formal control over all entities that collect, manage and update cadastral information in Guatemala indistinctly if they are institutions or not, public or private. According to Das (1998), formal control is a regulatory process by which elements of a system are made more predictable through the establishment of standards in pursuit of some desired objective; in addition such control is said to be aimed at the establishment of task reliability (Bijlsma-Frankema, 2005). These two keywords, predictability and reliability are essential in any cadastre with the characteristics of the Guatemalan one in which one institution must have control over the others. The fact that municipal cadastres are currently working under their own regulations (which by the way is by no means illegal) proves that a formal control by RIC is yet far from being a reality.

Cases like Guatemala City's cadastre training cadastral technicians (Municipality of Guatemala City, 2013) without supervision by RIC's cadastral school, the procedural manual used by the Municipality of Santa Catarina Pinula, conducting activities such as issuing cadastral certificates or regulating parcel subdivisions (Municipality of Santa Catarina Pinula, 2014) and the still in force *Cadastral Form for Properties* (In Spanish: Tarjeta Catastral de Inmuebles) in the municipality of Quetzaltenango which is a form for collecting legal data on parcels are examples of such lack of control by RIC.

Since the information held by the municipalities is in this manner distant from RIC's control, it does not let RIC fully accomplish its objectives as stipulated in RIC's law first chapter: Objective, Nature and Functions (Congress of the Republic of Guatemala, 2005) because in order to have access to that kind of information, it must first ask for it which is in contradiction with the legal mandate.

4.2.1.2. For Municipalities

The fact that municipalities are part of the cadastral fragmentation in the country (i.e. being separated from RIC's control) also brings consequences, although they are more closely related to each municipality's capacity because that condition can be an advantage in some cases and a disadvantage in other cases. Four main effects have been identified in this category.

The first effect comes from a possible lack of support from RIC as the main cadastral institution. This is true for those municipalities that lack experience or the sufficient resources to carry on a cadastre aligned with the Cadastral Technical Regulations; by not having access to a proper technical support, the work done by them is in risk of getting outdated or deviated from the expected quality.

The second effect, closely related to the prior one, can be in the form of incapacity to implement the Cadastral Technical Regulations. By not implementing those regulations, municipal cadastres with weak systems are in risk of losing validity in the national scene, leading to a possible waste of resources and time that as a consequence will lead to the need of redoing the whole process again.

The third effect is the risk of not having their information managed and protected by RIC. The fact that RIC was conceived with the purpose of building a nationwide cadastre implies that it has the capacity of organizing, maintaining and updating a cadastral database for the whole country. While municipalities are separated from RIC's cadastre, their information is at risk of being damaged or even lost if it is not stored in a proper platform like the one RIC has.

A fourth effect is the relative independence brought by the separation from RIC. This effect is an advantage and opportunity for stronger municipal cadastres because it gives them more power of action,

allowing them to have more freedom of choice for doing what they might need according to their own needs without being subject to a higher authority that can restrict their actions.

4.2.1.3. For the Property Registry

Currently in a transition stage, characterized by a digitalization and modernization of its work, the Property Registry (RGP, as abbreviated in Spanish) is already asking users to include RIC's Cadastral Plan (Registro General de la Propiedad (RGP), 2009) in the municipalities already declared as Zones in Cadastral Process (map 2).
The fact that the Guatemalan cadastre is currently fragmented has four main scenarios for RGP, which constitute a hindrance for the achievement of its own goals:

1) Municipalities already declared as Zones in Cadastral Process, whose cadastre is entirely controlled by RIC
2) Municipalities that are currently in a transition stage with two cadastres: their own and the one controlled by RIC.
3) Municipalities with their own cadastre with no control (at the moment) by RIC
4) Municipalities with no cadastre at all.

Considering these four scenarios, it is evident that RGP has to be very careful when requiring cadastral information, especially in the issuance of Land Titles because this dynamic situation can lead to blunders in the registration process such as using the inappropriate information as base data for its work.

This situation forces RGP to maintain a constant and careful supervision of what is going on in the cadastral domain in order to avoid acting illegally as well as carefully informing users of what is required in each case.

4.2.1.4. For DICABI

As indicated in the previous chapter, DICABI was for some time the only institution in Guatemala with the legal mandate of being in charge of cadastre and even though it did not manage to establish a formal cadastre in the country it actually did collect a huge amount of real estate information which is now used especially for tax collection and valuation.

The fact that now DICABI is focused on real estate information implies that it often needs to rely on cadastral information, however, cadastral information fragmentation in the country means that this institution has to choose from different sources which are not always appropriate for its needs, having to evaluate it first before deciding which one to use and which not.

4.2.2. Effects for the secondary Land Administration institutions

The Land administration State institutions in Guatemala are nine according to RIC's official point of view as presented in Table 5. In that table, RIC, the Property Registry (RGP) the Municipalities and DICABI constitute the core cadastral institutions while the other six (Group 2, Table 5) play a more passive role in terms of cadastral information management, meaning that even though they actively contribute to and make use of it, cadastre is not their primary concern.

Demand in cadastral products and services is quite ample for these six institutions since cadastral information provides detailed information about land tenure and property, in that sense, cadastre is a tool

that is used to identify, demarcate and manage parcels, areas or even regions that intersect, contain or are contained within these institutions' interest. These institutions are presented in the following table:

NO.	ACRONYM	NAME	NAME IN SPANISH
1	SAA	Agrarian Affairs Secretariat	*Secretaría de Asuntos Agrarios*
2	CONAP	National Council of Natural Reserves and Protected Areas	*Consejo Nacional de Áreas Protegidas*
3	OCRET	State Territorial Reserves Control Office	*Oficina de Control de Reservas Territoriales del Estado*
4	IGN	National Geographic Institute	*Instituto Geográfico Nacional*
5	IDAEH	Anthropology and History Institute	*Instituto de Antropología e Historia*
6	FONTIERRAS	Land Fund	*Fondo de Tierras*

Table 6. Secondary Land Administration institutions in the Guatemalan public sector (Registro de Información Catastral de Guatemala (RIC), 2009a).

The effect of fragmentation for this institutional structure (the Secondary Land Administration institutions) is directly related to the scope of each one of them. While for some institutions it might be far enough to know certain aspects of land tenure and property situation in relatively small areas where cadastral information from any source might be equally useful, there might be more complex cases in which it is necessary to look for information in different data sources.

A good example of working with a fragmented cadastre could be the delimitation of State Territorial Reserves which in most cases their coverage is larger than a municipality. In those cases, the institution responsible for that is OCRET, which can face a hindrance when trying to use cadastral information from municipalities that have different types of cadastres.

Another example is the case that a certain institution is used to work with a certain type of data format and when requiring information from another source the datasets do not match, having to recur to a possible data evaluation and transformation before being able to use it according to its needs.

4.2.3. Effects for other institutions in the public sector

As occurs in the case of the Land Administration structure, the diversity found in the different cadastres in Guatemala can constitute big challenges for an institution requiring cadastral information for relatively large areas. Guatemalan institutions such as the Meteorology Institute (INSIVUMEH), the Statistical Institute (INE), the Disaster Reduction Agency (CONRED), the 22 Departmental Governorships and the Secretariat of Planning and Programming (SEGEPLAN) are some examples of organizations that belong to this group.

These institutions can find it difficult to deal with cadastral fragmentation; there is however an ongoing initiative called SINIT that plans to overcome these difficulties through the use of a digital centralized data repository (Secretariat of Planning and Programming (SEGEPLAN), 2012).

The biggest difficulty in this case happens when any of these institutions needs to obtain cadastral information from different sources, which can easily hamper any of the uses that they want to give to such information. This is especially complicated when they also require historical data because in that case they would probably have to resort to other institutions, such as the ones that carried out a cadastre in the past and that were presented in Table 4.

4.3. Legal effects

In this section we refer to a law in the broad sense of the word, assuming that when we refer to a law we can also be talking about a regulation, norm, standard, procedure, guide or manual; in Guatemala, a law is a rule made by the Congress of the Republic of Guatemala while Regulations (also norms, standards, procedures, guides or manuals) are made by each State institution. For example, RIC's law was made by the Congress while the Cadastral Technical Regulations and the Cadastral Surveying Guide were made by RIC's Directive Board.

In Guatemala as in many other countries, in order to make a new law or regulation, a common practice is that the law maker (the Congress or State institution) draws up a first bill draft, gathers all involved or affected parties for which the potential law or regulation will be applicable, establishes general guidelines by consensus with them, evaluates full compliance and compatibility with other already existing laws or regulations and if accepted then the law is made, approved and published.

Since there is a state of fragmentation in cadastral information in which approximately 59 institutions are involved (the 4 core cadastral institutions from Table 5 plus the 55 municipalities with own cadastres), the consensus is difficult to achieve, thus becoming a hindrance both in law making and in law enforcement.

RIC's law has some articles for its relation with municipal cadastres: Article 3, sections L and N state that whenever municipalities require cadastral studies or reports, RIC is obliged to provide it as well as provide technical training when needed; Article 3, section P states that RIC shall coordinate with municipal territorial or real estate offices in order to observe RIC's law and its regulations; Article 50, section C states that municipalities and RIC will coordinate the adaptation of municipal cadastral information to the legal and technical regulations; Article 74 states that municipalities with cadastral information must give it to RIC, which will conduct an integration process of such information into its own cadastral database; Article 75 states that municipalities that wish to carry on cadastral activities must coordinate with RIC by means of an agreement in which both will define the actions to be taken

Since fragmentation occurs at the municipal level, it seems logical to assume that either the Congress or RIC can eventually make a new law or regulation in order to enforce any of RIC's law articles mentioned above i.e. make those articles operative.

Two negative effects of fragmentation in the legal aspect are identified: as a hindrance to cadastre-related law making and as a hindrance to law enforcement. In this context, hindrance is understood as the situation in which there is an impediment in a given law issuance process caused by a situation in which reaching a consensus is complicated or there is a compatibility problem with another existing law.

Hindrance to law making. To consider the existing fragmentation can be a big challenge that would not exist if cadastre was firmly integrated into one. In this case law making is subject to always consider cadastral fragmentation as a reality that must be taken into account in order to promote the maximum benefit from that situation as well as avoid possible obstacles that can turn into losses or unnecessary expenses for the State.

Hindrance to law enforcement. A municipality currently carrying out legal operations supported on its own cadastre can be in contradiction with RIC law mandates. In the same way, RIC can find difficulties when implementing its own law in certain municipalities that already have their own legal provisions.

4.4. Political effects

A well-designed Land Administration System (LAS) is essential for the implementation of political decisions such as minimizing disputes or achieving the protection of human rights (Wallace et al. 2010).

Since cadastre is often considered as the main LAS tool, it is then evident that a fragmented cadastre as it happens in the Guatemalan case, poses a difficulty in the implementation of land policies.

The Land Administration Project, financed by the World Bank, showed that the current efforts of this project in order to build a national cadastre (therefore eliminating the current fragmentation) have already started to have an impact on the political aspect in the government given the fact that it has built strong political support especially for the implementation of the Peace Accords (World Bank, 2007)

The two effects that cadastral information fragmentation bring into the country's political context are two: the difficulty to promote agrarian policies that rely on cadastral information and the difficulty to implement fiscal management policies.

In the first case, agrarian policies can be considerably affected in their formulation due to a fragmented cadastre since they cannot be founded on a unique type of cadastre; these policies are in danger of not being properly implemented due to the need of having a unique type of land property and tenure information. Agrarian policies such as municipal development, land conflict resolution, housing provision and urban planning as mentioned by Cabrera (2002) are examples of this.

In the second case, land tax collection and management is negatively affected because the fragmented state of the cadastral information does not allow the government to rely on consistent information as it varies from municipality to municipality. This is especially true for IUSI, a unique property tax which is widely based on cadastral information as it stated by IUSI law's Article 15 (Congress of the Republic of Guatemala, 1998).

4.5. Socio-economic effects

Four effects are observed in this aspect: access to public services, Peace Accords implementation, unequal land market and cadastre as a driver for investment.

Access to public services. A perceived effect on this matter is the inequality in access to services for the population in general because in many cases this depends on cadastral information. The fact that there is more than a source of cadastral information conditions the access only for those places that have such information; even when at a municipal level it can work, at a regional level access would be greatly reduced due to inconsistency in the different datasets.

Peace Accords implementation. The Peace Accords, in their Agrarian Situation and Rural Development chapter (Permanent Mission of Guatemala to the United Nations, 1996) establish several agreements that the State assumes for improving life quality of its citizens by improving access to land, transformation of land use structure and inclusion of rural population into the political, social and economic development. In order to do so, much of the information needed is in the cadastral databases which when being fragmented, constitute a big difficulty for the State and its responsible agencies for the accomplishment of these Accords since they must do additional investments to evaluate and make use of the required information.

Unequal land market. It is the effect produced by an unequal control over territorial information present in the cadastre, which by being fragmented and of diverse nature promotes inequality in the provision of incentives, transactions control and registration processes among other problems, causing different effects on the land market, making it more secure in some areas and less secure in other areas.

Cadastre as a driver for investment. In the context of public and private investment, the current state of fragmentation stimulates investment only on those areas that have an efficient cadastre that guarantees

land tenure and property security in contrast with those that are more focused on tax management. The fact that RIC law promotes the creation of a nationwide cadastre is an opportunity for new investments to arrive in areas where currently the fragmentation state does not allow that to happen.

4.6. Technical effects

The effects in the technical aspect come as a result of the different standards that the institutions have. While RIC has a very well defined standard for cadastral data defined by the Cadastral Technical Regulations (Registro de Información Catastral de Guatemala (RIC), 2008), the majority of municipalities have not implemented these regulations yet and as a result, the quality of the data that all the institutions have varies greatly in all different technical components of their cadastres.
The first technical effect is in the existing cadastral information diversity and the consequent difficulty to establish an integration process that considers all possible cases. Figure 5 shows how diverse municipal cadastres are and how their graphical part contrasts with RIC's information. It is important to point out that for the observer the graphical part in this figure plays a key role but it is necessary to remember that the characteristics of every cadastre also vary, this is true for example in the legal part where some municipalities don't collect land ownership information while others even have a well-developed link with RGP –the Property Registry– in order to guarantee the quality of the information that is been used.

In Figure 5, eight cadastres are shown: the first (upper right) is an extract of the cadastral information collected by RIC itself in 2012 in the municipality of Cabañas, Department of Zacapa; the information dataset was approved and is currently available for visualization in RIC's Geo-portal (http://www.ric.gob.gt/geo-portal) meaning that its quality complies with the Cadastral Technical Regulations and therefore its quality is sufficient for the requirements of the national cadastre. The second one (center right) is located in the municipality of San Agustín Acasaguastlán, Department of El Progreso basically consisting of just a property identification (no geometry attributes present). The third one (lower right) is an extract of the cadastral map by the municipality of Monjas, Department of Jalapa characterized by a "rectified" geometry in which all acute and obtuse angles have been turned into right angles. The fourth one (center below) is a depiction of Guatemala City's cadastre which is characterized by a highly accurate geometry and a very complete and reliable information on land parcels' legal and urban classification; the geo-portal allows access for general enquiries and basic urban planning information (http://mapas.muniguate.com/ipot/Run.jsp). The fifth one (lower left) only shows the shape of the urban land parcels of the municipality of Zunilito, Department of Suchitepéquez (http://municipalidaddezunilito.com/Descargas/MAPAS.rar). The sixth one (center left) shows the cadastre of the City of Quetzaltenango in which, due to projection and transformation issues does not match with the ortophoto meaning that it requires further analysis and transformation before being suitable for a potential integration into RIC's database. The seventh one (upper left) shows an identification of house numbers in the town of San Andrés Xecul, Department of Totonicapán; although it might not be a cadastre in the strict sense of the word, the information existing in that municipality can still be useful and therefore worth to be considered in a potential cadastral information integration process. The last one (upper center) shows an image of the former municipal cadastre of Pachalum, Department of Quiché, shows the considerable blunders that the graphical information presented; a study conducted by RIC in the area revealed that the data was graphically inconsistent and therefore could not be integrated into RIC's database (Jiménez, 2010).

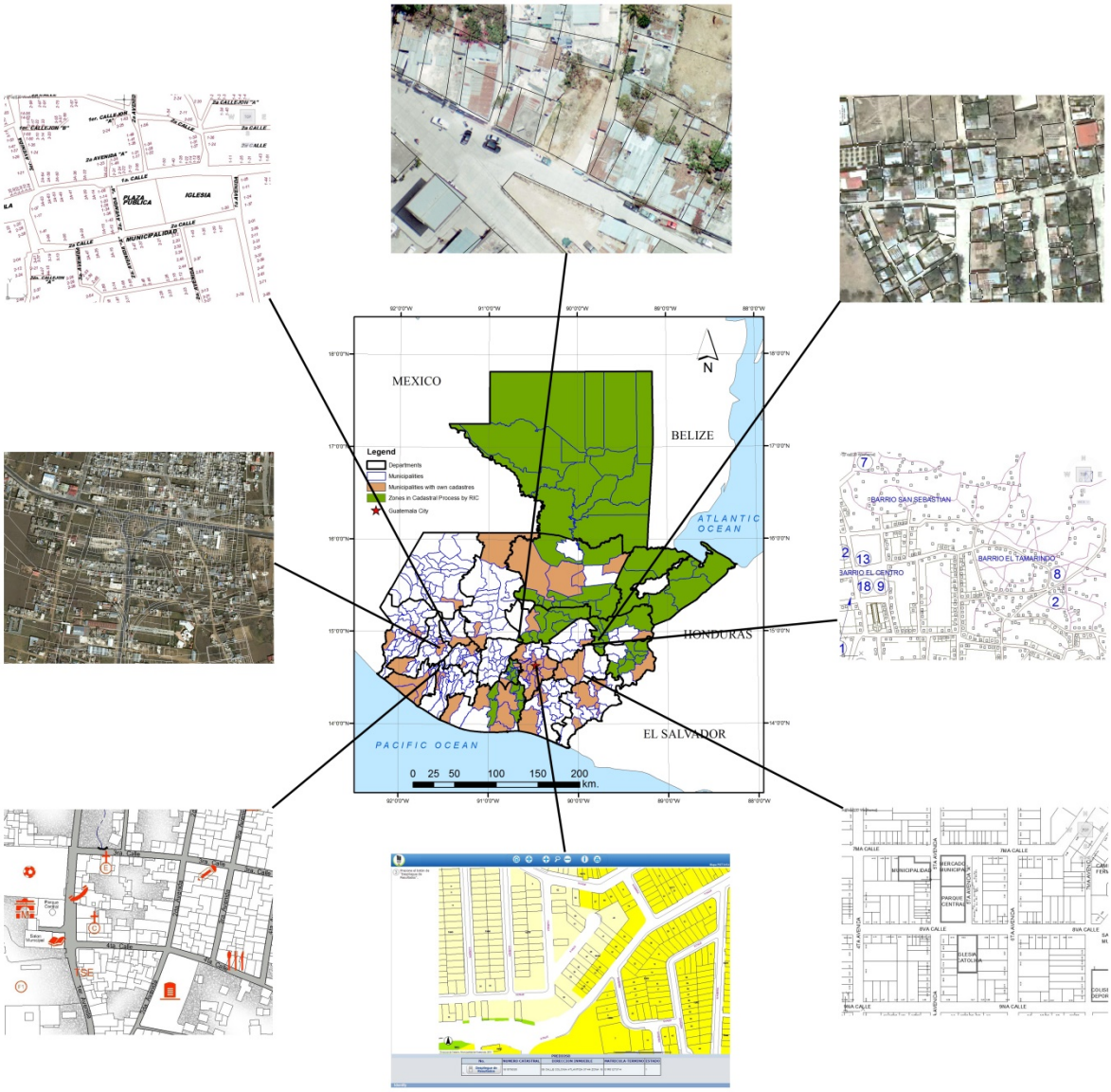


Figure 5. Eight different municipal cadastres in the Guatemalan context and their contrasting graphical differences.

Therefore, the huge diversity of possibilities presented in the technical nature of all the existing cadastres produces a negative effect on the technical integration process because it is necessary to conduct a research on the characteristics of each cadastre to determine the possibility of using that cadastral data.

A second effect in the technical part comes from the potential need of using different neighboring cadastral datasets for a specific purpose. If there is incompatibility in the technical nature between those datasets i.e. data provided at a variety of accuracies and resolutions, it is then difficult to decide which one to use, if no official criteria exists (such as a sound and official integration procedure), the institution, organization, agency or entity that wishes to use cadastral information for a specific purpose finds an obstacle because in principle there is no way of knowing which cadastral dataset is more suitable for that purpose.

A common practice in Guatemala when building new roads or broadening new ones is to locate the parcels in the area of interest in order to find out which of them will be affected for expropriation and

compensation matters. In Figure 6, a road network is crossing different municipalities which have their own different cadastres; which parcel data should be used in this case?

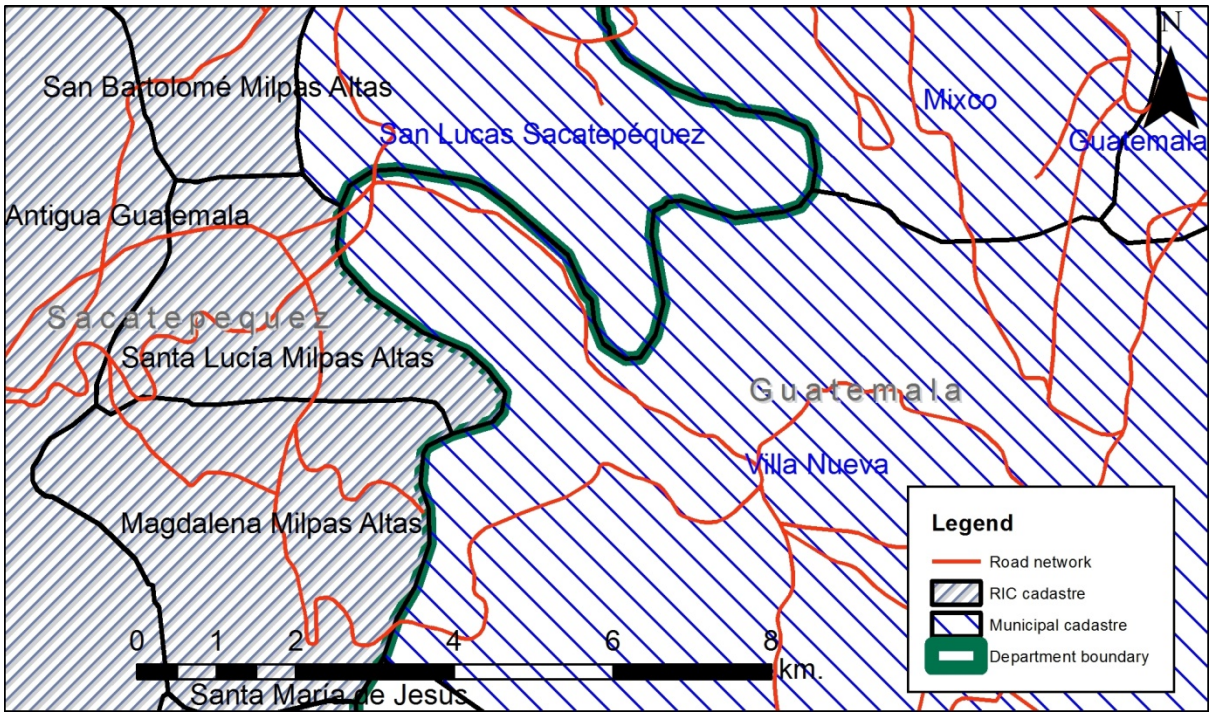


Figure 6. Example of different neighboring cadastral datasets and the difficulty that their difference presents when used simultaneously for road construction (Own work).

A third effect however is that this diversity also makes it possible to gain experience from it because there might be some procedures or applied standards that work better than those considered in the official Cadastral Technical Regulations, especially in the cases where municipalities had to implement certain strategies in their local contexts in order to conduct a successful cadastral data acquisition. If well studied, RIC can gain leverage from this knowledge and therefore apply it in the future when necessary.

4.7. Concluding remarks

The purpose of this chapter was to evaluate and list the actual and/or potential effects that cadastral information fragmentation may have in Guatemala, describe if they are positive or negative and for whom. In the following table the list of effects is summarized:

Type of effect	Positive effect	Negative effect	Main actor affected
Institutional	Relative independence from RIC's control	Challenge due to the need to consider the non-technical aspects of integration	RIC
		Lack of control over cadastral operations	RIC
		Possible lack of support	Municipalities
		Incapacity to implement the Cadastral Technical Regulations	Municipalities
		Risk of information loss when not having it properly secured	Municipalities
		Difficulty on using diverse cadastral information for a specific institutional purpose (complications presented when choosing which cadastral information to use)	Municipalities
			Property Registry (RGP)
			DICABI
			Land Administration institutions (SAA, CONAP, OCRET, IGN, IDAEH, FONTIERRAS)
Legal		Hindrance to law making	Congress of the Republic
			State Institutions
		Hindrance to law enforcement	Congress of the Republic
			State Institutions

Type of effect	Positive effect	Negative effect	Main actor affected
Political		Difficulty to implement agrarian policies	Government
		Difficulty to implement Fiscal management policies	
Socio-economic		Unequal access to public services	Civil society
		Difficulty on implementing the Peace Accords	Government
		Unequal land market	Civil Society
		Unequal conditions for investment	Civil Society
Technical		Difficulty to produce an integration procedure that considers all existing cases	RIC
		Incompatibility between neighboring cadastres makes it difficult to decide which one to use for a specific purpose	Any potential user of cadastre (RIC, State institutions, L.A. institutions, civil society, etc.)
	Possibility of gaining experience from the existing diversity in cadastres		RIC

Table 7. Summary of effects produced by cadastral information fragmentation in Guatemala.

The findings in this chapter show that effects of cadastral fragmentation in Guatemala have a mainly negative connotation. In the context of national cadastre, the huge diversity in cadastral information is seen as an obstacle for all of its users, especially the State, in the form of an executive power or in form of its institutions. The fact that there is a huge diversity of cadastres in the country constitutes a hindrance in the implementation of projects, programs and policies, especially when they are conceived in regional contexts i.e. more than two municipalities at a time but with different cadastral information structures.

The main institutional effect is lack of formal control by RIC. Not having formal control means that RIC cannot effectively manage the existing cadastral information in the country as required by its own law; this leads to poor predictability and reliability in the municipal cadastral information.

The lack of formal control by RIC produces a negative effect for municipal cadastres as well since they cannot have access to effective support and formal recognition by RIC which in turn would open opportunities for own development, obtaining technical and organizational improvements in their cadastral information management.

The level of detail regarding land property and tenure that a cadastre allows to identify is a big advantage for the State to accomplish its objectives, such advantage however, is considerably minimized because of

the varying nature of the cadastres present in the country turning into an additional cost for the State and its institutions, which has to spend more resources on determining the feasibility of using the different cadastres available and if feasible, spending on the adaptation of such cadastres for the required purposes.

Cadastral information fragmentation produces inequality of opportunities and development for the civil society in the socio-economic aspect. The problem that fragmentation represents in this case is that development projects focused on territorial or land matters cannot be based on reliable information which happens in the areas where there is more than one type of cadastre without a link between them. The effect for the civil society is that in general there is not equal access to services, benefits and support.

The positive effect of fragmentation is visible in two dimensions: as a generator of knowledge and experience for the ongoing nationwide cadastre i.e. for RIC and as independence and freedom of action for stronger municipal cadastres.

5. SOLUTIONS THAT HAVE BEEN TRIED SO FAR IN GUATEMALA TO SOLVE THE PROBLEM OF FRAGMENTATION

5.1. Introduction

Just before RIC's law, the documentation found does not seem to indicate that there was a big concern for solving the problem the fragmentation probably because the State did not want to get involved in the solution of a problem like that without having a proper law, i.e. a cadastral law. It was not until then when the first efforts appear to address the subject in a more direct way.

The present chapter describes on one side the different strategies or solutions that have been identified in the public sector in Guatemala to address the problem of cadastral information fragmentation and on the other side a couple of solutions that took place in the field of geo-information management which at the time of their implementation was fragmented as well.

In the case of Guatemalan cadastre, a search for relevant sources was conducted in every relevant institution as well as articles and white papers that describe the solutions that have been tried so far, resulting in the identification of three institutions where the solutions have taken place: RIC, municipalities and the Institute of Municipal Development (INFOM). In the case of geo-information management two main actors and their consequent solutions were identified: the National Geographic Institute of Guatemala (IGN) and the Secretariat of Planning and Programming (SEGEPLAN).

5.2. Solutions tried in the Cadastral domain

5.2.1. INFOM's Municipal Strengthening Policy

The Institute of Municipal Development (INFOM) is a Guatemalan State institution created in 1957 substituting the former Department of Municipal Credit (now defunct); it is based on the Decree 1132 by the Congress of the Republic and it has the objective of promoting the development of all the municipalities providing them with financial and technical assistance. INFOM's law Article 4 (Congress of the Republic of Guatemala, 1965) establishes (among other matters) that this institution will provide technical assistance to municipal cadastres.

In order to that article to be followed, it is necessary that being INFOM an entity in charge of municipal strengthening it gets to know which municipalities in Guatemala have an own cadastre and which ones are willing to establish one; it is also required that INFOM creates an effective coordination with all of them.

Even though no direct mention can be found in INFOM's official web page about how that institution carries out its municipal cadastral assistance policy, the National Economic Research Center (2003) states that INFOM has procedural guides that describe how and in which manner INFOM will assist municipalities in the establishment, management and updating of municipal cadastres. The existence of these procedural guides proves that somehow in the past, INFOM had an active participation in the municipal cadastral process and it is logical to assume that after RIC was created in 2005 as the institution responsible for cadastre in Guatemala, INFOM probably stopped providing municipalities with technical assistance in order to let RIC assume the responsibility for that.

Unfortunately, the fact that these procedural guides are only mentioned and that to date no record exists of them (at least in the web) does not let us know how exactly INFOM managed to help solve the problem of fragmentation or even worse, if it is still doing something to address that problem.

5.2.2. RIC's Non-official Manual for the Integration of Institutional Cadastres

Soon after RIC's law passing in 2005, cadastre was implemented in 6 Departments in Guatemala in which RIC had to work in coordination with the majority of the municipalities where cadastre was implemented in order to guarantee the success of cadastral operations and at the same time, some of those municipalities already had their own cadastres.

In view of this situation and considering that RIC's law Article 74 mandates that all State institutions having cadastral information must give it to RIC, that institution decided to elaborate a technical methodology to follow what Article 74 mandated.

The document (Registro de Información Catastral de Guatemala (RIC), 2006) describes the necessary steps to take in order to verify an institutional cadastre for a possible integration, it indicates how to verify that the obtained cadastral information complies with the technical requirements contained in RIC's Technical Cadastral Regulations (Registro de Información Catastral de Guatemala (RIC), 2008) and if it does it stipulates that RIC will prepare a report indicating the findings as well as a judgment of whether the verified cadastre is capable of being integrated or not into RIC's cadastral database.

This document currently lacks of an official character since it has not been officially approved by RIC's Board and it is neither present in the list of manuals, policies and regulations available at RIC's official web page. In addition, the document is currently not in use which gives it its character of 'non-official' in what respects to the present research.

In the referred document, the steps to be taken in order to verify an institutional cadastre are the following:

a) Social Communication: Process aimed to the population living in the areas where the cadastre is going to be verified, with the objective of announcing that verification and quality control activities will take place, including field data acquisition in some parcels.
b) Cadastres acquisition: Act in which all cadastral information belonging to an institution is requested.
c) Project reports acquisition: Process in which all technical and legal reports done by the entities responsible of data collection for the cadastre are obtained.
d) Control and follow-up: Assignment or hiring of the personnel that will be responsible for doing the verification and technical equipment.
e) Sample design: Calculation of the total number of land parcels to evaluate (5% according to RIC's Cadastral Technical Regulations) and geographic assignment of the sample.
f) Evaluation of Cadastral Support Networks: Establishment or selection of the proper geodetic network over which topographic verification activities will be done.
g) Form filling: personal and parcel data collection for filling the cadastral forms in order to compare them with the original ones.
h) Topographic sample: topographic surveying of the parcel boundaries and beacons of the sample.
i) Refinement of cadastres: process in which the digital files of the cadastre to be analyzed are inspected and cleaned before adapting it to the according standards.
j) Transformation to GTM coordinate system: projection and transformation of the dataset into the local GTM Guatemalan coordinate system as required by law.

k) Analysis: phase in which the obtained product is compared with the expected standards. It is done by analyzing the land parcels of the sample one by one to detect blunders, errors or inaccuracies in both graphic and descriptive data.
l) Final report: it is the report where the verification team indicates the verification findings as well as the judgment of compliance with RIC's Cadastral Technical Regulations.

The verification steps contained in this document address the problem of fragmentation from the technical perspective, especially from the point of view of RIC's Cadastral Technical Regulations in which all the verified cadastres must comply to these regulations; this is good since it seems to be the most reasonable way to perform the technical part of the integration process.

In this document it is not specified if the institutions whose cadastre is to be analyzed will directly or indirectly participate in the verification process as stated in a). This is a crucial consideration since municipal authorities have a better understanding and relationship with the local civil society and their organizations and thus the success of the social communication depends on their active participation. It is notorious that steps b) and c) are very limited not only in contents but also in explaining how the information request will be done. It is assumed that all of the institutions with own cadastres will provide the requested information in an immediate and effective way but it is not clear how this will be guaranteed; there is no mention of how each institution will be informed of the benefits of cooperating with the verification process and how doing so will effectively contribute to their own needs. It is neither mentioned what will be the role of each institution in the verification process, especially the institution's personnel, it is only mentioned that a "team" will be in charge of it but the selection process is not clarified, for example if it will be possible for some of the institution's employees to participate or if it will be RIC's responsibility to assign them, etc.

In summary, the main problem with this document is that it is focused on the technical part of the verification process. The document has in addition procedural holes which threaten the whole cadastral integration by not being clearer and therefore leading to misinterpretations.

5.2.3. Spontaneous adaptation of municipal cadastres to RIC's Cadastral Technical Regulations

Since RIC's law came into force, Article 75 (Cadastral acts to be done by municipalities and any other State institution) states that institutions with own cadastres are required to do the necessary changes in their cadastres to adapt them to the new RIC's Cadastral Technical Regulations. It is also implied that new cadastral surveys to be conducted in the future must follow such regulations. Article 75 states that in order to achieve this, involved institutions must establish cooperation agreements with RIC, which must contain: a) Instruments for data collection b) verification mechanisms by RIC and c) incorporation of the obtained information into the National Cadastre.

Despite the fact that these agreements are a good alternative because they encourage mutual understanding between RIC and institutions, the mandate stipulated by Article 75 must be followed therefore being necessary to lay down deadlines and conditions for its accomplishment. The first step would be that RIC identifies which institutions have a potential for entering the process, whether if they have a cadastre or if they are willing to have one, approaches them and takes them into account in all the current and future cadastral integration processes; this would let them participate contributing with knowledge and information and therefore supporting decision-making resulting in a more collaborative integration process.

On the one hand, some municipalities have already started the adaptation process after RIC's law issuance, however, such process can require considerable investments for the municipalities that currently do not

have the required technical capabilities for complying with RIC's Cadastral Technical Regulations and that is probably one of the main reasons of why not all of them have undertaken that process yet. In this case it becomes evident that municipalities need financial and technical support to adapt their cadastres to RIC's standards because otherwise just a few will get involved into adaptation, leaving it to RIC's responsibility in the future.

On the other hand, after RIC's law came into force some municipalities started their own cadastres using RIC's Cadastral Technical Regulations from the beginning in order to avoid any further required adaptation and at the same facilitate the imminent integration as a result of the establishment of a national cadastre. A good example of this situation comes from the western part of Guatemala where RIC is still seen as a distant authority that will take a long time before it arrives there: the case of San Pedro Sacatepéquez in the Department of San Marcos whose cadastre started in 2006 with the aid of a mutual agreement with RIC in which the municipality established the cadastre based on RIC's Cadastral Technical Regulations (Zapet, 2013).

5.2.4. RIC's policy to foster participation of municipalities in the cadastral process

Formulated in 2009, it is a policy that aims to establish a link between RIC and municipalities with emphasis on the diversity of situations and backgrounds that are found in the municipal context (Registro de Información Catastral de Guatemala (RIC), 2009b). This policy considers three possible cases: a) municipalities with an own cadastre; b) municipalities interested on establishing an own cadastre in cooperation with RIC and c) municipalities that do not comply with A or B but are located inside priority areas for RIC.

RIC's policy of participation of municipalities is divided into five strategies for the implementation of the cadastral process:

1. Cadastral implementation based on the technical capacity and degree of municipal interest
2. Definition and implementation of a promotion plan
3. Formulation and implementation of plans to address each municipality according to their own interests
4. Promotion of a synergic inter-institutional coordination
5. Establishment of a technical training workshop plan for municipalities

As an instrument for linking RIC with municipalities, this policy serves as the foundation for any planned cadastral integration process because it creates a mutual understanding while considering each municipal context as a priority. Three main characteristics of this policy have been identified:

- It lays down the action plan for each one of the five strategies although in a very general probably because RIC, in its will of adaptation to each municipality's situation, apparently left the door open for further considerations. In this sense, the five strategies mostly emphasize the vision of signing agreements aimed to promote mutual benefits between RIC and municipalities.
- It is characterized by RIC's openness strategy in which municipalities are expected to manifest their interest on getting involved in the cadastral process in one way or another. Once the interest is demonstrated, RIC will address those municipalities through the application of the necessary strategies based on their demands and own situations.
- It explains that priority areas for RIC are those that are located in relatively close distance from RIC's current presence (Map 2), which leaves the rest of the municipalities apparently unattended. This situation could be in part explained because by law, RIC as a State institution cannot perform investments outside its jurisdiction unless it is clearly stated on its annual budget.

5.3. Solutions tried in the Geo-information domain

5.3.1. SNIG Spatial Data Infrastructure

Described as a 'mechanism' to provide access to interested parties (National Geographic Institute of Guatemala (IGN), 2001), it is a Spatial Data Infrastructure (SDI) developed by the *Inter-institutional Unit in support for the development of the Geographic Information National System Databases*. SNIG stands for Geographic Information National System (in Spanish: Sistema Nacional de Información Geográfica).
At the beginning, SNIG's inter-institutional unit was directed by the National Geographic Institute of Guatemala (IGN) and the Secretariat of Planning and Programming (SEGEPLAN) comprising a total of 18 institutions and organizations, all of them having geoinformation for different purposes. The main objective was to build an SDI oriented to data sharing between organizations dealing with geoinformation in order to leverage the available information and establish a unique repository for geoinformation management.

SNIG's inter-institutional unit was organized in five commissions in order to provide the necessary elements for decision-making, management and coordination. These commissions are:

- Administrative Commission: responsible for institutionalizing, putting into operation and coordinating SNIG as well as obtaining financial resources
- Technical Commission: responsible for the definition and application of technical regulations
- Commercialization Commission: responsible for promoting and divulging the benefits of SNIG and implementing sales mechanisms.
- Logistics Commission: responsible for the identification of resources and needs of SNIG and the formulation of strategies, plans and projects to make SNIG operative.
- Training Commission: responsible for the identification, formulation and implementation of training plans.

The current most significant evidence of this project is in the form of geoportals which were implemented in four institutions' web pages in order to display the product of inter-organizational information sharing developed by SNIG.

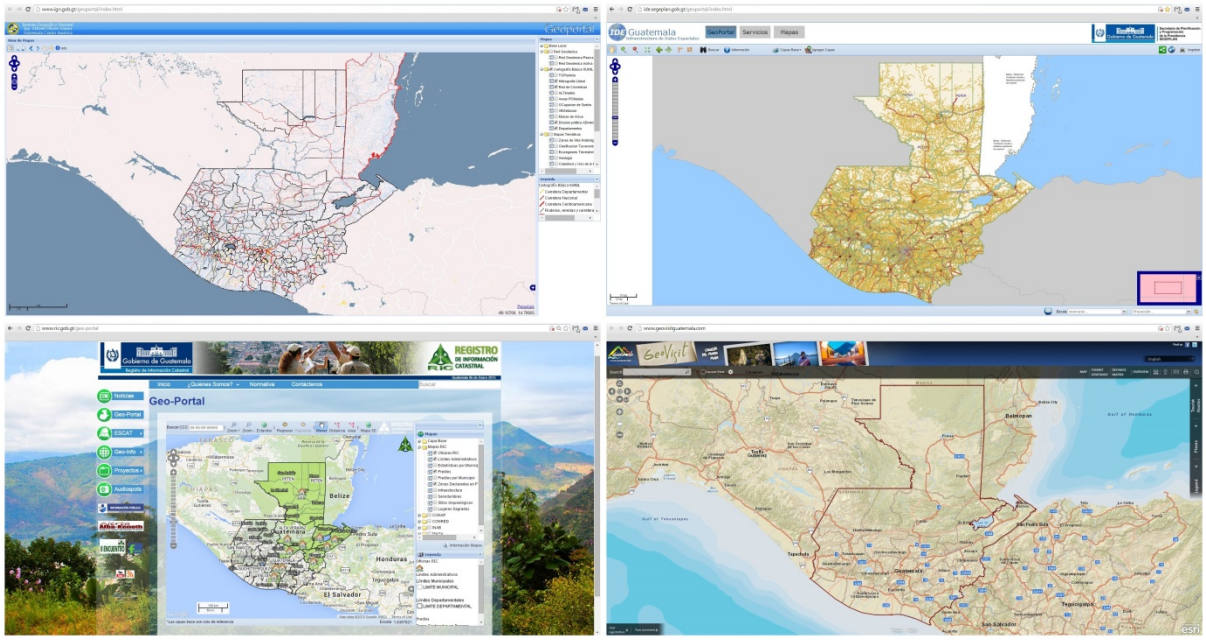


Figure 7. The four Guatemalan institutional geoportals show inter-institutional integrated information as a result of the SNIG project. Starting from upper left, going clockwise: IGN (http://www.ign.gob.gt/geoportal/index.html); SEGEPLAN (http://ide.segeplan.gob.gt/geoportal/index.html); RIC (http://www.ric.gob.gt/geo-portal) and INGUAT (http://www.geovisitguatemala.com/).

Although it was created in 1999, 12 years later Figueroa (2011) recognized that the SDI itself has not been developed yet, considering the current geoportals as 'initiatives' that will be the basis on which the objectives of SNIG will be achieved. This partial underachievement of SNIG to the present responds to two main causes: gradual loss of IGN's technical capacity especially in activities related to the implementation of SNIG and the advent of SEGEPLAN's SINIT project.

The gradual loss of IGN's technical capacity was driven by a series of factors which include budget and personnel cuts, the culmination of major international-funded projects aimed to strengthen IGN's capacities such as the Mitch-Clearinghouse project (financed by USAID) which lasted until 2001 (van Praag, E., Tieszen, L., Pedreros, D., 2001) and the Geodetic Network Strengthening project (financed by the US National Geodetic Survey) which lasted until 2001 (U.S. Agency For International Development, 1999) and the growing prominence of SEGEPLAN in SDI management.

SEGEPLAN's SINIT project (described in detail in the next subsection) was developed during the implementation of SNIG and eventually gained more prominence due to the fact that SEGEPLAN, being the Executive's power operative and strategic arm, has been strengthened in the later years not only by the government itself but also by the international community for follow-up and monitoring of Millennium Development Goals (United Nations Development Programme (UNDP), 2009).

5.3.2. SEGEPLAN's Territorial Information National System –SINIT–

According to the report elaborated by the Secretariat of Planning and Programming (SEGEPLAN) (2006), SINIT was created in that same year as a part of a major inter-institutional model called SINPET, which stands for Strategic Territorial Planning National System. SINIT is a system that makes territorial information accessible through different computer-based platforms in order to orient decision-making and contribute to the formulation of training programs. It is based on three major working areas:

- Access to municipal and departmental information for designers, planners, advisers and researchers.
- Information disclosure for communities, general public and international community.
- Support in decision-making especially for fund allocation according to Strategic Planning with a territorial approach.

SINIT is administered by SEGEPLAN with support by IGN (Secretariat of Planning and Programming (SEGEPLAN), 2012) in contrast with SNIG which is managed by both institutions in an equal level of responsibility.

SINIT was implemented by establishing a collaboration model between institutions that manage geo-information, particularly IGN and the Statistical Institute (INE). The main strategy for its implementation was the centralization of geo-information management through SEGEPLAN and the coordination through the Departmental Development Councils (multi-sectorial bodies appointed to serve in administrative and advisory functions to foster the development of each Department of the country) which are responsible for the coordination of strategic territorial and municipal development planning (Rodríguez, R., Aldrey, 2009). In addition, it added RIC as a major information provider and international alliances were incorporated in order to integrate Central American and even Latin American information (Secretariat of Planning and Programming (SEGEPLAN), n.d.)

While SNIG was intended to be what SINIT eventually became, especially in the development of an SDI and establishing an inter-institutional alliance the key success of SINIT comes from the fact that SEGEPLAN –its implementing institution– currently serves as the technical arm for the government, especially for the development projects that are conducted by the Executive Power.

Currently in the Guatemalan geo-information sector, SINIT is seen as a much more authoritative figure in terms of gathering spatial information as well as the main reference for obtaining geo-information. The amount of information available to the public in SINIT's geo-portal is greater than the information offered by the other institutions that have geo-portals, this can be confirmed by visiting and browsing the corresponding websites indicated in Figure 7.

5.4. Concluding remarks

The documentation presented along the chapter shows that in every case the solutions tried to address cadastral information fragmentation have a legal foundation as a principle where laws require establishing a link between all the institutions that deal with cadastral and geographic information.

With nothing found in the current INFOM's policy and related sources regarding cadastral technical assistance, it becomes clear that this institution lost prominence in the cadastral domain due to the issuance of RIC's law and especially, the creation of an institution responsible for cadastre in the country.

RIC's Manual for integration is a tool focused on the accomplishment of institutional cadastres to RIC's Cadastral Technical Regulations, it takes for granted however, that the establishment of a link between RIC and the institutions, coordination of activities and data transfer from those institutions to RIC will take place without problem.

The spontaneous adaptation of municipal cadastres unveils two major concerns for municipalities: the obligation of adapting their cadastres to the technical requirements in order to avoid possible negative consequences in the future and the look for a benefit as a result of getting involved in the ongoing cadastral process by RIC. In general, municipalities are not likely to initiate an adaptation process because of three reasons: 1) their technical standards are sufficient to their own needs and adapting to RIC's Cadastral Technical Regulations will not mean benefit or improvement in what they currently do; 2) municipalities lack the proper technical and financial resources to undertake an adaptation process and 3) no law enforcement mechanism exists obliging them to start the adaptation process right away.

The implementation of RIC's Cadastral Technical Regulations in municipal cadastres depends on RIC's ability to make them aware of the potential benefits, providing them support in their own cadastral needs and including them in decision making, of which the latter has a good starting point in RIC's policy for the participation of municipalities.

The assisted adaptation of municipal cadastres to RIC's Cadastral Technical Regulations is currently a polarized process to which only those municipalities located in RIC's priority areas have access. This leads to a continuation of the fragmented state of cadastre in Guatemala because by not providing all the municipalities with the necessary incentives that they need those outside the priority areas are left unattended and therefore free to keep separated from the ongoing national cadastre.

The two studied cases of integration in the geo-information domain had as initial goal the implementation of an inter-institutional collaborative model for geo-information sharing, however the achieved success for their projects greatly depended on properly addressing the political aspect. For SNIG, budget cuts that took place in the implementing institution as well as a shift in political will from the top authorities behind that project led to a weakening in its structure, leaving its original proposed outcomes far behind from expectations. For SINIT, the development of a SDI capable of providing technical assistance to the government, especially the Executive Power is what made of SINIT a much stronger system because all governmental projects that required geo-information as a basis for their planning needed an information provider, a gap that SINIT conveniently filled.

6. CHALLENGES TO BE CONSIDERED TO ADDRESS THE PROBLEM OF CADASTRAL INFORMATION FRAGMENTATION IN GUATEMALA

6.1. Introduction

This chapter evaluates the challenges that RIC as the main cadastral institution in Guatemala can face in order to solve the problem of cadastral information fragmentation. In the present research it is taken for granted that this can only be achieved by integrating cadastral information from State institutions into RIC's database, however, given the fact that integration must be done by means of a proper integration model and not just by chance; this chapter evaluates three different models of integration that are supported by relevant literature and compares equal number of scenarios for achieving cadastral information integration in Guatemala.

The three identified integration models are centralized integration, supply chain integration and reciprocal integration, the three of them constitute integration scenarios that were compared in two separate tables. The first one compares them with three integration general research directions, namely purposes, limitations and outcomes. The second one compares them with the five aspects of the integration lifesaver, identified in chapter 2: technical and non-technical (institutional, legal, political and socio-economic).

6.2. Cadastral Information Integration scenarios for the Guatemalan case

Thompson (1967) in his book *Organizations in Action* states that there are three ways of achieving coordination between interdependent organizations: pooled, sequential and reciprocal, which at the same time turn into integration models as explained by Bekkers (2007): centralized integration, supply chain integration (where it is possible to use an intermediary) and a reciprocal integration. These three scenarios are explained in the following subsections.

6.2.1. Scenario 1: Centralized Integration

Centralized Integration occurs when a super-ordinated institution takes absolute control of the integration process leaving the other institutions with the sole responsibility of providing the information. In the Guatemalan context this would mean that RIC, following the law mandate almost "literally", processes the institutional cadastral information directly becoming a centralized repository of information where all cadastral information to be integrated will be put into; in this model RIC receives the information to be integrated and is the only responsible for the integration process. In the hypothetic case where all required information is effectively provided (quickly and completely), no further effort will be made by the institutions after providing the information and therefore they will wait until such information is analyzed and a proper technical report is made by RIC notifying them if their information complies with the expected quality and if it is susceptible of being integrated into RIC's database.

This centralized integration model is implied by RIC's legislation itself which constantly suggests that the integration process will take place when the institutions provide the required information and no intermediary or collaborative mechanism is mentioned. References to such model can be found in RIC's

Law, RIC's Law Regulations and the Non-official Manual for the Integration of Institutional Cadastres, all of them explained in detail in the present work in Chapters 4 and 5, subsections 4.3 and 5.3 respectively.

This model has two main purposes: the first one is to accelerate and simplify the integration process by doing it in a single step meaning that the information to be integrated is directly taken to RIC, who will be responsible for all the integration processes needed to put it into its own database. The second one is to give RIC full control of cadastre in the country: by collecting and integrating all existing cadastres directly, RIC assumes command and control of cadastral activities in all areas where a cadastre exists.

The principal limitations for this model are two: possible mistrust from institutions and possible work overload for RIC. A possible mistrust is created in the institutions even before the process starts making them reluctant to cooperate with RIC because of perceived interference with their autonomy or as a threat for citizens' privacy. A possible work overload for RIC can become a hindrance since an integration process is *per se* complicated, integrating more than fifty municipal cadastres can be definitively challenging or even impossible in the short term.

The main outcome for this model would be RIC gaining full control of cadastre in the country, leaving it as the only commanding cadastral institution in the country which at the same time is the overarching goal of RIC.

6.2.2. Scenario 2: Supply Chain Integration

According to Bekkers (2007) a supply chain occurs when there is either a sequence in which the outcome of one institution becomes the income of the next one, or when there is an intermediary service between the source of information and the target. In the present research case, the role of the intermediary must be played by an entity under the direct command of RIC, either public or private, that serves as a facilitator between the source and the target in which such facilitation can include quality control, provision of information and aid for both RIC and the institutions, information processing and other necessary tasks that could help the integration process.

The intermediary service can in principle be provided by either RIC's Municipal Management Offices (MMO's), RIC's Technical Management Department, a new office or department created by RIC for the sole purpose of being the intermediary or by a private company hired for the effect. For the present scenario analysis, the intermediary role is assumed to be done by one of those entities regardless of their current status and capabilities since the main goal is to compare the different scenarios in a general perspective.

The purpose of this model is to establish a link between RIC and the State institutions by the use of an intermediary that has to be in direct contact with the institutions' environment in order to provide them with support and guidance to make the integration process more collaborative and transparent.

Limitations regarding this model come from the potential growth of bureaucratic procedures that might tend to slow down the integration process or either in the varying technical condition of each cadastre. The variety of situations that are present in the municipal cadastres can result in the intermediary service becoming an 'adapter' of institutional cadastres, concentrating its efforts in making cadastral information 'integrable' before RIC can put its hands on the information.

The major outcomes of this model are strengthening the relationship between RIC and the institutions as well as promoting a more equitable distribution of responsibilities for both organizations: while the institutions keep working on their cadastres, the intermediary service can serve as a quality supervisor and

RIC still performs the integration but with less work load since the information has already been checked by the intermediary service.

6.2.3. Scenario 3: Reciprocal Integration

Reciprocal Integration takes place when both the supplier (institutions with cadastral information) and the recipient (institution where cadastral information will be integrated i.e. RIC) conform a two-way communication link where both institutions obtain and provide information at the same time aiming to a state of full integration being also possible that the suppliers also share information in the process; this model leads to a multiple transmission of information.

The main purpose of reciprocal integration is to establish an integration structure in which both organizations obtain and provide information at the same time fostering collaboration at both levels. With this, the institutions can obtain access to aid from RIC (information, technical assistance, etc.) while RIC gains access to the institutional cadastral information.

Limitations for this model can be possible unequal technical capabilities from the institutions, making them dependent on what RIC can give them, an increased dependence on political will for cooperation especially from the institutions and possible slowing down of the integration process. Unequal technical capabilities from the institutions can become a limitation because RIC would have to make bigger efforts in order to obtain satisfactory results while institutions become more dependent on RIC's aid. Political will can also be a driving force in this model because not all involved institutions might necessarily cooperate which could become a threat for the model's success.

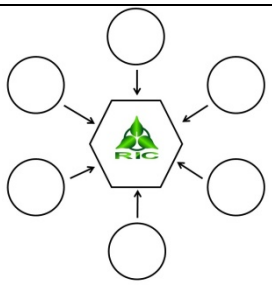
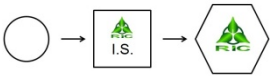
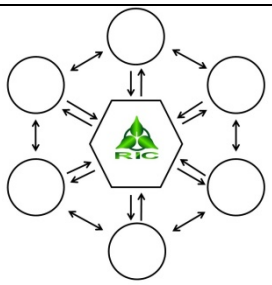
Outcomes for this model are: empowerment of RIC's and institutional cadastres and the enablement of strategic alliances between institutions. Cadastres can be empowered in this model because an installed collaboration can provide both parties with useful resources that can make them work better, for instance an institution can obtain technical assistance from RIC thus improving its technical capabilities while RIC can obtain access to the required cadastral information and also gain additional knowledge and experience. Strategic alliances aiming to an effective integration can be enabled, for example institutions can work together in the integration process or share knowledge and information between them.

6.2.4. Scenario comparison

For the scenario comparison, two tables have been built in order to assess the differences that the integration models present. The first (Table 8), shows a general view of the three models in contrast with the main purposes, limitations and outcomes that they would imply if implemented while the second one (Table 11) shows the impacts that these three models create on both sides of the integration process, that is RIC and the institutions. These scenario comparisons are not intended to portray the future but instead they aim to allow the reader identify possible outcomes.

6.2.4.1. Assessment of purposes, limitations and outcomes for the three scenarios

In the first table the assessment of purposes, limitations and outcomes is justified by the fact that Scholl & Klischewski (2007) explain that those three concepts must be taken into account when a research is done in the field of integration and interoperability. They consider them as key directions for evaluating different integration models and identifying the obstacles that can be faced in an integration process.

Type of integration	Centralized Integration	Supply Chain Integration	Reciprocal Integration
Model / Key directions			
Purposes	-Simplified integration process (integration in one step) -RIC assumes absolute control of the integration process	-To establish direct contact with the local environment allowing a smoother and more collaborative integration process -More transparent process	-To foster collaboration at both levels -RIC provides aid to the institutions while obtaining cadastral information from them
Limitations	-Possible lack of trust from institutions -Possible work overload for RIC	-Bureaucratic processes increased	-Possible unequal technical capabilities from the institutions, making them dependent on what RIC can give them -Depends more on political will for cooperation -Integration process can be slower
Outcomes	-RIC gains full control over cadastre in the country	-Enhanced trust between institutions and RIC by means of the intermediary -Better distribution of responsibilities among the participants	-Both RIC's and institutional cadastres empowered -Institutional technical capabilities improved -Enable strategic alliances between institutions aiming to possible joint integration

LEGEND

◯ State institutions with cadastral information

RIC's Intermediary service in the Supply Chain Integration

The Cadastral Information Registry –RIC–, the main cadastral institution in Guatemala where all cadastral information will be integrated into.

Table 8. Scenario comparison for cadastral information integration based on the key directions of purposes, limitations and outcomes (Scholl & Klischewski, 2007).

6.2.4.2. Assessment of impacts for the three scenarios

The second scenario comparison assesses the impacts that both organizations (RIC and State institutions) can face in each one of the aspects of the Cadastral Information Integration Lifesaver (presented in Chapter 2 as the dominating analytical tool for the present research). Each aspect has a certain degree of required effort and resources by an organization which can be less or more accordingly; the relation between impacts and effort and resources is proportional meaning that for example, less efforts and resources required by an organization in a certain aspect result in a low impact while more efforts and resources result in high impacts.

The impacts were classified as low, moderate and high, depending on the perceived implications for them: 'low' means that no major changes or efforts have to be made by the organization; the impact will not negatively affect its current situation or, there will be a positive outcome; 'moderate' means that some changes will take place in the organization's situation but those changes will be within due or reasonable limits with a balanced amount of benefits and harms; 'high' is considered to pose a challenge for the organization, meaning that its current state will be negatively affected or that major changes will have to be made in order to carry on the integration process under a particular integration model. In this context, a change or effort is a modification of the current budget, policy or administrative procedure that the organization already has in place while 'to negatively affect' means that for a given aspect, one of the proposed models of integration will act upon or influence in an adverse way one or several parts of the organization's current state.

Based on transaction cost economics theory, which provides tools for the assessment of institutional impacts, especially the asset specificities listed by David & Han (2004) and some of the particular issues addressed by authors reviewed on Chapter 2 of the present research (in particular documents 2, 3, 9, 10, 12, 15, 18 and 19 from Table 3), a careful selection of components has been chosen to evaluate each one of the aspects for the three scenarios. The components can be seen in the following table:

TECHNICAL	NON-TECHNICAL			
	INSTITUTIONAL	LEGAL	POLITICAL	SOCIO-ECONOMIC
-Specialized skills -Training needs -Development of transfer mechanism/ platform -Information security -Data pre-processing	-Complexity of process -Coordination needs -Internal arrangements -Institutional barriers	-Making of new laws / regulations -Modification of existing laws / regulations	-Transparency -Politically stability in the long term -Political risk -Trust on the counterpart -Perceived degree of response -External political support	-Integration cost -Return on investment -Changes in staff conditions (workload, income) -Employment opportunities -Change in organizational culture

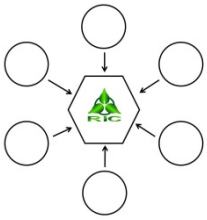
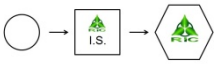
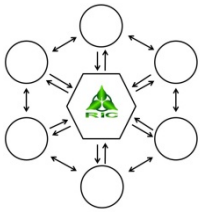
Table 9. Scenario comparison based on the aspects of the Cadastral Information Integration Lifesaver.

For each aspect, organization and scenario a value has been assigned: the more components perceived as potential risks for the evaluated organization, the bigger the mark given. So, for example, if for State Institutions a particular model represents more negative than positive consequences in the legal aspect, that aspect is given a "high" value of impact. In consequence, higher values of impact represent less probability of a particular model to succeed while lower values of impact provide bigger chances of a successful implementation.

Table 10 shows the results for each component, aspect, organization and integration model. Each component description has been slightly modified in the table with a 'negative' connotation making it easier to assess the impacts produced by each component in the involved organizations.

ASPECTS	ASPECTS' COMPONENTS	CENTRALIZED INTEGRATION		SUPPLY CHAIN INTEGRATION		RECIPROCAL INTEGRATION	
		RIC	INST.	RIC	INST.	RIC	INST.
TECHNICAL	Specialized skills needed	MOD	LOW	MOD	LOW	HIGH	HIGH
	Training needs	LOW	LOW	MOD	MOD	HIGH	HIGH
	Development of transfer platform	LOW	LOW	MOD	LOW	HIGH	HIGH
	Increase of information security risks	LOW	LOW	MOD	MOD	HIGH	HIGH
	Data pre-processing needed	LOW	LOW	LOW	MOD	LOW	HIGH
	IMPACT	LOW	LOW	MOD	MOD	HIGH	HIGH
INSTITUTIONAL	Complexity of process perceived	LOW	LOW	MOD	MOD	HIGH	HIGH
	Coordination needs	MOD	MOD	MOD	MOD	HIGH	HIGH
	Internal arrangements needed	LOW	MOD	HIGH	MOD	HIGH	HIGH
	Institutional barriers to overcome	LOW	MOD	HIGH	MOD	MOD	HIGH
	IMPACT	LOW	MOD	HIGH	MOD	HIGH	HIGH
LEGAL	Need to make new laws/regulations	LOW	LOW	MOD	LOW	MOD	MOD
	Need to change existing laws/regulations	MOD	MOD	MOD	MOD	MOD	MOD
	IMPACT	MOD	MOD	MOD	MOD	MOD	MOD
POLITICAL	Transparency needed	HIGH	MOD	MOD	MOD	LOW	LOW
	Ensure political stability in the long term	HIGH	MOD	MOD	MOD	MOD	MOD
	Political risk	HIGH	LOW	MOD	MOD	MOD	HIGH
	Build trust on the counterpart	HIGH	LOW	MOD	LOW	MOD	MOD
	Negative degree of response	HIGH	LOW	MOD	LOW	MOD	MOD
	External political support needed	HIGH	LOW	MOD	LOW	HIGH	HIGH
	IMPACT	HIGH	LOW	MOD	MOD	MOD	MOD
SOCIO-ECONOMIC	Integration cost	HIGH	LOW	HIGH	LOW	LOW	MOD
	Ensure return on investment	HIGH	MOD	HIGH	MOD	LOW	LOW
	Negative changes in staff conditions	LOW	LOW	LOW	LOW	MOD	HIGH
	Decrease of employment opportunities	MOD	HIGH	LOW	MOD	MOD	LOW
	Negative change in organizational culture	LOW	MOD	LOW	MOD	LOW	MOD
	IMPACT	HIGH	MOD	LOW	MOD	LOW	MOD

Table 10. Assessment of impacts based on integration aspects' components in the three integration scenarios.

		Type of integration	Centralized Integration	Supply Chain Integration	Reciprocal Integration
		Model			
ASPECT		IMPACTS			
TECHNICAL		For RIC	LOW	MODERATE	HIGH
		For Institutions	LOW	MODERATE	HIGH
NON-TECHNICAL	INSTITUTIONAL Administration, coordination	For RIC	LOW	HIGH	HIGH
		For Institutions	MODERATE	MODERATE	HIGH
	LEGAL	For RIC	MODERATE	MODERATE	MODERATE
		For Institutions	MODERATE	MODERATE	MODERATE
	POLITICAL	For RIC	HIGH	MODERATE	MODERATE
		For Institutions	LOW	MODERATE	MODERATE
	SOCIO-ECONOMIC social impact of economic change	For RIC	HIGH	LOW	LOW
		For Institutions	MODERATE	MODERATE	MODERATE

LEGEND

State institutions with cadastral information

RIC's Intermediary service in the Supply Chain Integration

The Cadastral Information Registry –RIC–, the main cadastral institution in Guatemala where all cadastral information will be integrated into.

Table 11. Scenario comparison based on the aspects of the Cadastral Information Integration Lifesaver.

6.2.5. Results discussion

The five integration aspects evaluated in Table 11 have different impacts for both RIC and the State institutions involved in the integration process, each scenario has different consequences for them and therefore they had to be looked at in a separate way.

Impacts on the technical aspect

In this aspect data conversion issues such as coordinate transformation, geodetic adjustment or digitization of data are not considered because they, if necessary, will take place regardless of the integration model that can be chosen.

For RIC, the number of efforts to be done is bigger in both cases of supply chain and reciprocal integration because in those cases RIC would have to take care of the whole integration process in all senses, resulting in a high mobilization of resources that go from the preliminary evaluation up to the final integration while State institutions just have to provide the required information, meaning that for them the technical impact would be the lowest. The technical effort is more balanced in case of a reciprocal integration where State institutions would play a more active role in the integration process and inter-institutional collaboration models and strategic alliances could be aimed at information gathering and improvement before providing it to RIC; in that model the technical impact would be moderate.

Impacts on the institutional aspect

The institutional aspect, in this case understood as a collection of administration and coordination procedures, has less impact in the centralized integration model because the necessary arrangements are directly related to RIC collecting the information for a further integration that will take place inside itself, leaving the institutions with the only responsibility of providing the information.

In contrast, the other two models imply much more collaboration-related arrangements; both RIC and the institutions have to implement a number of procedures in order to properly provide and receive the information. Especially in the reciprocal model, particular arrangements have to be done in both ways: provision and reception of information which includes an increased number of transactions and rules and this consequently brings much more necessary effort since according to transaction cost theory, an increase in them also increases the generalized impact for both organizations.

Impacts on the legal aspect

Impacts on the legal aspect depend on the nature of the legal changes that every organization has to make in order to adopt a given integration model; these legal changes can be in form of an "external" law being changed like for example governmental laws or decrees or "internal" laws such as each organization's internal regulations. For the three models, the perception is that no changes have to take place in any of the "external" laws because on one side none of them was made to regulate a process as specific as information integration and on the other side all of them contemplate the possibility of every organization sharing information with others in the public sector. Regarding "internal" legislation, the impact is directly proportional to the amount of changes or new regulations that have to be made.

There are two principal considerations that have to be taken into account regarding RIC: first, it is taken for granted that RIC has to make a new regulation that describes how to carry out the information integration process regardless of which integration model it will adopt. Second, RIC already has collaboration strategies in order to have a more close relation with State institutions so no substantial changes are needed in RIC's regulations regarding collaboration.

Given the prior considerations, the higher impact in the legal aspect for RIC is seen on the supply chain model because by implying the need for creating or adopting an intermediary service it is understood that RIC has to regulate the establishment of that service. A moderate impact is seen in the reciprocal integration model because some new arrangements might be needed in order to make this model work. In the case of a centralized integration model, the legal changes are less because RIC in that case would be just collecting information (assuming an effective collaboration from the State institutions).

For institutions, the centralized and supply chain integration models do not seem to constitute major impacts because in both cases the main contribution that they have to make in the integration process is to provide the information, something that changes when it comes to the reciprocal integration model where institutions might need to make changes in their internal regulations in order to conform a more collaborative model and especially if they want to make strategic alliances, which need legal agreements before being implemented.

Impacts on the political aspect

The political aspect has a more marked influence in the centralized model for RIC because it becomes necessary for that organization to demonstrate the purpose of the integration process as well as to guarantee the transparency of the process. The other two models have a potential moderate impact because a better understanding can be achieved through cooperation either by having an intermediary

service which would take care of the necessary arrangements or by establishing a mutual cooperation between the organizations enhancing trust from State institutions and therefore making them eager to cooperate in the process.

Impacts on the socio-economic aspect

The Socio-economic impact, understood as the social impact of economic change, depends on the economic mobilization that each organization has to make. For RIC, centralized and supply chain integration models represent more funding and resources to be allocated because both models basically imply that RIC is the only one that will be responsible for the integration process and therefore, the impact for the institutions is the minimum. In the reciprocal integration model, by having a collaborative model the required funding and resources can be distributed in the participating organizations thus resulting in a moderate impact for both RIC and State institutions.

Employment opportunities and changes in organizational culture and staff conditions find a more balanced scenario in supply chain and reciprocal integration models because by fostering collaboration opportunities are more likely to grow within the organizations.

6.3. Concluding remarks

The objective of this chapter was to identify the main challenges that have to be faced in order to address the problem of cadastral information fragmentation in Guatemala. The main idea is that this can be achieved by implementing a sound integration process that aims to put all cadastral information that currently is in the hands of State institutions, particularly municipalities, into a national database that by law has to be managed and held by the Cadastral Information Registry (RIC).

The challenges were evaluated by identifying three models of integration: centralized, supply chain and reciprocal which at the same time constitute scenarios for an eventual integration process. The three scenarios were compared in two tables, the first one identified the main purposes, limitations and outcomes of each scenario while the second one identified the impacts that the implementation of the three scenarios will have on the technical, institutional, legal, political and socio-economic aspects of integration which constitute the Lifesaver of integration identified in Chapter 2 of the present work.

The main challenges identified for RIC in the first scenario (centralized integration model) are: a) to face possible lack of trust from institutions and b) to face possible work overload for RIC. In the second scenario (supply chain integration model) the challenges are: c) to deal with an increase of bureaucratic processes and in the third scenario: d) to deal with possible unequal technical capabilities from the institutions, e) to address dependency on political will for cooperation and f) to avoid integration process going slower.

The findings also reveal that both supply chain and reciprocal integration models are less likely to work in the political context of Guatemala because they rely considerably on political will much more than with the centralized model. The biggest political challenge for RIC in the centralized model lies in the fact that it has to build trust because otherwise it is on the risk of being seen as an institution that just takes the information without giving anything in exchange.

The legal aspect has a moderate impact in the three models because in order to work, the amount of legal changes at the internal level is sufficiently balanced: RIC still has to make an integration regulation while State institutions would probably require to do some modifications in their internal cadastral regulations but the amount of those changes does not change considerably from model to model.

Centralized and Supply integration models produce higher impacts in the technical and institutional aspects on RIC because it is RIC who has to absorb the majority of responsibilities in all integration aspects while reciprocal integration model is much more balanced for both sides in the majority of aspects to the point that this model does not present high impacts on any side.

Administrative and political aspects are the less predictable because internal arrangements can take place between RIC and State institutions considerably facilitating the integration process but at the same time those aspects are more vulnerable to face unpredicted cutbacks that can compromise the integration process. These two aspects constitute a major challenge for RIC and therefore must be carefully studied in order to ensure a successful information integration process.

The resultant outcomes from the evaluations of each integration model show how important is to consider the non-technical aspects when performing such evaluations; regardless of the model, any integration process that may be conducted focusing only on the technical aspect is more likely to 'drown' just as the principle of the Cadastral Information Integration Lifesaver dictates.

In order to solve the problem of cadastral information fragmentation by performing an integration process, the main challenge comes not only from the fact that cadastre is fragmented but from the fact that every cadastre is different from each other making it more complicated for RIC who has to deal with the arrangements that have to be done before implementing any model, having to equilibrate the impacts that can be produced in each aspect.

Based on the evaluation performed in this chapter, the model that seems to be the most adequate for the Guatemalan case is Supply Chain integration because on one side its perceived limitations are less and on the other side it has an overall more balanced impact than the others in the evaluation of all technical and non-technical aspects.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Conclusions

The present research aimed to analyze how and to which extent cadastral information from Guatemalan State institutions can be integrated in the national cadastral information system. It was done by addressing the following objectives: a) To analyze the current land administration views on integration of cadastral information; b) To determine the causes and effects of cadastral information fragmentation in Guatemala and c) To develop approaches on the cadastral information integration process in Guatemala.

7.1.1. Conclusions based on objectives and research questions

For sub-objective 1: To analyze the current land administration views on integration of cadastral information

1. Which science-based views exist on cadastral information integration?

The found documentation comprises a total of 20 scientific works that show a great variety in points of view in which one or more of the following aspects of cadastral information integration are described:

- Technical
- Standards
- Institutional/organizational
- Political/policy
- Legal
- Social/cultural
- Economic
- Other particular aspects that the authors considered as relevant

Different mentions and descriptions of what the authors consider as crucial aspects that have to be taken into account before conducting an integration process are presented along the found documentation. The majority of documents uses either one or several of the aforementioned aspects.

2. How are these views different from each other?

In the reviewed literature, the predominant and best described aspects of Cadastral Information Integration are the ones present in the Lifesaver of Cadastral Information Integration that was derived at the end of the chapter and served as an analytical tool through the rest of the present work. This Lifesaver summarizes Cadastral Information Integration into 2 major aspects: Technical and Non-technical (institutional, legal, political and socio-economic).

The majority of reviewed documents consider the technical, institutional and political as the aspects that define integration, they demand more effort and the success of integration greatly depends on them. The other aspects (legal, social, economic and standards) are complementary and rather important in the integration process but demand less efforts and require less attention than the first ones. The political aspect is generally understood as an instrument for necessary legislation, a motivation and source of trust for supporting organizations behind integration

Most of the mentions to the Standards aspect done by the consulted literature refer to it as part of the technical aspect, it comes from a line of thought that considers that the technical aspect must start from a standards definition.

For sub-objective 2: To determine the causes and effects of cadastral information fragmentation in Guatemala

1. What are the causes behind cadastral information fragmentation in Guatemala?

The causes of fragmentation in the Guatemalan cadastre are:

- Technical
    - Different surveying and data acquisition methods used by the institutions
- Institutional
    - Frequent change of institutions responsible of cadastre along the Guatemalan history.
    - Discontinuity of established cadastral projects
    - Freedom of choice for municipalities on whether implement a cadastre or not and if so, which technical approach to use.
    - Lack of sufficient capacity from RIC to ensure observance of the Technical Cadastral Regulations across the country.
- Legal
    - Technical Cadastral Regulations passed until 2008 which means that all cadastres prior to that date were formulated according to arbitrary procedures.
    - Lack of synchronization between different laws and law articles prior to RIC law that led to freedom of action by the involved institutions.
    - Overlapping in functions and responsibilities caused by laws oriented to different purposes
- Political
    - Changing political will from the government in the second half of the 20th century responding to circumstantial factors typical of the time.
    - Diverse interests that have driven cadastres to be set up only in certain areas.
- Economic
    - Budget cuts for cadastre, leading to partial or total abandonment of cadastral activities
    - In the case of municipalities, economic inequality and priority changes over time have obliged them to abandon cadastres or kept them from establishing one.
- Social
    - Authorities in some cases have chosen to avoid the establishment of a cadastre in potential conflict areas because especially in rural areas, cadastre is perceived only as an instrument of taxation.
    - Population in general does not have a clear comprehension of cadastre ant its benefits, this has kept civil society from historically demanding a solider cadastral infrastructure in the country.

2. What are the effects of fragmentation for the Guatemalan Cadastre?

The effects that cadastral fragmentation produce in Guatemala are:

- Negative effects:
  - Technical
    - Difficulty to produce an integration procedure that considers all existing cases
    - Incompatibility between neighboring cadastres makes it difficult to decide which one to use for a specific purpose
  - Institutional
    - Challenge for RIC occasioned by the need to consider the non-technical aspects of integration
    - Lack of control from RIC over cadastral operations in the country
    - Possible lack of support from RIC to the municipalities
    - Incapacity from municipalities to implement the Cadastral Technical Regulations
    - Risk of information loss for the municipalities when not having it properly secured
    - Difficulty for State institutions on using diverse cadastral information for a specific institutional purpose (complications presented when choosing which cadastral information to use)
  - Legal
    - Hindrance to law making
    - Hindrance to law enforcement
  - Political
    - Difficulty for the government to implement agrarian policies
    - Difficulty for the government to implement Fiscal management policies
  - Socio-economic
    - Unequal access to public services
    - Difficulty on implementing the Peace Accords
    - Unequal land market
    - Unequal conditions for investment
- Positive effects
  - Technical
    - Possibility of gaining experience from the existing diversity in cadastres
  - Institutional
    - Relative independence from RIC's control

Effects of cadastral fragmentation in Guatemala have a mainly negative connotation. The positive effect of fragmentation is visible in two dimensions: as a generator of knowledge and experience for the ongoing nationwide cadastre and as independence and freedom of action for stronger municipal cadastres.

The main institutional effect is lack of formal control by RIC. The lack of formal control by RIC produces a negative effect for municipal cadastres as well since they cannot have access to effective support and formal recognition by RIC which in turn would open opportunities for own development, obtaining technical and organizational improvements in their cadastral information management.

The level of detail regarding land property and tenure that a cadastre allows to identify is a big advantage for the State to accomplish its objectives, such advantage however, is considerably minimized because of the varying nature of the cadastres present in the country turning into an additional cost for the State and

its institutions, which has to spend more resources on determining the feasibility of using the different cadastres available and if feasible, spending on the adaptation of such cadastres for the required purposes.

Cadastral information fragmentation produces inequality of opportunities and development for the civil society in the socio-economic aspect. The effect for the civil society is that in general there is not equal access to services, benefits and support.

3. Which solutions have been tried so far to address the problem of fragmentation in Guatemala?

Four solutions were found to be tried in Guatemala in order to address cadastral fragmentation:

- INFOM's Municipal Strengthening Policy. A short-lived policy that intended to assist municipalities in the establishment and development of their own cadastres. No trace of the aid provided by this institution is visible today as this institution lost prominence in the cadastral domain due to the issuance of RIC's law.
- RIC's Non-official Manual for the Integration of Institutional Cadastres. Tool focused on the accomplishment of institutional cadastres to RIC's Cadastral Technical Regulations, it takes for granted however, that the establishment of a link between RIC and the institutions, coordination of activities and data transfer from those institutions to RIC will take place without problem.
- Spontaneous adaptation of municipal cadastres to RIC's Cadastral Technical Regulations. This adaptation unveils two major concerns for municipalities: the obligation of adapting their cadastres to the technical requirements in order to avoid possible negative consequences in the future and the look for a benefit as a result of getting involved in the ongoing cadastral process by RIC.
- RIC's policy to foster participation of municipalities in the cadastral process. It is currently a polarized process to which only those municipalities located in RIC's priority areas have access.

For sub-objective 3: To develop approaches on the cadastral information integration process in Guatemala

1. Which specific challenges have to be considered in the cadastral information integration process?

The main challenge comes from the fact that cadastre is fragmented and from the fact that every cadastre is different from each other making it more complicated for RIC who has to deal with the arrangements that have to be done before implementing any model, having to equilibrate the impacts that can be produced in each aspect.

The specific challenges identified for RIC in the first scenario (centralized integration model) are: a) to face possible lack of trust from institutions and b) to face possible work overload for RIC. In the second scenario (supply chain integration model) the challenges are: c) to deal with an increase of bureaucratic processes and in the third scenario: d) to deal with possible unequal technical capabilities from the institutions, e) to address dependency on political will for cooperation and f) to avoid integration process going slower.

The integration model that seems to be the most adequate for the Guatemalan case is Supply Chain integration because on one side its perceived limitations are less (increase of bureaucratic procedures) and on the other side it has an overall more balanced impact than the others in the evaluation of all technical and non-technical aspects.

2. What lessons can be learned from integration in other domains of the public sector in Guatemala?

The achieved success for the two studied cases greatly depended on properly addressing the political aspect. In the first case, budget cuts that took place in the implementing institution as well as a shift in political will from the top authorities behind that project led to a weakening in its structure, leaving its original proposed outcomes far behind from expectations. In the second case, the provision of technical assistance to the government, especially the Executive Power is what made of it a much stronger system because all governmental projects that required geo-information as a basis for their planning needed an information provider, a gap that in this second case was conveniently filled which leads to the conclusion that political support was vital in both cases and therefore was the main driver behind the success achieved in the integration process of the second case.

3. What are the main elements of a potential approach?

The most important learnings documented and analyzed across the present research lead us to a redesign, which in the form of a potential approach for integrating cadastral information from State institutions into RIC's Guatemalan National Cadastre should include the following 12 considerations for RIC:

i. To make any potential regulation on cadastral information integration based on the key aspects of the Cadastral Information Integration Lifesaver: Technical and Non-technical (Institutional, legal, political and socio-economic) aspects.
ii. To consider the three scenarios of integration as the starting point of analysis for a potential regulation on integration: Centralized, Supply Chain and Reciprocal, evaluating in each case their feasibility for application.
iii. To gain control over cadastral operations in the country by enforcing observance of the Cadastral Technical Regulations in order to make the technical aspect of the integration process easier to conduct.
iv. To revise the current legislation in the cadastral field, especially internal regulations that might still be active inside the institutions that in the past dealt with cadastre in the country, removing any overlapping of functions and all potential hindrances to effectively perform cadastral information integration.
v. To properly address the political aspect in terms of making cadastral information integration an attractive option for State institutions and for the government in general in order to awaken interest and active support.
vi. To guarantee proper funding as well as economic sustainability safeguarding integration in order to avoid abandonment of undergoing activities as occurred in the past.
vii. To document and analyze all existing forms of cadastre in the country, especially paying attention to local realities and contexts in order to apply such knowledge in the development of new strategies in cadastral information integration.
viii. To recognize and respect all forms of current cadastral activities in the country in the first place, encouraging a smooth integration that does not compromise the current activities done by State institutions with an own cadastre.
ix. To evaluate and consider the possibility of establishing a strategic alliance with INFOM in order to strengthen the integration process leveraging INFOM's relationship with municipalities.
x. To consider for future regulations on the matter, the use of RIC's Non-official Manual for Integration, with clear understanding that its use only responds to the technical aspect of integration.
xi. To identify and guide the spontaneous adaptation of municipal cadastres to RIC's Cadastral Technical Regulations, facilitating aid and resources when possible.

xii. To make extensive use of RIC's policy to foster participation of municipalities in the cadastral process in order to address the political aspect of integration by using a policy that is already in place.

7.1.2. General conclusion on main research objective

The present research determined the most important causes and effects of fragmentation of cadastre in Guatemala, the solutions tried so far to reduce or eliminate such fragmentation as well as some experiences that have taken place in the geo-information domain. All this allowed identifying the challenges to be considered in order to address the problem of fragmentation in cadastre by means of a cadastral information integration process.

Cadastral information integration is possible as long as the best possible method is chosen, either if through a centralized, a supply chain or a reciprocal integration model. Once the model is selected by RIC, all integration aspects must be considered, technical and non-technical so that integration is divided in all its dimensions in order to formulate a sound methodology that allows that process to be carried on. In addition, an inclusion of existing strengths and weaknesses in the current cadastral system is necessary to provide additional considerations to improve the integration process.

7.1.3. Critical description of data and methodology employed

The methodology for the present research was based on documentation review: both primary and secondary sources come from printed material meaning that no interviews or questionnaires took place here, the only opinions and judgments come from the secondary sources which sometimes present them as part of their own scope. However, a small contribution of personal knowledge from the author was used in some cases but just as an aid for the general observations.

Overall, the strength behind this approach is that is based more on facts rather than opinions, this is at least valid for the majority of issues addressed, however since cadastral information integration occurs among institutions, which are reflections of the society, opinions from officials in both RIC and the State institutions and other involved stakeholders can also provide critical elements that in the end can change some assumptions done in this work. To cope with this, a passive tone was used and in much of the research the possibilities are open for debate, meaning that this research aimed more for an insight of the situation instead of trying to impose a solution.

In addition it was identified as necessary to further improve the data used in this research with more documentation than the one used in this research, especially in the case of past and present official reports since most of the institutional official websites do not contain such type of documents.

7.2. Recommendations

7.2.1. Elements for further exploration

Once they were identified, the five aspects of cadastral information integration (technical, institutional, legal, political and socio-economic) have a very complex nature and each one of them is related to a specific scientific domain like geo-informatics, organizational theory, legal theory, political science, sociology and economy. Hence, it is advisable to dedicate further research to those aspects from the specific point of view of their correspondent domains. More specifically, the non-technical aspects which

can be very complex in nature, have not been properly addressed in cases of integration because literature in the cadastral field is more focused on cadastre as an established system leaving integration (which normally only takes place once in several decades) apart from the picture.

In the case of Guatemala, further research is also strongly recommended in the municipal cadastral domain, it is advisable to look deeper into the aspects of municipal cadastres, their situation in the national context and their relation (if any) with RIC as well as to evaluate the internal perceptions of municipalities on cadastral information integration.

7.2.2. Recommendations for practitioners in the future

The results of the present research provide sufficient degree of insight into the cadastral information integration in general; however, it is advisable for future practitioners to make incursions in the following issues:

Evaluation of hybrid models of cadastral information integration, i.e. combinations of elements of the three models addressed in the present research (centralized, supply chain and reciprocal). Combination in scenario analysis is totally possible and especially useful in cases like the present one, it is then advised to evaluate the possible outcomes of combining these models.

Extent of applicability of transaction cost theory in the field of information integration. When dealing with evaluation of institutional impact, a great difficulty was observed when trying to evaluate the potential outcomes in the different aspects of integration; transaction cost theory provides useful tools that however are absent in the specific field of integration.

Finally, a handy advice is to leverage the current technology tools such as web-based machine translators that allow practically any user to conduct searches over the web in different languages. This is because when looking for information that is as specific as cadastral information integration, web results not always produce expected or sufficient results; by expanding the search to other languages sometimes better and quite useful resources can be found.

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