DESIGN OF A CONCEPTUAL LAND INFORMATION MANAGEMENT MODEL FOR THE RURAL CADASTRE IN BRAZIL

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PREFACE

This technical report is a reproduction of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Geodesy and Geomatics Engineering, January 2010. The research was supervised by Dr. Sue Nichols, and partial support was provided by the Canadian International Development Agency.

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DEDICATION

To my family, my love: my mom Socorro Paixão and my sister Simone Paixão. You are the reason for everything.

To my parents, as one more trophy of our victory; without your support and love everything could fail.

To Vira (in memoria), as a symbol that nothing can destroy what has been planted with love, you are and will be continue seen my victories.

To all my friends, thank you for all support. Especially for the Brazilians friends, you were my support when tears and smiles came up.

To Jose Miguel, as the recognition of your kindness, encouragement and emotional support.

ABSTRACT

The rural cadastral reform established by *Law# 10,267/2001* is the most recent benchmark in the land administration history in Brazil. It is important not only because after this law rural properties must be geo-referenced, but also because for the first time Brazilian law has called for a common multipurpose cadastral system, called the National Cadastre for Rural Properties – CNIR. CNIR will integrate legal (tenure information), fiscal (value information) and agrarian (land use and management policies) and environmental (protected areas) databases.

As in many countries which are in the process of a cadastral reform, Brazil faces serious political, legal, and technical challenges in developing a national rural cadastral system. However, through the harmonization of land information, it is hoped that land conflicts can be reduced, land can be more fairly redistributed and taxed, interests in traditional lands and protected areas can preserved and, most importantly, that what is registered at the registry offices is the same as what is represented on the ground.

This research supports CNIR implementation by providing the design of a conceptual model based on user requirements of all collaborating agencies. The primary purpose of the model is to provide a framework for the integration of the current cadastral systems, under several land administration agencies, in order to obtain more accurate and concise land information to support and regularization and secure tenure in rural areas. More specifically, the model is designed to provide a well defined, structured design for CNIR implementation based on user requirements and project management methodologies. The research includes problem definition, analysis of

requirements, constraints and opportunities, and design of a model using soft systems methodologies. The results are definition of required CNIR functions, data flow, and minimum content and implementation strategies. Working together with CNIR managers, the research has provided input for its development.

The research is based on the assumption that land information, well managed and legally formalized, can help to provide better security of tenure, and as a consequence it may become the proposed model to bring improvement in land reform programs and in public services in Brazil.

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- Marcia Carneiro and family, your constant warm and kind emails made me strong and happy; thank you for keep me in *alto astral.*
- Jose Miguel, your patience and kindness were essential. My kind gratitud. *Gracias por tus palabras, ellas me dieron más energía para continuar mi batalla.*

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List of Symbols, Nomenclature or Abbreviations

ABIN: *Agência Brasileira de Inteligência*, Brazilian Intelligence Agency

ADA: *Ato Declaratório Ambiental,* Environmental Declaration Act of ITR

BID: *Banco Interamericano de Desenvolvimento*, - Inter-American Development Bank

CAFIR: *Cadastro de Imóveis Rurais da Receita Federal do Brasil*, Rural Property Cadastre of the Revenue Income

CCIR: *Certificado do Cadastro de Imóveis Rurais, R*ural Property Certificates

CDN: *Centro de Desenvolvimento de Negócios,* Business Development Center

CENAFLOR: *Centro Nacional de Apoio ao Manejo Florestal*, National Support Centre for Forest Management

CERCO: Comité Européen de la Cartographie Officielle

CGU: *Controladoria-Geral da União*, International Commitments Against Corruption

CIDA: Canadian International Development Agency

CIGA: *Centro de Cartografia Aplicada e Informação Geográfica,* Centre of Applied Cartography and Geographic Information

CMM: Capability Maturity Model

CNEFE: *Cadastro Nacional de Endereço para fins Estatísticos*, Cadastre of the Address for Statistical Purposes

CNFP: *Cadastro Nacional de Florestas Públicas,* National Cadastre of Public Forest.

CNIR: *Cadastro Nacional de Imóveis Rurais*, National Cadastre System of Rural Properties.

CNJ: *Conselho Nacional de Justiça*, Justice National Consel

CNPJ: *Cadastro Nacional da Pessoa Jurídica*, Juridical Cadastre Number

CNSTDF: Chinese Spatial Data Transfer Format,

CNT: *Centro Nacional de Telemática*, National Center of Telematics

CONCAR: *Comissão Nacional de Cartografia,* Brazilian Cartography Committee

CONTAG: *Confederação Nacional dos Trabalhadores na Agricultura*, National Federation of Farm Workers.

CPF: *Cadastro de Pessoas Físicas,* Taxpayer Personal Identification Number

CPM: Critical Path Method

CPT: *Comissão Pastoral da Terra,* Pastoral Land Commission

CRECE: Completeness, Reliability, Efficiency, Consistency and Effectiveness Framework

CSDGM: Content Standard for Digital Geospatial Metadata

CSS: Cascading Style Sheets

CSW: Catalog Service for Web specification

Diac: *Documento de informação e Atualização Cadastral do ITR*, ITR's Communication and Data Upadate Form

DIAT: *Informação e Apuração do ITR*, Rural Property Taxation Form

DIEESE: *Departamento Intersindical de Estatística e Estudos Socioeconômicos,* Inter-Union Department of Statistics and Socio-Economic Studies

DIGEST: Digital Geographic Information Exchange Standard

DITR: *Declaração do Imposto sobre a Propriedade Territorial Rural,* RFB's Rural Property Taxation Form

DLG: Digital Line Graph

DNPM: *Departamento Nacional de Produção Mineral,* Ministry of Mines and Energy

DOI: *Declaração sobre Operações Imobiliárias*, Land Transfer System

DOM: Document Object Model

DP: *Declaração para Cadastro de Imóveis Rurais*, Declaratory Rural Property Cadastre

DSS: Decision Support Systems

EMATER: *Empresa de Assistência Técnica e Extensão Rural*, Government Agricultural Extension Services

EMBRAPA: *Empresa Brasileira de Pesquisa Agropecuária,* Brazilian Agricultural Research Corporation

EMBRATEL: *Empresa Brasileira de Telecomunicações S.A.,* Brazilian Telecommunication Company

e-PING: *Padrões de Interoperabilidade de Governo Eletrônico*, e-Government Interoperability Standards

ETL: *Extração, Transformação e Carga,* Extract, Transform and Load

FACIR: *Formulário de Atualização Cadastral do Imóvel Rural,* RFB Form for Rural Property Data Update

FAO: Food and Agriculture Organization

FARC: *Forças Armadas Revolucionárias da Colômbia*, Revolutionary Armed Forces of Colombia

FAST: Framework for Application of Systems Thinking

FEBRABAN: *Federação Brasileira de Bancos*, Brazilian Federation of Banks

FETRAF: *Federação dos Trabalhadores na Agricultura Familiar*, Family Farmers Union Organization

FETRAP: *Federação dos Trabalhadores na Agricultura Familiar*, Family Agriculture Workers Federation

FF: Finish - to – Finish Relationship

FGDC: Federal Geospatial Data Committee

FS: Finish - to – Start Relationship

FUNAI: *Fundação Nacional do Índio,* National Indian Foundation

GDF; Geographic Data Files

GeoTIFF: Geographic Tagged Image File Format

GINI: *Medida de Desigualdade de Renda,* Distribution of Land Ownership and Income Index

GIS: Geographic Information Systems

GML: Geography Markup Language

GML: Geography Markup Language

GPS: Global Positioning System

HTTP: Hypertext Transfer Protocol

IADB: Interamerican Development Bank

IBAMA: *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis,* Brazilian Institute of Environment and Renewable Natural Resources

IBGE: *Instituto Brasileiro de Geografia e Estatística*, Brazilian Institute of National Statistics and Geography

IEEE: *Instituto de Engenheiros Eletricistas e Eletrônicos*, Institute of Electrical and Electronics Engineers

IICA: *Instituto Interamericano de Cooperação para a Agricultura,* Inter-American Institute for Cooperation on Agriculture

INCRA: *Instituto Nacional de Colonização e Reforma Agrária*, Land Reform Institute.

INDE: *Infraestrutura Nacional de Dados Espaciais*, National Spatial Data Infrastructure

INSS: *Ministério da Previdência Social*, National Institute for Social Security

IPTU: *Imposto Propriedade Predial e Territorial Urbana*, Urban Property Taxation

IRIB: *Instituto de Registro Imobiliário do Brasil,* Brazilian Registry Office Institute

ISA: *Instituto Socio Ambiental*, Institute Socio Ambiental

ISO/TC211: International Organization for Standardization Technical Committee 211

ISO: International Standards Organization

ITR: *Imposto Territorial Rural*, Rural Property Taxation

JAD: Joint Application Design

LIS: Land Information Systems

LRP: *Lei dos Registros Públicos,* Law of Public Registers

MAPA: *Ministério da Agricultura, Pecuária e Abastecimento,* Ministry of Agriculture, Livestock and Food Supply

MDA: *Ministério do Desenvolvimento Agrário*, Ministry of Agrarian Development

MDS: *Ministério do Desenvolvimento Social e Combate à Fome*, Ministry of Social Development and Fight against Hunger

MMA: *Ministério do Meio Ambiente,* Ministry of Environment

MST: *Movimento dos Sem-Terra,* Landless Peasant Movement

NEAD: *Núcleo de Estudos Agrários e Desenvolvimento Rural*, Nucleo of Agrarian and Rural Development Studies

NGO: Non-governmental organization

NIRF: RFB Code

NIST: National Institute of Standards and Technology

NRC: National Research Council

NTF: National Transfer Format Map File

OECD: Organisation for Economic Co-operation and Development

OGC: Open GeoSpatial Consortium

ORDIT: Organizational Requirements Definition for Information Technology Systems

OTE: *Institutos Estaduais de Terras*, State land Institute

PERT: Program Evaluation and Review Technique Diagram

PGD: *Programa Gerador de Declaração do INCRA*, INCRA's Program to Generate Property Declaration

PID: Parcel Identifiers Code

PIECES: *Performance, Information, Economics, Control, Efficiency and Service Framework*

PIGN: *Projeto Infra-estrutura Geoespacial National*,National Geospatial Framework Project

PNUD: *Programa das Nações Unidas para o Desenvolvimento,* United Nations Development Programme

POLARIS: Province of Ontario Land Registration Information System

RAD: Rapid Application Development

RFB: *Secretaria da Receita Federal do Brasil*, Federal Revenue Service

RIP: SPU Code

SAD69: South American Datum 1969

SDI: Spatial Data Infrastructure

SERPRO: *Serviço Federal de Processamento de Dados*, Brazilian Federal Enterprise for Data Processing

SF: Start - to – Finish Relationship

SFB: *Serviço Florestal Brasileiro,* Brazilian Forestry Service

SGBD: *Sistema Gerenciador de Banco de Dados*, Database management systems

SIAPA: *Sistema Integrado de Administração Patrimonial,* Integrated System for Patrimonial Management.

SIPRA: *Sistema de Informações de Projetos de Reforma Agrária*, Information System for Land Reform Projects.

SIRGAS2000: Geocentric Reference System for the Americas

SIT: *Sistema de Terras Indígenas,* Traditional Land Cadastre

SMIL: Synchronized Multimedia Integration Language

SNCR: *Sistema Nacional de Cadastro Rural,* National Rural Cadastral System.

SPU: *Secretaria do Patrimônio da União do Ministério do Planejamento,* Secreatary of Federal Assets - Ministry of Planning

SRS: Software Requirements Specification

SS: Start - to – Finish Relationship

SSM: Soft Systems Methodology

SDTS: Spatial Data Transfer Standard

SVG: Scalable Vector Graphics

SWOT: Strengths, Weaknesses, Opportunities, and Threats Analysis

TI: *Terra Indígena*, Indigenous Territory

UFBA: *Universidade Federal da Bahia,* Federal University of Bahia

UFPE: *Universidade Federal de Pernambuco,* Federal University of Pernambuco,

UFSC: *Universidade Federal de Santa Catarina*, Federal University of Santa Catarina

UMC: *Unidade Municipal de Cadastramento*, INCRA's Minicipal Land Inventory Unit

UN: United Nations

UNB: University of New Brunswick

UNCHS: United Nations Centre for Human Settlements

UNECA:	United Nations Economic Commission for Africa
UTM:	Universe Transversal Mercator
W3C:	World Wide Web Consortium
WBS:	Work Breakdown Structure
WCS:	Web Coverage Service
WebCGM:	Web Computer Graphics Metafile
WFS:	Web Feature Service
WMS:	Web Map Service
XML:	Extensible Markup Language

CHAPTER 1

INTRODUCTION

1.1 Background

The relationship between land information systems (LIS) and multipurpose cadastral systems is intrinsic. LIS is defined as "*a combination of human and technological resources, together with a set of organizing procedures, which results in the collection, storage, retrieval, dissemination, and use of [land] data in a systematic fashion." [McLaughling, 1985* apud *Nichols, 1993a p. 5*]. NRC (1980, p. 13) define multipurpose cadastral systems as "integrated *land – information systems, which supports continuous, readily available, and comprehensive land –related information at the parcel level*." The land information at these multipurpose cadastral systems can be, for example, legal (tenure information), fiscal (value information), agrarian (land use), environmental (protected areas) and socio-economic (census data).

The goal of many countries is to have harmonized land information in a LIS or a multipurpose cadastre system to support land management projects. Nichols (1993a, p. 35) defines land management as *"process of making and implementing decisions about how land and its resources are distributed, used, and protected in society*." Having harmonized information also supports to have access to other benefits such as accuracy of property tax assessment, improvement governmental of decision-making, secure tenure and social inclusion. Brazil is no exception.

Brazil has been faced with serious land problems related to, for example, unequal land distribution, ethnic and environment issues that have came from the nation's history. Land also contains many highly charged political interests, which have been playing roles at institutional sphere. The issues are also caused by a multitude of separate cadastral systems (e.g., legal, fiscal, agrarian and environmental) that contain incompatible and incomplete land information. Priority issues include:

- ***Lack of research -*** Very little has been done in Brazil related to land administration, especially research related to cadastral systems and land information management. This lack of research limits the abilities of land managers to put methodologies together and to make decisions to improve their systems.
- ***Failure of governmental land programs –*** Land regularization programs have been goals of all presidential elections in Brazil. The majority of these land programs are ambitious and results are intangible, resulting in failure of the programs with average of less than 50% of the goals reached [e.g., Vasconcelos, 2007; Resende, 2008]. Part of this failure is caused by incompatible and incomplete national land inventory at the land administration agencies. This is also complemented by partial knowledge of public lands location and existence of land information into separate cadastral systems that are administrated under different agencies with different institutional policies.
- ***Security tenure -*** Traditional communities and poor farms have been struggling with governmental authorities to have their land rights recognized. As a

consequence, the number of land occupations (*posse*) with informal ownership has been increasing in Brazil, some with violent land conflicts.

- ***Outdate legislation* –** Legislation related to land management in Brazil is specific for each land administration agency and some are outdated. When progress is made in updating land legislation, as for example, with the new legislation for geo-referencing rural properties (*Law# 10,267/2001*) that creates a nation rural cadastral system in Brazil (CNIR), little progress is made to effectively establish them and preexisting legislation is inconsistent.

The goal of CNIR is to integrate a legal/fiscal/agrarian/environmental database. It is hoped that this new uniformity will in the future help to avoid conflicts of information about the same property. Brazil faces many difficulties in executing what this law establishes.

This research aims to support CNIR implementation by offering a systematic approach to design a harmonized land information management for rural properties in Brazil. It contains the design of a land information management model for CNIR with high level analysis based on soft systems methodologies, project management techniques and user requirements. The aim of this research is to provide a better tool to improve information management through a multipurpose cadastral model that integrates existing fiscal, legal, environmental, statistical and agrarian regularization systems. This includes the development of policy guidance for improved CNIR information management.

While this research did not physically implement the proposed system model, it demonstrates theoretically how the system could work if it was implemented. The problems, solutions and opportunities associated in the model are evaluated. The research evaluation was done, as best as possible given political barriers, through logical application of systematic methodology.

1.2 Research General Objective

The objective is to design a multipurpose land information management conceptual model for rural cadastral systems in Brazil based on user requirements, system methodologies development and project management.

1.2.1 Research Specific Objectives

To accomplish the general research objective, the following research tasks are required:

- To analyze and describe the Brazil rural cadastral systems situation;
- To examine land information systems and multipurpose cadastral systems and see how they could be applied in Brazil;
- To investigate systems development and project management to analyze how they could contribute to the design of the CNIR conceptual model;
- To investigate methods of determining user requirements and apply this analysis to the proposed model in Brazil;

- To identify and prioritize analysis of the user requirements and design the minimal content of CNIR;
- To evaluate the models produced by the user requirements determination, prioritization of the CNIR problems for its implementation and the CNIR conceptual model.

1.3. Research Methodology

The first phase of the research includes a literature review of multipurpose cadastral systems, information system development and management that were basis for the design of the CNIR conceptual model. It included user requirements collection and systems analysis, modeling, validation and solution, as well as principles and strategies for CNIR implementation (see Figure 1.1). Figure 1.2 shows a more detailed representation of the methodology demonstrated at a high level in Figure 1.1. Each phase developed during the research is also explained below.

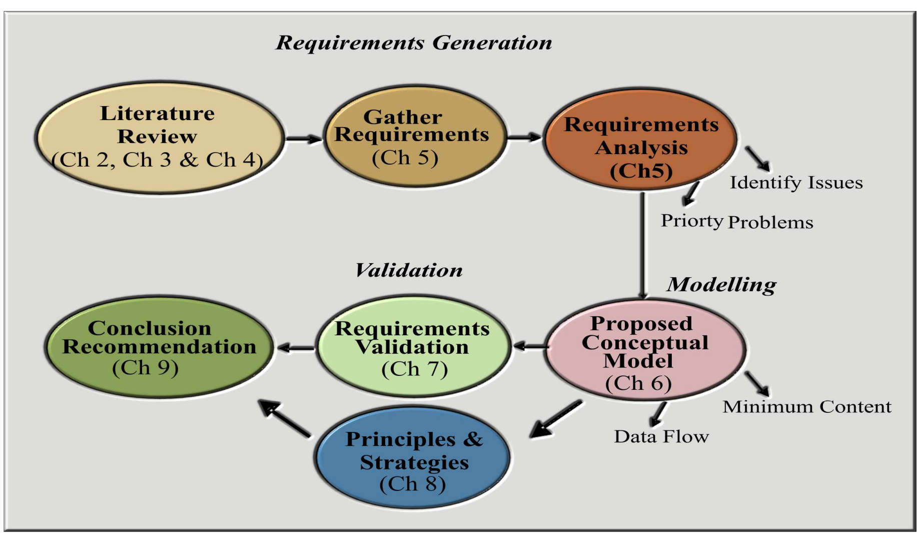


Figure 1.1 – General methodology

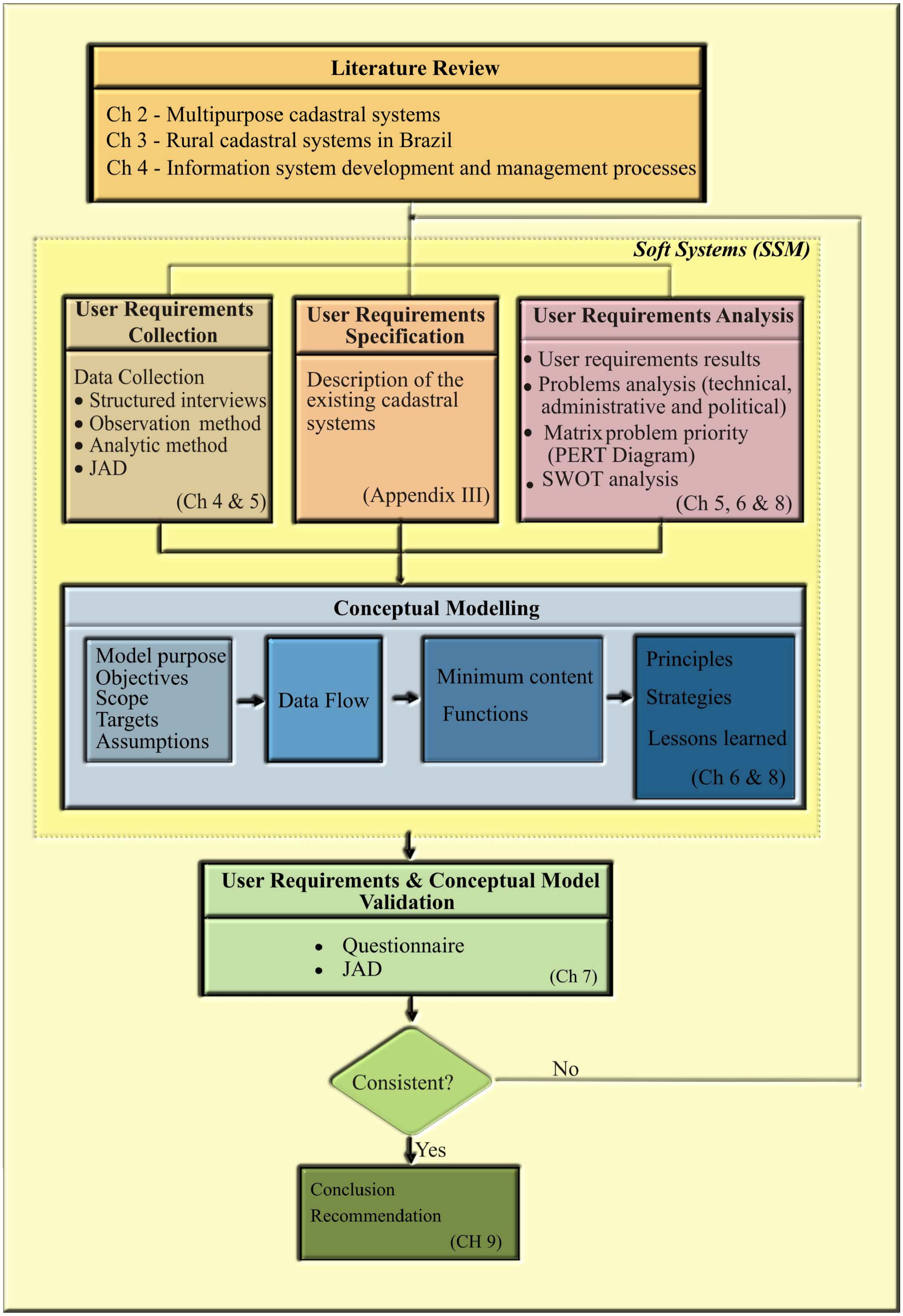


Figure 1.2 – Detailed methodology

In order to design a conceptual land information management model for CNIR in Brazil, subjects such as LIS and multipurpose cadastre systems (Chapter 2), land issues and rural cadastres characteristics in Brazil (Chapter 3), information systems development processes, requirements of engineering, systems interoperability and finally project management (Chapter 4) had to be reviewed.

The soft system methodology was chosen to design the CNIR conceptual model because it accommodates cognitive analysis that also considers political, cultural and social issues of the system (Chapter 4). The first practical step was the determination of user requirements. This was composed of user requirements collection, specification and analysis.

The user requirements collection was conducted in Brazil (in Portuguese) with CNIR managers from the Land Reform Institute (INCRA) and Fiscal Institute (RFB) and CNIR collaborating agencies [e.g., IBAMA, SPU and IBGE]. This step was only possible because this research is part of the National Geospatial Framework Project (PIGN) that intends to analyze social impacts of the reference framework in Brazil (Chapter 2).

The data collection involved a mix of techniques [i.e., interviews, questionnaires, documentation analysis and group focus]. This assemblage occurred during the months of June, July, August and December 2008, during which data collection was used to refine the model. The user requirement specifications were represented by a description of the existing cadastral systems. The user requirement analysis described problems as well as opportunities and constraints that CNIR is expected to have during its implementation. A matrix requirement priority was also created in order to nominate the priority steps that CNIR needs to pass. A CNIR SWOT analysis also was developed to support the policy guidance.

The next step was the conceptual modeling. This described what CNIR was planned to do and to whom it would target. CNIR implementation assumptions were also assigned. A data flow was proposed and from that, functions were highlighted. CNIR minimum content was analyzed based on the needs of the agencies. And finally, policy guidance was created to define principles, strategies and lessons learned. User requirements and conceptual models also were validated with the CNIR mangers.

1.4 Research Scope

This study deals only with rural areas and any traditional or public lands contained in these areas of Brazil. The conceptual model is based on user requirements gathered at federal agencies that directly work with land administration, and one private agency, *serviços registrais,* which administer the legal cadastral system at CNIR.

This research did not implement nor test the CNIR system. All analyses and specifications were presented at a high level and they are the result of user requirements analysis. All the results of this research are cognitive. CNIR managers' ideas were also cognitively analyzed in this thesis. This research has been officially undertaken in parallel with CNIR design development. Virtually, all documentation generated during the CNIR manager's focus groups has been used to refine this research. Partial results of the analysis and literature review also has been exchanged with CNIR working groups;

it has been helping CNIR managers to be aware of important facts that were not perceived by them and now are indicators that factors needs to be analyzed for CNIR by them. The content result of this thesis will serve as an important tool by giving not only indicators, but also by supporting the CNIR managers during their work on CNIR implementation.

This research is based on the assumption that land information, well managed and legally formalized, can provide better security of tenure, and as a consequence it may become the proposed model to bring improvement in land reform programs and in public services [Nichols, 1993a; Alston et al., 1999; Carneiro, 2000; Carneiro, 2003a]. With an effective rural cadastre, the government can know spatially where land boundaries are, who the owners are and which legal processes those lands are subject to. In theory then the cadastre could facilitate governance in resolving some land disputes and land grabbing could be minimized. Also, this information will aid public policies that ensure that peasant squatters have effective access to property rights.

1.5 Research Limitations

The unique outside factor that directly and indirectly affected this research was politics. Because of the political situation, the user requirements could not be refined and validated with the collaborating agencies. The user requirements refining and validation stage was done only with the implementing agencies INCRA and RFB, which were assigned by *Law#* 10, *267/2001.*

Since 2001 CNIR has been discussed but with little implementation. This has created some political issues which affected this research. Because the CNIR implementation agencies (INCRA and RFB) have not progressed, they are beginning to lack credibility and this is holding back information. At this point, they are focused only on their needs for the main systems. Therefore the user requirements component of this research was limited. On the other hand, CNIR managers were working and they included these results from the research in their discussions.

Some of the key people that were a part of the CNIR design focus group had changed because of political appointments. The new members did not know much about CNIR concepts previously discussed. This caused difficulties in the validation of the concepts proposed in this research. The amount of feedback was minimal, restricted only to the CNIR implementation agencies (INCRA and RFB) and the IT support, SERPRO.

1.6 Prior and Current Research

Research in Brazil related to land administration is extremely limited. Fiscal cadastres are normally studied by economists and lawyers, without association with spatial information. Land use normally is studied by planners and agriculture engineers; some of this research contain spatial information but are not related to the ownership. Technical cadastres, generally, are studied according to the geometric precision of the surveys, by cartographers, geodesists and land surveyors. Legal cadastres are reviewed by lawyers without spatial information expertise or interest. Also there is a huge body of literature on land tenure problems but these are not related to any potential roots in poor land administration and land information management.

As can be seen, each particular subject is analyzed by a narrow group of experts; in rare cases are the multidisciplinary. Some research has been done by others on rural cadastral systems, especially ones which accomplish the most recent legislation for geo-referencing rural property in Brazil, *Law# 10,267/2001* and its legal instruments. Land reform, unlike the technical cadastral system, has more political visibility and is of more interest to social and judicial researchers.

Carneiro (2000) investigated legal aspects of land administration in Brazil – in particular about the integration between technical cadastral system and registry office – while Shigunov (2005) offers a critical analyses of the parameters to accomplish *Law #10,267/2001.* At the technical level, some studies about the quality of the geometry of the parcel to improve cadastral measurement and boundary delimitation according to *Law# 10,267/2001* were completed, including the use of the new reference system adopted in Brazil, SIRGAS2000 [e.g. Brandao, 2003; Costa, 2004; Luna, 2004; Brito, 2005; Galdino, 2006; Bonifacio, 2007]. This research is a continuation of the Carneiro (2000) study to characterize the Brazilian rural cadastral system and propose improvements.

Therefore this research draws heavily on international literature dealing with how to define parcels, information requirements, integration between cadastral system and notary office and its maintenance [e. g. McLaughlin, 1975; Nichols, 1984; Barnes, 1988; Coleman, 1988; Dale and McLaughlin, 1990; Nichols, 1993; Palmer, 1996; Ting, 2002; Griffith-Charles, 2004; Tuladhar, 2004; Nkwae, 2006].

1.7 Research Contributions

This research provides contributions that can be classified in the following spheres:

For Academics and Researchers:

- This research provides a multidisciplinary literature review which associates the technical area (e.g., multipurpose cadastral systems) with cognitive studies (e.g., conceptual models) and project management (e.g., strategies of implementation).
- This thesis expands the research in cadastral systems and land administration in Brazil which is currently very limited. Literature review and references will support the academia in their lectures and other researches.
- Since there are still many gaps to be filled in the CNIR design, such as the determination of the parcel identifiers, this thesis is a first step for new researchers because it summarizes the problems and limitations found at CNIR and lightly describe CNIR collaborating agencies' current system. New research will have basis literature for their start.
- Articles are going to be published at the same time that experiences in designing CNIR has been developed. These articles also are going to give

another point of view to developing countries which are trying to develop an integrated cadastral system (e.g., Nicaragua and Guatemala [FAO, 2007]).

To Land Administration Managers:

- The results of user requirements have been truly applied by CNIR managers to support and understand the needs of the collaborating agencies. They are also the basis for the definition of the proposed minimum content.
- The conceptual model has a critical analysis of the problems and solutions of CNIR and it helps make CNIR managers aware of the constraints that CNIR have. The problem analysis was also based on international experiences of multipurpose cadastral system development in developing countries such as Africa. Besides that, the conceptual model contains strategies for CNIR implementation helps the managers set up priority implementation actions.
- This research adds value to the land administration agencies by providing study of impacts of the *Law# 10,267/2001,* the new law of geo-referencing the rural properties, to the design of CNIR.

To Brazil:

- This is one more opportunity to explain the land information management issues in Brazil, demonstrating to the general public how complex and difficult a cadastral reform is.
- This thesis will hopefully create interest in new research on cadastral systems and land administration, and might support further research.

- This research emphasizes that multipurpose cadastres contain social components that should be considered during the implementation phase, something that is dealt with very little in the international literature. The technical component cannot be analyzed by itself because of the historical land factors that Brazil has had since its colonial period.
- Land information management is a missing piece that needs to be more explored and valued in Brazil. Processes found in this thesis should be part of projects developed in land administration agencies, especially the user requirements that are not usually considered in Brazil.
- Brazilian rural cadastral system trends and issues were described. Internally in Brazil, it shows how difficult it is to accomplish cadastral reform in Brazil; it is more than technical factors.
- Worldwide rural cadastre description and issues in Brazil have been systematically described; this will help to plan international land aid programs by giving more transparence on Brazil land problems.

To developing Countries:

- This research highlights that cultural, political and social issues should be considered as primary factors when a cadastral reform is taking place. Those are factors that are going to make the cadastral systems different from country to country.
- CNIR lessons learned might guide the development of multipurpose cadastral systems in countries which have land tenure systems similar to Brazil.

1.8 Thesis Research Contents

The following is a brief description of the contents of each chapter presented and its respective appendices. Summaries by sections are also found in the beginning of each chapter.

CHAPTER 1. ***Introduction*** - This gives a general overview on how this research is presented: research problem and its objectives, methodology, research scope, potential thesis contributions and the main structure of the thesis.

CHAPTER 2. ***Multipurpose Cadastral Systems*** - Part of the literature review, this chapter goes over the main concepts of multipurpose cadastral systems, including components, trends and requirements; it also relates these concepts to Brazil's case. This chapter also examines requirements for the development of multipurpose cadastral systems in developing countries.

CHAPTER 3. ***Rural Cadastral System in Brazil*** - This chapter, also considered as literature review, presents a brief summary of historical factors and land issues in Brazil that were necessary to understand why Brazil has separate urban and cadastral systems, separate from the legal cadastre. It also provides background of the current situation of the *Law# 10267/2001,* which legislates the geo-referencing of rural property in Brazil and creates the National Cadastre System of Rural Properties (CNIR), the main subject studied in this thesis.

CHAPTER 4. ***Information Systems Development and Management Processes*** - This literature review examines models of information systems development, which include the need for understanding user requirements, systems interoperability and management that are support for the land information systems establishment.

CHAPTER 5. ***Analysis of the User Requirements for CNIR*** – This analyzes CNIR user requirements which included the identification of the expectations for CNIR and the discussion of CNIR main problems and its priorities, opportunities and constraints. This chapter is the basis for the proposed CNIR conceptual model.

CHAPTER 6. ***Design Conceptual Model for a National Rural Cadastre System in Brazil*** - This chapter describes the conceptual model proposed for CNIR: objectives, scope, potential audience and assumptions. The conceptual model *per se* contains data flow, minimum content and system functions. The CNIR minimum content is determined by the user requirements needs and was reclassified as *Law# 10267/2001* determines.

CHAPTER 7. ***User Requirements and CNIR Conceptual Model Validation*** - In this chapter, the author assesses the requirements for the designed conceptual model and the model proposed by existing CNIR managers. This author then compares and contrasts the two models.

CHAPTER 8. ***Recommended CNIR Implementation Strategies*** - A summary of CNIR problems is reviewed as SWOT analysis. This chapter proposes principles for CNIR and strategies to minimize the existing issues. A summary of lessons learned from experience acquired during the actual CNIR design phase in Brazil is also presented.

CHAPTER 9. ***Conclusions and Recommendations****.*

CHAPTER 2

MULTIPURPOSE CADASTRAL SYSTEMS

The evolution of the concept of multipurpose cadastre has been accompanied by the development of new technologies, from analog to digital data and integrated spatial information systems. Multipurpose cadastral systems, sometimes called Land Information Systems (LIS), have been increasing the possibilities for applications. Section 2.1 will define a multipurpose cadastral system, how it is related to Geographic Information System (GIS), and list its potential benefits. Section 2.2 will describe the evolution of multipurpose cadastral systems from the 1980s to today, including some observations about Cadastre 2014 and Spatial Data Infrastructure (SDI) in Brazil. Section 2.3 will develop the requirements to develop a multipurpose cadastral system as they are used in this research. This Section also includes critical commentary regarding the adoption of parcel identifiers and why cadastral overlays are an important part of a SDI framework. Section 2.4 will discuss why developing countries are not able to directly copy multipurpose cadastral systems from developed countries.

2.1 What is a Multipurpose Cadastral System?

The term *multipurpose cadastral system* has been used in different ways by various academics and professionals, in Chapter 1 one definition in described. This section will explain the concept of multipurpose cadastral system and how it can differ from the concepts of a LIS and a GIS that compose a spatial information system.

The National Research Council (NRC, 1983, p. 14) defines GIS as "*designed to gather, process and provide a wide variety of geographically referenced information… focused on people or on land*." NRC (1983, p.15) "if the information in the GIS focuses primarily on the land, then the information is part of a LIS". According to Dale and McLaughlin (1988, p.8) " *LIS gives support to land management by providing information about the land, the resources upon it and the improvements made to it.*" LIS is subdivided among parcel-based land information systems (e.g., juridical, fiscal, environmental and multipurpose cadastres) and any other land information system (e.g., forest and soil inventory).

The NRC (1980, p.1) defined a multipurpose cadastre as a "*framework that supports continuous, and comprehensive land-related information at the parcel level*." Nichols (1993a, p.98) augmented the definition by saying that "*multipurpose cadastre should combine elements of fiscal cadastre (to support taxation) and juridical cadastre (to support land transfer) and is capable of supporting a wider range of land administration and management needs*". The concept of a multipurpose cadastre offers a spatially based integration of property rights with the uses, values and distribution of natural and cultural resources [Chrisman and Niemann, 1985; McLaughlin and Nichols, 1987].

McLaughlin (1975, p.1) said that “cadastre has evolved as part of the social institution of property in land, the land tenure structure, which consists of a web of relations amongst men with regard to the use and enjoyment of the land.” Ottens (2004) defended the idea that the cadastral system should be a socio-technical system. The reason for that is based on the ownership of real estate, which is a social concept. McLaughlin and Clapp (1977, p.57) claimed that “social, economic and political impact upon the proprietary unit should be understood.”

Clapp et al. (1989), Hendrix and Moyer (1993) and Hendrix (1994) used the term *multipurpose land information system* as a synonym of multipurpose cadastre. For them, multipurpose land information is intended to coordinate and integrate records concerned with land that can be identified with respect to parcels. Erba (2004) highlights that, for a cadastre to be considered "multipurpose", it is essential to integrate all public and private institutions that work with parcel land-related data using a common parcel identifier and defining parameters for data and spatial information. ***For the purposes of this research, the multipurpose cadastre is exchangeable with multipurpose land information systems (i.e., including the use and the access of a land record which is facilitated by a cadastral system, ownership records and any other information related to the parcel level with socio-technical value).***

The benefits of a multipurpose system are not exclusive to local or national spheres but apply also to the private sector and individuals. For instance, a multipurpose cadastre helps the government to select appropriate land policies (e.g., land redistribution, land consolidation, land acquisition, allocation and land markets), institutional arrangements (e.g., decentralization management) and technical solutions (e.g., use of GIS systems) [FIG, 1995; Williamson, 2002]. The complete land inventory of all current parcels and their legal situation permits data exchange with other public services systems and helps environmental analysis, sustainable socioeconomic development and resource management [Tran and Grant, 2005].

Listed below are some of the potential benefits of a multipurpose cadastre [NRC, 1983; Chrisman and Niemann, 1985; Williamson, 1986; McLaughlin and Nichols, 1987; Nichols, 1993a; FIG 1995; McLaughlin and Palmer, 1996; Ting, 2002; Cowen and Craig, 2003]:

- ***Improves the accuracy of property tax assessment*** – Taxes can be more fairly applied and easily implemented. Land can be better appraised in the land market by having updated variables at the cadastral system.
- ***Improves data access and use*** – For example, ownership and any other interests in land might be easily identified. Also, land registration might be a faster process because the registrar can confirm the boundary description and land related data. The cadastre provides a direct link between parcels and records for geographical indexes. Data at a cadastral scale can also be available for planning public services and allows the linkage with other data records. The data integration with emergency response needs is also another good use of the cadastral data access. The cadastral data can also help to design efficient land regularization programs and identify public land susceptive to redistribution.
- ***Reduces costs*** – This is due to the reduction in the duplication of data gathering and in the maintenance of multiple sets of similar maps and land-related databases.

- ***Improves governmental decision - making*** – Updated land data not only improves the efficiency of the government to design and implement policies, but also helps them to create/manage land regularization programs which can make governments more accountable. Furthermore, it also allows the government and private sector to manage resources more effectively, enabling the government to enforce environmental and other regulations. It enables the private sector, for example, to make infrastructure projects and other basic services and use the cadastral data for emergency responses.
- ***Secure tenure*** – Accurate land records and greater assurance of their ownership helps to improve the efficiency of land transactions and supports the use of land as commodity in the land markets. Additionally, it also potentially brings more security of tenure in general, helping to prevent land disputes because property ownership and boundaries are checked.
- ***Assurance*** – Updated land inventories ensure the good use of the land, which may increase land productivity. It also makes the interests on land to be more clearly defined, reducing disputed land claims, and as a consequence this might help landowners obtain credit from financial institutions and other governmental benefits to improve their land. One general consequence of land improvement is the increase in land value within the land market. Security of land tenure also allows landowners to use land as collateral.
- ***Social inclusion*** – This is an important benefit that is brought with an updated multipurpose cadastre that was not mentioned by the authors above. The social inclusion occurs, for example, when addresses are assigned and citizens are not

only recognized by the society, but are also able to claim basic services and be included in social governmental programs. Having a recognized address also implies to individual landholders that job applications can be filled out with the assurance that they will receive mail, that emergency responder can find their properties, or even that they are countable for census purposes. In Brazil, for example, rural landholders can also prove their connection to the land for the retirement programs.

2.2 Components of a Multipurpose Cadastral System

The existence of technical standards and specifications is indispensable in linking all the elements of the multipurpose cadastre. For example, it should be built on a reliable and accurate spatial framework [NRC, 1980; Ayachi et al., 2003]. The development of the multipurpose cadastre may also require administrative reorganization, quality control of the existing information management processes, and gradual implementation due to legislative change and available financing.

The components of a multipurpose cadastre as seen in Figure 2.1 are listed below [NRC, 1980; NRC, 1983; Chrisman and Niemann, 1985; McLaughlin and Nichols, 1987; Dale and MacLaughlin, 1988; Buyong et al., 1991]:

Establishment of a spatial reference framework – This permits the correlation of real property boundaries with consistent and uniform definition in a coordinate system, a common datum and usually monumented control points. The common reference frame permits consistent definition of the spatial location of all land-related data for a variety of uses. Every layer in a multipurpose system must be referenced to the geodetic control network through the coordinate system. Densification of this framework might be required for integrated parcel surveys to improve and provide co-ordinate references for parcel information. The layers contained in the spatial reference framework are for example: tidal benchmarks (relating the vertical components), the geodetic reference network and the coordinates of geodetic reference points.

Preparation of large-scale base maps – These maps permit the graphical representation of the basic common land-related data within the geodetic reference framework and they are also the basis for cadastral overlays. Normally they are represented at scales from 1:1,000 to 1:25,000 and include topography, geodetic control points, public and traditional lands, transportation routes and hydrology.

Preparation of the cadastral overlay – The cadastral overlay contains the cadastral parcel data. They may contain, for example, property assessment units, zoning regulations, units described in legal records and for managing public utilities and service systems.

Creation of linkage mechanisms – These are essential to integrate the existing layers with other information. For example, the mechanisms might include the use of common technology, the standardization of the definition of the parcel unit and creation of a specific parcel index maps. The adoption of a unique parcel identifier also must be considered.

Interconnection of land-related data – These are any land-related data containing the parcel identifier (PID). They also can be referenced to the common spatial framework, through co-ordinates, but often as well to the cadastral layer through the PID (e.g., descriptive and graphical records from fiscal, administrative, legal, census, and environmental departments, see Figure 2.1).

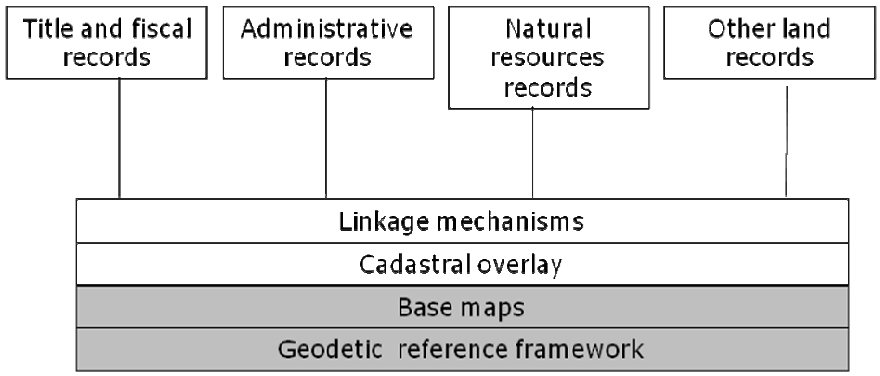


Figure 2.1 - Multipurpose cadastre components in 1980 (from NRC [1980, p. 14])

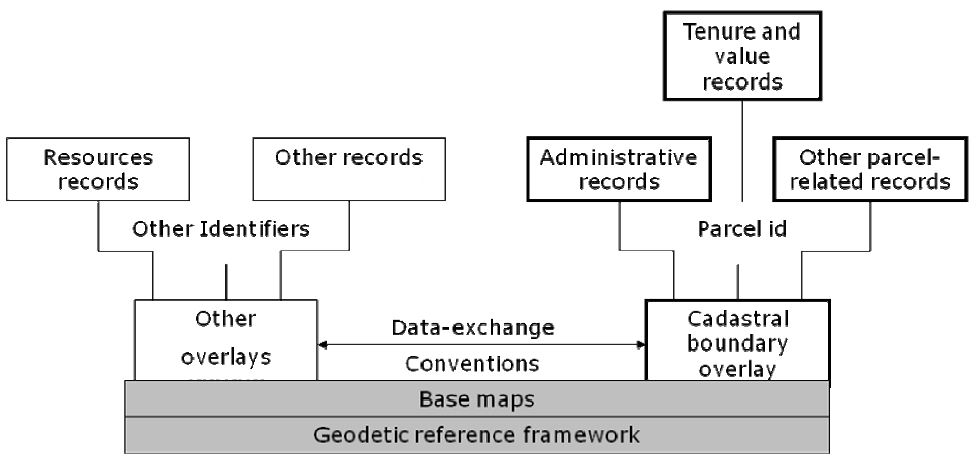


Figure 2.2 - Multipurpose cadastre components in 1983 (from NRC [1983, p. 16])

In 1983, the design of the multipurpose cadastre components changed slightly because it was observed that cadastral data were a part of the LIS and other data could be incorporated in the system without reference to PID since there was a common spatial dataset, see Figure 2.2 [Chrisman and Niemann, 1985; Larsson, 1991].

2.2.1 The Cadastre 2014 in Brazil

A hypothetical "new" vision of the cadastre described as Cadastre 2014. It showed how the traditional cadastral system could be evolved with GIS and Oriented Objects environments. According to Kaufmann and Steudler (1998); Kaufmann (1999); Bjornsson (2004) and Kaufmann and Kaul (2004) the main principles were:

- The land unit is a land object (i.e., based on a survey of object boundaries or legal description of the boundaries) that are related by topology with the parcel attributes. Additionally, the legal land object is determined by the legal content (i.e., based on right or restriction which are applied to demarcate the boundaries). It must be carefully delimited, verified, and registered;
- The legal data inventory is arranged into land objects defined by private and public land. There should not be a separation between map production and land registration. This linkage should be done by the use of information technology;
- Land can be modeled using several representations of the land object and allowing relationships among groups of land objects to be established. Standardization is one of the preconditions of the development of the models;
- Any cadastral system is now seen as a part of interconnected multiple systems (e.g., cadastral mapping systems, private land ownership records, taxation records, farm enterprise records and inventories of public lands). The Cadastre 2014 must also be flexible to integrate with new systems;
- In order to maintain the cadastral sustainability, cost recovery should be applied. It might be successful when there is a dynamic and high density of land records

that needs to be updated according to the fast evolution of the city. In rural areas, when the demand is lower, cost recovery by introducing fees might bring the cadastres to failure.

> *The Cadastre 2014 recognizes the changing relationship of humankind to land, the changing role of governments in society, the impact of technology on cadastral reform, the changing role of surveyors in society and the growing role of the private sector in the operation of the cadastre* [Williamson, 2001].

In Brazil, as discussed by Carneiro (2003 and 2008), there are some limitations that should be considered in the implementation of a Cadastre 2014 - type model. These include:

- ***Distinct and independent rural and urban cadastral system*** **–** As will be discussed in Chapter 3, rural and urban cadastre current act as separated systems.
- ***Lower financial support for cadastral reforms*** **–** Urban cadastres are developed for fiscal purposes, with the costs recovered over the long term through taxes collected. Municipalities receive low governmental aid funds to develop cadastral systems. On the other hand, the rural cadastre is supported by federal funds which are scarce.
- ***Non efficient accuracy control*** **–** Since there is no legislation for urban cadastres, there consequently is no control of the accuracy of the survey. In rural areas, the accuracy was only established in 2001 with the *Law # 10, 267/2001*. A parcel corner-point accuracy of ±0.50 m or greater is controlled and attested by INCRA. By law INCRA must to certify if all the rural properties are surveyed according to the *Law # 10, 267/2001*. The problem is

that there is not a uniform and national methodology for rural property's certification within INCRA.

- ***Non-existent or outdated maps at the agencies that deal with land information*** **–** In most of the agencies, when existent, maps are out of date and/or the information contained within is related to different datum.
- ***Privatized and independent legal systems*** – The legal cadastre in Brazil is separated from the technical cadastre. It is administrated under private registry offices that are controlled by the Ministry of Justice even though registrar offices are independent one each other.
- ***Bureaucratic administrative control*** – As Brazil is part of the civil law system, all the actions must be determined by law. Land laws in Brazil are specific for each agency and some are outdated. Formal agreements that provide agencies' stewardship and commitment are inexistent, or they take too long to be concretized.

From the author's perspective, the adoption of a Cadastre 2014 in Brazil can bring potential benefits, as listed below:

- The implementation of a land information system that could be used for numerous applications, including ones dealing with social data. It gives to the land – related data open opportunity to be widely analyzed and applied;
- Once there is a connection between the technical and legal cadastres in Brazil and spatial data is available, it could give more security for the registrar to validate the land titles. One of the consequences could be the improvement and

agility of the land registration process and faster opportunity for the citizen to get social and economic benefits;

- Land records could be centralized in one system with its related accurate data and spatial information. It could facilitate the data collection and maintenance;
- It could be easily accessible to all users (including governmental agencies, private sector and citizens);
- It could have more territorial coverage, even without complete data, than the existing individual land information systems. This could happen, for example, by putting together all land-related information that are available at the land information agencies but are covered in several isolated areas of Brazil;

2.2.2 The Spatial Data Infrastructure (SDI) in Brazil

Another evolution that impacts the cadastre is the adoption of a Spatial Data Infrastructure (SDI) to improve spatial information and management. SDI is a framework that must be widely available, easy to use, flexible and multipurpose. General benefits of SDI are related to enhancing data sharing, making data distribution more transparent, increasing the general level of knowledge about and access to information within the society, and minimizing the cost of extensive data collection schemes by increasing access to existing data and by establishing common standards [Coleman and McLaughlin, 1994; Coleman and McLaughlin, 1997; Coleman and McLaughlin, 1998; Nkwae and Nichols, 2002].

This is possible because SDI contain the following components [McLaughlin and Nichols, 1993; Eagleson et al., 2000; Masser, 2002; Williamson et al., 2003; Crompvoets and Bregt, 2003; Thompson et al., 2003; Warnest, 2005; Paixao et al., 2008]:

- ***Metadata*** – This describes the geographical referencing data and helps the communication at the data integration by having common standards.
- ***Institutional arrangements*** **–** These contain the management of the organizational structure that can manage the construction and maintenance of the SDI.
- ***Information technologies*** – These help to maintain, to process, to disseminate and to access spatial data (e.g., common servers to provide standardized information services to users, gateways and query languages to regulate the data flow).
- ***Networks and access mechanisms*** **–** These provide flexibility and accessibility to the spatial data.
- ***Policies and standards*** **–** These lead all other components. Standards allow the data to be processed and connected with common conventions. On the other hand, policies establish the environment within which the SDI will be developed and managed; they define the constraints and goals and, to certain extent, delineate the means by which the goals will be achieved.

From an institutional perspective, the use of SDI brings opportunities for federal agencies to review obsolete and specific legislation, and also to create new policies and agreements. It is important that the federal level develops land policies in Brazil that can effectively and efficiently incorporate appropriate SDI components. This will bring not only economic development for the rural areas, but also social value.

New technologies also must be adopted in order to meet all the needs for the SDI implementation in Brazil. This also includes not only the acquisition of software and hardware but also capacity building for skilled professionals. Digital inclusion of users (rural citizens) is also another point to be considered, it includes the easy access to the land information through technology, its dissemination and understanding. The integration of land-related systems brings opportunities to create an effective tool for the land information management in Brazil. As a consequence, the available land information might facilitate governance to resolve some of the land disputes and land grabbing could be minimized. Also this information will aid public policies that could ensure that peasant squatters have effective access to property rights.

In Brazil the implementation of SDI, or INDE as it is called, is relatively new. The Brazilian SDI framework was officially established in December 2008 by *Decree # 6,666/2008,* even though some initiatives for SDI in Brazil already were implemented without regulations [e.g., Paixao et al., 2008]. Some of these initiatives included standards for interoperability proposed by e-Government Interoperability Standards (e-PING). The e-PING was created in 2003 to establish criteria for the development of systems and data storage including a set of minimum premises, policies, and technical specifications that regulate the use of communication and information technologies [Brazilian Government, 2007; Santanna, 2007].

The INDE has been under the Brazilian Cartography Committee (CONCAR). According to Fortes (2008) CONCAR is responsible for promoting actions towards the signature of agreements and cooperation among federal, state and local administration institutions. IBGE is in charge to give technical and administrative support to CONCAR.

CONCAR established the spatial data standardization, it is the ISO19115 (Metadata) [CONCAR, 2009]. The interoperability of systems, dissemination of spatial information and its metadata is mandatory at the federal level and voluntary at the provincial and municipal level. More details about ISO and standardization can be found in Chapter 4, and appendices IV and V.

The Brazilian spatial reference framework was for several years used with different datum (e.g., *Córrego Alegre* and the South American Datum of 1969 (SAD69)), that created two legalized coordinate systems living side-by-side [IBGE, 2007]. The geocentric coordinate system, SIRGAS2000, compatible with modern positioning space technologies, was just adopted in Brazil in 1999. In 2004, the Brazilian Institute of Geography and Statistics (IBGE), in cooperation with the University of New Brunswick and many other governmental agencies and academics, began the National Geospatial Framework Project (PIGN) funded by the Canadian International Development Agency (CIDA) [PIGN, 2007]

One of the PIGN objectives was to give technological support and expertise to IBGE for the adoption the datum SIRGAS2000 in Brazil and to develop tools to disseminate spatial information to users. PIGN also accomplished the study of many social impacts of this geocentric framework in topographic and cadastral mapping, the inclusion of spatial information and access for women, the poor, and traditional communities [Fortes et al., 2006; Santos et al., 2009, Paixao et al., 2007]. The types of lands studied in the PIGN were indigenous lands, *Quilombola* territories, environmental conservation units and rural lands. The results of the studies can be found in Paixao et al., 2006; Freitas et al., 2007a; Freitas et al., 2007b; Carneiro et al., 2008].

This thesis will be part of and based on the studies generated by the PIGN's social impact in rural areas. Activities related to access to land and the process of regularization were analyzed from various aspects and helped to construct the conceptual model for a national cadastral system in Brazil.

2.3 Requirements to Develop a Multipurpose Cadastral System

Hendrix (1994) states that, to develop a multipurpose cadastral system, it is necessary to comply with the steps described below. In order to better understand how this thesis is organized, the following steps were also associated with specific chapters in this research. The explanation of why these steps are necessary is found in Chapter 4 and Appendix IV:

1. Determine the system's scope, using a the cost/benefit analysis (See Chapter 6);
2. Estimate the user requirements (See Chapter 5);
3. Analyze the requirements (See Chapter 5);
4. Design the system (See Chapter 6);
5. Design the implementation process (Not applied in this research however strategies for implementation are developed in the conceptual model);
6. Design pilot projects, demonstrations and operational examples (Not applied in this research);

7. Evaluation (See Chapter 7).

2.3.1 The Adoption of Parcel-Identifiers in a Multipurpose Cadastral Component

Defined by McLaughlin and Clapp (1977, p.61) “a parcel is an unambiguously defined unit of land within which rights and interests are legally recognized”. Larsson (1991) reinforces this definition, explaining that both the area and interests of this land unit must be continuous.

A parcel is identified by a unique parcel identifier code, or "PID". Defined by NRC (1983, p. 63), “parcel identifiers are codes for recognizing, selecting, identifying and arranging information to facilitate organized storage and retrieval of parcel records.”

Dale and McLaughlin (1988), NRC (1983), Nichols (1993a) UENCA (2007) indicate that the criteria to choose a land parcel identifier are:

- ***Uniqueness*** – There are no parcels with the same reference code and there is a cardinality of one-to-one between physical and recorded data property. Violation of this condition might lead to mis-identification (wrong parcel is identified) or non-identification (parcel is omitted).
- ***Simplicity*** – It should to be easy to understand and assigned with the least characters possible; they are less likely to be mistaken.
- ***Flexibility*** – It should be capable of being updated even with the change of the technology, allowing data sharing.

- ***Permanence*** – It should be permanent and change only if the boundaries of the parcel change. This means that in case of subdivision a suffix number might be added and in case of property conveyancing, the original parcel identifier must be kept.
- ***Economy*** – It should be easy to introduce processes and maintain a system by reducing the operational and implementation costs of the cadastral system. The ideal is also to keep the PDIs in logical sequence and spatial ordering as found in the ground.
- ***Accessibility*** – It should be easy to access from general public and administrators.
- ***Reference*** – It should be accurate and legally defined.

It is difficult to implement a parcel identifier system that meets all of the criteria described above. The best method to represent the parcel identifiers is the one that accommodates all of the needs of the system to be implemented. Respective advantages and disadvantages of each different method of creating and assigning a PID, as listed below, should be considered.

There are three fundamental forms of code: the name index identified by the claimants on the interested on the land, the random number index where there is uniquely identification of the records by a specific cadastral parcel and the location index where records are uniquely and geographically identified [McLaughlin, 1975; McLaughlin and Clapp, 1977]. The location index is also subdivided into hierarchical, co-ordinate and hybrid identifiers. Table 2.1 summarizes the common problems assigned of each forms of parcel code.

Table 2.1 – Common problems assigned to the parcel code [from (McLaughlin, 1975)]

	Name Index	**Random Index**	**Hierarchical Identifier**	**Co-ordinate Identifier**	**Hybrid Identifier**
Code Examples	Grantor /grantee index.	Sequential numbers	Street address or municipal unit, block and parcel number	Latitude and longitude or rectangular grid coordinates	
Uniqueness	Not unique	Unique	Unique	Unique	Unique
Simplicity	Complex index	Very simple index	Simple index	Complex index	Complex index
Flexibility	Inflexible	Relatively inflexible	Flexible	Very flexible	Very flexible
Permanence	No difficulty	No difficulty	Potential difficulties	Potential difficulties	Potential difficulties
Initial Cost	Low	Low	Low	High	High
Ongoing Costs	High	Moderate	Moderate	Moderate	Moderate
Accessibility	Complex system	Requires property mapping	Requires property mapping	Requires geodetic information	Requires geodetic information

McLaughlin (1975), Tomberlin et al. (2003) and UN (2004) point out that the problems in choosing the parcel identifiers are:

Name Index

- Names might be spelled in different ways;
- There might be homologous names;
- Names might change in marriage circumstances;
- Land inheritance might not be registered and the grantee might not be updated when transactions occur;
- As a public record, people might have direct access to the landowners names;
- It might be difficult to identify if the property was subdivided;

- It does not have any reference to geographic location.

Random Index

- It might have too long sequential numbers. It facilities the occurrence of errors at the data input;
- It might be difficult to be remembered;
- There is no logical mean at the random identifiers;
- It does not have any reference to geographic location.

Hierarchical Identifier

- Might change when political –administrative boundaries change;
- It might be difficult for maintenance if a large number of land subdivisions are taken in place;
- It might be difficult if one block is contained in more than one sector or municipality.

Co-ordinate Identifier

- It might require sophisticated data control;
- It might change if the reference system changes;
- Accuracy might be dependent on how many digits are used;
- They are not easy to remember.

Hybrid Identifier

- Problems are the mix of hierarchical and co-ordinate identifier.

2.3.2 Relationship between Parcels and SDI

The role of cadastral overlay in SDI is related to the data component. For National and State SDIs, the cadastral layer is considered as supplementary data and for locals SDIs they are primary data [NRC, 2001]. Siriba and Farah (2008) also add that cadastral layers provide thematic information and also provide a framework for integration of other layers. Representing the smallest land unit, the cadastral layer parcels provide information on land related to rights, restrictions and use (e.g., information related to agricultural subsidies, and land use and preservation) [Salzmann and Ernst, 2008].

Infrastructure for public utilities is another application that makes the cadastral layer important in SDIs. The infrastructure for public utilities is positioned at known offsets from parcel boundaries. If the parcel is accurately located, its coordinates are available as evidence in locating other physical services in the field [NRC, 2001; Elfick et al., 2005; Committee on Land Parcel Databases, 2007; Enemark, 2009]. The spatial inventory at a cadastral level also helps planners and developers bring all the necessary data together to detect hazards and make decisions on how to prevent and fix the damages to the utilities infrastructure [Onyeka, 2005]. The implementation of an SDI also brings an accurate geodetic network that is used as reference to establish control for the parcel boundary survey [Konecny, 2005].

For example, the benefits of an accurate definition of a parcel, it is possible [Committee on Land Parcel Databases, 2007; Salzmann and Ernst, 2008; Martín-Varés and Salzmann, 2009; Ernst, 2009]:

- to create general plan about urban and rural planning;

- to evaluate the soil and control its exploitation;
- to control areas with a specific risk of natural disasters;
- to guide land markets (conveyance of property, mortgaging, easements and land/property taxation) used to manage the comparable values on utility holdings;
- to locate infrastructure (e.g., power, telecommunications, water, sewage, and steam-heating networks).

2.4 Multipurpose Cadastral Systems in Developing Countries

Many developing countries have been struggling with the separation between the agrarian cadastre and the juridical cadastre. The changes proposed in the Cadastre 2014 addressed cadastral reform that might occur in these countries. However, separate systems are only one of the issues that make it practically impossible to copy a successful LIS from a developed country to the developing countries. The political and cultural constituents play strong roles in this process.

The separation between the agrarian cadastre and the juridical cadastre does not only necessitate the existence of different information systems, but also conceptual differences in the land unit definition. According to Coleman (1988), the acceptance of different types of parcel in the same LIS should not be a problem if: (a) the dataset is built in the same spatial framework; and (b) if the classes of parcels can be interrelated on a *1:n* or *n:1* basis and organized in a cross-referencing index. This is a common situation in nearly all countries before cadastral system reform.

Nichols (1993b) pointed out that to import system solutions is probably not an adequate action unless the countries (from/to) have similar situations and similar institutional support. Such situations are rare in any countries. Each country has unique economic, historical, political, legal and geographic roots, and these must be considered when imported systems solutions are planned.

In developing countries there is independency and lack of communication among the technical cadastre and the legal systems [Carneiro, 2003a]. Cadastres have generally incomplete coverage and most of the coverage is located in urban areas where formal procedures take place for planning [Fourie and Nino-Fluck, 2000]. Spatial information is a missing component in registry offices to confirm the boundary descriptions [Williamson, 1986]. Landholders have little or no documentation to prove ownership; adjudications are delayed by missing or conflicting evidence [Nichols, 1993b] and violent land disputes can happen.

Many unregistered properties are also conveyed without evidence of ownership [Fourie and Nino-Fluck, 2000]. In some cases, transactions occur on the basis of honoured words and handshakes of parties, with or without any documentation. This leaves opportunities for fraudulent negotiations. As pointed out by Molina (2007), numerous land transactions are unregistered in Latin America due to the bureaucracy involved in proving land ownership. Sometimes proof is never found; this leads to corruption in the transactions and registration processes. (e.g., boundary limits are not clearly defined and forged documentation are created to make land transactions, fraudulence documents are registered). Brazil is one example of this kind of bureaucracy.

According to FAO (2007) and World Bank (2007) there are 14 steps to register property in urban areas in Brazil, which altogether take about 42 days or more to complete with a 70% chance of corruption practices (i.e., score of 3.3 in 2006) . In comparison, in a developed country such as Canada, the process takes 10 days, follows 6 steps and with a 14% corruption perception[1] (i.e., score of 8.5 in 2006). Brazil has the greatest number of steps for registration of urban properties in Latin America and the Caribbean. In urban areas these steps also depend on the construction permit. In rural areas, after *Law# 10, 267/2001* that required property geo-referencing be validated by the Land Reform Institute (INCRA), the titling process in rural areas can take months. It depends on the ability of INCRA's local offices to certify the survey of the property boundaries, and only after this confirmation can the property can be registered at the registry office (see Chapter 3).

> *The lack of efficiency in the demarcation of lands and its titling system is caused normally by costly, confusing, slow and often politically manipulated and corrupt process of land registration [Pereira, 2003].*

As a consequence of the bureaucracy in Brazil, the registries of properties have become outdated and any subsequent transfer of property is normally informal. The technical cadastral system and the legal cadastres have not worked properly. Because of

[1] Costs of registering urban properties can be found in the World Bank report in 2007 (http://www.doingbusiness.org/ExploreTopics/RegisteringProperty/Details.aspx?economyid=28).The Transparency International Corruption Perceptions Index ranks countries in terms of the degree to which corruption is perceived to exist among public officials and politicians. The presented data is from report 2006 (http://www.transparency.org). A higher score means less (perceived) corruption. The scores range from 1 to 10.

this, there is uncertainty as to what is legally recognized in the land registers and what is represented on the ground.

Heeks (2002) and Methven et al. (2007) point out that in order to avoid the failure of LIS implementation, reform at organizational level should be considered beside the technological support. It should include, for example, commitments from the senior rank of the organizations to maintain the LIS, acceptance of organizational change within different cultural contexts and commitment of sufficient resource to implement the LIS.

As Tran and Grant (2005) state, the lack of success in copying multipurpose cadastral systems from developed to developing countries is based on unclear land policies, poor legal frameworks, lack of human resources and the high enthusiasm in wanting a system seen in other countries. Table 2.2 demonstrates factors that might be missing in developing countries that are usually present at developed countries. In fact, there is a stable and well defined institutional, organizational, legal and technical framework in the developed countries that contains the following requirements.

Table 2.2 – Reasons for successful multipurpose cadastral systems in developed countries

Institutional arrangements [Nichols, 1993b; García, 2001; Williamson and Ting, 2001; Cowen and Craig, 2003; Tran and Grant, 2005; Molina, 2007]	- Existence of good governance, including for example clear policies, proper organization, little corruption, adequate resources, culturally sensitive and equity approaches. - Creation of less ambitious goals that make the land policy tangible and easy to administrate. - Existence of technological support (i.e., hardware and software) and transparency on information dissemination. - Availability of financial support for long-term. - Working relationships with other departments and agencies which have overlapping responsibilities.
Technical arrangements [García, 2001; Williamson, 2001; Hawerk, 2006]	- Defined data standards, spatial reference networks, base map designs and assignment of parcel identifiers. - Existence of high level of education and professional training to support, for example, land titling programs and cadastral surveying systems. - Existence of norms, standards and specifications for the systems. - Existence of the latest technology.
Operational and management arrangements [Williamson, 1986; McLaughlin and Nichols, 1987; UNCHS, 1990; Pesl, 2003, Carneiro, 2003]	- Coordination and commitment among most of the participant agencies. - Adoption of management skills to get the activities done. - Delegation of responsibilities and the assignment of deadlines. - Attention to the true users' needs and system constraints. - Existence of awareness of the benefits of keeping the records updated. - Existence of political power and support. - Creation of land information policies to support the management of the information.
Legal arrangements [McLaughlin and Nichols, 1987]	- Updating of the existing legislation.

This chapter is an important overview of basic concepts that needed to be clarified in order to understand the development of a multipurpose cadastral system such as the National Cadastre of Rural Properties in Brazil (CNIR). This chapter not only clarified terminology associated with LIS and multipurpose cadastral systems, but also highlighted the benefits of a multipurpose cadastral system in terms of, for example: taxation, data access, security tenure, social inclusion and governmental practices. The components of the multipurpose cadastral system were also linked with the principles of the Cadastre 2014 and SDI framework, as they might be applied in Brazil.

The requirements for developing a multipurpose cadastral system are in the section which relates steps that are recommended in the literature for system development with each chapter in this thesis. From the recommended 7 steps, only two of them, design the implementation process and create a pilot project, were not applied in this thesis.

The subsection in this Chapter on adoption of parcel identifiers is related to the steps of analyzing the requirements and designing the system. This subsection gave criteria for choosing a land parcel identifier, what is one of the primary problems for the rural cadastre in Brazil. The subsection relationship between parcel and SDI is also part of the step on designing the system, where the importance of having cadastral data inside the SDI framework is stressed. So far this practice has not been adopted in Brazil. Finally the last section adds reasons (e.g., institutional, technical, operational and legal differences) why a multipurpose cadastral system cannot be fully copied from a developed country to a developing country. There is always a need to adapt a system to reflect cultural, political, and economic factors.

CHAPTER 3

RURAL CADASTRAL SYSTEM IN BRAZIL

In Brazil there are multiple cadastres for different purposes and areas. To understand the main issues related to cadastral systems in Brazil a brief summary of the historical factors will be presented in Section 3.1. The disparity of systems occurred because of the land issues that happened in Brazil during the colonial period, and they are still important factors today, as will be described in Section 3.2. Section 3.3 will contrast the main differences between rural and urban cadastral systems in Brazil. More detail of the rural cadastre is given in the following sections, since this is the subject of this research. Section 3.4 more specifically will describe the rural cadastre administration in Brazil; it highlights the importance of the new legislation (*Law# 10,267/2001*) which determines the geo-referencing of rural property in Brazil and the creation of the National Cadastre System of Rural Properties (CNIR). This section provides a summary of the land registration system in Brazil. Section 3.5 will identify one of the major problems related to CNIR, that is, the heterogenic concepts of the land unit or parcel that varies within the cadastral systems and recommend some requirements toward the CNIR PID assignment.

3.1 Historical Land Factors in Brazil

The historical facts in Brazil define well why land information is critical today. From the time of Portuguese colonialization, many uncertainties about property rights have occurred. This section summarizes chronologically the main factors related to property information in Brazil.

Brazil was discovered in 1500 by the Portuguese. The first land policy (1532) was a system called hereditary provinces (*capitanias hereditárias*) through which Brazil was divided into 14 sections with monopolies and licensing privileges [Powelson, 1987].

In 1548, the Portuguese Crown began offering large grants of land for productive land use. These grants, called *sesmarias,* gave full property rights over very large plots of land to the grantee, with the sole condition being that the land was to be cultivated [Alston et al., 1999; Krueckeberg and Paulsen, 2000; Galdino, 2006]. Carneiro (2003a) and Jacomino (2006) clarify that the delimitation of the *sesmaria* written in letters patent are simple. The problem in establishing the size and location of the *sesmarias* and further subdivided land was mainly due to the inaccuracies and vagueness of the descriptions. These methods were rudimentary until the nineteenth century. Alburquerque [1957] gives one description as: *"The surveyor filled his pipe, lit it, and went to his horse. Then he let the horse walk step by step. When the pipe ended, it was stated to mark 1 légua"*.

Not until 1850, with Law of the Lands (*Law# 601/1850*), did the first separation of private and public lands (*terras devolutas*) occur [Foweraker, 1981]. Also this was when the first form of land registration occurred at the churches. The Priest was responsible for making a declaratory inventory of the lands (*Registro do Vigário*) but only recognized the types of land use for statistical purposes [Arruda, 1999]. According to the Law of the Lands, all lands that were not registered or did not have title were public lands.

It was not until 1964, with the creation of the Land Statute (*Law# 4,504/1964*), that technical cadastres appeared. The Land Statute of 1964 was the agrarian legislation benchmark because it regulated the rights and restrictions of rural properties, now a concern of agrarian reform and promotion of agrarian policies [Loch, 2007]. This Statute also created rural property taxation (ITR) [Nascimento, 2007].

In 1972, the first legislation for the rural cadastre (*Law# 5,868/1972)* created the National Rural Cadastral System (SNCR) which contained rural properties and public lands; no positional accuracy was established for the surveys. Finally, in 2001, the positional accuracy of the property corners was defined to be a maximum of ±0.50m according to the *Law# 10,267/2001.* This law also determines the geo-referencing of rural property in Brazil [Carneiro, 2003a; Loch, 2007].

Since 1946 fiscal urban cadastres were available, but creation of a systematic urban property taxation (IPTU) occurred in 1966 [*Law# 5,172/1966*; Carneiro, 2003a; Galdino, 2006]. The 1988 Brazilian Constitution established that cities must have Master Plans to manage their urban occupation. In 2001, the Statute of the Cities (*Law# 10,257/2001*) made municipalities responsible for managing the municipal territory and IPTU [Loch and Erba, 2007]. Urban cadastres were created without legislation [Krueckeberg and Paulsen, 2000; Loch, 2007]. In 2009 the Ministry of the Cities established directives for the urban cadastres that were created by a work group formed by experts' academics and professionals. These directives were not published yet but they are available to the general public as recommendation for urban cadastres implementation. The contrast between the rural and urban cadastres in Brazil will be explained in Section 3.3.

3.2 Land Issues in Brazil

Land issues in Brazil started during the Portuguese colonization, when lands were distributed under social and economic privileges. It consequently created an inequitable land distribution in Brazil that is seen until today. This affects mainly indigenous, blacks and remaining black ex-slaves and poor white populations. The fight for land access is marked as well by violent conflicts. It also has been accompanied by social movements. Programs of land reform in Brazil also have been increasing the political interest by being seen as a factor to elect politicians. This section will give more details of the land issues in Brazil.

Poverty in Brazil is the result of unequal distribution of both income and land. The economic power is concentrated in the hands of a small part of the society; it is also reflected in the GINI[2] index. In 2000, the land ownership concentration coefficient of Brazil was 0.802, the ninth position among the countries of the Americas. Canada is at a greatest ranking with 0.602 [INCRA, 2001; DIEESE, 2008; Souza and Pereira; 2008; Sauer and Souza, 2008].

2 The distribution of land ownership and income of a country is measured by the GINI Index, ranging from zero "0", to "1", with zero indicating absolute equality and 1 means absolute concentration [Sauer and Souza, 2008].

Additionally, a small portion of the society owns the larger areas in Brazil, where sometimes there are contestable land titles. As seen in Appendix I, Table I.1, 31.6% of all rural properties are smaller than 10 ha and these properties occupy only 1.8% of the total land area. At the same time properties larger than 2,000 ha account for only 0.8% of the total number of properties; but they occupy 31.6% of the total area [MDA, 2005; DIEESE, 2008].

The land ownership concentration and social exclusion in Brazil have been creating violent agrarian conflicts. Appendix I (Figure I.1) shows that the number of deaths in agrarian conflicts has decreased over time from 1986 to 2006. These conflicts are used as strategies for political pressure and ways to get the general society attention [Sauer and Souza, 2008]. Social movements such as Landless Peasant Movement (MST - *Movimento dos Sem-Terra*), Pastoral Land Commission (CPT -*Comissão Pastoral da Terra*), the National Federation of Farm Workers (CONTAG -*Confederação Nacional dos Trabalhadores na Agricultura*) and Rural Workers Syndicate were created to help the landless and small farmers to combat, for example, unproductive large tracts of lands (*latifúndios*), fraudulent occupation on public lands through the use of invalid documents or forgery of titles (*grilagem*), environmental degradation, and corruption in governmental departments that deal with agrarian issues [Carli and Tocantins, 2009]. The social movements also defend the transformation of the unproductive *latifúndios* for family agriculture [Girardi, 2008].

The creation of the *latifúndios* in Brazil started in 1850 when agrarian legislation was absent and, without control, they still exist today [Souza and Pereira; 2008]. Initially *latifúndios* were related to sugar cane plantation and coffee; today they are related to cattle ranching and agro-industry [Mattos Neto, 2006]. Carli and Tocantins (2009) point out that 18% of the Amazon forest was deforested for cattle ranching and soya plantations.

Grilagem in Brazil is increased by legal insecurity and lack of clear property boundaries, by inexistent or partial knowledge of the location of public lands by fraudulent titling, and by institutional corruption that allows the registration of overlapping properties [Pereira, 1980; MDA, n.d]. Mota (2002) adds that, in some cases, the *grilagem* are also helped by corrupt land registrars together with public institutions, judiciary divisions and citizens. Plata and Reydon (2006) argue that the area of *grilagem* might be approximated to that of Central America plus Mexico (i.e., around 100 million hectares). See Appendix I (Figure I.2).

Despite the fact that the 1988 Brazilian Federal Constitution recognizes the rights to land for all people, it does not specify that the rights actually imply ownership of the land. According to DIEESE (2008, Appendix I – Table I.2), from the existing rural area in Brazil, 82.6% of the area is registered in *Serviços registrais*, remain area is a mixture of ownership and rights of occupation (4.8%) and just rights of occupation (12.5%).

Finally, there are also numerous traditional lands that have been apart or neglected in the governmental inventories. Examples of those ethnic groups are the indigenous and black ex-slaves (*quilombolas*).

Even though Article 68 of the 1988 Brazilian Constitution establishes obligation to recognize the territories of *Quilombolas,* information on *Quilombolas* communities today is still scarce and flawed. A survey made by the Centre of Applied Cartography and Geographic Information (CIGA) of the University of Brasilia in 2005 reports that, in sixteen years [1989 to 2005], just 73 *Quilombolas* lands were titled and that, if the government continues at this rate, it will take more than four centuries to recognize the 2,228 areas identified by CIGA [Anjos, 2006]. It is also seen in the DIEESE (2008, Appendix I – Table I.3) agrarian atlas, that the number of the titles issued per year (less than ten) for the recognition of the *quilombolas* communities does not keep up with the claim processes (more than hundred yearly).

Article 231 of the same Brazilian Constitution recognizes indigenous peoples' rights. The 2000 Census counted that 0.6% of the total Brazilian population (188, 298.099 inhabitants) are indigenous. The NGO Institute Socio Ambiental (ISA) [2007], shows that 599 indigenous territories exist in Brazil and occupy 13% of the Brazilian territory. Only 64.6% indigenous territories are registered at the Secretary of the Federal Patrimony (SPU).

3.3 Cadastral Structure in Brazil

The structure of the cadastral system in Brazil differs from those in North American countries because there are independent cadastral systems for rural and urban areas and because the land registration system is a private notorial system (i.e., services are private, but regulated by the federal government). Titles are written by the notary and registered by the registrar. In this section, the rural and urban cadastral systems will be contrasted.

As Carneiro (2006), Loch and Erba (2007), and Erba and Carneiro (2008) all comment, the cadastral system in Brazil is fragmented according the location of the property. In rural areas, there is a centralized cadastre administered by the federal government, which is also responsible for imposing legislation such as *Law# 10,267/2001*. In urban areas, the cadastral system is decentralized and the municipalities are independently responsible for the inventory of land information. In addition, the legislation directive for the urban cadastres was created by the Ministry of the Cities only in December 2009 (Legislation MinCidades # 511/2009).

The fiscal cadastral systems are also different in urban and rural areas. The urban property taxation (IPTU) is administered by the city halls with independent methods of data collection and maintenance. Until 1990, the ITR was administrated by the Land Reform Institute (INCRA). After this period, the Federal Revenue Service (RFB) was put in charge of operating the taxation system and managing the fiscal information [*Law # 8,022/1990*]. In 1992, for the first time, RFB issued the ITR from the fiscal cadastre (CAFIR system) created by them.

As a consequence of the divergent administration, entities act separately and there is no integration of the systems. Some of the main differences between rural and urban cadastres are displayed in Table 3.1.

Table 3.1 – Contrast between the rural and urban cadastral systems (after Carneiro, 2003; Loch and Erba, 2007; Erba and Carneiro, 2008; Galdino, 2006; Directives Ministry of the Cities, 2009).

Characteristics	***Rural Cadastral Systems***	***Urban Cadastral Systems***
Organization	- Under federal government responsibility through INCRA - Centralized power.	- Under municipal responsibility through the city halls; they can be under the departments of planning, or revenue, or infrastructure. They are independent cadastral systems. - Decentralized power.
Legislation	- Outdated until 2001 when the geo-referencing property law was created (*Law# 10,267/2001*). - National level.	- Non existent legislation, municipalities were guided by the Master Plans until June 2009 when the Ministry of the Cities proposed a national directive. - Local and National level.
Cadastral Systems	- The cadastral systems depend on the purpose: SNCR for the agrarian regularization under INCRA and CAFIR for the fiscal purpose under RFB. In the future there will be a unique national cadastre, called CNIR that will contain legal, agrarian, fiscal and environmental inventories. - Contains inventory of public land, but does not cover all Brazilian territory. - Rural properties taxation (ITR) issued under RFB. - By law data update should occur each 5 years, or when a new conveyance occurs but this does not always happen.	- The cadastral systems are implemented for fiscal purpose, but can also be used for other multipurpose interests (i.e., used for example for social, economic, administrative, security, public purposes). - Urban property taxation (IPTU) issued under city halls.

Table 3.1 – Contrast between the rural and urban cadastral systems (Continued)

Characteristics	***Rural Cadastral Systems***	***Urban Cadastral Systems***
Land Unit Identifier	- The land unit is a rural property which has several definitions according to the cadastre involved. - Before 2001, rural properties were identified by written description. After 2001, co-ordinates of the corners are used with the written description. - In transition period, the corners co-ordinates are identified by an alphanumeric code: code of the professional responsible + number of the corner + sequential number.	- The land unit is the property, which might contain more than one parcel. - The parcel is normally identified by the following numeric code: municipality + district + sector + square + lot + unit.
Financial Aid	- Federal or international resources.	- Municipal budgets or funds generated by the cadastral systems.
Legal Rights	- Legal rights are registered in the private registry office (*serviços registrais*).	- Legal rights are registered in the private registry office (*serviços registrais*).

3.4 The Rural Cadastral System in Brazil

Since the subject of this research is the rural areas, this section will add more details about the rural cadastre administration under INCRA. Also it will discuss the new legislation (*Law# 10,267/2001*) which requires that rural properties be geo-referenced, to highlight why this law has been difficult to implement. The land registration system in

Brazil, and the national cadastral system (CNIR) to be established under the *Law# 10,267/2001,* will also be described.

At INCRA the rural cadastre is administrated under the Sector of Agrarian Structure, through departments such as Cartography, Rural Land Regularization, and Regularization of the *Quilombola* Territories (See Figure 3.1). Each of these departments works independently, even when there is overlap of interests. As described by INCRA [2009], the normative acts, manuals, and technical procedures are produced under the Rural Cadastre Department. This department also administers the current Rural Cadastral System (SNCR) and provides statistical studies and controls the acquisition of the rural lands by foreigners.

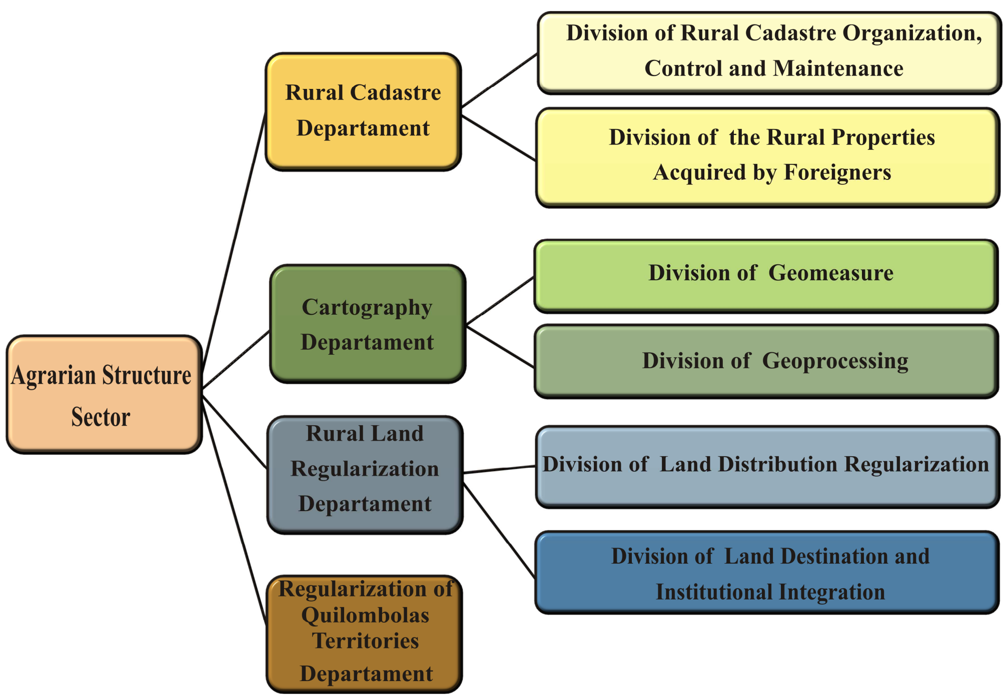


Figure 3.1 – Organogram of the INCRA's agrarian structure (after INCRA [2009])

3.4.1 Law# 10,267/2001 for Geo-referencing Rural Properties in Brazil

Law # 10,267/2001 (regulated by *Executive Order # 4,449/2002* and *Decree # 5,570/2005*) is the most recent legislation for geo-referencing rural property in Brazil. This law declares that all rural parcels, in the long term, will be geo-referenced and described by Cartesian co-ordinates with minimum precision of ±0.50m on each parcel corner. The geo-referenced rural property will be integrated with information from the s*erviços registrais* in a multipurpose geographic database available to governmental and general users. With geo-referenced property descriptions, the s*erviços registrais* will tend to have the tools to identify overlaps, gaps, and even possible the *grilagem,* when new titles or physical changes to properties are filed.

The use of geographic coordinates to describe land parcels according to the *Law # 10,267/2001* is intended to promote better evidence of the property location and boundaries through physical survey procedures on the ground. These surveys link parcels from the registration system and projects of agrarian regularization to a specific location. Altogether this provides the basis for the integration of socio-economic data in a community and creates information for the better functioning of the land registration system. Until *Law# 10,267/2001,* is enacted, each property has only a declaratory description or, if it was surveyed, the surveys were isolated (not integrated in a co-ordinated system) without certainty about the common boundaries among properties (as shown in Figure 3.2).

Before *Law# 10,267/2001* After *Law# 10,267/2001*

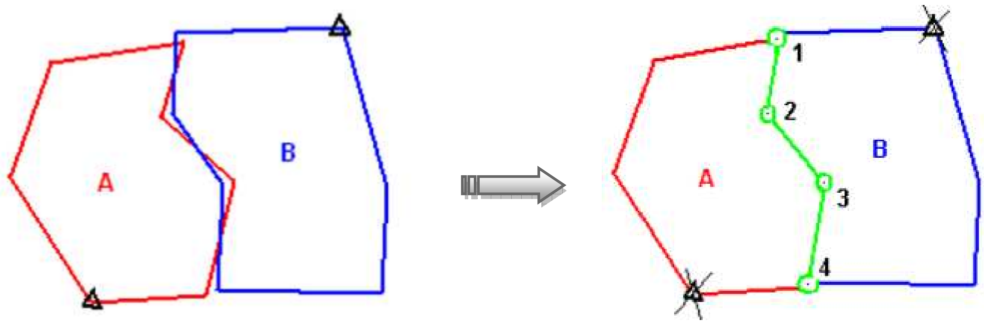


Figure 3.2 – Spatial representation according to the *Law# 10,267/2001* (from Philips [2008]).

There are three key elements that should be highlighted in the *Law # 10,267/2001* [Carneiro, 2006]:

- ***Creation and operation of CNIR (the new integrated cadastre) under INCRA and RFB responsibility*** **–** It is a multipurpose geographic cadastre available to public and private users;
- ***Establishment of the geo-referencing requirement for the CCIR*** **-** It is a unique document identifying parcels using the geographical coordinates referenced to the Brazilian Geodetic System. Traditionally this has been the South American Datum 1969 (SAD69). Since 2004 the Geocentric Reference System for the Americas (SIRGAS2000) has been designed to replace SAD69 and is currently in implementation;
- ***Information interchange of INCRA (rural cadastral system) and serviços registrais (land registration)*** **-** The responsibility of the registry office is to report to INCRA on a monthly basis all changes to real property records. This

information will then entered into CNIR, making a well defined and regularly updated cadastre and avoiding the need for periodic updating exercises.

3.4.2 *Serviços Registrais* and Land Registration in Brazil

The legal cadastre is held by registry offices (*Serviços registrais* as also known as *cartórios de registro de imóveis*) that are a notorial system (although operated privately); these registries are controlled by the Ministry of Justice which also creates technical regulations to standardize legal transactions. The Civil Code states that **property rights do not exist if the property is not registered** [Melo, 2006]. Registration of records in the registry offices allows the governmental authorities to identify who is the owner of the property, where it is located, its size, as well as whether there are debts and the value of these debts. The full description of the land registration system in Brazil is found in Appendix II.

The registrars' services in Brazil are decentralized by county (i.e., each property must be registered in the county where the property is located) as prescribed Law of Public Registers (LRP), *Law # 6,015/1973* [Balbino Filho, 2001]. The *Serviços registrais* in additional validating and registering property rights has historical records of the property transactions that describe:

- who is the owner;
- any modifications made by the property holders to the property;

- the cost of the transaction.

According to Balbino Filho (2001), each property is identified by a code called *matrícula* (i.e., this is both, a number assign to a property registered at the registry office and the folio itself). *Matrícula* have been used since 1973, when they were created by *Law # 6,015/1973*. Each property can have only one *matrícula* assigned to it and each *matrícula* can only refer to one parcel. The subject of the *matrícula* is (are) the landowner(s), but the object of the *matrícula* is the parcel. In practical terms, the real estate register is folio-based and has three main characteristics [Diniz, 1992; Carvalho, 1997; Santos, 2006]:

- The information is indexed by parcel (*matrícula)* and not only by the parcel's owner;
- The property record contains the entire history of the property all together; and
- Each record corresponds to a single parcel and each has its own record.

The land registration system problems in Brazil started during the colonial period of the *sesmarias* when an unsystematic property recording, as well as many fraudulent and forged ownership documents occurred. Over the years, land was transferred to individual ownership, by legal right or by occupation, without suitable cadastral mapping or by registration at the legal systems. In Brazil, the land registration system is separated from the cadastral system; there is no integration. Before *Law# 10,267/2001*, information about rural land parcels was declaratory, and the notarization of the legal land documents might not represent the physical situation on the ground.

3.4.3 National Rural Cadastre System in Brazil (CNIR)

Created by *Law # 10,267/2001* and its normatives, the National Rural Cadastre System in Brazil (CNIR) is designed to be a multipurpose cadastral system which contains land information based on geo-referenced rural properties. Basically CNIR has the following features:

- A common database of all rural lands;
- Exchange of data between the registry offices and INCRA, including monthly update of all modifications occurring to the land registered. Governmental organizations such as SPU, IBAMA and FUNAI need to exchange land information;
- A unique identification code for each rural land unit contained in the land certificates issued by INCRA;
- Geographically referenced plans of each parcel, eventually based on SIRGAS2000, to identify characteristics, boundaries, location and area of these rural land unit (See Figure 3.2);
- Costs of geo-referencing to be waived for landowners holding proprieties with less than 4 fiscal modules[3] (this represents around 85 % of all rural properties in Brazil).

In addition, *Decree # 4,449/2002* states that CNIR must have spatial and descriptive information with different access levels for different users. The responsibility to create,

[3] A fiscal module differs from municipality to municipality, and it is defined by the income acquired by the land for use in subsistence agriculture and in other exploitation; and idea of family agriculture [INCRA, 2001].

implement and maintain the CNIR system is under two federal agencies: the Federal Revenue Service (RFB) and Land Reform Institute (INCRA).

INCRA is the agency nominated to operate the rural cadastre system in Brazil, including rural properties which only have rights of occupation (*posse*). In 1964, the Land Statute (*Law # 4,504/1964*) obligated owners of all rural properties to declare their interests to INCRA. In 1972, the **National Rural Cadastre System (SNCR)** was created by *Law # 5,868/1972* and also required a declaratory description for fiscal purposes. Currently, SNCR is the agrarian regularization cadastral system used to support land distribution and land reform in Brazil.

INCRA also has the responsibility of granting rural property certificates (CCIR). A rural property certificate includes all the data on a given property in terms of its physical features, geographic location, use of the land, and information on the persons in possession of the property. The certificate is a legal prerequisite for any change in the rights in a rural property, including mortgage, sale, or leasing [Costa and Loch, 2004; Carneiro, 2003a].

On the other hand, RFB is the agency designated to operate and to manage the fiscal information (*Law # 8,022/1990*) that was until 1990 INCRA's responsibility. Aiming to improve the application of the ITR, the RFB created the **Rural Property Cadastre of the Revenue Income (CAFIR);** it has been used to locate, classify and characterize the rural properties for taxation proposes, and does not signify any legal right to the land under any circumstances.

3.4.3.1Collaborating Agencies and their Cadastral Systems

According to INCRA and RFB, the users of CNIR are categorized as direct and indirect collaborators. The direct collaborators are the agencies that actively help with the CNIR implementation by supplying data to the system, such as IBAMA, SFB, SPU, IBGE, FUNAI and RFB, Figure 3.3. These institutions are at the federal level. *Serviços registrais* are also considered direct collaborators and they are part of the private environment. The indirect users are those which will just consult the CNIR system for their own proposes. They may supply data to the specific direct institution collaborator, but without affecting the CNIR data input. They are from the federal, state and municipal levels. A brief description of the direct CNIR collaborating agencies according land categorization and existing cadastral system is given below. The complete system descriptions can be found in Appendix III.

Figure 3.3 – CNIR collaborator agencies and its systems

Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) - IBAMA has responsibility for recording federal national parks and environmental protection areas. These areas have great political interest, as deforestation is a crucial issue in Brazil.

According to the IBAMA Normative# 2,166-67/2001, the farms located in the Amazon must have 80% of their areas for the legal reserve (i.e., area located at the interior of the rural property or rural occupation that is not allowed to be deforested). In regions of the Amazon dominated by the *Cerrado*, the reservation must be 30%. In the other regions of the country, the percentage that should be protected is 20%.

Environmental protected areas have been occupied by third parties aiming to commercialize natural resources, and as a consequence, there have been land conflicts. In additional, IBAMA also administers environmental protection areas in the custody of the state land and environmental agencies – generally smaller areas than the federal lands. These areas have less technological control and media attention and are easily trespassed by landholders of a large tract of land (*latifundiários).*

To inventory protected timber on properties in rural areas, IBAMA has the **Environmental Declaration Act (ADA).** ADA is a system created in 1996 to allow the rural landholder to get a tax reduction in the rural property taxation by *Law # 9,393/1996*. The act requires registration, control, and inspection of areas of environmental interest in rural properties.

Brazilian Forestry Service (SFB) - In 2006, the Brazilian Forestry Service (SFB) was created by *Law # 11,284/2006.* SFB is in charge of managing public forests performing activities that are consistent with national planning directives and environmental policies that affect the forest segment. The **National Cadastre of Public Forest (CNFP)** also was created in 2006 under SFB administration. CNFP has been used to support the use of community forests, to create conservation units and to create forest concessions. Also it offers mapping of the Brazilian public forests to managers in public administration and to society at large; it classifies the forests that are inside public lands and archives the areas where forests have been lost.

Secretary of Federal Assets (SPU) - SPU works with public lands that are occupied but without legal ownership (*terras sem dono*). They belong, by definition, to the National Commonwealth whether they are administrated by federal or provincial agencies. The Nation can neither dispossess itself, nor be compensated for its own lands. A third party having trespassed on or occupied public lands can also not be compensated for eviction [Jones, 1997]. Moreover SPU registers lands belonging to indigenous communities, which are administered by the National Indian Foundation (FUNAI).

To help administer these public lands, SPU created the **Integrated System for Patrimonial Management (SIAPA).** The goal of the SIAPA is to identify and register public properties; it includes identification of the landholders who have legal occupancy, to better manage and redistribute federal assets. Illegal occupancy of public lands is not included in SIAPA.

Brazilian National Indian Foundation (FUNAI) - FUNAI is the agency which takes care of the protection of Indian interests and their culture. This includes: issues such as land demarcation, defense of Brazilian Indian rights, and everything that concerns the Brazilian indigenous populations including health and education. To support judicial and administrative processes of land demarcation, land regularization, land control and land planning, FUNAI created the **Traditional Land Cadastre (SIT).**

Brazilian Institute of Geography and Statistics (IBGE) - The Brazilian Institute of Geography and Statistics (IBGE) is the agency which provides census data in Brazil including its collection, processing, statistical analysis and dissemination. Among many research activities, IBGE also has the agrarian census which provides statistical response of ownership and land use, the activities executed by the landholder and the technological level of the production process. Aiming to improve statistical surveys, the analysis and the dissemination of the agrarian census information by census district, IBGE created the National **Cadastre of the Address for Statistical Purposes (CNEFE).** This system has been used since 2007.

3.5 Problems with the Meaning of Rural Property in CNIR

One of the biggest problems for CNIR is that the land unit is defined as a **rural property**, which has different definitions depending on the objective of the specific cadastral system involved. The definition of a rural property in CNIR has relevance because a rural property can be defined by its land use for agrarian proposes (under INCRA according to the Agrarian Law, *Law# 8,629/1993*), by its location for fiscal proposes (under RFB according to the National Tributary Code, *Law # 5,172/1966*) and by its physical subdivisions, independent of location, for land registration (s*erviços registrais).*

At INCRA, within the agrarian perspective, rural property is determined by its land use rather than by its location in rural or urban areas. This property should be potentially productive land for agriculture; the intention is to stimulate the development of the agrarian economic sector and consequently promote the settlement of families. Also the definition of property is used to support the identification of unused lands, for redistribution under land reform.

> *Rural property is a property with continuous area, located anywhere, that is or can be destined for agricultural exploration, cattle, extractive vegetation, forest or agro-industry* [Translated - *Law # 8,629/1993* article 4].

Under INCRA, a rural property can be considered as an unique rural property when there are one or more confined areas (adjacent and non adjacent), registered in the *serviços registrais* or not, owned by the same owner or claimed by occupants (*posseiros*), whether as individual or communally held rights (i.e., condominium or shared landholders - *composse*), even if the following applies:

- it is located totally or partially in one or more municipalities;
- it is located totally or partially in rural or urban areas; and
- it has physical interruptions such as streams and roads, as long as active or potential economic unity is maintained.

INCRA is responsible for maintaining the primary rural cadastre. INCRA controls the geo-referenced surveys and gives a certification of the corners co-ordinates of the geo-referenced property to confirm that there is no overlap with the adjacent properties already certified [Augusto, 2006].

At RFB, for fiscal proposes, rural property is determined by its location. The area must be located in the rural zone as defined by law but is independent of the legal ownership occupation (i.e., the occupant pays the tax). When there are several deeds or titles, even with several landholders, rural property will be considered a unique continuous area if occupied by one taxpayer.

> *Rural property is a continuous area, formed from one or more land parcels, located in the rural zone of some municipality, despite whether the occupant has just possession to some part of the area* [Translated - *Law # 9,393/1996* article 2].

The ITR defined by *Law # 9,393/1996* is based on the quantity of productive land and the size of the property [Borges, 1999; Assunção and Moreira, 2000; Camargo, 2003].

When *Law # 10,267/2001* created CNIR, it did not specify the concept of which rural property definition should be the basis for CNIR. It must meet both purposes. Figure 3.4 shows the cases from INCRA and RFB perspectives. Case 1: if a rural property –Lot A - has a rural land use, it will be included by INCRA. However, if it is located partially in an urban area, the RFB can only issue a rural land tax for that part of Lot A contained in the rural area. Case 2: if a rural property – Lot B - has a rural land use and it is located in the urban area, it continues to be included by INCRA. However, again, RFB cannot issue a rural land tax because it is located in an urban area. If Lot C was located totally in the rural area and did not have an agricultural use, the Lot C would be included by RFB, but not by INCRA.

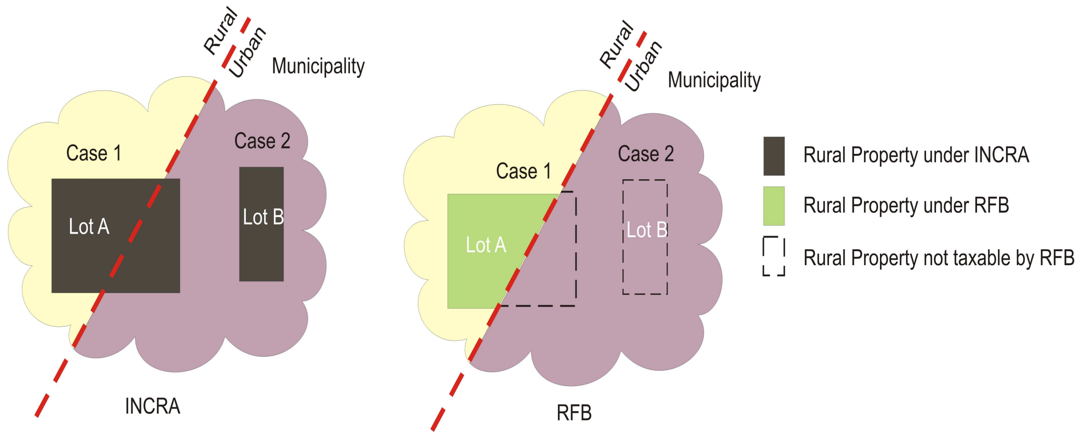


Figure 3.4 – Contrasting the concept of rural property under INCRA and RFB

When the various types of property rights are brought together inside the CNIR system, then there is another conceptual problem. The registry offices, *serviços registrais*, which register legal rights, recognize immovable properties (*bens imóveis*) as land and everything that it incorporates, whether natural or artificial [Translated - Civil Code – *Law # 10,406/2002* article 79]. It is registered under the *serviços registrais* with a rural parcel ID (*matrícula).* This means that the *serviços registrais,* instead of using the concept of rural property to include ownership and possession, only use the concept of real property *(propriedade imobiliária*) which considers ownership. In the *serviços registrais*, each portion of real property separated by features such as road and rivers is considered different properties parcel to be registered with distinct *matrículas* even if acquired by the same landowner or with the same document [Law of Public Registers (LRP), *Law # 6,015/1973*].

Figure 3.5 shows cases from s*erviços registrais* perspective. Case 3 and 4: if a rural property is located partially in a rural area (Lot A), totally within a rural areas (Lot C) or urban areas (Lot B), and if there are no features to separate the land, then for the s*erviços registrais* each lot will be registered under separate *matrícula*. Case 5: if a rural property is subdivided physically by features, then the registration of the lot (Lot A) will receive different *matrícula,* whether held by the same owner or not.

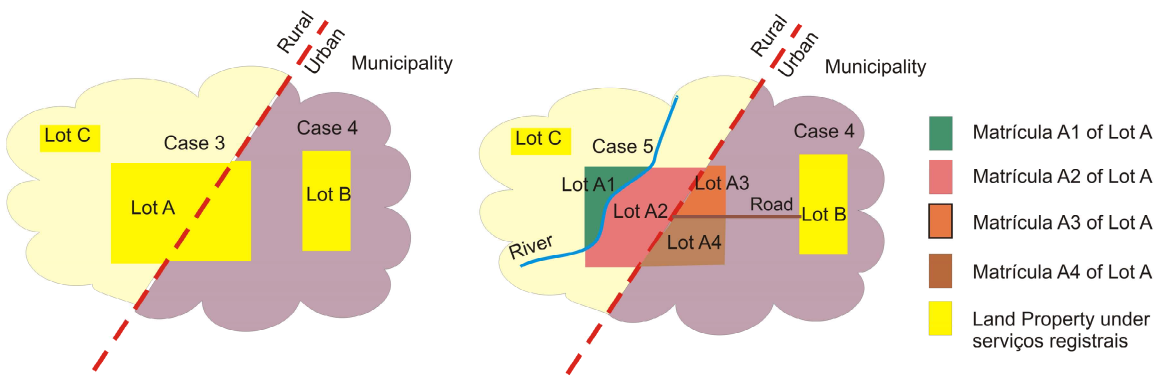


Figure 3.5 – Concept of real property under *Serviços registrais*

Another concept that must be considered is the agrarian establishment under IBGE. For statistical proposes, rural property is considered as an agrarian establishment. It is the entire production unit devoted wholly, or in part, to the agricultural activities, subject to a single administration (producer or manager), regardless of size, shape, legal situation, location (urban or rural) or purpose of production (subsistence or market).

If the parcels are noncontiguous but exploited by the same producer or manager, they are considered as a unique establishment if they use the same technical and human resources and are located in the same census sector. To IBGE, each agrarian establishment separated by features such as roads and rivers is considered a continuous area. Figure 3.6 demonstrates the concept of agrarian establishment. Case 6: if an agrarian establishment is located in the same census sector and has the same landholder or owner, then for IBGE it is considered as a unique agrarian establishment – Lot A + Lot C = unique agrarian establishment 1. Case 7: If this does not occur, then it is another agrarian establishment 2 (Lot B). Case 8: if an agrarian establishment is subdivided physically by features, then under IBGE it is a unique agrarian establishment 3 (Lot A).

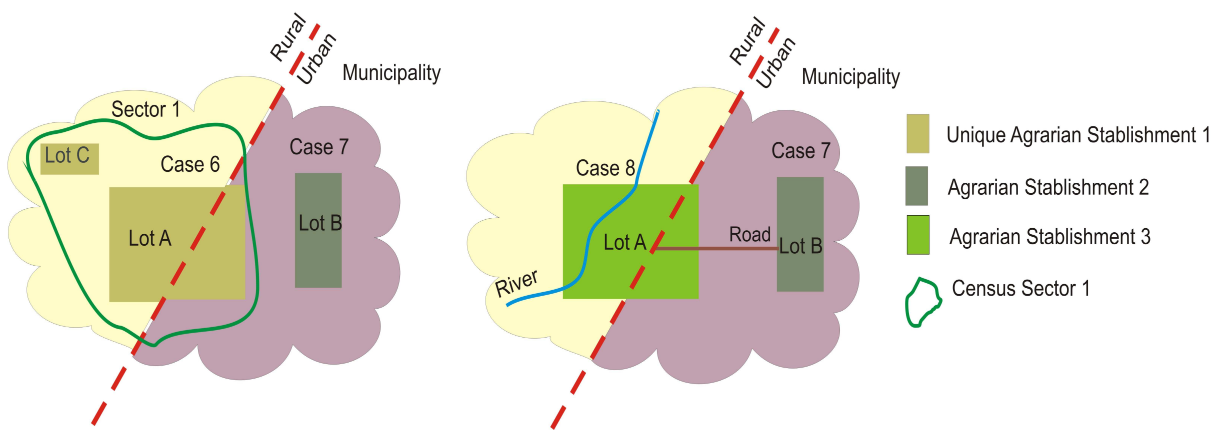


Figure 3.6 – Concept of agrarian establishment under IBGE

Despite the agrarian census only being collected every 10 years, it can still be used to indicate to INCRA the number of rural properties per municipality. It also supports public policies for the rural sector helping to plan and implement new actions and new sustainable programs for regional development.

The obscurity surrounding the definition of rural property (i.e., different cadastres, different parcel definitions, and different rules for types of owners) confuses surveyors and other professionals. Without knowing what the final object is to survey, it is impossible to get the correct data input for CNIR, and consequently, to execute the Law of the Public Registers.

CNIR intends to be a common base, with structural information that allows matching and interrelating the concepts and understandings of the territorial units adopted by the three main agencies involved - INCRA, RFB and s*erviços registrais.* To work harmoniously with these differences in a single cadastre, it is necessary to model a land unit that connects the varied concepts of rural property.

The use of parcels as defined by the s*erviços registrais* does not interfere nor modify any of the rural property concepts presented above. It also does not create a new concept. A parcel is a technical element of the cadastre unit, and it is used to integrate information about rural properties which have distinct concepts, as it was explained in Chapter 2. A parcel is not a legal unit. Just to clarify, INCRA and RFB are not concerned with whether or not a rural property is composed by more than one *matrícula* or by possession (*posse*). Therefore the use of the parcel as a territorial unit in CNIR will work because only information relevant to the s*erviços registrais* will be sent to them, and for INCRA and RFB there will be no alteration of their concept of what a rural property is.

3.5.1 Requirements for resolving the common parcel identifier (PID) at CNIR

This research does not recommend a specific solution for the CNIR parcel identifier because of the complexity of the political and legal issues that must be resolved by the agencies involved. Instead, it gives guidance and basic information for new research on this subject. The types of parcel identifier and the general issues in implementation was discussed in Chapter 2. This research now highlights some specific Brazilian requirements that should be met before a specific solution for the CNIR parcel identifier can be found. They are:

- ***change of the legislation*** – This will allow changes in various agencies in how they define and reference parcels and determine the responsibilities for the system custodianship;
- ***official agreements*** – This will allow agency commitment related to data custodianship of and access to CNIR;
- ***agreement of the land unit at CNIR*** – All the collaborating agencies must accept the land unit assigned to CNIR (e.g., parcel) in order to accommodate their own needs and creates ways to exchange data;
- ***delimitation of rural/urban zones*** – Since, for some current land cadastral systems such as the fiscal cadastre, the land unit definition is based on the location of the property, the delimitation of rural/urban zones should be officially drawn up for all municipalities in Brazil;

- ***commitment of agencies*** –Agencies collaborating with CNIR need to allow the CNIR designers to have access to their systems and agree with all CNIR concept designs.

This chapter contrasted the characteristics of the rural and urban cadastral systems in Brazil related to organization, legislation, cadastral systems, land unit identifier, financial aid and legal rights. These characteristics have been influenced by the historical land factors that *per se* explain many of the land issues in Brazil today. This also explains why there differences between the rural and urban cadastres.

This chapter also introduced *Law# 10, 267/2001* which determinates the geo-referencing of rural property in Brazil and the creation of the National Cadastre System of Rural Properties (CNIR). Brazil has been having some difficulties in executing what this law establishes (e.g., implementation of the CNIR, certification of the survey of the rural properties limits, data interoperability). The lack of that interoperability is also related to the legal data which is under private registry offices (*serviços registrais*) and they are part of a separate system in Brazil. In addition there have been insufficient lands in rural areas that have been surveyed and, consequently, there is a lack of reliable land rural information to build CNIR on.

The concept of CNIR was also presented as a multipurpose cadastral system that is planned to integrate the current fiscal, agrarian, legal, environmental and statistical cadastral systems maintained by several governmental agencies (i.e., SPU, IBAMA, SFB, FUNAI, IBGE, RFB, and INCRA) and the private *serviços registrais.* One of the main benefits of CNIR is to identify all public lands that can be an instrument for the process of both land regularization and land reform. However to accomplish this data from various systems needs to be integrated and verified.

This chapter also highlighted the problems related to the common definition of the rural property, which is the reference land unit that CNIR needs have in order to integrate and access multi-agency data. The definition of the land unit is different for the RFB, INCRA, IBGE and *serviços registrais.* In order to have a unique system with harmonized data, there should be an agreement among these agencies about the land unit that can cross reference data from all of the systems. The last subsection discussed some of the requirements that CNIR must meet to be able to assign a common parcel identifier. These requirements are also based on the literature review in Chapter 2.

CHAPTER 4

INFORMATION SYSTEMS DEVELOPMENT AND MANAGEMENT PROCESSES

CNIR is a complex multipurpose cadastral system that is planned to create better data sharing (see Appendix V) amongst the CNIR collaborating agencies. This can successfully occur if there is interoperability among agencies' databases. In order to propose a conceptual model, a study is necessary of existing methods to develop systems, the need to address user requirements, how systems can be integrated, and how they should be managed. A literature review is presented in this chapter. Appendix IV summarizes some existing models for develop an information system

Section 4.1 discusses system requirements determination. This is intended to produce a clear understanding of the problem that needs to be solved and the requirements for the information system. Section 4.2 will highlights advice about project and data management. Finally Section 4.3 will provide the linkage on why this literature review is important to CNIR.

4.1 Requirements Engineering

The determination of user requirements is one of the most important phases in system development. It will be used to represent systems that respond to the users' expectations. The results of the user requirements for the CNIR system will be found at the Chapter 5.

The term **requirements** is defined by Sommerville (2000, p.98) as the "*high-level, abstract statement of a service that the system should provide or is a constraint on the system"*. The IEEE Standard Glossary of Software Engineering Terminology (1990) defines a requirement as "*A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document."* Requirements define what the system will do without describing exactly how it will be accomplished [Sommerville and Sawyer, 1997; Bell, 2000; Davis, 2005; Pfleeger and Atlee, 2006]. The description of these services and constraints and the process of analyzing, documenting and checking them is known as **requirements engineering.**

Requirements engineering helps the system developer to understand the problems that may be incurred in the system development project by preventing incompleteness, errors, and lack of satisfaction for the users. It also brings both users and developers to an agreement about their real needs. Moreover, it provides a starting point for project management activities by remedying estimate costs, time and resources needed [Burg, 1997].

Errors which are detected early in the system requirements phase are cheaper to solve compared with ones which are discovered during the design system or implementation stages. Figure 4.1 from McAllister (2006, p.26) compares the relative costs of errors from the requirements determination phase to the operations and maintenance phase. It can be seen that the relative cost might be 200 times more, if not identified early.

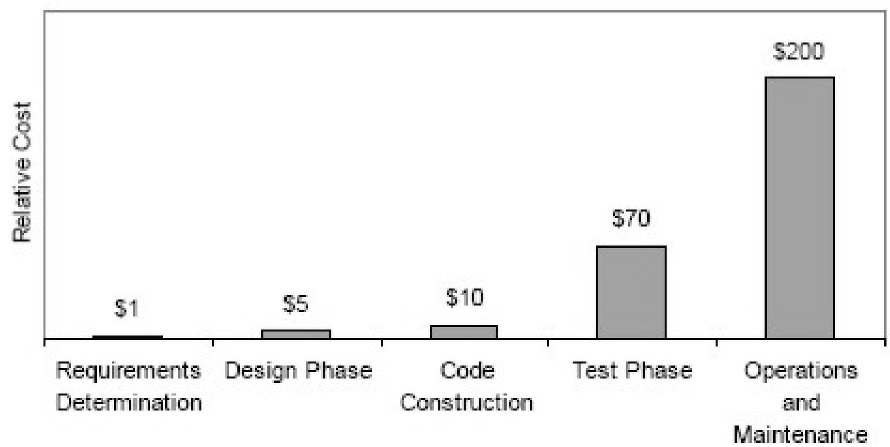


Figure 4.1 - Relative cost to identify and correct defects during the software development phases (from McAllister [2006, p.26])

Davis (2005) presents data collected by Hall, Beecham and Rainer in 2002 where 2000 people from 12 companies were surveyed about error identification. It was discovered that 49% of the errors were found at the requirements stage (Figure 4.2).

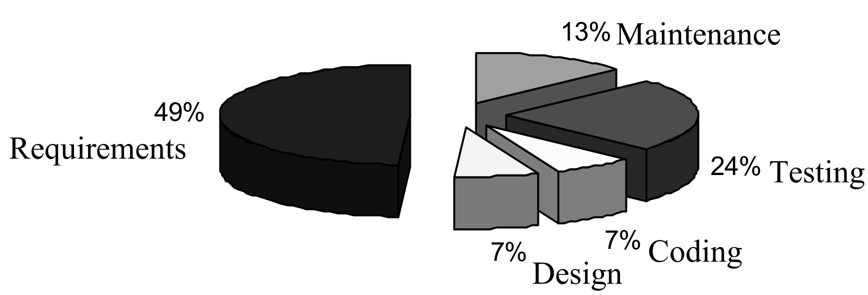


Figure 4.2 – Percentage of errors found at the system development phases (from Davis [2005, p. 37])

McAllister (2006, p.25) also warns that "*the cost of requirement errors is not limited to the price of creating the system. If the requirements are wrong or incomplete, the system may not be used, or its use results in lower productivity*". The delay from when the defect was introduced until it was detected and the cost of the rework involved repairing the defect are also facts that should be relevant [Daniels and Bahill, 2004].

Stakeholders are individuals or organizations that have something to contribute to the requirements and what the product does, or how the product should be improved. Pfleeger and Atlee (2006, p. 146) list a number of possible stakeholders:

- ***Clients****,* who are paying for the software be developed;
- ***Customers****,* who buy the software after it is developed;
- ***Users****,* who are familiar with the current system and will use the future one;
- ***Domain experts,*** who are familiar with the problems that the software must automate;
- ***Market researchers,*** who, by surveys, determine future trends and potential customers' needs;
- ***Lawyers or auditors,*** who are familiar with government, safety, or legal requirements;
- ***Software engineering or technology experts****,* who ensure that the product is technically and economically feasible.

Another fact that makes requirements important is that it is a unique form to homogenize what the stakeholders wants the system do with what the developers think that the stakeholders want or how the system should be. The stakeholders' and developers' concepts often have different contexts that can be divergent. This can be explained by the fact that the context for stakeholders (users) is associated with the real-world problem while the context of the developer is associated with the software contract [McAllister, 2006].

Figure 4.3 represents the relationship between users' and developers' view of requirements. It shows that the area of common understanding of requirements is often small compared with each users' and developers' viewpoint that might lead to misunderstanding of the requirements. It also explains that the requirements originate in (business) objectives that need to be addressed by an information system. The description of its concepts between users and developers is done via knowledge sharing.

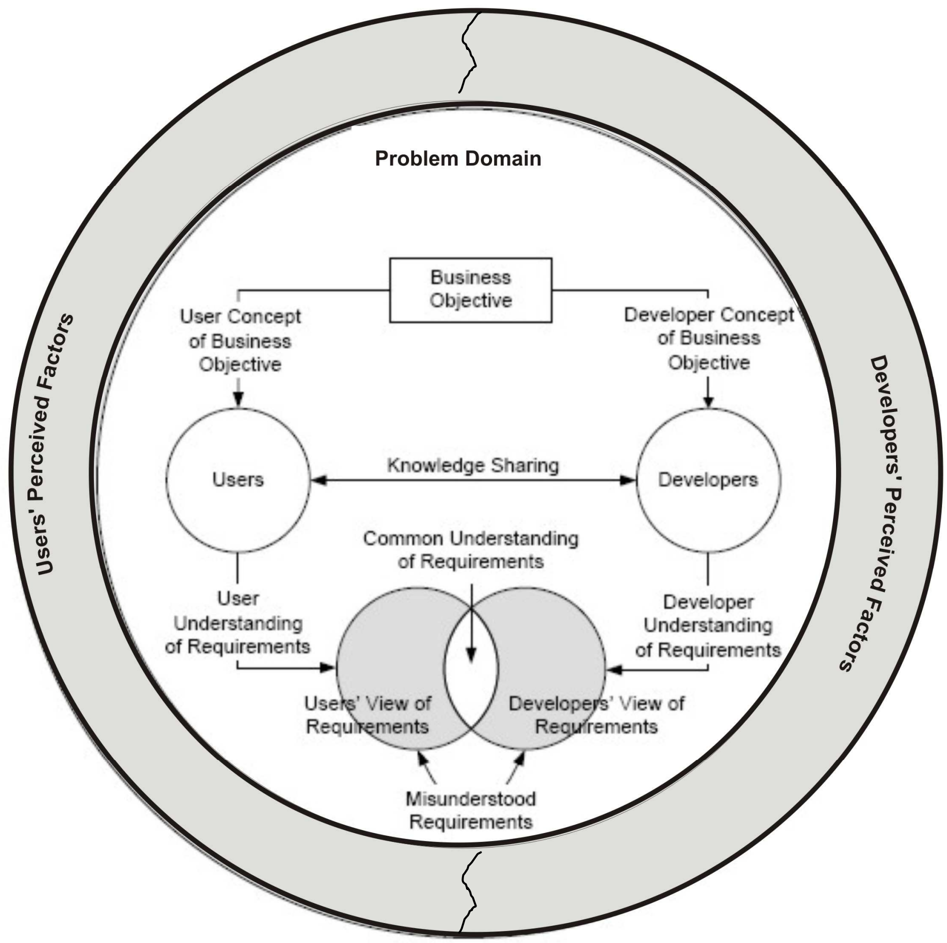


Figure 4.3 - Relationship between users' and developers' view of requirements (from McAllister [2006, p.7])

4.1.1 User Requirements vs. System Requirement

Different users of the system may have different viewpoints about the system development because they often focus on a subset of the system features. They may identify points of interest that identify which subject areas and which system aspects are important, or which levels of abstraction should be used in the process and which stakeholders are involved [Haan, 2008].

The user requirements define what services the system is expected to provide based on the constraints that the system must be operated within. However, when it involves too much information, the process might also limit the freedom of the system developers to provide innovative solutions to the user problems and might make the requirements difficult to understand [Sommerville, 2000]. Tomlinson (2007) also adds that the practice of defining user requirements helps to identify what set of technology is required (hardware, software and networking). The documentation produced at this stage is written for the client and contractor managers, whose technology knowledge is not too specific.

Unlike user requirements, the system requirements lead to structured documents, detailed descriptions of the system's functions, services and operational constraints. They can be divided into functional and non-functional requirements. Functional requirements define what the system must do from the user needs and define its capabilities or services, such as how the system should react to particular inputs, and how the system should behave in particular situations [Protsyk, 2006; Przybilski and Tuunanen, 2007]. Non-functional requirements show how well the system must perform.

They refer to the quality attributes (e.g., performance and system needs such as security and archiving) and technical constraints (e.g., coding language and database structure) [Kadarmanadalgi and Martin, 2006].

4.1.2 Requirements Fact-Finding Techniques

Karten (1994, p. 63) emphasizes the importance of the information gathering when she states:

> *You cannot meet users' expectations if you do not know what they want. You cannot just ask and assume they have told you what you need to know. In fact, it is safest to assume they have not, because what they say they need may differ from what they actually need.*

To gather the information needed for the requirements determination and to minimize the gap cited by Karten above, the developers can count on a number of traditional and modern techniques. Belgraver (2003, p.8) categorizes the gathering of the information into different classes of methods, five of which are described below:.

- ***Traditional methods -*** introspections, interviews and questionnaires.
- ***Observational methods -*** observations, ethnographic studies, protocol analysis and contextual inquiry.
- ***Analytic methods -*** requirement reuse, documentation study and logging actual use.
- ***Prototype methods -*** prototyping, scenarios and storyboards.
- ***Group elicitation methods -*** focus groups (JAD), brainstorming and workshops.
- ***Other modern methods -*** model-driven, cognitive and organizational modeling.

4.1.2.1 Traditional methods

Interviewing and listening: This might be the primary method of gathering information about the information system. Facts, opinions and information can be collected with respect to what people want and how they assess the current system [Valacich et al., 2001]. Listed below are some tips that might be useful during an interview [Gause and Weinberg, 1989]:

- Ask questions and maybe rephrase them from a different perspective as it helps to relate problems that were not addressed before. This question should be more related to the overall process or project than about their specific activities and problems, to avoid touching on sensitive issues.
- Ask for clarification, it can ensure understanding and differentiate opinions from the facts.
- Ask the same questions in separate interviews with different individuals and compare their responses. Different points of view might give the overall picture of what they need.

Questionnaire: Questionnaires have the advantage of gathering information from a large number of stakeholders simultaneously in a short period of time, at people's convenience. They can also protect anonymity. Unlike interviews, questionnaires do not give the opportunity of checking if the person is answering the questions truthfully or fully by the words that they use or by their body language [Valacich et al., 2001]. In the same way, there is no guarantee that all questions will be answered. There is no immediate opportunity to clarify a vague or incomplete answer [Whitten et al., 2004].

4.1.2.2 Observational methods

The observation-based approach or ethnography also has an important role in determining requirements. Using this method it is possible to discover unconscious actions that people might not see as important (e.g., actions that can demonstrate how the work is shared among employees on a daily basis, the behavior of the high workload day, and what the interrelationships among employer/employees are). Observation also demonstrates exactly what is being done [Sommerville and Sawyer, 1997; Whitten et al., 2004]. On the other hand, Whitten et al. (2004) warns about bias that can occur by using the technique of observation. Uncomfortable being observed, some people may perform differently, people might only let be seen what they want to be seen. Moreover the observed work might not represent the normal volume of work or level of difficulty.

4.1.2.3 Analytic methods

Examining system and organizational documents such as organizational mission statement, business plan, policy manuals and reports are useful ways to discover more details about the current system. Additionally, problems with the existing system, opportunities to meet new needs, indication of key stakeholders names, data, rules for processing data and organizational policy might be some added information that the developer might be looking for in the procedures and documents [Valacich et al., 2001].

4.1.2.4 Prototype methods

The prototyping method was discussed in Appendix IV. It basically transforms the description of requirements into physical systems, as a basis to test the current requirements and add new ones. Suggestions in that case would be reviewed, and the prototype would be redesigned to incorporate the suggested changes. Valacich et al. (2001) explain that the usefulness of the prototype for requirement determination is more expressive when user requirements are not clear. If it is complex system or if there is miscommunication between stakeholders and developers, a prototype may assist in eliminating problems. It gives a complex design a concrete form to be evaluated.

4.1.2.5 Group elicitation methods

Joint Application Design – JAD (also called Joint Requirement Planning) is the technique of putting together key stakeholders in the same place to discuss the requirements. This is where agreements and conflicts occur [Valacich et al., 2001]. In addition to having stakeholders and developers all together, JAD also reduces the amount of time required to develop the system by having a group meeting with consensus results [Whitten et al., 2004]. Apart from this, the brainstorming with current/potential users might be a useful technique to discuss how to improve the proposed system [Pfleeger and Atlee, 2006].

4.1.2.6 Other modern methods for determining requirements

Model-Driven (Use-cases): Use cases have been used for capturing functional requirements if object-oriented development methods are applied. It captures who (*actor*) does what (*interaction*) with the system, for what purpose (*goal*). It includes identification of alternative sequences to satisfy the goal, indication of sequences that may lead to failure to complete the service because of exceptional behavior, error handling, etc. [Malan and Bredemeyer, 2001]. At an extensive point of view, the use case can also be considered as a cognitive method [Siau and Wang, 2007].

Use cases are represented by a semi-formal description called a *scenario*. "*Scenario is a technique of asking questions related to a descriptive story in order to ascertain the design requirements"* [Williams, 2004]. Information is most often expressed in natural language (e.g. diagrams or referenced documents). This structure mainly acts as simple guideline for the stakeholder writing down the requirements and specifications [Protsyk, 2006].

> *...to maintain the use cases simple, readable, and manageable, they can only tell a fraction of the complete story without becoming unwieldy and difficult to understand. The fact is that use cases alone were not meant to capture all of the requirements. A use case is very good at capturing the functional requirements for a system in an understandable and unthreatening way [Daniels and Bahill, 2004].*

Cognitive methods: Cognitive methods are based on the use of abstracted models, which capture and represent user needs and systems requirements in the form of a mental map [Siau and Wang, 2007]. Nuseibeh and Easterbrook (2000) and Siau and Wang (2007) identify some of cognitive techniques which include:

- protocol analysis is used to provide the observer with insights into the cognitive processes when an expert thinks aloud while performing a task;
- laddering is used to probe the structure and content of stakeholder knowledge;
- card sorting is used at a group of stakeholders where a card is sorted containing a domain entity and each theme is described by them;
- repertory grids is used to construct an attribute matrix for entities, by asking stakeholders for attributes applicable to entities and values for cells in each entity;
- causal mapping or cognitive mapping is used for a variety of problems to operationalize a theory or test a hypothesis

Organization modeling (ORDIT methodology): Organizational requirements have social context such as power structures, obligations and responsibilities, control and autonomy, values and ethics. From many existing techniques, ORDIT methodology is based on soft systems, defined in Appendix IV [Damian, 2000]. ORDIT discusses human requirements of socio-technical systems, and demonstrates how these are linked to the technical features of the system design (i.e., the initial set of requirements starts with the design process). It is gradually refined into a systematic and coherent statement of requirements with the refinement of the design [Herlea, 1996]. With ORDIT, responsibilities and relationships are modeled rather than activities [Shaw and Gaines, 1996].

4.1.3 Types of Requirements Determination Processes

Wiegers [2003] subdivides requirements engineering into requirements development and requirements management. **Requirements development** encompasses: *requirement collection (elicitation)*, where the information to understand the user needs is gathered; *requirement analysis*, where the requirements are analyzed; *requirement specification,* where the official documentation of the system is realized; and finally *requirement validation*, where the requirements officially described are tested.

Parallel to the requirements development, there is the **requirements management** which controls all changes that might occur at the requirement development done by the stakeholders or developers. Figure 4.4 shows the boundary between requirements development and requirements management. These approaches encompass all the activities involved with gathering, analyzing, documenting and evaluating requirements for a software development.

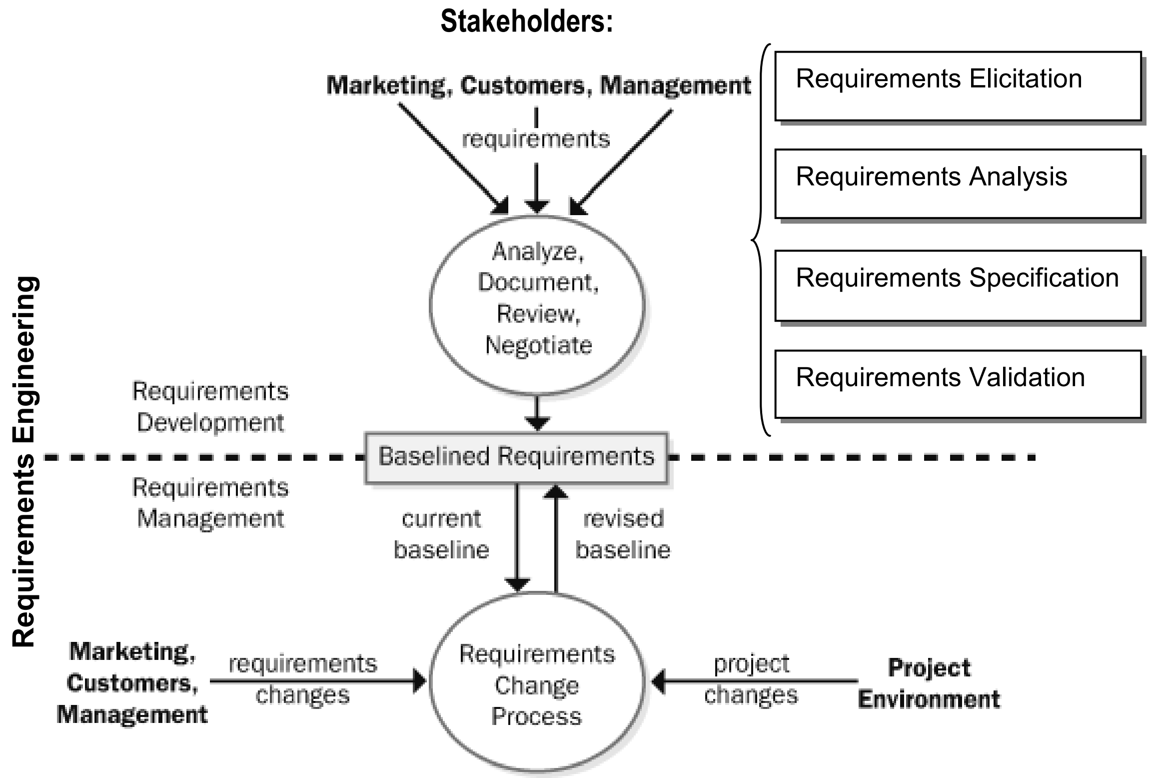


Figure 4.4 – Types of requirements engineering and their boundary (after Wiegers [2003, n.p.])

4.1.3.1 Requirements Elicitation

In the beginning of a project, requirements are usually ill-formed and ill-understood by users and developers. Jargons and assumptions may be present to support an incoherent set of requirements [Pfleeger and Atlee, 2006]. Aiming to clarify what users' needs are, requirements elicitation is done. Elicitation involves listening to the user needs and asking questions in order to help to the users to define their goals and constraints [Bell, 2000]. It also requires a careful analysis of the organization, its political behavior and its applications and how the system is likely to be used [Sommerville and Sawyer, 1997].

Ways of eliciting requirements (information gathering) were described in Section 4.1.2. Furthermore, the user problems should be well-understood in order to minimize risk of building the wrong system. Davis (2005) points out that maintaining a glossary of terms and making the stakeholders involved and listened to are some secrets to having an adequate requirement elicitation.

4.1.3.2 Requirements Analysis

Requirement analysis is the abstract study of services or constraints that a system should provide [Sommerville, 2000]. As Whitten et al. (2004) and Değirmenci et al. (n.d.) recommend, at the requirements analysis stage questions should be asked about the needs of the users, the system and the software. The following questions briefly exemplify the requirements analysis:

- What do the users need and want from a new system?
- Who needs the information and what information is necessary?
- For what purpose will the information be used?
- When and in what time interval is information needed?
- In what quality, standard and quantity is information needed as a minimum?
- In what way is information transferred to related persons or institutions?

During the requirements analysis the checking is done related to missing requirements, or to identify ones that have conflict, ambiguity and overlap, or to indicate the unrealistic requirements [Sommerville and Sawyer, 1997]. Davis (2005) moreover alerts that in the requirements analysis the candidate requirements should have some triage related to the priority and estimated cost to adjust the project schedule and quality of the outcomes, thus helping the project management. To ensure the right quality of the requirements analysis process, it is necessary to highlight some characteristics that are desirable to be checked during the requirements analysis. It also can help to decide whether information collected to do the requirements specification is enough, or whether a particular requirement should be better defined. Table 4.1 indicates some desirable characteristics of the requirements.

Table 4.1 - Characteristics of the requirements (after Sommerville and Sawyer [1997], Wiegers [2003], Whitten et al. [2004], Davis [2005], Pfleeger and Atlee [2006])

Characteristics	***Why?***
Correct	- To ensure that the requirements conform to stakeholders and developers understanding and can be documented.
Consistent	- To avoid possible conflicts with another set of requirements that may be previously approved and documented.
Unambiguous	- To eliminate multiple interpretation of the requirements made by different groups of stakeholders and developers. It should be written as simply, concisely and as straightforward as possible.
Complete	- To ensure that all possible inputs under all possible constraints were described.
Feasible	- To make certain that it is possible to meet stakeholder needs under the available resources. The developer can provide a reality check on what can and cannot be done technically and what can be done only at excessive cost.
Relevant	- To dispose of unnecessary functions that is not directly related to the stakeholder needs or has minimal priority.
Testable	- To clearly demonstrate that the product meets the requirements.
Traceable	- To well organize and compare the new entries at the requirements documentation. The requirements should directly locate the functions and features made by its unique identifier (ID) or label.

The representation of the requirements analysis can be done by creating a context diagram, which shows how the new system fits into its environment, or by creating a data dictionary, where all the data items and structures associated with the system were defined. These tools enable everyone working on the project to use consistent data definitions, mainly if there is a friendly user interface and prototypes of the system.

4.1.3.3 Requirements Specification

This is the official documentation phase of the requirements development. The produced documentation, software requirements specification (SRS), along with the system development promotes the measurement and control of the changes in requirements and formal documentation for communication between stakeholders and developers. At the same time it provides a reference for the project managers. It indicates how to allocate the right resources at the right time, to know when people are performing their designated responsibilities and to agree in terms of the content [Davis, 2005]. SRS is written for the software engineers who will develop the system; also it might be used as the basis for the contract for the system implementation. The targets at this level are the senior technical people (from both client and contractor side) and project managers [Bell, 2000; Sommerville, 2000].The SRS should have a standard format which facilitates easy comparison and understanding of the relationship between previous documents and the new one. Also it can be used as a check list, minimizing the chance of omitting information [Sommerville and Sawyer, 1997].

Furthermore, the requirements specification is used to ensure that all stakeholders know why every requirement belongs in the SRS, facilitating further clarification and to uniquely identify each requirement with labels. The specification permits requirements traceability, the recording of changes made, and links between requirements and corporate policies, government regulations, and computational algorithms. It also documents the quality requirements in the SRS [Wiegers, 2003].

4.1.3.4 Requirements Validation

This requirement process shows the review of the complete draft of the requirements documentation where known incompleteness and inconsistency has been removed during the requirement analysis. Its importance is to detect errors before the system is implemented. Normally it is related to checking the system validity, its consistency, its completeness, its realism and its verifiability [Sommerville and Sawyer, 1997; Sommerville, 2000]. Test cases with stakeholders can be done to ensure that the requirements described at SRS reflect the desired system behavior. Tracing these tests is a way to verify the correctness of analysis models and prototypes. Another fact is that the requirements validation can be used by the stakeholders to determine whether the system meets their needs [Wiegers, 2003].

4.1.3.5 Requirements Management

This is considered the process of controlling all changes that might occur in the system requirements. During the system development different users might have different priorities that might change over time, or the business or the technical environment of the system has changed [Sommerville, 2000]. It is the basis for the quality management, which is incrementally developed and updated and follows organizational policies in order to be workable [Sommerville and Sawyer, 1997].

Wiegers (2003) enumerates key requirements management activities as follows:

- Review the change of the requirements and evaluate its impact on the project;
- Negotiate and incorporate new requirements changes into the project identified by unique identifiers to avoid confusion between drafts and baselines and between previous and current versions;
- Ensure that project plans are according to the requirements;
- Track requirements status and change activities during the system development;
- Record the dates that requirements specifications were changed, the changes that were made, who made each change, and why;
- Measure requirements volatility. That might indicate that the problem is not well understood, the project scope is not well defined, the business is changing rapidly, many requirements were missed during elicitation, or politics are running rampant;
- Create requirements traceability matrix to identify the other requirements, design elements, source code, and test cases that you might have to modify.

Table 4.2 summarizes the main activities performed at each type of requirements development. It also indicates the boundary activities among requirements elicitation, analysis, specification and validation.

Table 4.2 – Summary of the activities developed at the type of requirements (from Wiegers [2003, n.p.])

	Requirements Development
Elicitation	- Define requirements development process - Define vision and scope - Identify user classes - Select product champions - Establish focus groups - Identify use cases - Identify system events and responses - Hold facilitated elicitation workshops - Observe users performing their jobs - Examine problem reports - Reuse requirements
Analysis	- Draw context diagram - Create prototypes - Analyze feasibility - Prioritize requirements - Model the requirements - Create a data dictionary - Allocate requirements to subsystems
Specification	- Adopt SRS template - Identify sources of requirements - Uniquely label each requirement - Record business rules - Specify quality attributes
Validation	- Inspect requirements documents - Test the requirements - Define acceptance criteria

4.1.4 Why Might Requirements Determination Fail?

Requirements determination might fail due to, for example, misunderstanding of the needs, miscommunication, and political pressure, as listed below. The requirements engineers should be aware of these facts and should resolve these issues by discovering the common points of view and by minimizing conflicts:

- Stakeholders might not know exactly what they want from the system, or they may make unrealistic demands because they are unaware of their needs and costs. The lack of the exactly objectives might make the needs of the stakeholders not be completely represented [Sommerville, 2000].
- Stakeholders might express requirements in their own terms and implicit knowledge or communication; it might be misunderstood by the requirements engineers. As a consequence of this misunderstanding, the stakeholders might refuse to accept the system because it did not meet their expectations [Gause and Weinberg, 1990; Karten, 1994].
- Miscommunication might occur from stakeholders to developers and vice versa and among developers. The communication should incorporate culture and clarity of context and concept mainly because between them there are different languages, different backgrounds, motivations, and objectives [Leffingwell and Widrigand, 2003].
- Different stakeholders might have different requirements that are expressed in different ways and may also have different priorities [Sommerville, 2000].
- New requirements might emerge from new stakeholders who were not originally consulted; it might change the structure of the requirements by the dynamics of the economic and business environment [McAllister, 2006].
- Specific requirements might bring influence decision-making power for certain stakeholders [McConnell, 1996].

- Politics can have a chilling effect on a stakeholders' evocation of information for fear of offending someone or of harming a political position [Browne and Ramesh, 2002].

4.2 Managing Projects for Managing Information

Project management is a crucial component at the development of systems. It brings strategies to minimize the costs in the budgets at the same time that it ensures that all the users' needs are implemented. In additional, it is a bridge between stakeholders and developers. It also facilitates the management of the information within a system development project.

Whitten et al. (2004, p. 142) define project as *"a [temporary] sequence of unique, complex, and connected activities that have one goal or purpose and that must be completed by a specific time, within budget and according to specification*". Managers are the ones that should understand the needs in complex situations in order to be flexible enough to select the right solution at the right time, for the right problem. The more methods and tools the manager can handle, the better the solutions will be [Highsmith III, 1999].

Project mangers are the professionals trained to create strategies for managing projects, including resources, schedules, change control, risk management and specially communication. They are the one in charge of negotiation and conflict resolution within a project [Bell, 2000]. Project mangers also must determine whether a risk event may occur during the development or maintenance of the project, make plans to avoid these risks and if the risks are inevitable, try to minimize their negative consequences [Pfleeger and Atlee, 2006]. Additionally they must ensure that the departments involved in the project communicate appropriate information among each other [Purba et al., 1995].

Project management is defined by Bell (2000, p. 432) as being "*about monitoring what is happening and taking control to remedy things that are going wrong*". According to Paul (2007, p.12) there are five questions that must be asked during project management, of which the answers must be understood and agreed upon by developers and stakeholders:

- Who needs to be involved in managing a project? The project should involve the necessary number of stakeholders. It is necessary to establish clearly the roles and responsibilities of directing and managing a project from start to completion.
- What must a project deliver? The deliverables should be well-defined in order to achieve intended results.
- When must it deliver? Milestones must have their own completion date and the date for the end of the project should be clearly identified.
- How much must be invested? How much will the project cost? Projects should be feasible and not exceed their budgets.
- Why is this project necessary? If this question cannot be answered authoritatively and persuasively, it is doubtful that the project is justifiable.

Effective project management is necessary to ensure that deadlines and deliverables will be met within the planned budget, with quality standards and according to users' expectations and specifications [Whitten et al, 2004]. Project management also ensures that a well-defined method is used and there a clear product to be delivered at short intervals [Bell, 2000].

4.2.1 Project Management Functions and Techniques

The classical management functions of the management are: scoping, planning, estimating, scheduling, organizing, directing controlling and closing. They are described below:

- ***Scoping*** **–** Scope defines the boundaries of the project as related to planning the activities, estimating costs, and managing expectations. Scope definition also defines the general problems, opportunities and directives [Whitten et al., 2004].
- ***Planning -*** A project plan should identify what is required, when it is required, and when it is possible, along with the quantity required [Purba et al., 1995]. This includes indentifying the activities, milestones and deliverables produced by a project guided towards the project goal [Sommerville, 2001].
- ***Estimating*** **–** Each task involved in a project for its completion must be estimated. It varies, for example, according to the size and experience of the team, number of users, complexity of the system, information technology available, time committed and experience with other projects [Whitten et al., 2004].
- ***Scheduling -*** Project schedule enumerates the phases of the project and breaks each into activities that must be done to successfully complete the project.

Additionally, the schedule gives an idea of interactions among the activities and estimates the timeline [Pfleeger and Atlee, 2006].

- ***Organizing*** **–** This carries the organization of human and physical resources, indicating what is involved and why [Cleland, 1998].
- ***Directing*** **–** This clarifies who decides what and when [Cleland, 1998].
- ***Controlling*** **–** Project manger must monitor and report progress against goals, schedules and costs that should be adjusted when there is need [Whitten et al., 2004]. The main objective of project controlling is to keep track of the progress and compare actual and planned progress and costs [Sommerville, 2001].
- ***Closing*** **–** The success and failure of a project should be assessed for the improvement of the systems development process. The purpose is to learn lessons from the actual projects that can be applied to future ones [Lewis, 2006].

Hall (1998) explains that in summary there are six discipline models that essential to managing successfully the development of software systems: envision, plan, work, measure, improve and discover. They are related to the CMM levels explained in Appendix IV. Figure 4.5 shows the relationship among them.

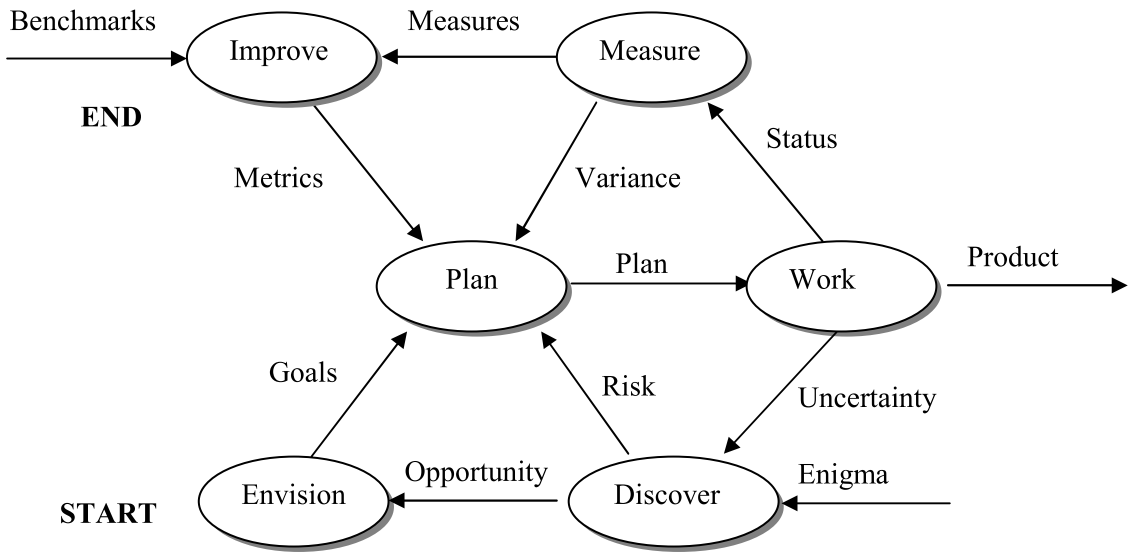


Figure 4.5- Six discipline model for the software development (from Hall [1998, p.14])

Level 1 of CMM, **Envision** is related to transform ideas into goals and objectives. **Plan** is direct related to mapping the resources available to establish the goals. This is provided by CMM level 2 which also includes the development of standards and procedures for the software development. **Work** is designated to produce the product based on the current plan. Status and uncertainty are developed as work is progressing. If uncertainty can not be solved, it must be communicated to be analyzed. As described in CMM level 3, products will remain in work discipline until it satisfies the quality control. **Measure** discipline reports the variance between expected and actual results to update the plan; it determines the progress of the plan and work status. Measure is related to CMM level 4. **Improve** discipline analyzes benchmark and organization project measures to improve processes and metrics. This is related to learn from experience (i.e., by lessons learned to support continuous improvement); the CMM level 5 provides key process areas for improvement. **Discover** provides input required to change the vision. It also assesses the uncertainty of the work and enigmas for risk and opportunities.

There are many existing techniques to demonstrate the tasks and their completion (e.g., work breakdown and network diagrams). Most of the time, these techniques are used during the phases for planning, estimating and scheduling. With graphical representation these tools help the understanding of the project management.

A work breakdown structure (WBS) defines the work to be completed in the project by showing its component parts [Richman, 2002]. It provides definition to the project scope by showing a hierarchical decomposition of the project into phases, activities and tasks [Whitten et al., 2004]. It can be represented by activities graphics to depict the dependencies. Special tasks, called milestones, can also be included in the WBS. Milestones indicate the level of progress that has been made (i.e., the completion of an activity) [Pfleeger and Atlee, 2006]. In reality, WBS is the device that ties the entire project together. It should be developed before the schedule [Lewis, 2006].

The Gantt charts show in parallel the activities and their degree of completion. A Gantt chart helps the project manager to understand which activities can be performed concurrently, and which ones are on the critical path [Pfleeger and Atlee, 2006].

A PERT chart (Program Evaluation and Review Technique) is a network technique and is event oriented. PERT is used to show major steps and their interrelationships, for planning and controlling projects with well-defined activities and events; normally it is plotted against time and uses probability to estimate when a certain project can be completed by some given time. The interconnections depend on the technological relationship described in an action plan [Burch Jr. et al., 1983; Grady, 1992; Rosenau, 1998]. The arrows indicate that one task is dependent on the start or completion of another task [Whitten et al., 2004].

To complement this network technique, the Critical Path Method (CPM) normally is used to demonstrate the longest route of the problem in the network path. According to Meredith and Mantel Jr. (1995), CPM is designed to control time and cost aspects of a project by revealing the activities that are most critical to completing the project on time [Pfleeger and Atlee, 2006]. Also CPM demonstrates which activities will be impacted most heavily and what might need to be done to regain lost time [Lewis, 2006].

The main advantage to system development is that PERT and CPM can tell whether it is possible to meet an important project completion date, and can also tell exactly when various tasks must be finished in order to meet that deadline. Knowing where the critical path is in a project allows for determining the impact on the project of a scope or priority change [Lewis, 2006].

4.2.2 Risk management

As Hall (1998, p. 21) defines, "*risk is a measure of the probability and consequence of not achieving the goal (an unsatisfactory outcome); it exists whether or not it is acknowledged*". The major sources of the risk are the generic and the project specific risks. The generic risks are the risks that commonly occur in all software projects (e.g., misunderstanding of the requirements and loss of key personnel). The project specific risk is a particular vulnerability (e.g., a planned specific delivery at a determined time that will not be ready) [Pfleeger and Atlee, 2006]. Risks are dynamic; they change over time [Hall, 1998].

Like problem analyses, risk management can also be represented by an Ishikawa (fishbone) diagram. In a fishbone diagram, the main horizontal line represents the quality factor under examination. The diagonal lines are brainstormed potential causes of the primary lines. Any other additional lines represent more detailed cause information [Grady, 1992]. The basic concept of the fishbone diagram is that the problem is displayed on the right side of the diagram (fish's head) and the causes of the problems are drawn as bones off of the main backbone [Whitten et al., 2004]; see Figure 4.6 as sample.

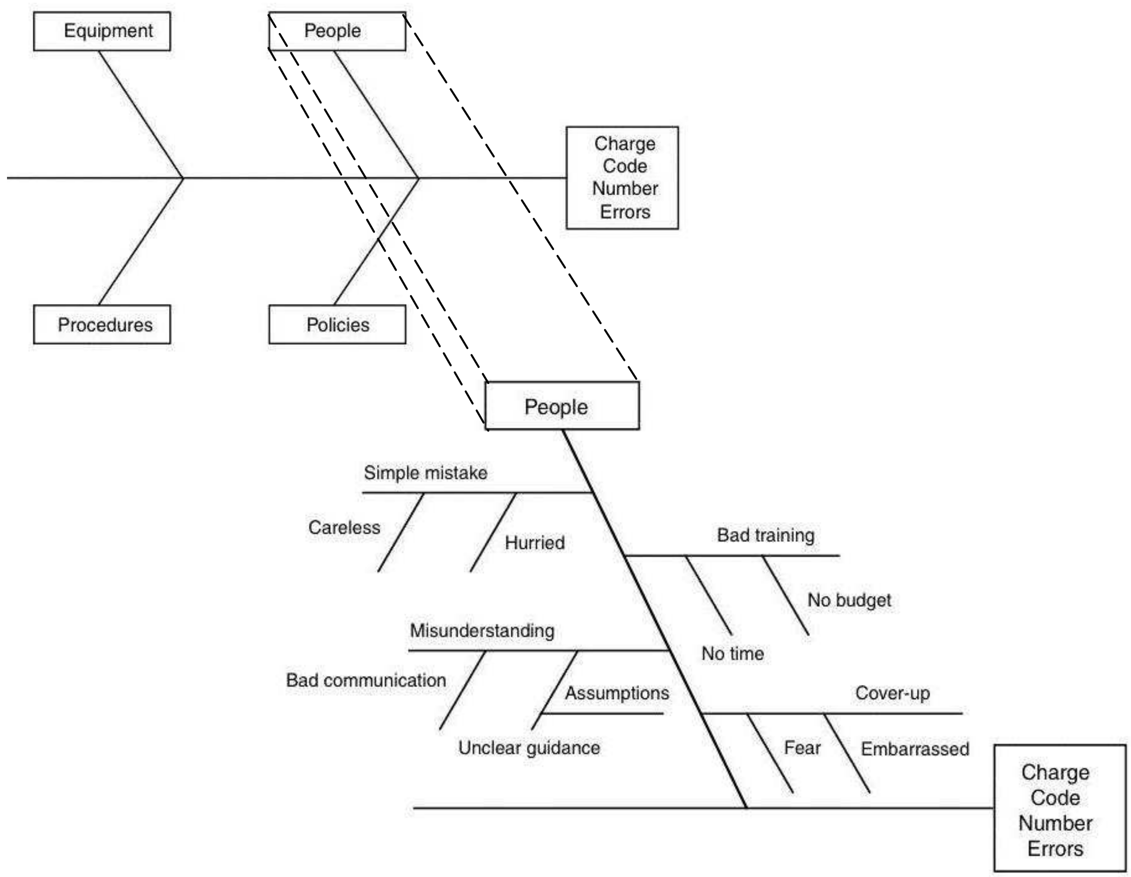


Figure 4.6 – Example of a fishbone diagram. Left side general concept and right side detailed concept (from [Rose, 2005,p. 117])

Cleland (1998); Hall (1998) and Pfleeger and Atlee (2006) indicate three types of risks related characteristics that are present in a project:

Risk Impact – this is related to losses (e.g., loss of time, of quality, of money, of control and understanding). Culture also can be observed inside the risk impact. Culture influences managerial philosophy which in turn affects the organizational philosophy. The organizational culture can be affected by the lack of a management philosophy on which plans, policies, procedures, guidelines, rules, and basic values important to the growth and survival of the organization are based.

Risk Probability – this is related to the likelihood that the event will occur. It is measured from 0 (impossible) to 1 (certainty). When the risk probability is 1, then the risk is a problem.

Risk Control – this is associated with what can be done to minimize or avoid the impacts of the risks, it includes the process of developing and implementing risk resolution plans, monitoring risk status, and correcting for deviations from the plan.

4.3 Information Management Policy

The process of managing information is, in practice, complex. The challenge of information management is to ensure that required information is captured and well delivered in the system. It might be assisted if an organization has strong leadership that defines a clear direction for the information management strategies. This chapter gives an overview of the CNIR problems, and highlights some principles that CNIR needs to meet. Recommended strategies are also listed, even thought they do not cover all the gaps existing in CNIR system.

Information management activities should be planned to address, in parallel, the many needs and issues that can be found in a software development project. This approach might result in efficient delivery and allows the solution to be targeted to individual needs. Risks must be identified and mitigated throughout the project to ensure that organizational complexities do not prevent the delivery of effective solutions [Robertson, 2005].

Hall (1998) defines policy as an administrative procedure or guiding principles designed to influence people in a particular course of action. Policy is determined at the highest level in the organization. A simple policy to address risks might make people comply with the established procedures. The policy should describe how employees should go about doing their daily work, how the employees are supposed to behave or act, and what values they are supposed to live up to each working day [Kasse, 2004].

Measures for policy implementation (e.g. laws, regulations, directives or programmes) are necessary to ensure that policy can be put into practice. Policy implementation does not happen in isolation. It is conditioned and shaped by the political, social and economic environment, as well as historical factors [Groot, 1997; Pasteur, 2001].

Below are listed some policy implementation directives that should be considered in CNIR development. They are related to partnership, relocation of resources, and involvement of key professionals in the project and adaptation of the existing policies to accommodate the project needs:

- ***Obtain commitments*** **–** This is the first step in a policy. The need for management commitment is related to quality in terms of resource allocation, staffing, and providing the necessary leadership to create an overall quality [Vitharana and Mone, 2008]. Political issues, present in a system development, should be minimized. Political games to get attention for promotions or more influence inside the organization should be avoided [Purba et al., 1995].

  Lewis (2006) explains that the rules for developing commitment to a project team, or among institutions, is to have the members interact frequently, so that they gain a sense of being a team and that individual needs are being met through their participation. It is also necessary that all members know why the project is important and that the goals have been shared by them.

- ***Allocate resources*** – When the administrator allocates resources to implement policy, it demonstrates the importance of the policy into the organization. When the budget is not allocated yet, the idea is to briefly state the cost and benefits to a sponsor. If the budget is incremental, then activities should be scheduled to show progress at each increment [Hall, 1998].
- ***Adapt existing practices*** **-** Never eliminate the existing organizational practices, completely, they should be molded and improved over time. Knowing the level of risk in management practices helps to provide the training material needed to implement the policy [Hall, 1998].
- ***Key people involvement*** **-** Involve the leaders with the most to gain or lose in the beginning of the draft policy; they are ones who are going to influence others by their opinions and beliefs. The review of the draft policy should promote

understanding of the practices expected within the organization and result in incorporating the feedback of the people who will practice the policy. The policy should be articulated in documented standards and incorporated in a manual of operating procedures. Once approved by the highest levels, it should be communicated to the organization in a memorandum that states when it will take effects [Hall, 1998].

4.3.1 Data Policy

As part of the legal framework, a data policy defines basic principles concerning data such as how it will be generated, collected, transformed, managed, disseminated and used [Martínez et al., 1999; Agbaje and Akinyede, 2005]. It might include, for example, the commitment of an institution to apply national standards for its data collection and its transformation for users, the documentation of its data assets using metadata standards, the contribution through metadata to data discovery, regularly updating its data and related metadata, and allowing external users to have access to these data under general and specific conditions. In return, the contributing institution will have access to the invaluable national data asset for the purpose of its various activities [UNECA 2003].

Data policy improves the ability to respond to priority issues at different levels. Besides, it helps to develop capacity by identifying strengths, opportunities and weaknesses in information management, by documenting and facilitating the exchange of best practices and by maximizing coordination and minimizing duplication and overlap in production data [Martínez et al., 1999]. Chapman (2005) lists other benefits that the development of a data policy can bring to a project:

- force the organization to think more broadly about quality and to re-examine their daily practices;
- formalize the processes of data management helping to implement data strategy activities;
- assist the organization in being more clear about its objectives with respect to reducing costs, improving data quality, improving customer service and relations, and improving the decision-making process;
- provide users with confidence and stability when accessing and using data from the organization;
- improve relations and communication with the organization's clients (both data providers and data users);
- improve the standing of the organization in the wider community, and
- improve the chances of better funding as best-practice targets are approached.

4.4 Relevance of the Literature Review to CNIR

Because of the diversity of contexts in which Requirements Engineering is conducted, and the variety of systems development processes to which it is applied, there is no 'one way' to do requirements engineering or to develop a system. It will be different from process to process and it depends on the budget, time, team work, available resources and so on.

There should be a high degree of interactivity between the methods chosen to develop the system and the technique to do the requirements determination in order to enable stakeholders to learn about, better understand, and respond to their needs. There is no point in providing the stakeholders with the “best” solution if they do not understand how the solution may be jointly employed to meet their needs. Particularly in CNIR, when there are several “stakeholders”, not only must they learn to understand their own needs but also those of the others and how they may conflict.

CNIR, as a multipurpose cadastre, must attend to all stakeholder needs not only to the agencies responsible for implementing it (INCRA and RFB). The collaborating agencies must be listening and their needs must be considered before the CNIR system can be designed. One simple way to see to it that all needs are considered is to ask the stakeholders: Which? Where? Who? Why? How? When? and What?

Which problem needs to be solved? It is important that the CNIR stakeholders have an ability to choose the possible problems, or choose the part of a large complex problem that can be feasibly solved. These problems should be associated with CNIR as a system and not to benefit a specific collaborating agency. The requirements analyst in this case, can help to set an appropriate scope for the project by identifying Problem Boundaries.

Where is the problem? CNIR should have both the physical and organizational context investigated in order to identify which areas are affected by the problem, or which will need to be involved in implementing a solution. This is why it is important that all participants of the development process understand the Problem Domain.

Whose problem is it? The CNIR problems will affect all stakeholders that have competing needs, and different perceptions of the problem. It means:

- ***Clients (INCRA and RFB),*** who are paying for the software to be developed;
- ***Customers (INCRA and RFB),*** who buy the software after it is developed;
- ***Users (the collaborating agencies: SPU, IBAMA, FUNAI, SFB, IBGE and serviços registrais, INCRA and RFB),*** who are familiar with the current system and will use the future one;
- ***Domain experts and software engineering (SERPRO),*** which are familiar with the problems that the software must automate and who ensure that the product is technically and economically feasible.

Why does it need solving? In order to make good design decisions, it is necessary to understand the motivations that the stakeholders have for wanting the problem solved. This is what identifies the CNIR goals.

How might a software system help? It is impossible to completely separate requirements from design. If it is possible to develop scenarios or prototypes that capture the stakeholders' expectations for how the problem might be solved, it might easily fulfill stakeholders' expectations for CNIR.

When does it need solving? It must be solved before the information gets outdated or the requirements do not meet stakeholders' needs anymore. In this case the timing will be associated with the resource constraints such as cost, available staffing, and so on.

What might prevent the problem from being solved? The CNIR requirements should balance the selection and scoping of the problem with the feasibility of implementing a solution within the given constraints. Project management will be one of the most important parts of CNIR development. It should be clear that a defined and documented system development process and rigorous project management of costs, schedule and changes of requirements are prerequisites for an effective CNIR system.

Without a complete picture of CNIR issues, development methodologies might be exposed to failure. Because the development methodologies are not a magic wand to deliver a product, the user requirements analyses, specification and validation are indispensable. An understanding of users' needs, operational priorities, related data and database requirements, and stakeholders' participation at each stage of the development are absolutely fundamental to a successful and cost effective CNIR implementation.

The CNIR good results will be related to the existing opportunities and political interest that Brazil is supporting and the abilities of the people involved to implement and maintain CNIR system. The involvement of a project manager within CNIR should help to handle every stage of the development cycle, because the project manager can take corrective actions for the success of CNIR with impartial political and institutional interest.

To CNIR the benefits of the quality management system might be related to faster registration of cadastral records: more efficient map production, to complete and consistent land (tenure, use) records, to improve data and management. It only can occur if the datasets in CNIR and among agencies are standardized. The data standardization, ISO standards or others, intends not only to make digital cadastral data and its attributes more uniform and accurate, but also gives the opportunity for data interoperability and sharing. The data sharing might be under the existing Brazilians platform or by creation of new ones. Some governmental agencies such as Ministry of Environment (MMA) are already making available their data in WFS platform. Besides, at CNIR it can promote the efficient, effective, and economic use of digital data by eliminating duplication of data collection and maintenance efforts. Policies also must be created to ensure the collaborating agencies commitment to continue involvement at CNIR and mainly related with data custodianship (collect, process and update their data).

CHAPTER 5

ANALYSIS OF USER REQUIREMENTS FOR CNIR

Since user requirements are the phase of system development which reflects the users needs, this chapter will illustrate the results of the user requirements conducted in this research based on the theoretical study done in Chapter 4. Section 5.1 will present how the CNIR requirements collection was completed. Section 5.2 will illustrate user requirements analysis, which will identify expectations for CNIR and show actual situations of the existing cadastral systems and discuss the main problems, opportunities and constraints of CNIR. Section 5.3 will use management tools to identify the priority for CNIR problems.

5.1 User Requirements Collection

In this research the data collection was done using qualitative methods. Çagdas and Stubkjær (2008) say qualitative methods are ones basically discerned from the perspectives of people; but they are not limited to this. Methods about information gathering methods are found in Section 4.1. All the user requirements collection was done in Brazil (Brasilia, Rio de Janeiro, São Paulo and Recife, Petrolina and Salgueiro) and interviews were held in Portuguese. The purpose was to identify user requirements for designing a conceptual model for CNIR. This research used the following methods.

***Structured interviews* –** These were conducted during June to August 2008 and December 2008 at the collaborating agencies indicated by INCRA (responsible for implementing CNIR). The final version of the structured interviews is included in Appendix VI in Portuguese. It contains general questions that applied to all agencies and more detailed specific questions. Table 5.1 translates the main subjects of the structured interviews:

The governmental agencies that according to *Law# 10,267/2001* (art. 2) are the producers and users of rural land information in Brazil are: IBAMA, IBGE, FUNAI, SFB, SPU, RFB and INCRA. *Serviços registrais* and IT support, SERPRO, were also interviewed. Table 5.2 contains the number of interviews by time and its associated departments. During this interval of time (2008-2009), information was also exchanged by email with the people interviewed.

Observation method – This happened in June to August 2008, when the structured interviews were applied at the collaborating CNIR agencies. It was observed how the work is done and the processes on a daily basis at INCRA's cadastral department and at the *serviços registrais.*

***Analytic method* –** This occurred from the first visit to the agencies in June 2008 until January 2009, when was possible to have access to documentation of the existing cadastral systems such as input/output forms, reports, system architecture.

***JAD* –** The focus group meeting occurred in December 2008 when high level managers from INCRA and RFB and academia cadastral specialists from Federal University of

Pernambuco (UFPE), Federal University of Santa Catarina (UFSC) and Federal University of Bahia (UFBA) were also present. They form the group who are implementing CNIR. This JAD in December 2008 helped to define the existing problems for CNIR implementation, the start to construct the matrix priority problems criteria.

Table 5.1 - Subjects of the structured interviews

General interview questions	***Specific interview questions***
General information: - Objective - Areas that can the cadastre be applied - Main functions **Relationship with other agencies:** - Expectative of CNIR implementation - Data sharing capacity - Data access **Diagnostic of the cadastre actual situation:** - Data input/output format - Data format storage and sharing - Data quality control - Department infrastructure - Backups - Operational system - Related database and GIS software - Standard and metadata - Human resources - Physical infrastructure **System security:** - Access authorization - Access control - Degree of system security	**To Fiscal Cadastre Department (RFB)** - Definition of rural property - Actual and potential users and their needs - Type of properties included at the cadastre - Properties located in more than one municipality - Existence of data consistency report among INCRA and RFB - Process to issue tax property - Limitations and opportunities of CNIR implementation - Data management - Relationship of the parcel identification **To IT Support (SERPRO)** - Role of the IT at INCRA and RFB - Data control - Data certification - System architecture **To *Serviços registrais*** - Serviços registrais jurisdiction - Process to registry private and public lands - Demand for public and collective lands - Understanding about *Law# 10,267/2001* - Adjusts to attend the *Law#10,267/2001* - Property ID rectification according the *Law#10,267/2001* - Training about use *Law#10,267/2001* - Type of titles registered - When maps are registered

Table 5.2 – List of the interviewees and related departments

Current Cadastral Systems (Agency)	Department	Interviewee	Number of Interviewees by Department	
			June to August 2008	December 2008
ADA (IBAMA)	General Department of Forest Resources (SCEN) – Brasilia/DF	General Coordinator of the Forest and Flora Resources Use	1	-
		Coordinator of the Forest Control	1	-
		System Analyst of the Telematics National Center	1	-
CAFIR (RFB)	Cadastre Management Department – Brasilia/DF	Special Coordinator of the Cadastre Management	1	1
		Acting Chief of the Cadastre	1	1
		Fiscal Auditor of the SRF	1	1
CNEFE (IBGE)	Agrarian Census Department – Rio de Janeiro/RJ	Coordinator of the CNEFE	-	1
		Coordinator of the Analysis and Agrarian Planning	1	-
		Coordinator of the Territorial Structure (RJ)	1	-
CNFP (SFB)	Brazilian Forestry Service (SFB) – Brasilia/DF	Executive Manager	1	1
		Coordinator of the Forestall Identification Service	1	-
Serviços Registrais	Sao Paulo and Araraquara/ SP	Official	2	-
	Brasilia/DF		1	
	Petrolina and Salgueiro/PE		2	-

Table 5.2 – List of the interviewees and related departments (continued)

Current Cadastral Systems (Agency)	Department	Interviewee	Number of Interviewees by Department: June to August 2008	Number of Interviewees by Department: December 2008
SIAPA (SPU)	Public Lands Characterization Department	National Director of the Public Lands Characterization	1	1
		General Coordinator of the Public Lands Inspection and Identification	1	-
		Represent the PSERJ/MPO-GRPU	1	-
SIT (FUNAI)	Indigenous Demarcation and Protection Land Department	General Coordinator of the Demarcation and Protection	1	1
SNCR (INCRA)	General Coordination of the Rural Cadastre (DFC)	General Coordinator of the Rural Cadastre	1	-
		General Coordinator of the Cartography	1	1
		Manager of the Cadastral Statistics Studies Nuclei	1	1
		Manager of the Foreign Owners Department	1	-
		Manager of the SNCR Cadastre	1	1
		Technical Assistant	2	4
SERPRO	SERPRO/SNCR	Manger of the Clients' Relationship Department	1	1

5.2 User Requirements Analysis

Experience with the user requirements collection showed that long interviews tended to have lower responses than short ones and some answers sent by email were also not complete; they did not show much motivation from the respondents. The lack of communication between INCRA and RFB was also reflected in the interviews. The agencies did not describe as much as could about their cadastral information. The draft of the cadastral systems descriptions based on all the user requirements collection methods are in Appendix III. This section only summarizes main results that are necessary for understanding the problem analysis.

5.2.1 Results of the User Requirements

The expectations for CNIR implementation varied from agency to agency and from the needs of the specific existing cadastral system within each agency, as can be seen at the Appendix III. Table 5.3 compile the expectations for CNIR from each collaborating CNIR agency.

Table 5.3 – Lists the CNIR expectation for collaborating agencies

Cadastral System (Agency)	***Expectations about CNIR Implementation***
ADA (IBAMA)	- To know the rural properties which are not registered at ADA but are registered in other institutions; - To use CNIR as tool to update their records; - To be able to share land information.
CAFIR (RFB)	- To be able to match INCRA's database with RFB's database. CNIR will be used to minimize agrarian conflicts by having unique land information; - To use CNIR information to confirm the land information from other agencies. As a result, it may promote land titling and income and credit to the landholder; - To minimize duplication of land information and administrative work; - To improve the fiscal system and its deliveries.
Serviços Registrais	- To locate rural properties; - To obtain data from restricted and preserved area contained at the environmental cadastre; - To obtain information about land use and its improvements; - To obtain economic value of the land.
CNEFE (IBGE)	- To refine IBGE address database; - To use the maps produced at CNIR as a reliable agrarian map.
CNFP (SFB)	- To have aggregated land information acquired from many other institutions to know more about the characteristics and dynamic of the rural lands; - To help CNFP to identify public lands.
SIAPA (SPU)	- To help SIAPA to identify federal lands; - To improve the control of SPU properties; - To contribute for the improvement of the land regularization in Brazil.

Table 5.3 – Lists the CNIR expectation for collaborating agencies (Continued)

Cadastral System (Agency)	***Expectations about CNIR Implementation***
SIT (FUNAI)	- To obtain information from other institutions about the deforestation, the preserved forest areas, the roads location, the forest fire and so on; - To be able to match CNIR information with FUNAI database; - To have a complete agrarian map with the adjoiners. It will facilitate to monitor and to inspect the indigenous land.
SNCR (INCRA)	- To eliminate isolated land cadastres with common information. It will minimize or eliminate unlike information that is declared at all institutions by the landholder; - To be able to use data from agrarian census (CENEFE-IBGE) to update SNCR-INCRA's database; - To be able to match INCRA' database with RFB' database. It helps to figure out unknown rural properties; - To connect with services registrais to know the landowners information mainly nationality, to control the foreign land market; - To optimize and to control land certificates issued by RFB and IBAMA; - To allow the access of land information for internals INCRA' sub-system such as the Land reform System (SIPRA- *Sistema de Informação para Projetos de Reforma Agrária*); - To give support to the land settlement programs.

Table 5.4 defines the land information activities related to each CNIR collaborating agency, also separated by the cadastre category: environmental, agrarian regularization, public land, statistical and fiscal.

Table 5.4 - Land information related activities

	Environmental		***Agrarian Regularization***	***Public Land Administration***		***Statistical***	***Fiscal***
	ADA (IBAMA)	***CNFP (SFB)***	***SNCR (INCRA)***	***SIAPA (SPU)***	***STI (FUNAI)***	***CNEFE (IBGE)***	***CAFIR (RFB)***
Support to the Rural Infrastructure	**X**		**X**		**X**	**X**	
Rural Land Regularization	**X**		**X**	**X**	**X**	**X**	
Rural Technical Assistance	**X**	**X**		**X**		**X**	
Public Land Administration		**X**	**X**	**X**	**X**	**X**	
Environmental Monitoring	**X**	**X**	**X**	**X**	**X**	**X**	
Formulation of Rural Public Polices	**X**	**X**	**X**	**X**	**X**	**X**	
Environmental License	**X**				**X**		**X**
Demarcation of *Quilombola* Lands			**X**			**X**	
Demarcation of Indigenous Lands					**X**	**X**	
Demarcation of Traditional Lands						**X**	
Demarcation of Public Lands		**X**	**X**	**X**		**X**	
Support of Rural Technical Workers	**X**						
Rural Property Valuation	**X**		**X**		**X**		
Rural Planning/ Zoning	**X**					**X**	
Rural Settlements	**X**			**X**			
Research	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Rural Legal Support	**X**					**X**	

Table 5.4 - Land information related activities (Continued)

	Environmental		***Agrarian Regularization***	***Public Land Administration***		***Statistical***	***Fiscal***
	ADA (IBAMA)	***CNFP (SFB)***	***SNCR (INCRA)***	***SIAPA (SPU)***	***STI (FUNAI)***	***CNEFE (IBGE)***	***CAFIR (RFB)***
Sustainable Development	**X**	**X**			**X**	**X**	
Formulation of Regulations	**X**		**X**		**X**		
EIA/RIMA		**X**			**X**	**X**	
Regularization of *Quilombola* Lands			**X**	**X**			
Regularization of Indigenous Lands				**X**	**X**		
Regularization of Traditional Lands				**X**			
Regularization of Public Lands		**X**	**X**	**X**			
Taxation							**X**

The majority of the laws created to regularize the existing cadastral systems in each of the collaboration agencies are dated before 2001, when the *Law # 10,267/2001* created CNIR. Appendix III lists the existing legislation for specific cadastral system proposes. Only *Decree # 6,063/2007* (Article 8), environmental legislation, which established the National Forest Cadastre (CNFP) mentions that the data produced at SFB should be designed to meet CNIR interoperability with INCRA and RFB.

Table 5.5 indicates the IT support that is funded by the agencies and which kind of database used among the agencies. Support varies according to the demand of each agency. The list of type of information contained within each dataset and which GIS software is found in Table 5.6.

Table 5.5 – Types of databases and IT support in each agency

	ADA (IBAMA) **E**	CNFP (SFB) **E**	SNCR (INCRA) **S**	SIAPA (SPU) **S**	CNEFE (IBGE) **I**	CAFIR (RFB) **S**	STI (FUNAI) **P**
Oracle	x	x	x		x		
Dbase						x	
Access							x
SQL Server	x		x	x			x
Legend for IT support: I= Institutional, *S= SERPRO, **E= EMBRATEL, P = Private							

* SERPRO - Federal Data Processing Service (*Serviço Federal de Processamento de Dados)*
**EMBRATEL - Brazilian Telecommunications Company (*Empresa Brasileira de Telecomunicações S.A.*)

Table 5.6 – Types of datasets and GIS software in each agency

	ADA (IBAMA)	CNFP (SFB)	SNCR (INCRA)	SIAPA (SPU)	CNEFE (IBGE)	CAFIR (RFB)	STI (FUNAI)
Descriptive	x	x	x	x	x	x	x
Spatial		x	x		x		x
GIS Software		ArcGis (**E**) i3geo (**FS**)	Geomedia (**I**)		Microstation (**B**) SisCart		Geomedia (**I**) ArcGis (**E**) Microstation (**B**) GVSIG (**OS**)
Legend for GIS software companies: E = ESRI, FS = Free software, I = Integraph, B = Bentle, OS = Open Source							

5.2.2 Problem Analysis for CNIR Implementation

By analyzing what researchers realized in doing the user requirements evaluation for the systems LOTS in South Australia in 1979, POLARIS in Ontario in 1980 and Newfoundland in 1985 it is possible to observe that the problems in implementing the CNIR system are not new. Actually, they are common in most of the systems above if analyzed from the technical, administrative and political perspectives. (see Table 5.7.) However, in Brazil, the problems have a larger scale and they are more directly associated with politics, regulation that are not followed in some cases, and lack of geo-referenced data at appropriate cadastral scales. These issues will be largely described and applied to CNIR system below.

Table 5.7 – Some technical, administrative and political issues existed during the user requirements of the systems LOTS, POLARIS and Newfoundland (after Palmer [1984]; Nichols [1984]; Nichols [1987]; Baxter et al. [1992]; Coleman and McLaughlin [1986]; Geospatial Projects Integration Office [2001])

Technical	- Duplication and storage of the same information into individuals systems; - Information collected from one system was not available to users of other systems; - Data of interest to another department were not collected during regular operations, even when it was possible; - Lack of unique identifier for land parcels; - Lack of updated maps; - Lack of a complete and updated land inventory; - Inconsistent and/or incompatible information; - Lack of capacity building.
Administrative	- Lack of communication among departments; - Lack of coordinated services; - Project time-frame; - Mapping priority; - Funding constraints.
Political	- Definition of goals to accomplish; - Indication of priorities area of implementation; - Sustainability; - Responsiveness to outsiders' users.

The following examples of technical, administrative and political issues at CNIR were developed based on analysis of the information gather from the agencies and the problems that were raised by the respondents of the user requirements interviews. Complementary, examples were also described based on the observations made during the agencies visit and analyses from the accessed documentation.

5.2.2.1 Examples of Technical Issues at CNIR

- Some of the current surveying projects are still using the SAD69 datum instead SIRGAS2000, the new reference system in Brazil. From 2006-2014 institutions are allowed to use both SAD69 and SIRGAS2000. After 2014, only SIRGAS2000 will be accepted. [IBGE, 2000]. Besides SAD69, in some agencies it is possible to find mapping with *Córrego Alegre* datum. Local datum where the conversion to SIRGAS2000 is nonexistent are also found. In 2005, the transformation parameters among the SAD69 to SIRGAS2000 were available without accuracy via TCgeo program. In December 2008, the transformation parameters among all Brazilian datum to SIRGAS2000 was disseminated for the general user with accuracy and models of transformation. This is made via ProGrid program at IBGE website developed by PIGN[4] [IBGE, 2008; IBGE, 2009a].
- The existing maps are insufficiently precise for cadastral mapping, as *Law # 10,267/2001* establishes (minimum precision of 0.50cm on each vertex). Environmental mapping at IBAMA is produced at scales of 1:250,000 or smaller, the indigenous mapping at FUNAI is from 1:100,000 to 1:300,000 and agrarian mapping existing at INCRA is 1:100,000. These scales meet the needs of each agency; but in CNIR, once this information is displayed on a precise large scale map, there will be unclear boundary delimitations. Imprecision will also occur when the property

[4] The National Geospatial Framework Project (PIGN) was developed by the University of New Brunswick - UNB and the main Brazilian partner IBGE. Since 2004 PIGN has been giving technical support to the SIRGAS2000 adoption and evaluating its social and environmental impacts. This is a technology transfer project supported by the Canadian International Development Agency (CIDA) and the Brazilian Cooperation Agency (ABC) [Paixão et al. 2006; PIGN, 2007].

borders bodies of water or roadways and these features are taken from mapping at a small scale.

- Most of the existing systems that will compose CNIR are declaratory systems and the same type of information is actually collected by several institutions. This creates a number of different responses for the same variable (e.g., area) because the information declared depends on the tax benefits that this information can bring to the landholder. This means: at IBAMA, the environmental cadastre, area might be declared higher than at the RFB, the fiscal cadastre, because it is known that the landholder can have deductions in the rural property tax by preserving the timber on their property. At INCRA, in the agrarian regularization cadastre, information about area of a given parcel can be found to be larger than one declared to RFB because the landholder might have social land rights or can easily get credit at the bank. There may be considerable discrepancies between the information declared in the INCRA cadastre and the real situation. Besides this, all of these areas may differ from the area registered at the *serviços registrais*, which recognizes legal rights.
- Current cadastral systems have different parcel identification (PID) but the information about taxpayer personal identification (CPF) and juridical identification (CNPJ) is normally requested. This might help in the systems integration. In Figure 5.1 the dashed boxes are the primary keys in each system and the arrows show how these PIDs can be linked. The rural property certificates code (CCIR), PID used by INCRA, can be found in the CAFIR (RFB) and ADA (IBAMA) systems, even though this is not obligatory. The co-ordinate information does not follow any standards; it can be found in Cartesian co-ordinate and UTM (Universe Transversal

Mercator), in SNCR (INCRA), CNEFE (IBGE) and CNFP (SFB) systems; and in geographic co-ordinates (Lat/Long) at ADA (IBAMA). The RIP code, the PID used by SPU, can be found at SIT (FUNAI), but will just appear when the indigenous area is registered at SPU. The NIRF Code, PID used by RFB, can be found at CAFIR (RFB) and ADA (IBAMA) systems.

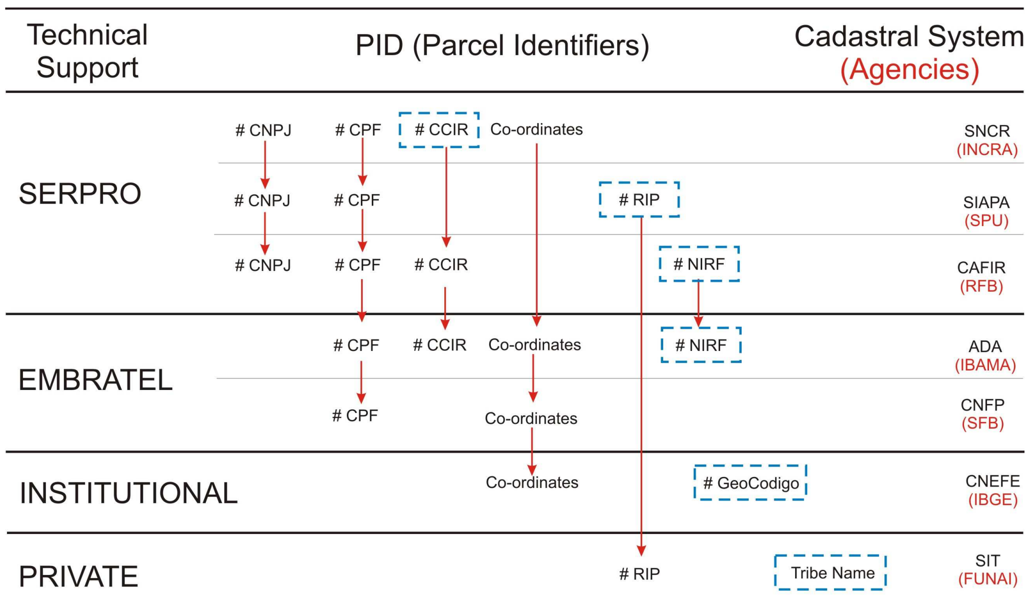


Figure 5.1 – Relationship of the existing PIDs

- There is a lack of system management and metadata at ADA (IBAMA), CNFP (SFB) and SIT (FUNAI). For system organization, SNCR (INCRA) uses the Capability Maturity Model (CMM) adapted to Brazil by SERPRO. SIAPA (SPU) has Decision Support Systems (DSS). CAFIR (RFB) has control of the data quality made by data validation. CNEFE (IBGE) has its metadata in the Geographic Data Files (GDF) with standard ISO 14825 and ISO 19115.

5.2.2.2 Examples of Administrative and Technical Issues at CNIR

- Brazil has a lack of mapping resources. Oliveira [2009] states that about 1% of the Brazilian territory is mapped to a scale 1: 25,000 or larger. Some of these maps are not standardized. Besides, just a few rural properties have been surveyed with costs provided by the government according to *Law # 10,267/2001* and certified by INCRA. If there is not enough information at a cadastral scale, CNIR might fail.
- There are no national standard procedures for the rural property certificates issued by INCRA; these requested certificates are accumulating in some of the INCRA regional offices. In 2005 a study made by the Interamerican Development Bank (BID) in partnership with INCRA estimated that Brazil had around 4,560,000 rural properties, counting legal and informal properties [Beckmann, 2009].

  Even though *Law # 10,267/2001* was created in 2001 and proclaimed in 2002 by *Decree # 4,449/2002,* the first certifications occurred only in 2004. From 2002 until March 1st 2009, Brazil had only 12,485 rural properties certified by INCRA. The requests for rural property certification can be done privately or by INCRA. Figure 5.2 shows the accumulated processes for rural property certification in INCRA office (Figure 5.2).

Figure 5.2 - Accumulated requests for rural property certification [Salomoni, 2008].

- In all agencies there is a need for human resources; these include GIS experts, surveyors, analysts, cartography engineers and so on. They should have training at several levels, from the certification of the geo-referencing rural properties according *Law# 10,267/2001* issued by INCRA to the capability to migrate existing data in CNIR with minimal loss of data, and to the use of the new system.

  The lack of skilled professionals capable to survey rural properties according to the *Law#10,267/2001* are mainly in the North and Northeast regions of Brazil. Until July 2008, 4,596 professionals were registered at the Engineering Association (CREA) to survey rural properties according to the *Law# 10,267/2001.* From the total of professionals surveyors engineering were 27.28% and technical in surveying was 22.39%. Cartography engineering appears only with 6.64%. Geodesists and topographer engineers who have skilled background were also the minority with 0.11%. The remaining 43.69 % of the professionals were agronomist, civil engineering, mechanical engineering, geologist and electrical engineering.

- Among institutions there are few formal agreements and as a consequence, data cannot be easily exchanged. In extreme case, such as CNFE (IBGE), SNCR (INCRA) and CAFIR (RFB) systems, data is confidential information. Table 5.8 shows the current agreements among CNIR collaborating agencies and outside them.

Table 5.8 – Current Formal Agreements

ADA (IBAMA)	**CAFIR (RFB)**	**CNEFE (IBGE)**	**CNFP (SFB)**	***Serviços Registrais***	**SIAPA (SPU)**	**STI (FUNAI)**	**SNCR (INCRA)**
RFB, environmental organizations	INCRA, IBAMA	None	None	INCRA, RFB, City halls	City halls, RFB	None	City halls, IBGE, RFB, CGU, OTE

- There is also a lack of technological support in some institutions, which makes the cadastre inefficient. An example of this is the SIT (FUNAI) cadastre that was not operating in 2005 because there were no financial funds to maintain it. In other cases, there is departmental support, but the agencies are still depending on private companies to develop the cadastral tools. The type of the technological support in each cadastre was described at Table 5.5.
- Lack of feedback from INCRA on legal information that has been sent from the s*erviços registrais* and lack of interoperable information system to connect the two agencies are also important problems. Besides, the flow of information between s*erviços registrais* and INCRA is in analog format. The fact that INCRA needs to retype the data might generate human errors.

- There is not a specific legal registry for public land in Brazil. There was the *Vigário* registry in 1850, but because there was no continuity of this inventory, this information is not complete, and some has been lost over time. Today, SPU maintains an inventory of these lands, as they are identified by the government even the registrations are done at s*erviços registrais*.
- There is lack of communication among INCRA and RFB and the other agencies. There is also some concern about CNIR implementation from the agencies side. Decisions cannot be taken just from one side; neither should decisions be taken without consultation with the s*erviços registrais* to ensure that the decision is legally valid. Institutions must be aware about the restrictions and responsibilities that each one will have in the CNIR, the deadline for the deliverables and what they should give as a result.
- Since CNIR is using landholders' personal information via the internet, the system must provide an adequate firewall to prevent hackers from accessing applicants' personal information. Agencies such as RFB, INCRA, IBGE and SPU point out security as an issue. The control must include who has access to which kind of information. It also must be documented to be easily tracked. The collaborating agencies must ensure that their data transfer will be not hacked, especially one who has landholder confidential information. Other concerns related to control is for the data quality control itself, since each collaborating agencies has each its own method for quality control, CNIR should have a validating tool to check its quality. The coordination role might be included here, to ensure that all people are doing what

they were in charge of doing and decisions can be faster done in order to solve conflicts.

- Lack of administrative decentralization in some existing collaborating agencies affects the efficiency of collecting and managing their specific information for all of Brazil. The situation is worst in the countryside and in northern Brazil where citizens need to travel significant distances to the closest main city where they can declare their information.

5.2.2.3 Examples of Political Issues at CNIR

- Some land titles issued by INCRA in 1960's in the Amazon region, for political reasons exist, but do not have legal recognition. They have been cancelled by INCRA because some of them were proved to be fraudulent (*grilagem*). This mainly occurs when loggers, cattle farmers and land speculators hold public lands illegally for their exploitation [Greepeace, 2009], which is prohibited according to *INCRA legislation # 10/ 2004*. Either these rural properties will be part of CNIR (i.e., accepted), or they will need to have their land information validated in order for land transactions. These *grilagem* lands also overlap traditional land held by, for example, aboriginals, *Quilombolas* (black ex-slave communities) and other marginalized groups, causing land conflict in Brazil.
- CNIR has federal aid to be implemented with INCRA and RFB responsibility. Since it will take a long time to implement, it also has constraints related to political

decisions. Political decisions may influence the changing of the priority areas that are supposed to be surveyed or to be approved the cutting of funds, or even the changing of the goals of CNIR.

- Strikes are a common feature in Brazil and administrative heads and operational support also are political appointments that changes with the change of the government (i.e., technical positions are denominated by employees with political appointments. They do not have stability; they might change every 4 years, when new governmental elections occur, or even during this period). These features might cause inefficiencies in CNIR management. They can also cause delays in the CNIR implementation and for the future; they might cause lack of system maintenance and delays of the CNIR deliveries. Furthermore, they also might change the requirements and decisions that were agreed for all agencies involved to CNIR implementation. Regulations should be updated to assure more responsibilities from collaborating agencies part and correct data retrieve at CNIR.
- There is a lack of information for the general public about what *Law # 10,267/2001* is, what it represents to Brazil and what are the short and long term benefits that its brings to the citizens. Thus there is no pressure from the citizens on government to realize the potential of CNIR.
- According of the Land Statute, INCRA is responsible to indicate priority areas to be regularized; it must be approved by the Federal Congress. Since this function is not realized by INCRA, in practice, the social movements, such as MST, CONTAG and CPT end up defining the priority areas. The indication of priority areas sometimes is

done by the groups' interest to increase political power. As much area will be surveyed as more data input CNIR will have.

5.2.3 CNIR Opportunities Analysis

- ***Existence of databases*** **–** Even if in some cases there is an absence of metadata, all the collaborating agencies have a database; but the data needs to be verified, updated and maintained and this is a very large task. The technology for data standardization also exists. Also, to improve their data collection and processing the federal government has been investing in the acquisition of new equipment and software and other new tools such as data integrity and data security.
- ***Modernization of the serviços registrais*** **–** The *serviços registrais* are starting to be computerized, even though many still using only paper records (Figure 5.3). This should result in better organization of the registered real property and easy data availability to CNIR. Assessments made from CNJ [2008] show that Brazil has 23,129 *serviços registrais,* this with include notaries, civil and juridical registry, and registry for marine agreements, general documents and *serviços registrais*. But only 17.3% *Cartórios* are computerized [IRIB, 2008]. From the total amount of *serviços registrais* in Brazil, 12.6% (2,913) are *serviços registrais* [CNJ, 2008].The transition period, analog to digital, will demand skilled workers to use new technologies and significant time to convert the documentation. As a consequence, this may bring additional costs to the *serviços registrais* up front while the benefits are more long

term. The incentive for the *serviços registrais* system to change is that once the technology is functioning, they should be able to register more land titles and consult information in a shorter time. Also they can check land information from other sources at CNIR and update their database.

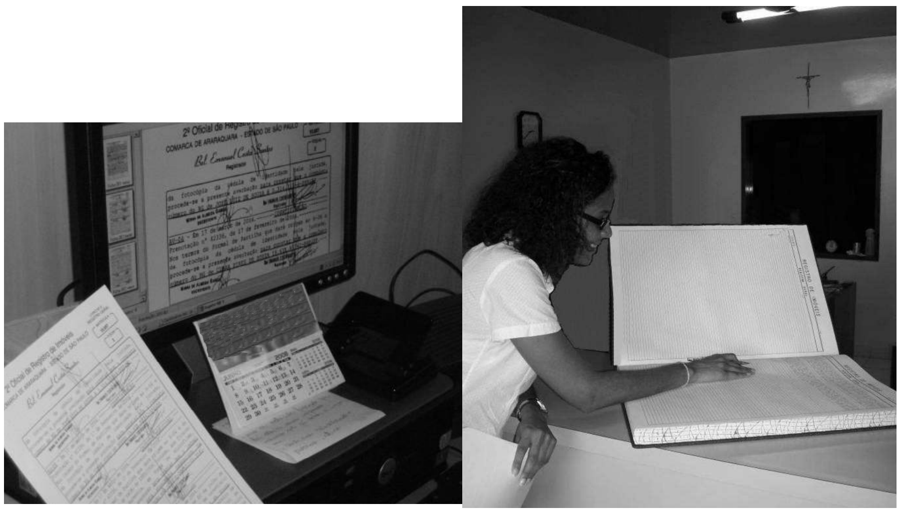


Figure 5.3 - Analog registry office in Salgueiro/PE (left side) and computerized registry office (*2º Registro de Imóveis de Araraquara/SP*, June 2008) (right side)

- ***e-PING (e-Government Interoperability Standards)*** - The e-PING project was created in 2003 to establish criteria for the development of systems and data storage including a set of minimum premises, policies, and technical specifications that regulate the use of communication and information technologies. Consequently e-PING facilitates the consultation of electronic information at several governmental levels by allowing systems with different applications to generate and exchange information in real time. Besides the Executive Branch of the federal government, e-PING has participation at the state and local spheres, legislative and judiciary power, international organizations, Brazilian and foreign companies, and finally the private sector [Brazilian Government, 2007; Santanna, 2007; Paixao et al., 2009].

- **Establishment of the Spatial Data Infrastructure (SDI) in Brazil** – In Brazil, the geospatial data is incompatible and does not cover the Brazilian territory as a whole. According to IBGE (2009b) the establishment of the SDI in Brazil will benefit to geospatial data because it will help to create a harmonized framework with:
    - Definition of the data standardization;
    - Creation of a well-defined documentation and metadata;
    - Facilitation of the access of the systematic data through IBGE sources;
    - Harmonisation of the current data between datasets at different geographical scales;
    - Minimizing the duplication of information collection;
    - Definition of the data policy which including restrictions and data custodianship;
    - Creation of a general GIS portal called SIG-Brasil. This GIS portal was established at the *Decree# 6,666/2008*.

The densification of the provincial GPS network and the availability of its data through IBGE portal was another way used to improve the data collection for the SDI framework and also to improve the precision of the control points used as primary basis for the surveys according the Law# 10,267/2001. Da Silva et al. (2008) explain that the spaces among the geodetic benchmark were minimized and the configuration of the GPS network was well-spatially distributed. In consequence, the number of geodetic GPS station increased, the control points were even more precise. The densification of the provincial GPS network also allowed the use of mono-frequencies GPS receptor, what reduced the cost of the surveys and in some cases, eliminated the need for transporting co-ordinates.

- ***Political interest -*** Serious land conflicts in Brazil, such as *Raposa Serra do Sol* indigenous reserve, the Revolutionary Armed Forces of Colombia (FARC) trespass at the Brazilian border, and foreign investments in public lands without legal recognition, have shown the importance of having an integrated system to manage land information. Politically these are strong arguments to gather votes. Also, from the environmental side, there is national and international interest in defining the location and extent of deforestation especially in the Amazon region.

5.2.4 CNIR Constraints Analysis

- Data is the critical element for CNIR. Without appropriate datasets it is not possible to develop an effective system. Graphical data in cadastral scale is minimal as well as the number of rural properties certified by INCRA. Descriptive data are declaratory and with no same period for updating. Some information has an annual update (IBAMA, CAFIR), others are updated every 10 years (agrarian census) and the remainder is updated when there is demand for creation of new areas, when there are land conflicts or when new surveys need to be done for expropriation or dispute resolution (SFB, FUNAI, SPU, SNCR). The legal information is updated when there is need for land conveyancing, or when there is need for communication of new restrictive areas at the rural properties.

- Lack of technical expertise has strong impacts on CNIR implementation. The lack of professional surveyors and its heterogenic distribution in Brazil, as explained above, are the causes for rural parcels being surveyed by numerous other professionals that sometimes do not have enough knowledge about either the *Law# 10,267/2001 or* the SIRGAS2000 datum. Besides, administrative heads and operational support are political appointments, and skilled professionals might change over the implementation period because of political instability;
- As a Civil Law country, laws and regulations are mandatory to support the CNIR implementation. The existing laws need to be updated and new ones created to provide standards and to outline responsibilities with regards to CNIR. Legislative changes could delay implementation (and even the design of the CNIR system);
- During the CNIR implementation process, there will mostly likely be significant staff changes at the professional and management levels that might create new requirements. In addition the whole concept of CNIR must be introduced to new staff;
- Even though CNIR is paid by federal resources, the cost to improve the existing cadastral systems at the collaborating agencies needs to be considered. It is not clear how this will occur with *serviços registrais,* since they are considered as private sector. There are also costs involved for training the entire range of professionals (e.g., surveyors, notaries, etc.) and for contracting new resources;

- Tests can only be conducted through the prototype of a module. This means that the assurance of the user requirements will just be seen tested relatively late. The supporting agencies must be involved to maintain the commitment for data production and update;
- Bureaucracy might delay the signature of formal agreements amongst the agencies. This may result in voluntary maintenance of the system and none of the systems properly functioning. This is like to occur during strike periods.
- Citizens might not have access to the land information data within CNIR, or at the worst case, citizens could not travel long distances to declare data at CNIR.

5.3 Matrix Problem Analysis for CNIR

The indication of the priority tasks in system development is one of the steps to be taken after user requirements are evaluated, when all needs and problems have been already analyzed. This section will present one way to define problem priorities using PERT diagram analysis as a management tool. PERT uses mathematical models to generate analysis. This research is using the classification of the criteria and task dependency as subjective parameters that were based on user requirements results. This methodology was used because the problem priorities were not indicated by the CNIR stakeholders.

5.3.1 CRECE Framework

Matrices were created to analyze the problems of software development. One example is the PIECES framework matrix. PIECES stand for the correction or improvement of ***performance, information, economics, control, efficiency and service.*** **Performance** is related to what a system does and how the system needs to perform for the user. **Information** or data is related to the basis for the information or data model that the system needs to maintain. **Economics** have a direct correlation with project development and operational cost and also savings associated with the system. **Control or security** is associated with system security issues as well as the editing required on inputs and outputs. **Efficiency** of people or process is a measure of method correctness and how operations can be improved or what values can be added to the environment. **Service** users and partners takes into account functional requirements and implementation concerns, such as ease of use and needed support for ongoing use of the system, maintenance of the system, and training and documentation requirements [Meredith and Mantel Jr., 1995; Mustafa et al., 2002; Whitten et al., 2004].

With the PIECES framework in mind, the CRECE framework matrix was developed to analyze the existing problems for CNIR implementation. CRECE stands for ***completeness, reliability, efficiency, consistency and effectiveness.*** **Completeness** occurs when there is no more information to be added, or when a process is fully completed. **Reliability** “is the ability of a system or component to perform its required functions under stated conditions for a specified period of time” [IEEE, 1990]. **Efficiency** is a productivity measurement to achieve the goals with minimum resources.

It is focused on process. **Consistency** is an agreement or logical coherence among data or processes. **Effectiveness** is a measure of quality and usefulness of the system. It is focused on outputs. In Table 5.9, the CRECE criteria were also summarize and classified the CNIR problem exemplified in Section 5.2.2 above in terms of technical, administrative and political issues.

Table 5.9 – Current problems for CNIR implementation into CRECE framework

CRECE Framework	***Technical***	***Administrative***	***Political***
C *Completeness*	– Lack of unique identifier of land parcels. – Lack of spatial and descriptive land information. – Lack of common standard for the descriptive data – Lack of parcel mapping and outdated maps – Lack of metadata.	– Existing dimension of the network is not adequate for CNIR demand.	– Changing of the priority areas for mapping – Lack of a complete and updated land inventory.
R *Reliability*	– Duplication and storage of the same information into individual systems. – Noncontinuous data update	– Lack of skilled professionals to work with CNIR, in the majority of cases there are not enough professionals. – Lack of rules to update data.	– Lack of funding to train the current professionals. – Inexistent formal agreement among the agencies. – Noncontinuous interest in land programs. – Noncontinuous permanence of skilled professionals.
E *Efficiency*	– Lack of technology system in some agencies that might complicate the interoperability amongst systems. – Lack of tracking of the information changed and accessed. – Insufficient control of internal user access and security of the information accessed.	– Lack of time response from existing system caused by the lack of technical support. – Lack of access to new technology by some agencies. – Lack of quality control.	– Lack of physical structure for CNIR demand. – Lack of professional capacity building and insufficient skilled professionals.

Table 5.9 – Current problems for CNIR implementation into CRECE framework (Continued)

CRECE Framework	***Technical***	***Administrative***	***Political***
C *Consistency*	– Inconsistent and/or incompatible information. Majority of the systems contain declared data from the landholder. – Some current cadastral systems have inadequate system architecture. – Inconsistent and redundant data. – Maps have different scales, precision and datum. Only the agrarian map now surveyed according the *Law# 10.267/2001* has a cadastral scale.	– Duplication of data in current cadastral systems.	
E *Effectiveness*	– Lack of technological support. – Insufficient user-friendly interface systems. It delays the update and makes the production of the outcomes more difficult.	– Lack of current system management. – Too many steps to produce the outcomes, such as certificates and reports.	– Miscommunication between INCRA and RFB with the CNIR collaborating agencies, including *Cartórios de Registro de Imóveis*.

Based on the examples of the problems interpreted from the user requirements (more details in Section 5.2.2), 13 criteria were chosen and categorized in terms of the CRECE framework (see Table 5.10). This gives some indication about the problems' importance from the user requirements perspective.

Table 5.10 – Problems identified during the user requirements placed in the CRECE framework.

	Criterion	**C**	**R**	**E**	**C**	**E**
	Legend **C** = Completeness, **R** = Reliability, **E** = Efficiency, **C** = Consistency, **E** = Effectiveness respectively					
1	Consistency of the data input/output	x	x		x	
2	Integration of spatial and descriptive data with other agencies		x	x	x	x
3	Spatial and descriptive data quality control		x	x	x	x
4	Easy data update	x	x	x		x
5	Easy to use system / Easy users' interface			x		x
6	Easy access to CNIR by other institutions		x	x		x
7	Easy generation of data outputs				x	x
8	Training for professionals			x		x
9	Data standardization and metadata		x	x	x	x
10	Users' access control		x	x		
11	Internal availability of the CNIR (intranet)			x	x	x
12	Web-based availability			x		x
13	Flexibility to aggregate new systems			x		x
TOTAL		2	7	11	6	11

The frequency of each criterion, shown in the problem matrix above, indicates that efficiency and effectiveness are the top priority concerns. In order to have a successful CNIR implementation, all the others categories of the CRECE framework need to be solved. Completeness appears to be of the least concern, maybe because the CNIR system will have several systems that have lack of spatial and descriptive data. This means that CNIR will be implemented but in the short term CNIR might not have completeness.

Since the priority of the criteria was not established by the agencies, the problems interpreted from the user requirements were reorganized with their respective relationship (task dependency), as is demonstrated in Table 5.7. This priority matrix gives some indication from where the problem-solving should start for CNIR. The PERT diagram representation will assist in understanding the development process because it indicates how each task needs to be linked. To build Table 5.12, it was necessary to understand the dependency among criteria and its task dependency. The types of task links are start-to-start (SS), finish-to-finish (FF), finish-to-start (FS) and start-to-finish (SF), as illustrated in Table 5.11 [Microsoft Office Project 2003, 2009].

Table 5.11 – Link of task dependencies (from Microsoft Office Project 2003 [2009])

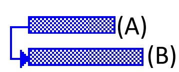
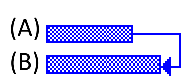
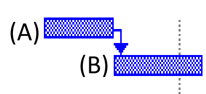
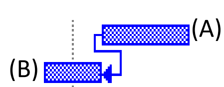
Task dependency	**Example**	**Description**
Start-to-start (SS)		Task (B) cannot start until task (A) starts.
Finish-to-finish (FF)		Task (B) cannot finish until task (A) finishes
Finish-to-Start (FS)		Task (B) cannot start until Task (A) finishes
Start-to-Finish (SF)		Task (B) cannot finish until Task (A) starts

Table 5.12 – Problem matrix criteria and its task dependencies

	Criterion (TASK B)	Dependencies (TASK A)
1	Consistency of the data input/output	3(SS), 8(FS), 9(FS)
2	Integration of spatial and descriptive data with other agencies	6(SF), 8(FS), 9(FS), 13(SS)
3	Spatial and descriptive data quality control	1(SS), 8(FS), 9(FS)
4	Easy data update	5(FS), 9(FS)
5	Easy to use system / Easy user's interface	6(SS), 7(SS)
6	Easy access to CNIR by other institutions	5(SS), 10(SS), 13(FF)
7	Easy generation of data outputs	2(SF), 5(SF), 8(SS)
8	Training for professionals	1(FF), 2(FF), 3(FF), 7(FF), 9(FF), 11(FF), 12(FF), 13(FF)
9	Data standardization and metadata	1(SF), 8(FS)
10	User's access control	13(FF)
11	Internal availability of the CNIR (intranet)	1(FS), 2(FS), 5(FS), 8(FS), 9(FS)
12	Web-based availability	8(FS), 9(FS), 10(FF), 13(FF)
13	Flexibility to aggregate new systems	6(FS), 8(SS)

The result of the criteria relationships is shown as a PERT chart (Figure 5.7). PERT charts, as explained in Section 4.2, have been used to show major steps and their interrelationships for planning and controlling projects with well-defined activities and events. No activity should begin before the preceding activities are completed. The task dependencies are the activities that the arrows come from [Burch Jr. et al., 1983; Grady, 1992].

The CNIR PERT chart illustrates how the problems are related, within the CNIR structure. These relationships create pathways through the process. The longest pathway is the critical pathway. The process cannot end before the critical pathway ends. This means that the critical pathway in the CNIR PERT chart might indicate the priority paths that the CNIR developers might choose to be first resolved in order to implement an efficient system. The CNIR critical pathway is represented with thick arrows in Figure 5.4, and emphasized in Figure 5.5.

Criterion #8 was chosen as pre conditional, because it is understood that the requirements will be met if there is a skilled person to execute them. Notice that Criterion #8 will not be a task dependent on all criteria. Under this methodology, if the system is user-friendly, then there will be no need for skilled professionals in these phases (i.e., Criterion #4, #5 and #6). Criterion #7 still needs a skilled professional because it is related to generating outputs from the data availability, criterion #11.

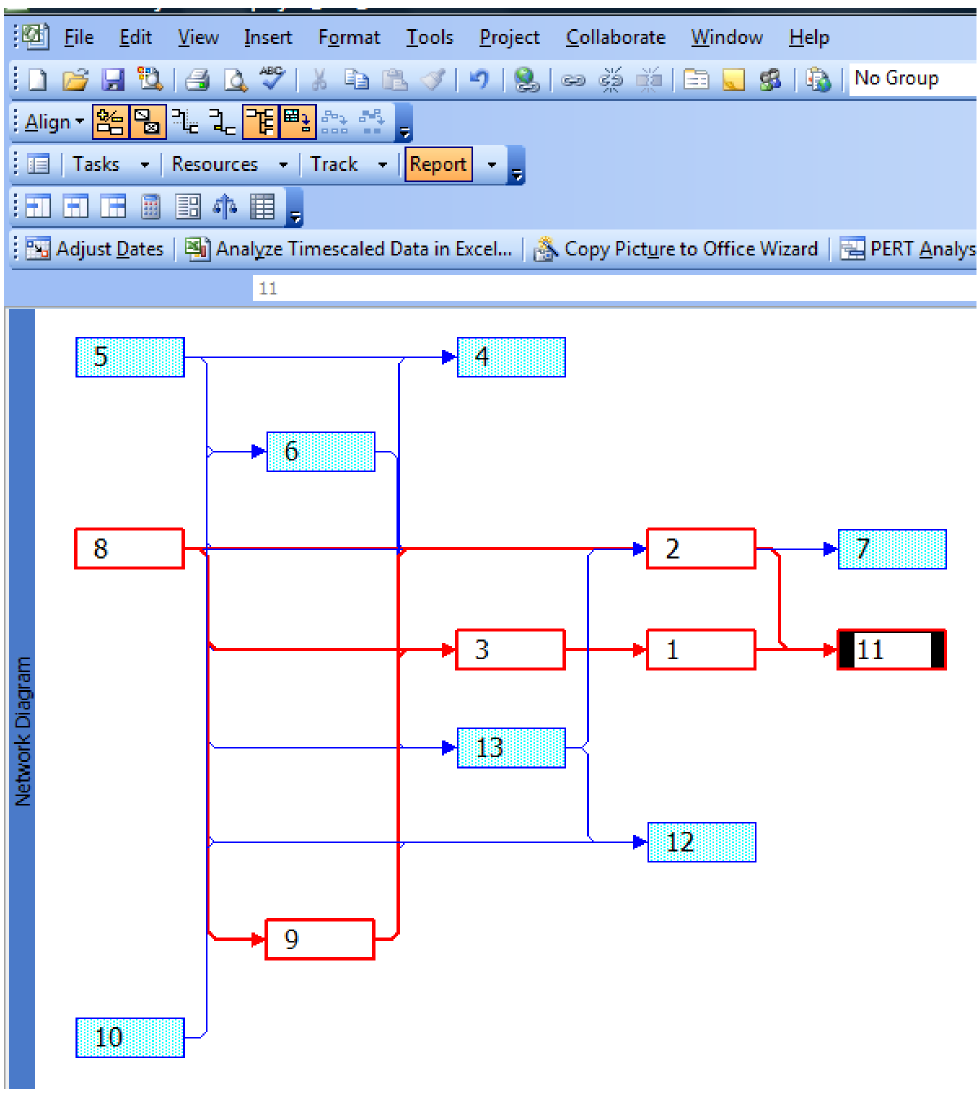


Figure 5.4 – Representation of the problem matrix criteria and its task dependencies by a PERT diagram

Figure 5.4 can be interpreted, for example, route 5, 4 - in order to have easy data update (#4) the system should be user friendly (#5). Route 5, 6, 13, 12 and route 5, 6, 13, 2, 11 show that the fact that the system is user friendly (#5) will facilitate easy access to CNIR by the collaborating agencies (#6). Easy access by the agencies (#6) will also influence the aggregation of new systems (#13), which can occur in one of two ways. On one hand it (#13) will directly affect the availability of the CNIR web-based (#12). And on the other hand it (#13) will affect the integration of the existing systems (#2). The addition of a new system and its integration (#2) will have a direct correlation with how the information will be available at the data availability (#11).

Notice that each criterion will be linked with many other criteria creating many possibilities of interpretation, but the routes will always be from the left to the right side (i.e., predecessor to successor). The precedents are graphically represented as activities that the arrows come from. The critical pathway indicates the problems that must be solved.

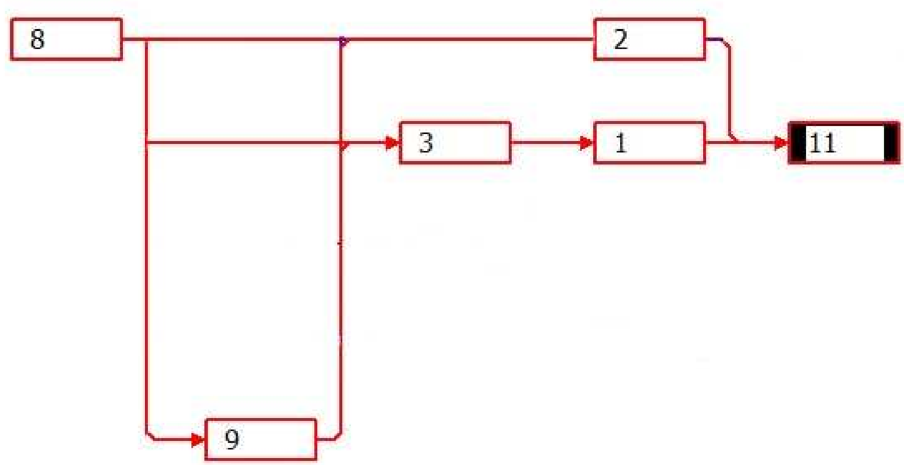


Figure 5.5 – CNIR critical pathway

Figure 5.5 also can be interpreted, for example, route 8, 2, 11 - skilled professionals (#8) will be essential to set up the integration of the existing systems (#2) in order to be available for the internal users (#11). Route 8, 3, 1, 11 - Skilled professionals (#8) will also be a requirement for quality control (# 3), which should be is precedent of the data consistency task (# 1), to finally be possible to be available at the intranet for the internal users (#11). Route 8, 9, 2, 11 and route 8, 9, 3, 1, 11 - the skilled professionals (#8) will finally be important to data standardization (#9) that will influence the routes described above. It is clear that if there are no skilled professionals to maintain the CNIR system, it might fail.

These routes interpreted from the Figure 5.5, CNIR Critical Pathway, were re-classified in terms of CRECE framework (Table 5.13). This helped to refine the critical pathway and indicate the priority problems via weights (Table 5.14). If it is possible for the CNIR developers to prioritize any of these routes in CNIR implementation, it might minimize the effort to implement and manage CNIR.

Table 5.13 – Possible routes of the critical pathway

Critical Routes	**C**	**R**	**E**	**C**	**E**
8 2 11		2	2,8,11	2,11	2,8,11
8 3 1 11	1	1,3	3,8,11	1,3,11	3,8,11
8 9 3 1 11	1	1,3,9	3,8,9,11	1,3,9,11	3,8,9,11
8 9 2 11		2,9	2,8,9,11	2,9,11	2,8,9,11

Finally, weights for each critical pathway criterion were obtained as if priority had been chosen by the agencies. Table 5.14 captures the CNIR Critical Pathway criterion frequency (weight) counted from the Table 5.13. Notice that any solution adopted will directly affect the CNIR implementation.

Table 5.14- CNIR critical pathway criterion and its weights

	Criterion (TASK B)	Weights (Frequency)	Dependencies (TASK A)
1	Consistency of the data input/output	6	3(SS), 8(FS), 9(FS)
2	Integration of spatial and descriptive data with other agencies	8	6(SF), 8(FS), 9(FS), 13(SS)
3	Spatial and descriptive data quality control	8	1(SS), 8(FS), 9(FS)
8	Training for professionals	8	1(FF), 2(FF), 3(FF), 7(FF), 9(FF), 11(FF), 12(FF), 13(FF)
9	Data standardization and metadata	8	1(SF), 8(FS)
11	Internal availability of the CNIR (intranet)	12	1(FS), 2(FS), 5(FS), 8(FS), 9(FS)

Once the weights were established for the CNIR critical pathway (Table 5.14), a new PERT diagram was processed, shown in Figure 5.6. The new CNIR critical pathway, refinement I, eliminates the criteria # 3 and # 1 (consistency of the data and data quality control). This means that, from the critical pathway perspective, these criteria (#3 and #1) were of the least concerns.

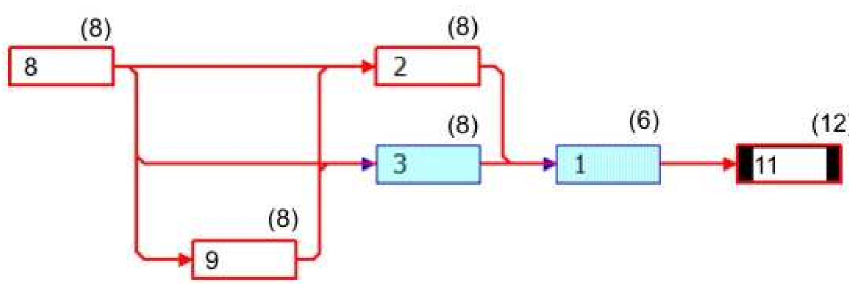


Figure 5.6 - CNIR critical pathway, refinement I

Aiming to determine the best indication for the CNIR critical pathway, a second refinement (Refinement II) was performed with the remaining criteria. The new routes are displayed in Table 5.15. Notice that the routes were reduced because two criteria # 3 and #1 were eliminated. Table 5.16 shows the new weights counted from Table 5.15 and Figure 5.7 shows the representation of the critical pathway at refinement II.

Table 5.15 – Possible routes of the critical pathway at refinement II

Critical Routes	C	R	E	C	E
8 2 11		2	2,8,11	2,11	2,8,11
8 11			8,11	11	8,11
8 9 2 11		2,9	2,8,9,11	2,9,11	2,8,9,11
8 9 11		9	8,9,11	9,11	8,9,11

Table 5.16 - CNIR Critical Pathway criteria and its weights at refinement II

	Criterion (TASK B)	Weights (Frequency)	Dependencies (TASK A)
2	Integration of spatial and descriptive data with other agencies.	8	6(SF), 8(FS), 9(FS), 13(SS)
8	Training for professionals	8	1(FF), 2(FF), 3(FF), 7(FF), 9(FF), 11(FF), 12(FF), 13(FF)
9	Data standardization and metadata	8	1(SF), 8(FS)
11	Internal availability of the CNIR (intranet)	12	1(FS), 2(FS), 5(FS), 8(FS), 9(FS)

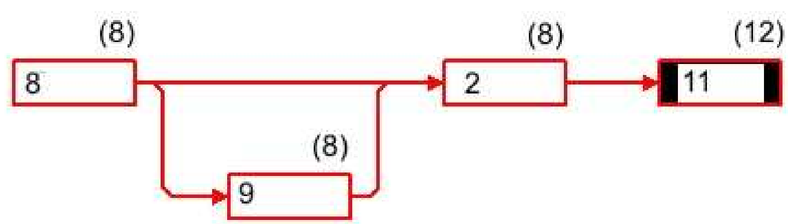


Figure 5.7 - CNIR critical pathway, refinement II

Comparing the weights determinate in Table 5.14 and Table 5.16 (Refinements I and II, respectively) notice that, in Refinement 2, the remaining criteria (i.e., # 2, #8, #9, #11) received the same weights as in Refinement I, no more criteria were eliminated, but the configuration of the CNIR PERT changed. To ensure these criteria were the worst problems, a Refinement III was made (see Table 5.17 and 5.18).

Comparing Refinement II with III, it is observed in Table 5.18 that there were no more modifications about the number of criteria remaining even though the number of possible routes had decreased. Weights also had changed but the configuration of the CNIR PERT remained the same as Refinement II. This indicates that Refinement III illustrate the worst problems in the critical pathway.

Table 5.17 – Possible routes of the critical pathway at refinement III

Critical Routes	**C**	**R**	**E**	**C**	**E**
8 2 11		2	2,8,11	2,11	2,8,11
8 9 2 11		2,9	2,8,9,11	2,9,11	2,8,9,11

Table 5.18 - CNIR critical pathway criteria and its weights at refinement III

	Criterion (TASK B)	**Weights (Frequency)**	**Dependencies (TASK A)**
2	Integration of spatial and descriptive data with other agencies	8	6(SF), 8(FS), 9(FS), 13(SS)
8	Training for professionals	4	1(FF), 2(FF), 3(FF), 7(FF), 9(FF), 11(FF), 12(FF), 13(FF)
9	Data standardization and metadata	4	1(SF), 8(FS)
11	Internal availability of the CNIR (intranet)	6	1(FS), 2(FS), 5(FS), 8(FS), 9(FS)

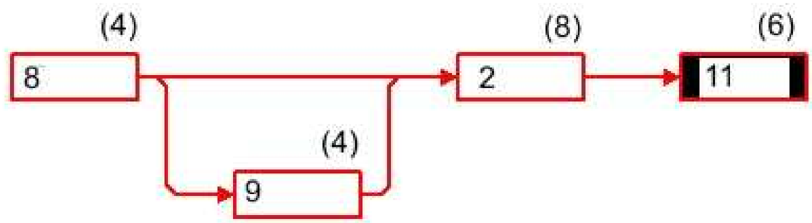


Figure 5.8 - CNIR critical pathway, refinement III

Because the routes of the CNIR critical pathway criteria did not change anymore in Refinement III, neither criterion was eliminated (Figure 5.8). It is concluded that the route 8,2,11 – skilled professionals, integration of the systems and CNIR availability to internal users sums 18 points. By comparison, Route 8, 9, 2, 11– skilled professionals, data standardization, integration of the systems and CNIR availability to internal users sums 22 points and it is considered the worst critical pathway.

Ordering the criteria in terms of the critical pathway, it is possible to conclude that from 6 primary criteria (#1, #2, #3, #8, #9, #11) calculated to be the most critical problems, after being refined; the most critical criteria are the following 4 criteria:

1. ***Criterion #8 -*** Training for professionals
2. ***Criterion #9 -*** Data standardization and metadata
3. ***Criterion #2 -*** Integration of spatial and descriptive data with other agencies
4. ***Criterion #11 -*** Internal availability of the CNIR (intranet)

It concludes that, from 13 criteria, only 4 criteria were considered the most critical pathway for the CNIR implementation. Criteria (# 1 and # 3) were primary identified as critical tasks, even though lately on the refinement they were eliminated. It might be interpreted that task dependency were subjectively chosen for the CNIR implementation phase, when the agencies will be integrated (i.e., software interoperability). Criteria (# 1 and # 3) could be relocated for the maintenance phase of CNIR. That runs parallel in the end of CNIR implementation phase.

This chapter is important for the following reasons:

- It uses description of the existing cadastral systems (Appendix III) to identify problems, opportunities and constraints of CNIR;
- It indicates the priority of the CNIR problems that were not listed during the user requirements analysis;
- It serves as basis for the design of the conceptual model and to recommend strategies for CNIR implementation and maintenance (Chapter 6 and 8).

CHAPTER 6

DESIGN CONCEPTUAL MODEL FOR A NATIONAL RURAL CADASTRE SYSTEM IN BRAZIL

This chapter describes the conceptual model proposed for CNIR. Section 6.1 will define a conceptual model and list the objectives of the CNIR conceptual model. Section 6.2 will describe the CNIR scope and potential CNIR targets users. CNIR assumptions will be described in Section 6.3. Lastly, Section 6.4 will detail the proposed model, including the data flow, minimum content and system functions.

6.1 Objectives for a Conceptual Model for CNIR

The definition of a conceptual model differs among authors and with the context. Normally when a conceptual model is referred to, a high level view of the real world domain is proposed. A conceptual model might be a valuable tool to assess the relevance of existing rules for descriptions, formats, data models, and ways to improve them. It is intended to convey a common conceptualisation for development and can be validated only by agreement by a group of participants who actually need such a model [Le Boeuf, 2006]. The choice of models influences how a problem is attacked and how a solution is shaped; this means that every model may be expressed at different levels of precision. There is no one single model; the best models are those connected to reality [Pace, 2000].

The evaluation of the conceptual models is based on several criteria. Pace [2000] defines the key criteria as follows:

- ***Completeness -*** entities and processes of the problem domain should be identified to ensure that specifications for the conceptual model fully satisfy the requirements;
- ***Consistency -*** entities and processes are addressed from compatible perspectives;
- ***Coherence -*** a conceptual model is organized to demonstrate the functions and potentialities;
- ***Correctness*** - a conceptual model is appropriate for the intended application and has potential to perform in agreement with the requirements.

Soft system methodology (SSM) was chosen for CNIR conceptual model development (details Appendix IV). SSM considers the cognitive manner to analyze the social, political and cultural issues that are behind the CNIR system.

> *SSM recognises that a real world situation can never be described definitively. Ensuring the best understanding of a real world situation requires a collaborative debate. Through this debate, possible improvements to the problem domain may emerge and be determined* [Schmidt, 2006].

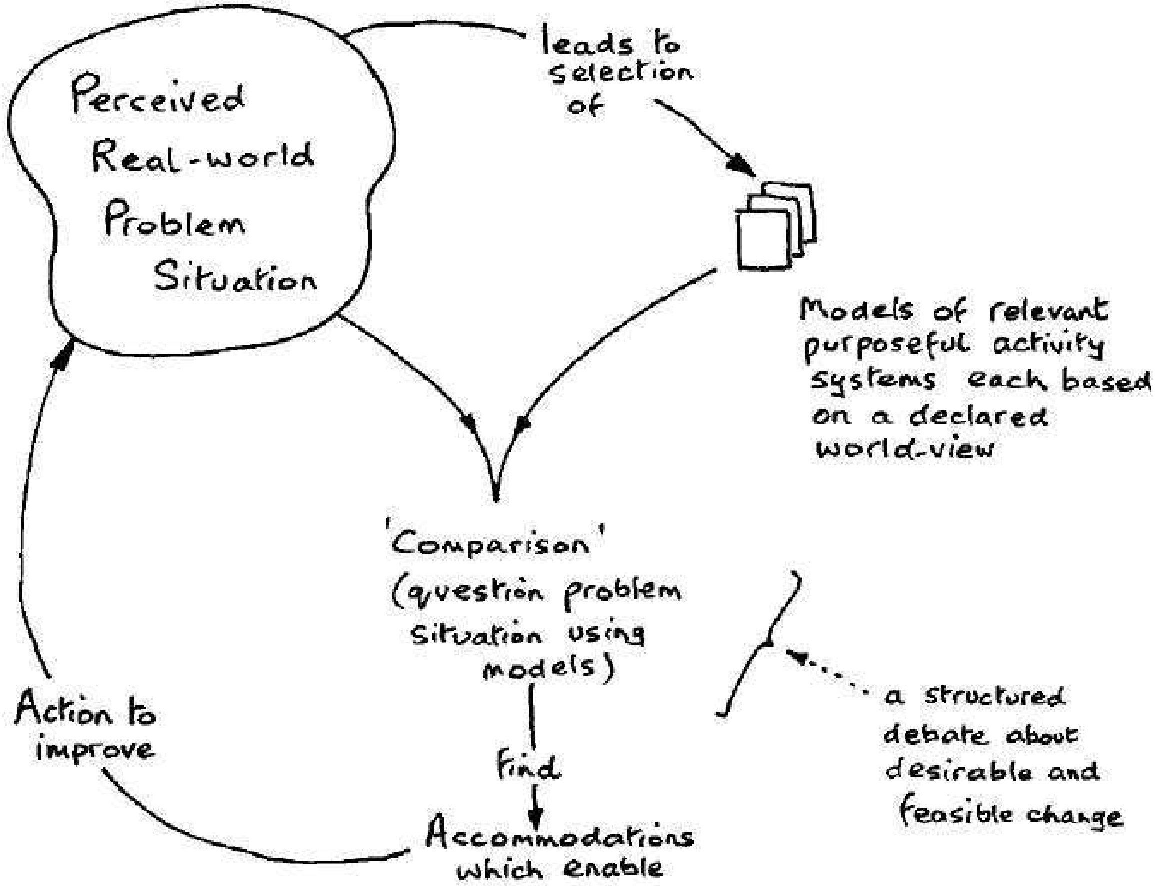


Figure 6.1 – SSM cycle (from Schmidt [2006])

Figure 6.1 shows that in SSM the real world is perceived from a social viewpoint, focusing on values, roles and the social system. It needs to be associated with potential relevant systems for later modelling. This new model is compared with the real-world problem situation which can itself be treated as a system. This analysis ensures that attention is given to the important aspects of the problem situation as a culture. It is completed when interventions are made to improve the subject system and evaluation. Improvement is judged with wide point of view.

The primary purpose of the CNIR conceptual model is to provide a framework for the integration of the current cadastral systems under several land administration agencies to obtain concise land information to support dispute resolution, land reform, land redistribution and secure tenure in rural areas of Brazil. More specifically, the conceptual model has been designed to provide a clearly defined and structured design for CNIR implementation based on user requirements. It includes the problem definition, indication of the constraints and opportunities, design of a model, its functions, analysis of CNIR minimum content and strategies of implementation.

The objectives of the conceptual model for this Brazilian system are to:

1. Facilitate land transfers by having accurate ownership information and characteristics and value of the rural properties;
2. Support the accuracy of the property tax and fair taxation by validating environmental protected information, fiscal information and land use;
3. Help decision making in land disputes and land reform by having the location of the traditional, public and private lands, and their environmental, fiscal, legal and agrarian information all together;
4. Support land registration processes by confirming the physical characteristics of the rural properties.

6.2 CNIR Scope Definition

For the purposes of this study, the conceptual model deals only with rural areas and any traditional or public lands contained in these areas. Only federal agencies which are dealing directly with land administration (i.e., the implementation partnership including

INCRA and RFB and the collaborating partnership including SPU, IBAMA, FUNAI, SFB) were considered for the user requirements and design of the conceptual model. The unique private sector component included in this design was the s*erviços registrais,* responsible for the real properties records. The general public and other potential users were not consulted.

The current cadastral systems of the implementation partnerships and collaborating partnerships were considered within the design. Individual and collective tenure, occupants (*posseiros*) and federal ownership (e.g., parks, roads and traditional lands) were the types of property rights considered within the conceptual model. Existing mapping for these agencies, even with different precision and scales, was also included. Priority maps are the maps which have been surveyed according to *Law #10,267/2001*. The information obtained from these priority maps has priority over the citizens' declared information or previously described parcels.

All analysis and specifications were presented at a high level. This conceptual model also does not support the testing of the implementation. The implementation of CNIR might occur years later after this study is finished.

6.2.1 CNIR Potential Target Users

The direct targets are the implementation partnership agencies (INCRA and RFB) and the collaborating partnership agencies (SPU, IBAMA, FUNAI, SFB and s*erviços registrais*). Their expectations for being connected to CNIR were described in Chapter

5. Apart from these agencies, the potential targets for the CNIR system include, for example, research centers, academia, land policy agencies, consultants and international aid agencies, land regularization agencies, land institutes, national defense agencies, social movements and technical assistance agencies. These indirect users are those who will just consult CNIR for their own proposes. They may supply data to the specific direct institution collaborator, but without directly affecting CNIR's data input. Appendix VII lists the potential targets users for the CNIR system and describes some reasons for them to be linked with the CNIR system.

CNIR will be used as a land information resource in Brazil helping the national, regional and local levels to manage and produce land information, and consequently it should improve the information used for land regularization and land reform in rural Brazil. Additionally, the information related to land and its landholders might help the government to redesign some of their programs, such as rural worker pensions, Brazil land-based poverty alleviation projects (*Crédito Fundiário*), technical assistance and rural extension (*Ater*), family agriculture and rural credit (*Pronaf*). The list of the potential CNIR users is found in Appendix VII.

6.3 CNIR Design Assumptions

In the opinion of this author, success of the CNIR implementation is dependent on the following key assumptions:

- All collaborating agencies will be listened to and considered during the user's requirements stage in order to have all necessary inputs for the CNIR design, mainly the *serviços registrais:*
- All collaborating agencies clearly understand and agree with CNIR requirements
- Formal agreements among agencies will be developed for data sharing and maintenance;
- All agencies will create their own metadata according to a common standard for data input by all agencies;
- All data input at CNIR will be triaged and classified according its degree of precision to improve consistency;
- Descriptive data, when possible, will be validated with the graphical data before coming be part of CNIR content;
- Federal funds will be available for CNIR implementation to the implementation agencies (INCRA and RFB).

6.4 Proposed Design Model

6.4.1 Flow of the Information

All head managers of the current cadastral systems must have full access to the CNIR system. They are responsible for identifying their employees and also determining the level of security access that the employees will have. Once the employees login with their personnel identification, any changes that they might make should be automatically tracked by employer. Each agency can only edit its own data, but they can see the data from other agencies, depending on the level of access that was delegated to them. The flow of information within CNIR system happens as follows and is shown in Figure 6.2.

6.4.1.1 Phase 1 of the Flow of the Information

There will be a standard format to input data at a portal. This must be a format agreed upon by all collaborating agencies. There will be two possibilities:

- ***Agencies can input data for storage*** – This data is part of the minimum CNIR content (more details in Section 6.4.2). After the data input, tables will be internally created according to the minimum content categorization (e.g., parcel identification, dimensions and landholder information). Agencies can edit all data under their stewardship, since they respect the priority data. Priority data are from INCRA, *serviços registrais* and RFB.
- ***Landholders can complement the data input with their declaratory information*** **–** This happens after the data from the collaborating agencies is matched and stored in CNIR. Since this is another level of access, landholders will be allowed to edit selected information (e.g., personal information and area) that must be analyzed (validated) later on to match the agencies inventory. Landholders will have the option to go to any collaborating agency close to their property and request to access CNIR portal or directly connect the portal, if they have access to internet in their properties.

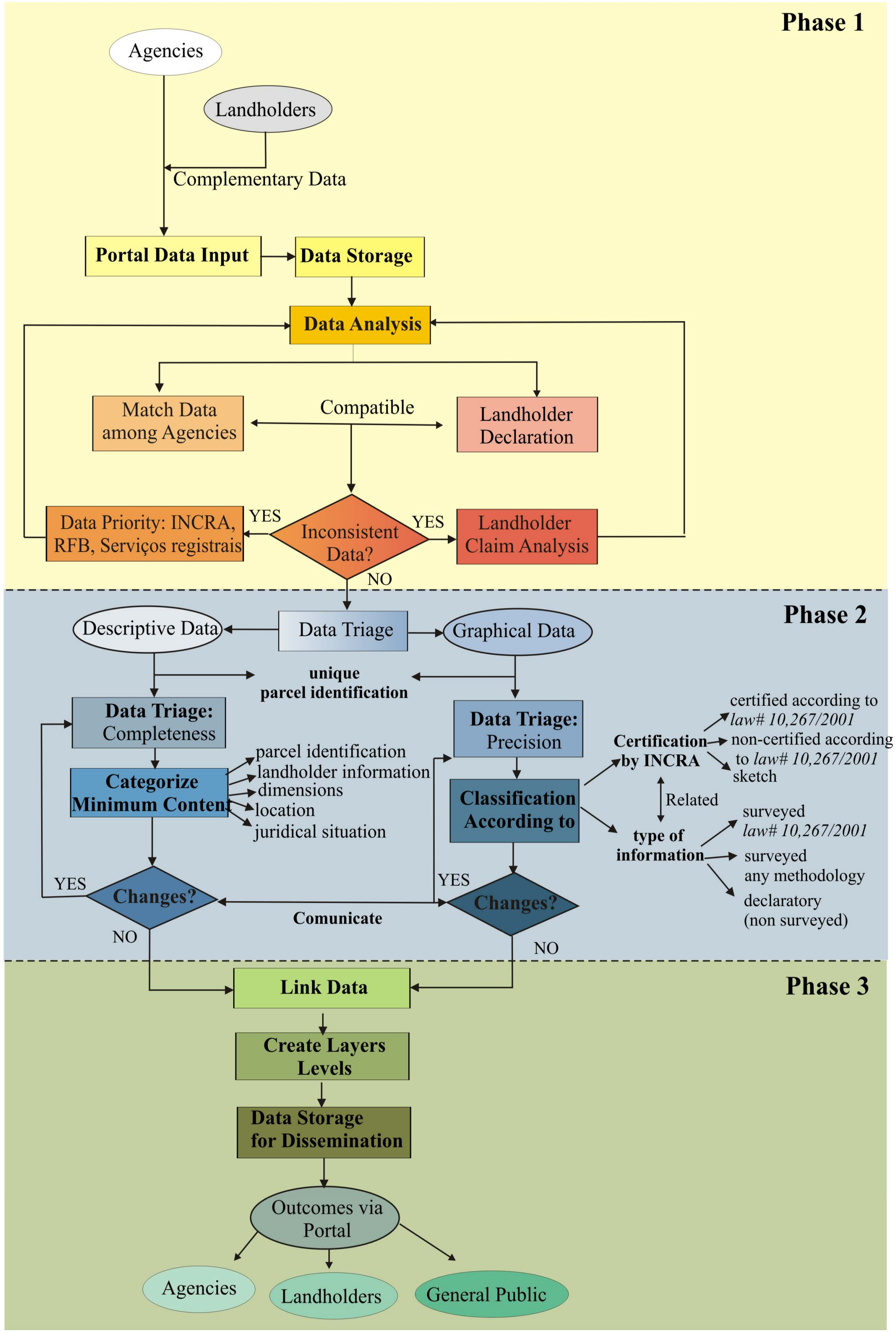


Figure 6.2 – Flow of the Information within CNIR

Data input should be open for editing all year around. When a specific cadastral system has a closure time, a message should appear that the modification will be considered for this specific cadastral system on the subsequent year declaration (e.g., ADA, environmental declaration, is open only from January 1st to September 31st of each year).

Updating of data is needed when physical characteristics or interests in the rural property change. For security reasons, any modifications made need to be tracked by the personal identification (i.e., taxpayer personal identification number (CPF) for employees and landholders). The date of the last modification must be shown at the system.

Data in text fields entered by employees of any of the agencies cannot be edited by the landholders. In cases of inconsistencies, landholders can ask for file review and/or agencies can open administrative or juridical processes to resolve the inconsistency; this data will be in standby mode until all data is matched and processes solved. A message of new data pending should appear at CNIR portal to make all users aware that this data is inconsistent.

6.4.1.2 Phase 2 of the Flow of the Information

All the data must pass to an internal "triage" to separate graphical data from descriptive data. At this level, the descriptive and graphical data must have the unique parcel identification (PID) of the rural property for future linkage between the features and attributes. *Decree # 4,449/2002* established that the PID is to be the code of the property issued by CCIR. As a parcel must be identified in a unique context, and not all the rural properties in the current cadastral systems have CCIR IDs, this code cannot be used as the common PID. An alternative for PID must be created by agreement with INCRA, RFB and *serviços registrais.*

Once the graphical and descriptive data are separated, there should be another level of triage. At this time the descriptive triage will check completeness and categorize data according to the minimum CNIR content and the graphical triage will classify data according to the class of positioning precision and manner of information collection (e.g., surveyed according the *law# 10,267/2001).*

The descriptive data triage will be used to classify whether the data meets the CNIR minimum content established by *Decree # 4,449/2002* (i.e., parcel identification, location, dimensions, landholder information and juridical situation). It is important to highlight that at the descriptive data triage, standardization control and metadata should be created. This classification occurs at the parcel level only. These assigned categories are then maintained as descriptive (attribute) data. The proposed minimum CNIR content and layers can be seen in Figures 6.5 and 6.6 in Section where CNIR minimum content is described.

In the graphical data, at this triage, the data is classified according to the possibility of INCRA certification of the rural property and the type of information. If, for example, any edits are made in the descriptive database related to the parcel geometry, then it will directly impact the dimensions and location fields in the graphical database. If changes occur in both databases, descriptive and graphical, they must be re-examined at both triage classifications.

Any descriptive changes must be communicated to the graphical database for physical changes and vice versa. Most will probably be in the middle range of precision; it will depend on the resources available for surveys. The administrative limits, such as country, provinces, municipalities, rural/urban zones, will not need to be classified because they are officially defined in law even if the demarcated boundary is different. This layer must be from official resources such as IBGE. Another layer not classified is the registry office jurisdiction by county: this layer can be created by merging municipalities layers in the majority of the cases. Layers such as hydrology (e.g., streams, rivers and lakes) and roads might be classified.

6.4.1.3 Phase 3 of the Flow of the Information

To ensure that all the geometric data and their referred attributes are related, there will be another step of checking the data geocode linkage. Metadata and spatial standardization will be created during the data linkage step. Only after all these examining process are complete will the graphical data finally be part of the parcel layer. Topologies must be created to interconnect adjoining parcels. At long last, all data goes to the CNIR storage system. There, data can be processed to produce reports and maps for requests and be disseminated to different levels for the agencies, landholders and general public through a portal.

6.4.2 CNIR Minimum Content

According to *Decree # 4,449/2002* the minimum CNIR content is categorized as parcel identification, location, dimensions, landholder information and juridical situation. It is not specified in the decree which specific attribute fields these categories should have. To propose the minimum content in this research, the alternative was to observe the current system descriptions (See Chapter 5 and Appendix III) and analyze the needs of the users as was done in this research. Table 6.1 indicates which information each current cadastral system might need from CNIR, according their own purpose, including their own data.

Table 6.1 – Data needed by collaborating agencies from CNIR

Current cadastral systems (Agency)	***Data needed at CNIR***
ADA (IBAMA)	- Landholder information - Location of the property - Area of the preserved forests - Legal status - # NIRF (RFB code) - # CCIR (INCRA code) - *Matrícula* (registry office parcel code) - Rural and urban limits - Municipal and state limits
CAFIR (RFB)	- Landholder information - Location of the property - Area of the property - Area of the preserved forests - Property value - # CCIR (INCRA code) - # NIRF (RFB code) - Rural and urban limits - Municipal and state limits

Table 6.1 – Data needed by collaborating agencies from CNIR (Continued)

Current cadastral systems (Agency)	***Data needed at CNIR***
Serviços Registrais	- Landholder information - Location of the property - Location of traditional and public lands - Area of the property - Area of the preserved forests - Property value - Legal status - *Matrícula* (registry office parcel code) - County jurisdiction limits - Municipal and state limits
CNEFE (IBGE)	- Landholder information - Location of the property - Rural and urban limits - Municipal and state limits
CNFP (SFB)	- Location of the public forests - Location of the property - Location of public lands - Location of the indigenous reserves - Area of the public forests - Legal status - Biomass - Municipal and state limits
SIAPA (SPU)	- Landholder information - Location of the property - Location of public lands - Location of the indigenous reserves - Area of the property - Property characteristics - Property improvements - Property value - Land use - Land credit and debit - Legal status - # NIRF (RFB code) - # RIP (SPU code) - Rural and urban limits - Municipal and state limits

Table 6.1 – Data needed by collaborating agencies from CNIR (Continued)

Current cadastral systems (Agency)	***Data needed at CNIR***
SIT (FUNAI)	- Indigenous identification - Indigenous census - Location of the indigenous reserve - Area of the indigenous reserve - Location of the property - Location of the forests - Location of public lands - Legal status - # RIP (SPU code) - Rural and urban limits - Municipal and state limits
SNCR (INCRA)	- Landholder information - Location of the property - Location of the forests - Location of public lands - Location of the indigenous reserve - Location of traditional lands - Area of the property - Property characteristics - Property value - Land use - Legal status - # NIRF (RFB code) - # CCIR (INCRA code) - # RIP (SPU code) - *Matrícula* (registry office parcel code) - Rural and urban limits - Municipal and state limits
DOI (*Serviços Registrais* /RFB)	- Landholder information - Location of the property - Area of the property - Property value - Legal status - Serviços registrais identification - # NIRF (RFB code) - *Matrícula* (registry office parcel code)

Figure 6.3 shows the relationships amongst the current cadastral systems and the data needed from CNIR. It was drawn using Table 6.1. The circular symbol represents

descriptive data, the square symbol represents graphical data and the superimposed circular/square symbol represents both graphical and descriptive data. As Figure 6.3 demonstrates, the interconnection with the current systems is not simple and the needs vary. In Figure 6.4, a cognitive map explains better how this interconnection is accomplished. Appendix VIII contains the cognitive map of the each existing cadastral systems showing its data relationship proposed at CNIR.

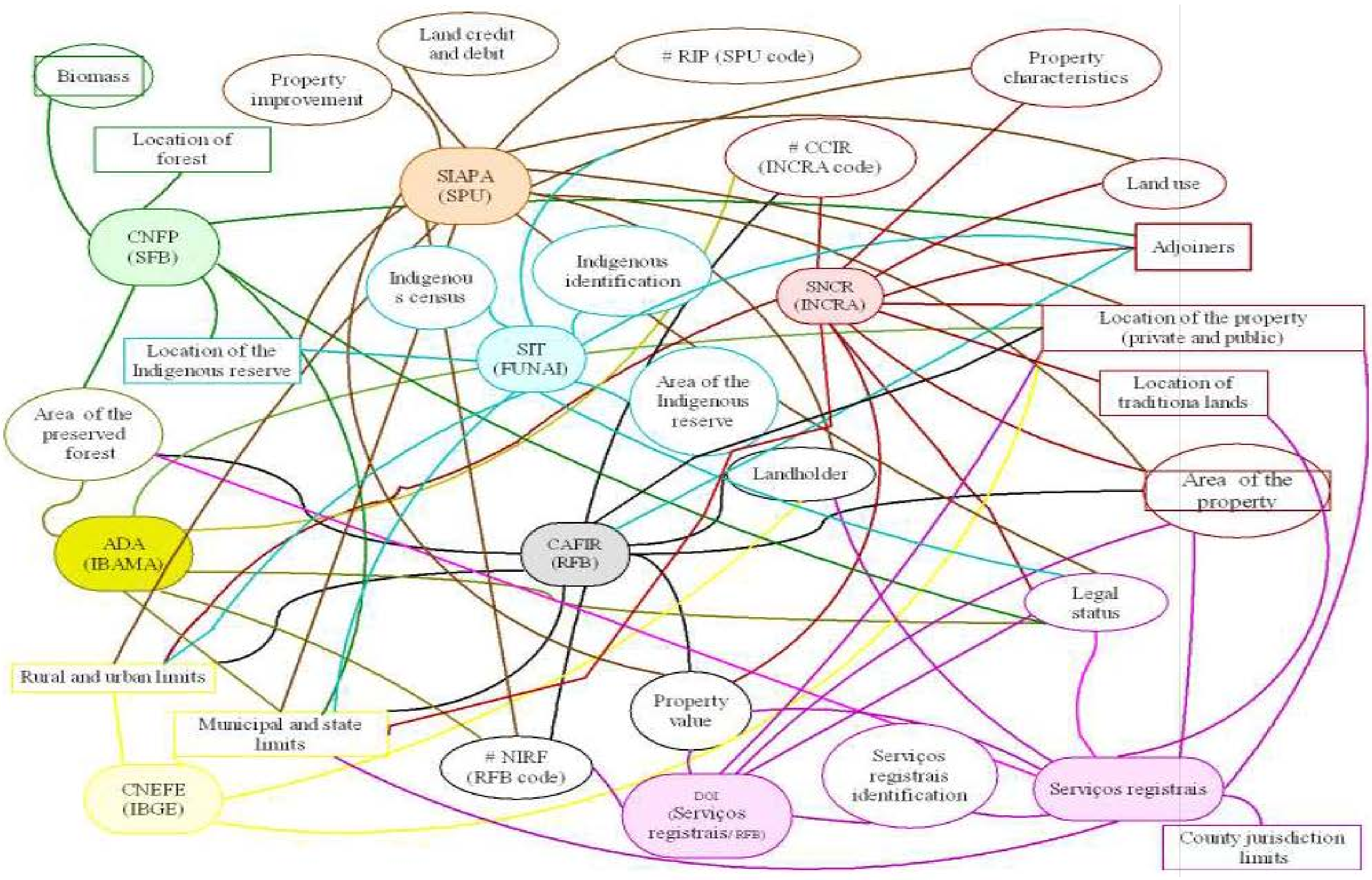


Figure 6.3 – Relationships amongst the current cadastral systems and the data needed from CNIR.

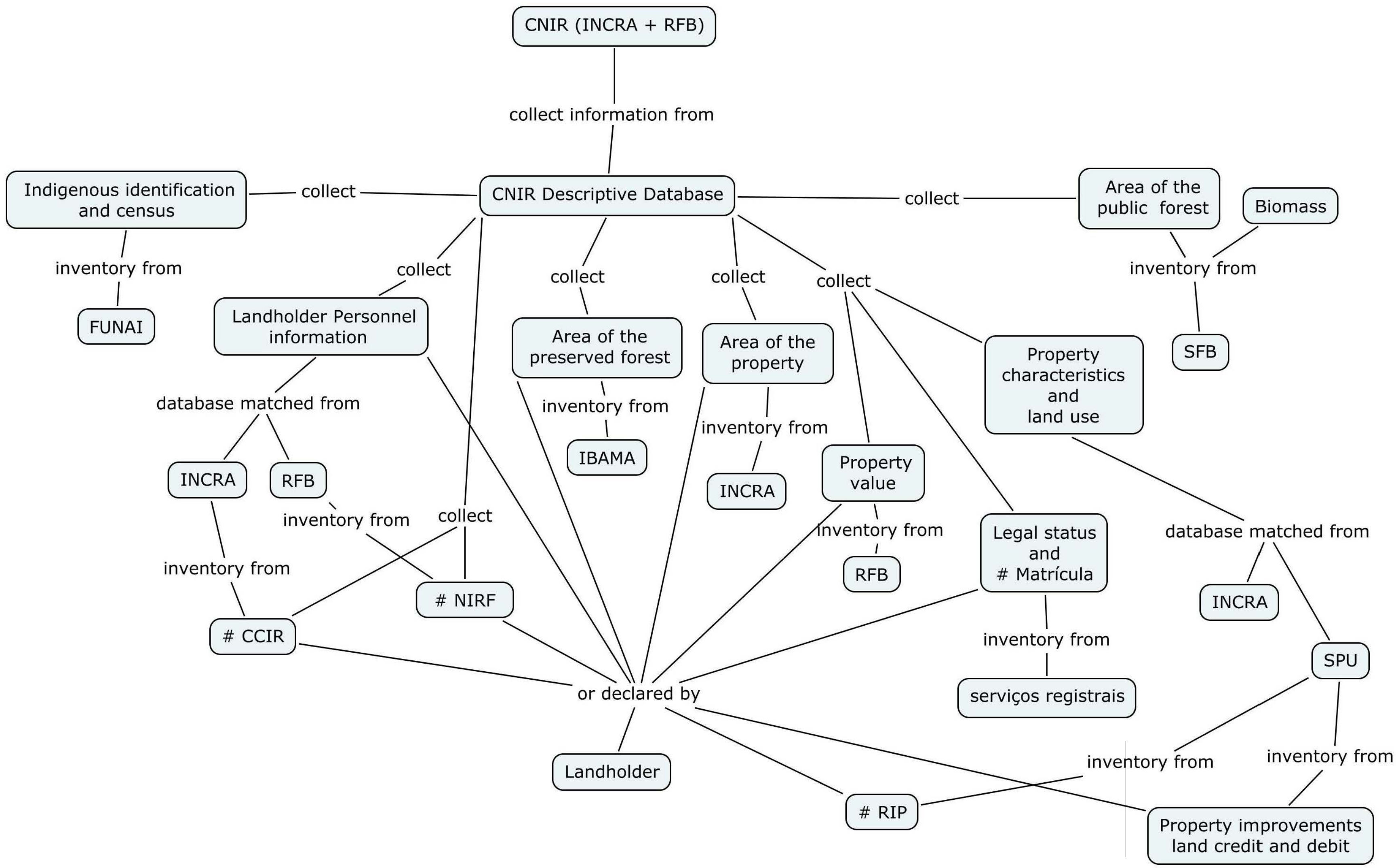


Figure 6.4 – Cognitive map of CNIR descriptive database

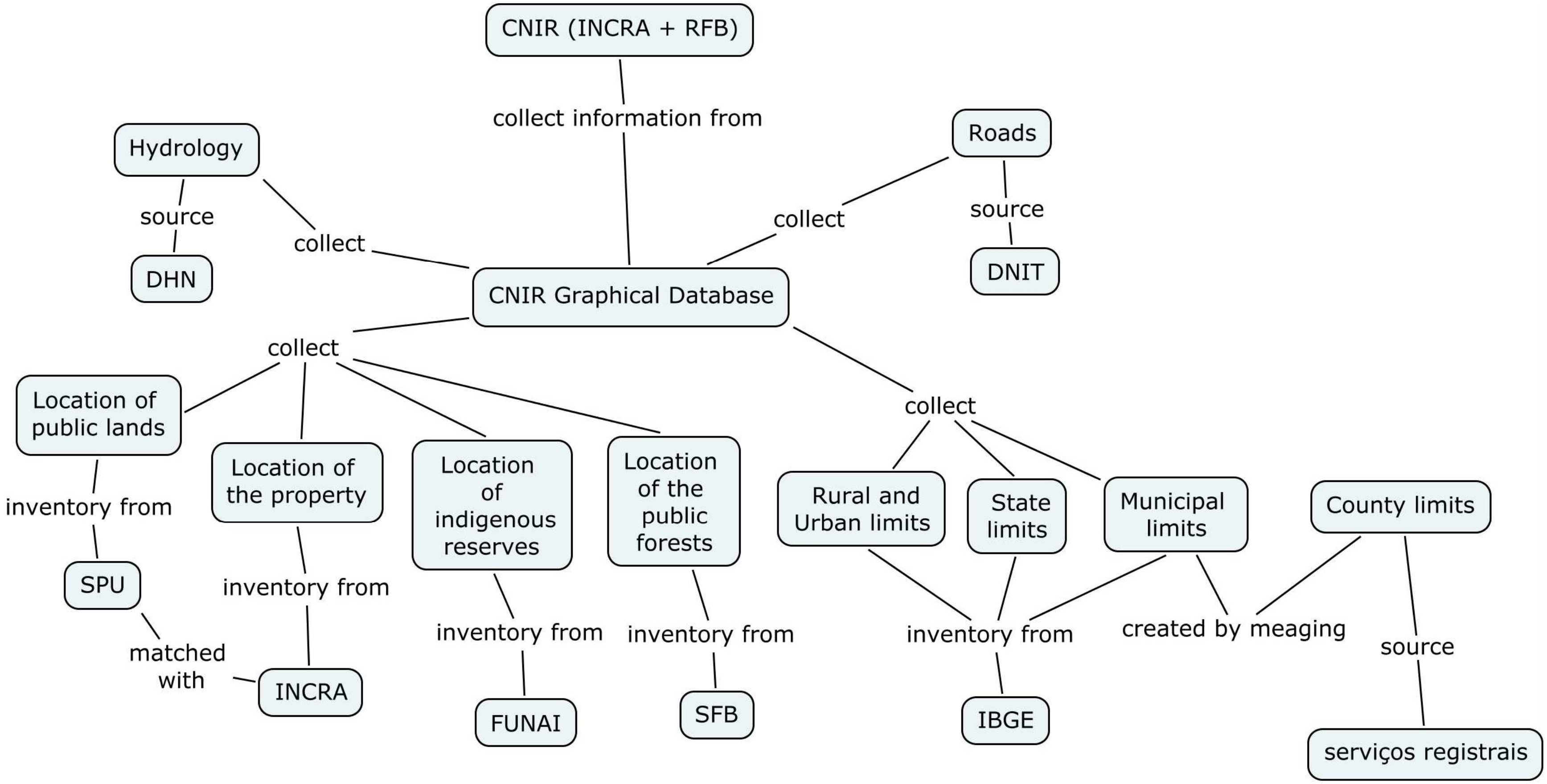


Figure 6.5 – Cognitive map of CNIR graphical database

As can be seen in the flow of information within CNIR (Figure 6.2), the graphical data is classified into three classes: certified by INCRA, non-certified and sketch.

- ***Certified by INCRA*** – These are all rural properties that physically were geo-referenced according to the *Law # 10,267/2001* with accuracy ±50cm. This type of information should be certified by INCRA;
- ***Non-certified*** – These are all rural properties that did not received approval from INCRA that the survey is according to the *Law # 10,267/2001,* but were physically geo-referenced.
- ***Sketch*** – These are rural properties non geo-referenced (what includes any possible sketch). They might be surveyed through topography.

The classification must be added to the descriptive database. Most data from INCRA and possibly some from FUNAI will be in the **certified by INCRA** category. **Non-certified** data classification can apply to any rural property from the current cadastral systems of INCRA, FUNAI and SFB, or from any of the other collaborating agencies with existing graphical data. **Sketch** data classification can apply to properties from any current cadastral system that are non-georeferenced or described by a sketch. If the graphical database is edited, these changes need to be reclassified.

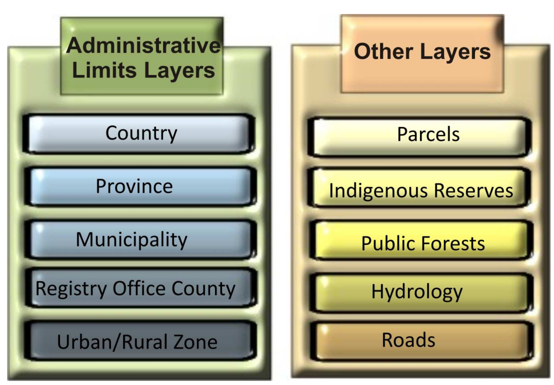


Figure 6.6 – Graphical CNIR minimum content

Figure 6.6 shows the CNIR graphical minimum content. It contains the administrative limits layers that cannot be edited, unless a new municipality is created and then the configurations of the registry office counties and the limits of urban/rural zones may also change. The other layers are the parcels, indigenous reserves and public forests that which can have dynamic spatial changes. The responsibility of editing these layers is under each respective agency INCRA, FUNAI and SFB. In this research the hydrology and road layers are considered less precise data. They also cannot be edited within CNIR. They must come from official sources, such as the Brazilian Navy's Department (DHN) and the National Department of Transportation Infrastructure (DNIT). This CNIR minimum content meets needs of each current system, as outlined in the Table 6.1.

Even though the minimum content must be as established by *Decree # 4,449/2002,* the content of each class is the result of this research. To facilitate the users' perception, tables were created internally in the CNIR system during Phase 2 (Categorization). These tables fulfill the decree and the needs of the agencies; they are described below. They should be primarily filled with the existing data from INCRA and RFB which has been compared and validated. On one hand, the landholder declaration saves time and on the other, it ensures that the landholder is declaring information for the right rural property (see Figure 6.7).

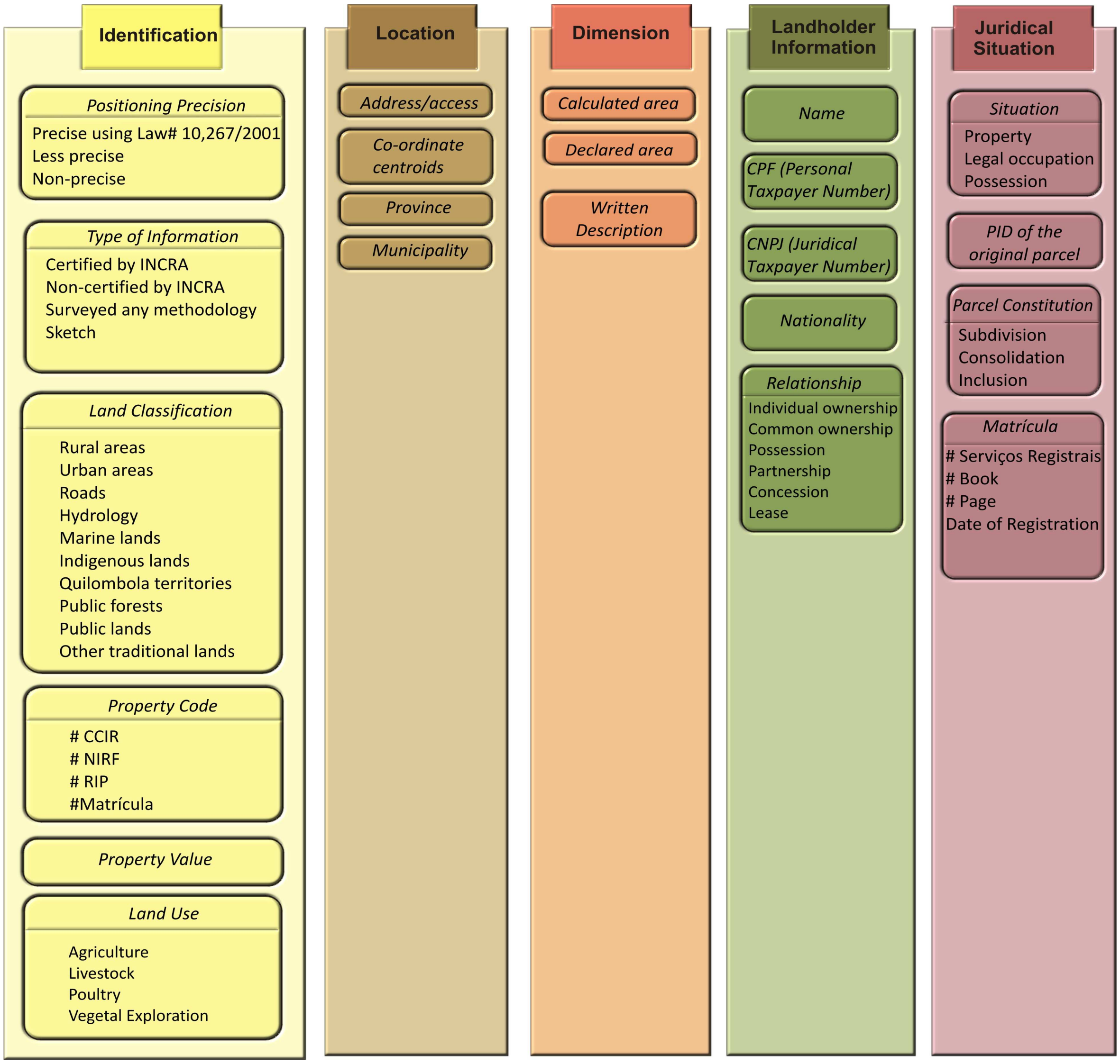


Figure 6.7 - Descriptive CNIR minimum content

Identification table – This category should contain the "type of information" that classifies the property geometry (e.g., certified by INCRA, non-georeferenced) and "land classification". This land classification indicates the objects of the property rights (e.g., rural areas, urban areas, roads, hydrology, marine lands, indigenous lands, *Quilombola* territories, public forests, public lands and any other traditional lands). This information is filled out by CNIR controllers, who will classify and standardize the data.

Location table – This table is associated with the spatial positioning of the land unit. It contains a written description of the address or relative description declared by the landholder. The address must be according to the standard used by IBGE for its census. This common IBGE format will help all agencies to maintain updated correct addresses. This table also contains the co-ordinates of the parcels' centroids calculated by the GIS software, and an indication of the province and municipality in which the parcel lies. The centroid information cannot be edited unless the parcel boundaries change.

Dimension table – This contains both the declared dimension information from the landholder and the graphical information calculated by the GIS software. For graphical categories, precise and less precise, the dimensions cannot be changed by declaration. When there is a large distortion among calculated and declared dimensions, a field inspection should be done. Changes in the graphical database will directly impact this table and vice-verse. The parcel written description is also found in this table.

Landholder information table – This table contains the personal information about the landholder that can be updated at any time by the landholders, when changes are necessary.

Juridical situation table – This table contains the type of rights that the landholders hold, the PID of the original parcel and information about *matrícula* such as # book, # page and date of registration. When the landholder declares this information, it must be matched with the CNIR *serviços registrais* database. Any discrepancy puts the data input process on standby until the data discrepancy is resolved. The history of the parcel should indicate the PID of the original parcel and how it was constituted. There are three major types of rights that are considered in CNIR:

- ***property*** **–** these are considered properties from: i) the public patrimony owned by state and ii) registered in the *serviços registrais* where landholders have full rights.
- ***legal occupation (posse a justo título)*** **–** these are properties that have a title but the titles are not registered.
- ***possession by simple occupancy*** **–** these properties are occupied, but there are no valid documents for registration.

6.4.3 CNIR System Functions

As seen in Figure 6.2, CNIR's main functions are data input, storage, analysis, triage, and dissemination. They were categorized into three phases. Figure 6.8 highlights the relationship of these functions into phases.

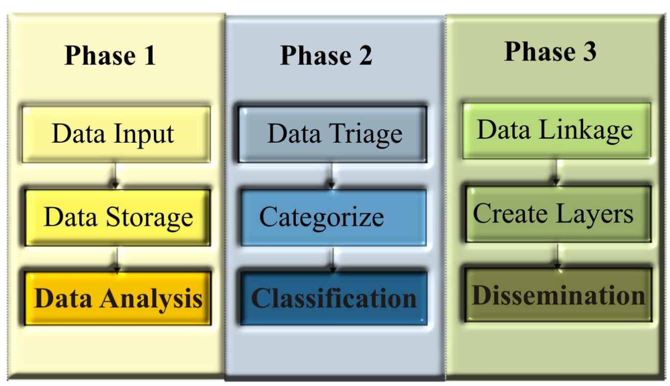


Figure 6.8 - The main functions of the CNIR system

- ***Data input*** – This is completed by agencies and complemented by landholders' declarations. There should be different entrance points for agencies and landholders.
- ***Data storage*** – In this phase, all the data (i.e., declared by the landholder or the existing inventory matched from the CNIR collaborating agencies) will be stored without restriction.
- ***Data analysis*** **–** This function consists of checking if there is consistency between the data inventory of the collaborating agencies and data declared by the landholders. Priority data are from INCRA, s*erviços registrais* and RFB.
- ***Data triage*** – Once CNIR data is validated and there are no more inconsistencies, then CNIR employees will separate graphical and descriptive data.
- ***Data categorization*** – This function aims to categorize internally all the descriptive data input into several tables that, all together, are the CNIR minimum content (see Figure 6.7). These tables facilitate finding specific data for the agencies interests and also identifying selected data that can be available at CNIR portal for the general public.
- ***Data classification*** **–** This function classifies graphical data according its geometric precision. It also provides unambiguous locations of parcels.
- ***Data linkage*** **–** This function ensures that the data geocoding of existing geometric features and their attributes in the descriptive database are related.
- ***Layer creation*** – Layers are updated when new and more precise information about rural land information is available.

- ***Dissemination*** – This allows the dissemination of the land information as outcomes, such as discrete data, parcel location, statistics and reports. CNIR collaborating agencies can view relevant information inside CNIR, but can only add, edit and delete their own records. The CNIR land information is disseminate for any agencies which are directly or indirectly involved in land information management, land reform and land development and for the general public, such as citizens, academics, researchers and politicians.

The relevance of this chapter is related to the design of the CNIR model. It contains a high level of detail, to give a general ideal for the CNIR managers on how CNIR should be constructed. Notice that this research is using soft system methodology (SSM), but any other model of system development can be applied. The advantages and disadvantages of some existing models are found in Appendix IV.

To have some understanding about data interoperability, Appendix V also gives a brief overview of the data sharing methods and data standardization that will be primary guide for CNIR data sharing. For CNIR managers, this Appendix is important because it presents some international standards organizations and their standards, mainly with respect to spatial data standards.

The use of SSM at the conceptual model stage (see Chapters 5 and 6) gives freedom for the cognitive results. Notice that their interpretation will change from person to person depending on person's background. The conceptual model was composed of many elements, and the importance of each is listed below:

- The objectives for CNIR system give some factors that raise the importance of CNIR implementation;
- The potential target users shows that there are a variety of uses for the CNIR system that are not limited only to the collaborating agencies; once implemented, governmental, private, public sector and general public can fit. This increases the responsibility for complete and consistent data in CNIR and urgency for its implementation. Appendix VII contain a list of the potential target users for CNIR;
- The scope limits the research in order to create a tangible model;
- The design assumptions create cognizants; if they are available, the conceptual model can be realized. Assumptions were assigned; they are the author own opinion based on the analysis done until now. There was not intervention from the CNIR managers to define these assumptions;
- The flow of information describes how the data should be treated in CNIR system. There is no detailed information such as type of metadata or standard. These will all depend on how the CNIR managers design CNIR. Further research about metadata and data standardization needs to be conducted for CNIR, but it is not the direct subject of this thesis. However some information is found in Appendices IV and V to assist future work;
- The minimum content follows the classification imposed by *Law# 10,267/2001.* Because the content is based on the results of the user requirements, this research proposes that CNIR contain some data were not thought by the CNIR managers.

Currently CNIR managers are developing a proposal design to be presented to the CNIR collaborating agencies and society in general. Their design is at the initial stage and currently does not consider user requirements. Analysis made in this these have been used to indicate parameters that were until now not considered by the CNIR managers. As an ongoing project with deep political involvement, CNIR objectives and stakeholders might change over time. The initial part of the CNIR managers model can e found in Appendix X. It was presented in May 2009, and since then some improvements have been made as explained in Chapter 7.

CHAPTER 7

USER REQUIREMENTS AND CNIR CONCEPTUAL MODEL VALIDATION

In Chapter 6, a conceptual model for CNIR was proposed based on the user requirements analysis (more details see Chapter 5). In this chapter, the requirements for the designed conceptual model will be verified by assessment questions. The assessment questions were formulated to evaluate both of the following cases: if the requirements were filled by the proposed CNIR system and if the proposed system fairly reflects the expectations of CNIR system as seen by the implementation agencies (INCRA and RFB) developed during the design phase (Section 7.1). Section 7.2 gives an overview evaluation.

This research started effectively in 2006 when different processes of land regularization in Brazil were occurring. The research began within a PIGN subproject (see Section 2.2.2). The goal was to study socio-economic impacts of the SIRGAS2000 adoption. One of the subprojects dealt with land reform on the basis of *Law# 10,267/2001.* The PIGN land reform subproject had just begun the discussion of the use of SIRGAS2000 as referential framework and how this adopted framework could accelerate land regularization in Brazil.

To assist tools for INCRA and RFB to implement CNIR system and improve land information management in Brazil for land registration, for example, this research started with the user requirements studies in June/August 2008, which were refined in

December 2008 and finalized in May 2009. The conceptual model was developed in May/April 2009.

During this period information for this research was exchanged with CNIR managers. After many meetings with CNIR managers and academics, the CNIR managers' first model was presented in June 2009 for the stakeholders (i.e., INCRA, RFB, SERPRO and academics from UFPE, UFSC and UFBA) The CNIR managers' model with improvements was presented in the end August 2009.

7.1 Evaluation of the CNIR Problems

An assessment was conducted with CNIR managers to evaluate both the results of the user requirements in the proposed conceptual model and the conceptual model *per se.* The methodology chosen was a mix of focus groups and structured questionnaires. The original Portuguese version of the questionnaire is available in Appendix IX

In December 2008, the results of this research to date on the user requirements were presented to the main stakeholders and refined based on their input. A new presentation of the user requirement analysis was made in May 2009 in parallel with a structured questionnaire evaluating this research. This presentation in May 2009 was necessary because some of the managers in the focus group were new to the process. Besides, it gave them the opportunity to obtain the final results of the user requirements, the list of CNIR priority problems and an understanding of flow of information proposed for CNIR. Their second feedback, in May 2009, tested if the conceptual model was consistent and if it had met their expectations. The focus group meeting was attended by a total of 7 members (four managers from INCRA, two from RFB and one from the IT support agency (SERPRO)). The results of this evaluation are described below. The limits of having a very small sample to evaluate the proposed conceptual model are recognized by the research but no additional opportunities were available to increase the sample.

Question 1. Evaluate the problem criteria matrix according to the CRECE framework

The first question of the questionnaire evaluated the results of the Problem Priority Matrix. The goal was to ensure that the chosen criteria in the CRECE framework (see Chapter 5, Table 5.10) were correct. Table 7.1 compiles analyses from user requirements based on INCRA, RFB, and SERPRO points of view for the CRECE framework. The follow observations are highlighted:

- For some CNIR managers, all the criteria should be completely filled in the CRECE framework, except for completeness. In the real world, however, it is known that is impossible to meet all criteria in one system. There must be priorities. Because of this, it was decided to eliminate the answers where all the criteria were completely filled in the CRECE framework; it was not clear if they understood the definition of each category as explained in Section 5.3.1. For this question, specifically, three questionnaires were eliminated (two from INCRA and one from RFB).
- The problem matrix analysis in Section 5.31 (Table 5.10) indicated that efficiency and effectiveness are the top priority concerns — both had total score of 11. In analyzing and comparing their respective total scores in the CRECE matrix in Table 7.1, the top concern for INCRA was effectiveness (receiving score of 7), for RFB it

was reliability (receiving score of 8), and for SERPRO it was consistency and efficiency (respectively scores 8 and 7).

- The representative from SERPRO, the IT support agency, mostly agreed with the classification of the CRECE framework analyzed from the user requirements and proposed in this research. The four INCRA representatives partially agreed on the user requirements analysis. However, the two RFB individuals present in this session mostly disagreed with the user requirements analysis.
- When the criteria were categorized in the CRECE framework, INCRA and RFB also had higher divergence.
- Mostly all interviewees understood that CNIR will not be complete, because the data itself is not complete nor cover all Brazilian territory.

Conclusion on Question 1. The evaluation of the CRECE framework shows that the implementation agencies involved in process of designing CNIR still put their self-interest first instead of seeing CNIR as a system with common and unified interests. Also the way that the matrix CRECE was evaluated demonstrated that conflicts on CNIR problems were not totally resolved between the INCRA and RFB. This is a step that should be solved before the design of any system.

Table 7.1 – CRECE framework contrasted between the analysis from user requirements and from INCRA, RFB and SERPRO point of view (X = User requirements analysis, ¥ = SERPRO, □ = RFB, • = INCRA)

	Criterion	***C***	***R***	***E***	***C***	***E***
	Legend **C** = Completeness, **R** = Reliability, **E** = Efficiency, **C** = Consistency, **E** = Effectiveness respectively					
1	Consistency of the data input/output	**X**	**X** • □ ¥		**X**•	•
2	Integration of spatial and descriptive data with other agencies		**X** ¥	**X** □¥	**X**	**X**•¥
3	Spatial and descriptive data quality control	•¥	**X**	**X**•¥	**X** ¥	**X**□
4	Easy data update	**X**	**X**	**X** ¥	□ ¥	**X**•
5	Easy to use system/Easy user's interface		□	**X** ¥	•	**X**
6	Easy access to CNIR by other institutions		**X** •¥	**X**	□	**X**
7	Easy generation of data outputs			•	**X** ¥	**X** □¥
8	Training for professionals		□	**X**• ¥	¥	**X**•
9	Data standardization and metadata		**X** •□	**X**	**X**• ¥	**X** •¥
10	Users' access control	•	**X** □ ¥	**X**•	¥	•
11	Internal availability of the CNIR (intranet)		□	**X** •¥	**X** ¥	**X**• ¥
12	Web-based availability		•	**X** ¥	□	**X**
13	Flexibility to aggregate new systems		•	**X**	□¥	**X**
	Symbols X = User requirements analysis, ¥ = SERPRO, □ = RFB, • = INCRA					
	TOTAL					
	Analyzed from user requirements	**2**	**7**	**11**	**6**	**11**
	INCRA	2	5	5	3	7
	RFB	0	6	1	4	2
	SERPRO	1	4	7	8	4

Question 2. Do the selected criteria represent the problems for the CNIR implementation? The second question concerned the 13 criteria chosen in Section 5.3.1. Overall the criteria represented major issues for CNIR implementation; this was agreed upon by all interviewees. They did indicate that some criteria were missing from the established CRECE framework at the Section 5.1.2. These were:

For INCRA

- Political interests
- Increasing the number of personnel
- Organizational reform
- Acquisition of financial resources
- Adequate management of infrastructure
- Adequate physical infrastructure

For RFB

- Adequate technological tools
- Increasing the number of personnel
- Adequate physical infrastructure
- Acquisition of the financial resources
- Communication with Ministry of Agrarian Development (MDA) and Financial Ministry (MF)

For SERPRO

- Adequate management infrastructure
- Acquisition of the financial resources

Conclusion on Question 2. Note that the missing criteria elected by the CNIR managers are not system criteria, but criteria for implementing CNIR, which contain political and organizational issues. Agencies again might have seen their particular needs that are directly related with political interests.

Question 3. Do you agree with the prioritized criteria indicated by this research? This question was indirectly related to the construction of the PERT diagram to analyze the critical pathway (Figure 5.7). The PERT diagram application demonstrated that the most critical criteria for CNIR implementation are prioritized as following:

1. *Training for professionals*
2. *Data standardization and metadata*
3. *Integration of spatial and descriptive data with other agencies*
4. *Internal availability of the CNIR (intranet)*

From the feedback, INCRA again partially agreed with the results proposed in this research. The criteria mostly were the same, but the level of the priorities changed. Instead of having the criterion "internal availability of the CNIR (intranet)", it was replaced by criterion "data consistency". INCRA reclassified the priorities as:

1. Training for professionals
2. Data consistency
3. Data standardization and metadata
4. Integration of spatial and descriptive data with other agencies

RFB disagreed and reclassified the priorities as:

1. Political interest from Agriculture Ministry (MDA) and Financial Ministry (MF) to implement CNIR
2. Data standardization and metadata
3. Create formal agreements among the involved agencies
4. Integration of spatial and descriptive data with other agencies
5. Training for professionals

SERPRO again had a position similar to what was proposed in this research based on the user requirements. The unique change occurred at the fourth criterion:

1. Training for professionals

2. Data standardization and metadata
3. Integration of spatial and descriptive data with other agencies
4. Data consistency

Conclusion on Question 3. It can be concluded that the results of the Problem Priority Matrix mainly represented the critical needs that CNIR must meet. The agencies responsible for implementing CNIR (INCRA and RFB) together with SERPRO (IT support), are aware of where they need to start enforcing efforts for successful CNIR implementation. RFB made training for professionals such a low priority compared to the other two organizations, SERPRO and INCRA, it might be signal that they considered that the level of the skilled professionals is high, and training should not be a top priority. What they might misunderstand is that CNIR system will be an object oriented system (i.e., it will involve spatial data) which is not the strong area of the SERPRO. Besides, the entire professional involved should have a minimal knowledge in GIS and multipurpose cadastral system in order to understand the CNIR system.

Question 4. Do you agree with the flow of information proposed for CNIR in Figure 6.2? The information flow of the proposed CNIR model was also presented at the group focus meeting. Managers from INCRA unanimously agreed with the flow; however, they also highlighted that CNIR should have one unique entry point for the data input that should be linked to the agencies' specific databases (as opposed to what is proposed in this research, i.e., two different levels for data entry: one for the agencies and the other for the landholders). RFB said that they agree with the model proposed, but CNIR will follow the description that has been designed in agreement with INCRA, RFB, SERPRO and academics from UFPE, UFSC and UFBA (see Figure 7.1 and Appendix

X) which occurred after this research began. SERPRO said that the model should be better drawn to be more understandable.

Changes related in this meeting in May 2009 were further considered. It was explained to the CNIR managers that this research is proposing a conceptual model that has been based on user requirements collected from all the collaborating agencies using a high level of analysis.

The design of the CNIR managers in Figure 7.1 and in Appendix X differs considerably from what has been proposed by this research. The CNIR manager's model has details of data relationships. In addition, the data relationship in this research proposed also links all collaborating agencies systems needs (as can be seen in Appendix III; this explains which data is needed at CNIR and from which agency inventory). To date, on the other hand, the CNIR manager's model (Figure 7.1) only considers the needs of INCRA and RFB agencies and does not include the collaborating agencies.

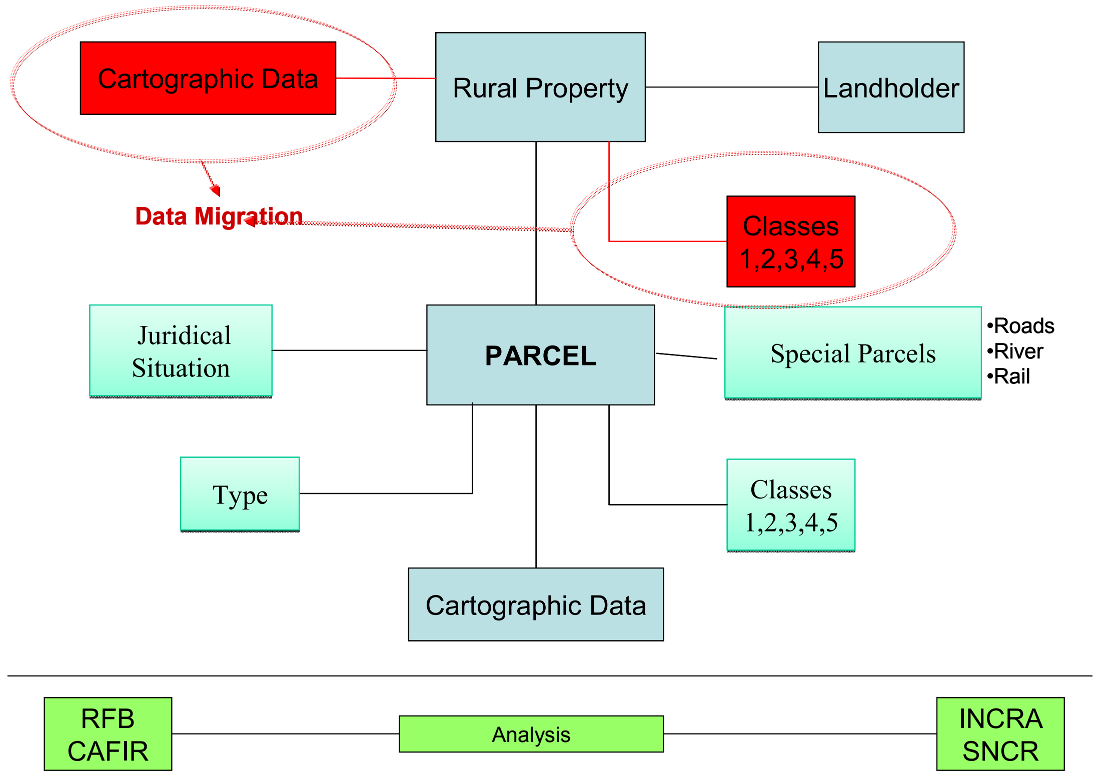


Figure 7.1 – CNIR flow of information from CNIR managers view in May 2009

Conclusion on Question 4. Between CNIR managers there is a consensus that descriptive and graphical data needs to be separated even though they are related. The isolation of these databases gives opportunities for experts work on their field and go through problems that they can eliminate or minimize. This independence avoids the vision that the graphical data can only be updated when the descriptive data is, or *verse versa*.

One difficulty in creating one model which integrates both the graphical and descriptive databases — which has high demand — is the problem of lack of skilled personnel. For example, INCRA's Cartographic Division does not have enough people to develop such a complex system. SERPRO (IT support) has experience only with relational data and not object data.

The advantage of having different project managers with different backgrounds in this case is that they can help open the spectrum of alternative solutions. Besides, they are able to technically communicate with the technical support and be the mediator among all agencies, clarifying any misunderstanding.

Question 5. Do you agree with the minimum content for CNIR indicated in Section 6.4.2? For this question, INCRA, RFB and SERPRO all strongly disagreed with the results proposed in this research. According to them, the minimum content is expressed in their model Figure 7.1 and Appendix X. Table 7.2 and 7.3 show the contrasting points of view between the CNIR manager's model and the proposed model on this research. What was not perceived by the CNIR managers was that the proposed minimum content is almost the same as the one they presented, but depicted in different way, as seen in Table 7.2 and 7.3.

It is also important to remember that the classification of the CNIR minimum content was established by *Law# 10,267/2001* and cannot be changed. Adaptation needs to happen in order to meet the needs of all agencies.

Table 7.2 – Contrast of the minimum descriptive content models in May 2009

Categories	***Minimum Content Proposed in this Research***	***Minimum Content Proposed by CNIR Managers***
Identification	*Type of geometric precision* - ***Certified by INCRA –*** properties geo-referenced according to the *Law # 10.267/2001.* - ***Non-certified -*** properties geo-referenced with only the indication of the methodology used. - ***Sketch –*** non geo-referenced rural properties. *Type of information* that classifies the property geometry in: - certified by INCRA - non-certified by INCRA - surveyed any methodology, non-georeferenced - sketch *Land classification* that indicates the objects of the property rights: - rural areas - urban areas - roads - hydrology - marine lands - indigenous lands - *Quilombola* territories, - public forests - public lands - any other traditional lands *Property code* - # CCIR (INCRA Code) - # NIRF (RFB Code) - # RIP (SPU Code) - # *Matrícula* (Registry Office Code) *Property value* *Land use* - Agriculture - Livestock - Poultry - Vegetal Exploration	***Property Code*** - # CCIR (INCRA Code) - # Parcel Code to be define later

Table 7.2 – Contrast of the minimum descriptive content models in May 2009 (continued)

Categories	***Minimum Content Proposed in this Research***	***Minimum Content Proposed by CNIR Managers***
Location	*Descriptive address and access* *Co-ordinates of the parcel centroid* *Province* *Municipality*	***Class 1*** - rural properties geo-referenced according to the *Law # 10.267/2001* and certified by INCRA. ***Class 2*** - rural properties geo-referenced according to the *Law # 10.267/2001* and potentially certifiable by INCRA. ***Class 3*** - rural properties geo-referenced with only the indication of the methodology used. ***Class 4*** - non geo-referenced rural properties. ***Class 5*** - Descriptive address and access
Dimension	*Declared area* *Calculated area* *Written Description*	***Declared area*** ***Calculated area and uncertainties*** ***Written Description***
Landholder information	*Name* *# CPF or # CNPJ* *Nationality* *Type of relationship with the rural property* - Individual ownership - Common ownership - Possession - Partnership - Concession - Lease	***Name*** ***# CPF or # CNPJ*** ***Address*** ***Nationality*** ***Type of relationship with the rural property*** - Individual ownership - Common ownership - Possession - Partnership - Concession - Lease

Table 7.2 – Contrast of the minimum descriptive content models in May 2009 (continued)

Categories	***Minimum Content Proposed in this Research***	***Minimum Content Proposed by CNIR Managers***
Juridical Situation	*Type of rights* - Property - Legal occupation - Possession - Public land *# Original parcel PID* *Parcel constitution* - Subdivision - Consolidation - Inclusion *Matrícula information* - # Serviço registral - # book - # page - date of registration	***Type of rights*** - Property - Legal occupation - Possession - Public land ***# Original parcel PID*** ***Parcel constitution*** - Subdivision - Consolidation - Inclusion

From Table 7.2 it is possible to observe the following:

The descriptive content shows divergence of points of view. It appears that CNIR managers are not considering the collaborating agencies needs at this stage in contrast to what has been proposed by this research. The conclusions include:

- ***Identification table -*** Besides the main codes that identify the rural properties in some of the CNIR collaborating agencies systems, this research proposes descriptive content containing geometric classification and its type of information, type of rural property and, property value and land use. This is the data that will serve as identification for the CNIR collaborating agencies for their own specific proposes. CNIR managers propose to identify the rural property by # CCIR (INCRA code) as is defined by the *Decree # 4,449/2002.* The problem is that not all of the rural properties can be identified by this code. (See Chapter 5, Figure 5.1.) The # Parcel identifier (PID) has not yet been defined by the CNIR managers because of the lack of common definition of a rural property for the CNIR system. All that is agreed upon is that the unique PID will help the integration among the current cadastral systems, since each one will have to structure its rural property concept in accordance with common "parcel".

- ***Location table -*** This research proposes that CNIR contains, besides the descriptive address, the co-ordinates of the parcel centroid, province and municipality. This gives opportunities for the CNIR collaborating agencies to locate parcels at a large scale, or even use this data in their fieldwork. The descriptive address is the same as Class 5 proposed by the CNIR managers. CNIR managers are also associating geometric precision identification with location. It means that **"certified by INCRA"** category proposed in this research contains Class 1 proposed by CNIR managers. The "**non-certified**" category contains Class 2 and 3. And "**sketch**" category is the same as Class 4 proposed by CNIR managers. The labels "**certified by INCRA", "non-certified"** and **"sketch"** were choose because they have direct and simple correlation of the precision classification that is determined by the Law#10,267/2001; these labels can be understandable for all kind of professionals. But these categories do not locate the parcels; they classify parcels according their geometric precision.
- ***Dimension table -*** This research proposes to accept both declared and calculated areas, giving preference to areas calculated by coordinates set in comparison with the declared area by the landholder. It is also important to have the written description in case the geometry needs to be confirmed. CNIR managers are proposing to have only calculated area from their classes 1 to 4, and declared for Class 5. CNIR

managers are also planning to add the uncertainty measurement when it is possible to be determined; this might be too detailed information and might bring misunderstanding of the interpreted area. The uncertainty measurement is information that demands high technical skill to interpret.

- ***Landholder information table -*** There is no disagreement with this data. CNIR managers are adding each landholder's address because he or she might not reside at the rural property in question.
- ***Juridical situation table -*** Although there is no disagreement with this data, it was not clear if the CNIR managers are planning to add the information about *matrícula* (registry office code) in this category. This also depends on the availability of the data and the degree to which *serviços registrais* participate in CNIR.

  CNIR managers have been trying to be linked with *serviços registrais* via the land transfer system (DOI) which connects fiscal events (RFB) with land registration (*serviços registrais*). Since this system already exists, it might be an alternative connection to CNIR. But, since some of the data contained in DOI is confidential, these requirements may limit the information be available only to CNIR. It also means that the DOI system needs to be restructured.

Table 7.3 contains the minimum graphical content comparison. Graphical content was not discussed among the CNIR managers until May 2009. Until that time, they assumed that location is associated with graphical database and parcel should be a layer represented by the Classes 1 to 4. This research proposes having administrative limits and other layers besides parcels. From continued contact with CNIR managers, this research was informed that they have since formed a focus group meeting in the end of

August 2009 and some progress has been made with respect to refining CNIR manager's model, such as relationship of the graphical data and data dictionary.

Table 7.3 – Contrast of the graphical minimum content models in May 2009

Categories	***Minimum Content Proposed in this Research***	***Minimum Content Proposed by CNIR Managers***
Administrative limits	*Country* *Province* *Municipality* *Registry office county* *Rural and urban zone*	Not discussed
Other layers	*Parcel* *Indigenous reserves* *Public forests* *Hydrology* *Roads*	***Parcel*** Others not discussed

Conclusion on Question 5. – Difficulties in integrating INCRA and *serviços registrais* are still a huge barrier that needs to solve for CNIR implementation, even though it was established by *Law# 10,267/2001* in 2001. In this aspect, no progress has been made.

It is important to highlight that despite differences of approach, this research considered user requirements while CNIR managers have only considered internal needs. Since CNIR is an ongoing project, decisions might change over time. Because the results of this research are at a high level, it has been an important aide for the CNIR managers and academic collaborators to identify factors that might impact CNIR in the middle to long term and that had not been considered so far.

Also this research has contributed to steps that CNIR managers will need to address in the future (e.g., user requirements assessment, description of the current systems and data relationship at CNIR and its collaboration agencies). Finally, it is also important to highlight that the differences in the models presented in Table 7.2 are based primarily on the consideration or not of the user requirements analysis.

7.2 General Evaluation of the CNIR Model

Finally, this research evaluates the use of Soft Systems (SSM) (more details in Chapter 4) to develop CNIR conceptual model, the characteristics of the requirements (see Chapter 4) and criteria to evaluate conceptual model designs (see Chapter 6). It is not expected that all criteria will be met since this research was based on SSM principles for the analysis of the CNIR problems and design of the conceptual model.

SSM is an interactive and dynamic approach that needs to be modified when a new or different perception of the real-world (i.e., the problem) occurs. By having a cognitive ending, it also opens doors for interdisciplinary components. All together, this reflects the real complexity of the system. As Nkwae (2006) expressed, SSM's main strategy is to engage people in discussions with the purpose of reaching consensus on the problem.

Also Nkwae (2006, p. 62) listed that the main activities contained at the SSM approach are:

- Finding out about a problem situation, which includes cultural and political dynamics of the situation;
- Building conceptual activity models of the various systems that exist to structure an exploration of the problem situation;

- Evaluating conceptual models by comparing the models to the real situation and using the comparison to define desirable, feasible changes that would improve the situation; and
- Taking action for improving the problem situation.

With respect to CNIR, the results are cognitive based on organizational, political, social and cultural issues that the CNIR collaborating agencies might be considering now or in the future. Because of this, there is no correct answer for the conceptual model proposed. This is only one interpretation of many potential conceptual models that could be developed for CNIR, the difference being that this was based on user requirements analysis. The proposed model was developed for an open view of the CNIR problems with non specific interests. The impartiality in this process produced the opportunity for this research to criticize all levels of problems and agencies equally, focussing on problems that need to be solved for successful implementation of CNIR.

The comparison of the models in Tables 7.2 and 7.3 show how abstractions of a complex system such as CNIR can differ. These are different point of views, based on different methodologies. CNIR managers have been developing their model with specific technological approach and this research is derived from a soft system and user requirements basis. The hope is that the contrast of the models in Tables 7.2 and 7.3 might bring up discussions on the data that needs to be in CNIR to meet all agencies' needs. Action for the conceptual model improvement can also be realized with the help of the proposed strategies for CNIR implementation (Chapter 8).

To relate what the literature suggests as criteria for evaluating system requirements and criteria to develop a conceptual model, this research presents a scaled evaluation. These contrasts are respectively related to Table 4.1 from Chapter 4 and Section 6.1. The result of CNIR evaluations with respect to the literature is found in Table 7.4 and 7.5 below. They use a scale from 0 (not satisfied) to 10 (satisfied). This scale was assigned in this research after the CNIR managers' evaluations described in the sections above.

These scores are the author's own assessment cognitively assign for the degree of satisfaction of the evaluations received from the CNIR managers. Because of this, no mathematical model was used; these score change from people to people perception.

Table 7.4 – Evaluation of the CNIR conceptual models, scaled from not satisfied to satisfied (0 to 10)

Characteristics (scale of satisfaction)		***Evaluation***
Complete: (9)	-	CNIR data flow was recommended and it should meet all users (agencies, landholder and general public) expectation.
Consistent (10)	-	CNIR conceptual model can be considered consistent because processes are seen with compatible user perspectives.
Coherent (9)	-	CNIR conceptual model was proposed to be simple and maximize the system's potential benefits.
Correct (9)	-	CNIR conceptual model can be considered performed in agreement with user requirements expectations.

Table 7.5 – Evaluation of the criteria of the user requirements after the evaluation of the CNIR managers, scaled from not satisfied to satisfied (0 to 10, respectively)

Characteristics (scale of satisfaction)	***Evaluation***
Correct (10)	- This research indicated requirements and proposed a model for CNIR considering the needs of the collaborating CNIR agencies and CNIR stakeholders.
Consistent (9)	- There was conflict in the design of the conceptual model and CNIR managers' model as summarized in Table 7.2 and 7.3, but not on the indication of the problems and analysis. - The study of user requirements' priorities was also consistent (see Table 7.1 and its conclusion).
Unambiguous (10)	- Requirements and their analysis were written as simply, concisely and as straightforward as possible (see Chapter 5). It is believed that multiple interpretations will not be found.
Complete (5)	- The data gathered was from 2008; it is predicted that there have been some changes today in the agencies' needs that were not updated. Because the user requirements analysis should be a dynamic process of updates it is affirmative that the CNIR requirements are not complete.
Feasible (6)	- Requirements were mostly feasible, but only some organizational and technical elements are improved. All changes are technically possible, but it will require certain resources (e.g., people, funding, laws) to be to be accomplished.
Relevant (10)	- To maximize the design of CNIR, requirement priorities were assigned (see Chapter 5), and principles and strategies to implement CNIR were recommended (see Chapter 8).
Testable (8)	- Mostly of the requirements can be tested once implemented.
Traceable (10)	- This research can be used as the start of the CNIR user requirement documentation. It will facilitate the comparison of new requirements entries. Requirements are mostly found in collaborating system description (Appendix III), user requirement analysis (Chapter 5) and design of CNIR conceptual model (Chapter 6).

This thesis points out some of the implications that Brazil might experience with the current CNIR model proposed by the CNIR managers. They are listed below:

- The model is not based on user requirements until the present moment. CNIR managers are aware that the user requirements input is necessary for CNIR successful implementation;
- At this stage, the model is only considering the implementation agencies (INCRA and RFB).
- *Serviços registrais* are not directly participating on the discussions;
- There is not an impartial feature of a project manager or project management unit planed for CNIR to date;
- A common parcel identifier was not yet agreed upon although the model is based on thus;
- The land unit in CNIR was not formally presented and accepted by the collaborating agencies. The CNIR formal presentation was scheduled for December 2008 when a national conference would take in place. For political reasons, it was delayed to date and reschedule to 2010. The CNIR managers' strategies were to design a proposed model for CNIR and to present to the collaborating agencies during the conference.
- There was no formal communication nor agreements between the implementing agencies (INCRA and RFB) and all of the collaborating agencies. The bureaucracy to formalize these agreements may make the process span goals; what can generate agencies work without any obligation or commitment related to CNIR data custodianship;

- Implementing agencies are not exploring nor funding academics to undertake research to help CNIR system improvement;
- There is no exchange of international experience with other countries to absorb the lessons learned when addressing similar issues in order to develop their cadastral system.
- There is no ongoing effort to report on what has been happening with CNIR design to be shared with the general public or even at the academic level. Consequently, CNIR might lose credibility over time;
- The implementation of a cadastral reform such as CNIR often takes more than 30 years to be fully complete (e.g., Sweden, Maritimes Canada). If one considers the size of the Brazilian territory, the need for sustained federal funding over this time period is essential.

CHAPTER 8

RECOMMENDED CNIR IMPLEMENTATION STRATEGIES

This chapter contains important recommendations for CNIR implementation. While this is not the main objective of this research, it is important to advise CNIR managers with key principals and strategic guideline. Section 8.1 will proposes principles for CNIR implementation based on the user requirements analysis. A review of CNIR issues was also described as SWOT analysis. Section 8.2 will describe strategies to minimize the issues exposed in CNIR. These strategies are mainly designed to solve technical problems, but there are also strategies to minimize administrative and political issues. Section 8.3 will propose a CNIR committee to manage the CNIR system.

8.1 Recommended Principles for CNIR Implementation

In order to propose principles and strategies for CNIR implementation a summary of CNIR problems and opportunities is presented in this section as SWOT analysis. A project SWOT analysis gives critical evaluation of the project internal and external capabilities. It also helps to identify strategies to fill out existing gaps or to reduce risks of failure by providing **strengths, weakness, opportunities** and **threats** of the project to be implemented [Milosevic, 2003].

Tables 8.1 and 8.2 display a CNIR SWOT analysis obtained from the results of the user requirements analysis (for more detail see Chapter 5). These tables contain internal and external CNIR factors. They evaluate the CNIR concept as so far discussed.

Table 8.1 - SWOT analysis of the evaluation of CNIR design, internal factors

	STRENGTHS	**WEAKNESSES**
Technical	- Existence of databases. - Adoption of a unified datum (SIRGAS2000). - CNIR implementation committee are multi-disciplinary, including academia. - Strong IT support for CNIR development.	- Lack of technological skills from same collaborating agencies. - Lack of data integration among institutions. - Lack of CNIR parcel identifier. - Lack of a common land unit from all agencies. - Incomplete spatial and descriptive land information. - Lack of metadata and appropriate system architecture. - Inconsistent and/or incompatible information. - Out-date maps with different scale, precision and datum. - Lack of skilled professionals - User requirements will be tested relatively late.

Table 8.1 - SWOT analysis of the evaluation of CNIR design, internal factors (Continued)

	STRENGTHS	WEAKNESSES
Administrative	- Management is committed and confident.	- Do not have a detailed plan yet. - Poor communication and management among institutions. - Lack of human and physical resources. - Lack of priority indication for training. - Lack of the system maintenance procedures.
Legal		- Legislation is out-dated and is too closely-tied to specific systems.
Political and Administrative	- Cooperation among INCRA and RFB to implement CNIR. - Political and institutional pressure to implement CNIR. - Agencies partnership identified.	- Low credibility of CNIR from external user's view. - Lack of formal agreement among the agencies. - Lack of federal funding to implement CNIR

Table 8.2 - SWOT analysis of the evaluation of CNIR design, external factors

	OPPORTUNITIES	THREATS
Technical	- Official implementation of SDI in Brazil. - Increase in the number of rural properties surveyed according the *Law # 10,267/2001* and with free cost. - Common geospatial web service development. - Existence of e-PING (e-Government Interoperability Standards). - Researchers at academic level who have developed an understanding of the benefits of SDI to land management.	- CNIR as designed does not meet all the collaborating agencies needs. - CNIR collaborating agencies do not totally adopt CNIR standards and data can be lost. - Some agencies do not have the technology needed for CNIR. - Noncontinuous data update from CNIR collaborating agencies. - Noncontinuous governmental interest in CNIR in the long term period.

Table 8.2 - SWOT analysis of the evaluation of CNIR design, external factors (Continued)

	OPPORTUNITIES	THREATS
Administrative		- Lack of commitment of collaborating agencies to CNIR. - Cost to improve the existing cadastral systems at the collaborating agencies exceeds budgets. - Circumstantial strikes at institutional levels that might demand long period. - Landholders do not have access to internet. - Landholders will not travel to declare their rural property information. - CNIR system would not be available to the citizen users.
Legal	- Creation of the geo-referencing Law (*Law # 10,267/2001*). - Modernization of the registry offices.	- Majority of the registry offices do not have technology to be integrated with CNIR. - Legislation might not be updated.
Political and Administrative	- Ongoing land regularization programs. - Political interest. - Land social movements pressure for CNIR implementation. - Increased number of potential CNIR users a part land information agencies.	- Lack of funding to train the current professionals. - Formal agreements among the agencies take too long to obtain. - Loss of key staff by political appointments.

As can be seen from the tables above, the CNIR weaknesses are greater than its strengths. The hope is that as soon as the CNIR system is implemented more governmental support will occur. This will not only help to increase the data completeness by having more agencies providing data, but also it will create more visibility and trust in CNIR which should bring more financial and political support. If the administrative weaknesses are not solved during the initial CNIR design phase, then it is more likely that technical weaknesses will also fail by not having a strong management basis.

CNIR implementation also can lead to the creation of new opportunities. the opportunities that already exist should be emphasized to minimize the threats. The majority of the threats are influenced by politics which can either benefit or more likely hinder CNIR success.

Before proposing appropriate principles and setting strategies for an information system implementation, it is necessary to understand the issues that need to be solved or gaps that needs to be minimized [Ward, 1995]. For the CNIR case, these have been discussed in Chapter 5 and its respective appendices, as well as in the SWOT analysis in Section 8.2. Table 8.3 determines the principles for CNIR implementation based on these sources. They were subdivided into: management, engagement, content, quality, and access. They will be basis for the strategies to be presented in Section 8.4.

Table 8.3 – Recommended principles for CNIR implementation

Criterion	***Principles***
Management	1. Develop strong project management. 2. Have a well-defined and appropriate management structure and processes. 3. Delegate duties and responsibilities for the collaborating agencies, which including data collection, data update and quality control. 4. Ensure that all processes are documented and metadata procedures are implemented. 5. Foster partnerships to subsidize some costs and to ensure mainly graphical data availability. 6. Create an agreement on where CNIR will be physically located, who will directly manage it and how the access control, backup and data recovery will be. 7. Create normative instructions to guide how data quality control and update must to be done and at which frequency.

Table 8.3 - Recommended principles for CNIR implementation (Continued)

Criterion	***Principles***
Engagement	8. Maintain constant communication with CNIR committees, via a project manager. Workshops should occur periodically to verify whether the requirements are still being met, or if there are problems and how to resolve them to. 9. Create consciousness among CNIR collaborating agencies about the value of the rural land information to Brazil and the benefits that it can bring. 10. Have technical support designed to meet the needs of all collaborating agencies. 11. Retrain staff involved. 12. Introduce educational programmes to update skilled workers knowledge and show the benefits of CNIR to the general public. 13. Produce procedures and manuals teaching how to use the system, clarify doubts and give training for the external users.
Content	14. Monitor constantly the requirements of users and whether those requirements have been meet. 15. Assign priorities for data in collaborating agencies (i.e., data from INCRA, RFB and *serviços registrais* has priority). 16. Standardize data and create rules of validation on entry stage. 17. Develop a common land unit. 18. Be based on independent updating of the graphical and descriptive data. 19. Minimize duplication of data collection and management.
Quality	20. Validate only accurate data. 21. Create metadata. 22. Create quality standards for spatial information compatible with the implemented SDI standards in Brazil. 23. With the involvement of knowledgeable staff in geographic information and information systems, build the capacity as the system is developed and provide continuous training on using the system properly.
Access	24. Recognize confidentiality and security access arrangements via traceable login codes. 25. Harmonize datasets to maximize sharing. 26. Be a public system with well-defined levels of access in order to maintain the confidentiality of the citizen personal information. 27. Be free of charge. 28. Allow downloading only for the collaborating agencies under terms of responsibilities. 29. Develop manuals and procedure to minimize time and cost of system failure.

8.2 CNIR Implementation Strategies

According to OECD (2001), the establishment of strategies implies setting goals and identifying means of achieving them by setting priorities and giving direction to solve the problems. "*Strategic planning frameworks are more likely to be successful when they have a long-term vision of sustainable development with transparent objectives, and when they include clear priorities upon which stakeholders agree*."

Nkwae (2006) complements this by stating that developing a strategy is a matter of determining what alternative actions are necessary to minimize the problem situation; these actions will lead to improvements that are necessary to occur in order to meet the recommendations proposed. The following strategies were recommended to minimize the threats, solve the weaknesses and support the strengths and opportunities of CNIR. These recommended strategies for CNIR implementation are related to the principles criteria: management, engagement, content, quality, and access seen in Section 8.3. Some of these policy implementation strategies might ensure CNIR easy data access and dissemination.

8.2.1 Management Strategies

The recommended management strategies for CNIR implementation basically deal with organizational independency (i.e., a new division), which should contain a structured committee advisor with a technical support center, working groups to resolve conflicts such as standards, integration with *services registrais* and common parcel specifications and a team of project managers with different backgrounds. The creation of a new division for CNIR means that all the work that needs to be done for CNIR will be delegated to one specific division and employees' functions will be devoted only to CNIR issues. The closer the CNIR division is to the INCRA Cartographic and Rural Cadastral Division, the better; cutting physical distances might be a strategy to solve smaller issues with the CNIR data. The sustainable institutional management should be possible if the CNIR committee is created as recommended further in Section 8.5.

The communication with collaborating agencies via a project manager or team is an immediate action for CNIR implementation. All agencies should be aware of the problems that need to be solved in their specific current cadastral system (see CNIR problems in Chapter 5 and current system description in Appendix III) and for CNIR itself. Also good communication among agencies will build commitment and trust.

Agencies can only be formally tied if official agreements among them are developed and signed. Signing agreements is a bureaucratic process in Brazil that usually takes a long period of time. This is a second step that needs to be implemented. It probably will occur in parallel with many other CNIR steps because the bureaucracy will also have a political component that needs to be discussed inside each particular agency.

In additional, skilled professionals might be a key action to implement CNIR. Training must be a continuing action. This means that it must occur for all relevant employees before CNIR is tested with the first data sample, and during CNIR implementation, data maintenance and dissemination. Table 8.4 summarizes the recommended management strategies for CNIR implementation.

Table 8.4 - Management strategies for CNIR implementation

Strategies Categories	***Create of new division***	***Communicate with agencies***	***Sign formal agreements***	***Train staff***
Organizational streamlining	Create a new division (CNIR) by adding/relocating skilled professionals that would be entirely responsible for data input/output, training, cadastral support and information dissemination. **(Principle 2)** Establish an overarching body for project and to keep the implementation of the system as free as possible from political interference. **(Principle 2)** Create a detailed management plan for the system (CNIR): design, implementation and testing. Establish data input/output standards and metadata to enforce quality assurance. This might include the adoption of the existing governmental standards (such as e-PING) **(Principles 1, 2 & 3)**.	Hire a team of project manager that are not employed by any of the participating agencies involved at with the system. These professionals beside management will bring strategic solutions for the system (CNIR). They also must be institutionally apolitical. This impartiality helps to establish communication amongst agencies, and create solutions for the system that will serve all agencies requirements. **(Principle 2, 3 & 4)**	Create a simplified and standard agreement process with all agencies. **(Principle 5)**	Implement capacity building of data capture and management (technology and human infrastructure) at the agencies involved from the headquarters to local levels. **(Principle 5)**

Table 8.4 - Management strategies for CNIR implementation (Continued)

Strategies Categories	***Create of new division***	***Communicate with agencies***	***Sign formal agreements***	***Train staff***
Accountability	Create a committee for CNIR which must contain members of all agencies to discuss CNIR issues. **(Principles 2 & 5)**	Make all agencies involved feel that they are part of the system (CNIR) in order to have their commitment in data update and maintenance, even during long strike periods. **(Principle 7)**		
Roles and responsibilities	Agree on agencies' responsibilities with respect to data custodianship. **(Principle 3)**		Minimize bureaucracy by signing agreements among agencies that formally delegates responsibilities, restrictions and rights. **(Principle 6)**	

Table 8.4 - Management strategies for CNIR implementation (Continued)

Strategies Categories	***Create of new division***	***Communicate with agencies***	***Sign formal agreements***	***Train staff***
Capacity building				Develop constant training workshops for the skilled professionals that are involved at the system (CNIR); updating their skills will provide the capacity for training other professionals. **(Principle 7)** Develop visual training material to be disseminated among local agencies in formats of e-learning tools; online tools training might disseminate CNIR manuals faster with the same level of training for all. **(Principle 7)**

8.2.2 Engagement Strategies

Similar to the training plan, CNIR managers should take action to promote the image of CNIR in order to get more credibility and political interest. This strategy might bring long term CNIR sustainability by not only increasing the number of land regularization programs, but also by updating the existing legislation. This can be done by using media such as TV, radio and newspaper, or even by organizing workshops. It is important to get the attention of the population in general in order to communicate the benefits that CNIR will bring to them.

The promotion of the CNIR image also must occur during all processes of CNIR implementation and maintenance. The dissemination of the idea of a successful CNIR also might bring more interest from the academic and industrial level to develop tools and research to help the improvement of CNIR implementation. It also might bring partnerships to add value and more commitment from the collaborating agencies for data custodianship.

Appendix III brings some expectation for CNIR implementation seen from current and potential CNIR users' perspective. Note that, these expectations can give indicatives for CNIR managers to develop CNIR short term benefits to be presented for the federal agencies and raise partnership. Table 8.5 gives an overview of the engagement strategies.

Table 8.5 – Engagement strategies for CNIR implementation

Strategies Categories	***Promote CNIR image***	***Manage political interests***	***Add partnerships***
Organizational streamlining	Disseminate information about the system (CNIR) among federal, states and private agencies in order to add new mapping agency partnerships to provide and update the cadastral mapping. These new agencies might provide specific contributions (e.g., electric companies which updated some elements of the cadastral maps). **(Principle 9)**	Update legislation and create tangible land policies. **(Principle 10)**	Create a newsletter for CNIR with general subscription to promote CNIR benefits and ongoing project. **(Principle 12)**
Accountability	Identify short benefits that can be used to demonstrated CNIR importance to Brazil. **(Principle 9)** Identify measurable criteria for determining CNIR progress and success. **(Principle 9)**	Continuity of implemented policies and laws from one political regime to the other can be sustained by involving politicians in the system committee. This will help communicate to politicians the benefits and impacts of the system (CNIR) during the election period. **(Principles 8 & 12)**	Use workshops and seminars to improve organizational trust and coordination between them (including governmental, NGOs, private and public), to educate the citizens, and to support researchers at academic level. **(Principles 8, 11 &12)**

Table 8.5 – Engagement strategies for CNIR implementation (Continued)

Strategies Categories	***Promote CNIR image***	***Manage political interests***	***Add partnerships***
Policies	Provide constant educational campaigns at local levels supported by social movements, using their language and dissemination tools (such as radio programmes, communitarian meetings, church meeting), to disseminate the examples of the tangible benefits of the system. **(Principles 9, 12 & 13)**	Ensure adequate fiscal provisions and funding from the federal government (i.e., for technological, training, physical and human resources). **(Principles 9 & 10)** Develop cost management strategies rather than cost recovery since CNIR is funded by federal funds and there should not be fees for the users. Each agency must cover its own cost for data custodianship. **(Principles 8, 9 & 10)** Ensure continuity of land regularization projects to ascertain that land units will be surveyed systematically. **(Principle 10)**	

8.2.3 Content Strategies

Once agencies are committed together and understand and agree with the CNIR concept, then the next step is to create an incremental prototype. Developing small and tangible pieces of the system helps not only to manage it, but also to identify futures problems that can be easily corrected in small scale. At the same time, it might ensure that there will be deliverables for the current resources. Benefits of the incremental prototype are exposed in Appendix IV. This also helps to sell the idea that CNIR has tangible goals, is self-sustainable and will provide real benefits. More financial support might be implied.

This research proposes to first work only with all data that are at the **"certified by INCRA"** classification from the Figure 6.2 (i.e., any data that was surveyed according to the *Law# 10,267/2001*). This might be the least problematic sample and the smallest in comparison with all the other classifications.

The rate of rural properties certified from INCRA is not high, and in this case, this is a positive factor (e.g., in May 2009 that was 12,485 rural properties certified by INCRA and in January 2010 it is 17,195 properties). This data would primary come from the *Quilombola,* settlement and rural cadastres (INCRA's divisions) and indigenous reserves from FUNAI's database, as discussed in Section 6.4.1.3.

The definition of a land unit, as a parcel or not, should be agreed upon all agencies. Only with this agreement can standards and metadata be created that will respect the existing SDI standardization in Brazil. A PID should be designed and assigned for further geocoding.

From the graphical data perspective an official map of the rural and urban zones in all Brazilian territory should be created. This is an important layer which will help to implement the concept of the common land unit at CNIR (see Section 3.5 for more details). Other layers such as road and hydrology should then be added. Parcels should be given the geocodes.

From the descriptive data perspective there should be a match of the existing database from all collaborating agencies. See Figure 5.1 for the existing PIDs relationship. Tables can be created for the minimum content as discussed in Section 6.4.2.

This is the default data for CNIR system that will be available for the agencies and landholder to be updated and visualized via a web portal. The data flow should be as described in Section 6.4.1. If this prototype works well, then only the **"non-certified"** data should be added. This data also should go through the whole process and, if successful, then the **"sketch"** data can finally be added. By the end of the process, all the land types and geometric precision issues should be covered. Table 8.6 outlines key strategies to lead with content criterion in CNIR implementation.

Table 8.6 – Content strategies for CNIR implementation

Strategies Categories	***Design an incremental prototype system***
Organizational streamlining	Create an incremental system that gives tangible goals to CNIR and adds credibility. **(Principles 14 & 15)**
Accountability	Establish prototypes to get the attention of other organizations. It might bring both partners and increase pressure for CNIR be implemented. **(Principles 14 to 19)** Maintain user requirements analysis **(Principle 14)**
Standards and procedures	Create a unique, understandable, and common definition of the land unit used at the system (CNIR) that can be applied by all, including the registry offices. **(Principle 17)** Create a common PID to accommodate all the collaborating agencies needs. **(Principles 17 & 18)**
Policies	Create data standardization policy. **(Principle 15)** Create a common legislation for CNIR system. **(Principle 19)**

8.2.4 Quality Assurance Strategies

The quality assurance strategies are related with the all the principles and strategies. They are the ones which ensure the quality control for CNIR successful implementation. Generally speaking, any criteria should be tested at the quality assurance stage. Management and quality assurance strategies are directly related with CNIR project management team. Some of the quality assurance strategies are listed in Table 8.7.

Table 8.7 – Quality assurance strategies for CNIR implementation

Strategies Categories	***Quality Assurance***
Organizational streamline	Carefully define physical and human resources requirements. Employees might be relocated from one division to another to better serve CNIR demand. New employees should be hired.**(Principle 23)**
Accountability	Carry out user requirements survey and analysis, including an inventory of the existing geospatial datasets and resources, and their standards (similar description can be found at Appendix III). This indicates that CNIR is still meeting all needs of all agencies, what somehow helps to maintain the agencies involved at CNIR. **(Principles 20 & 22)** Evaluate if the criteria been met. **(Principle 22)**
Standards and procedures	Ensure the traceability of CNIR documentation.**(Principle 21)** Ensure that the spatial data will be delivered by the agencies in a common cartographic system (datum, projection) and with their metadata to facilitate eventual data transformation and interoperability. **(Principles 20, 21 & 22)** Constantly evaluate the system (CNIR) requirements to satisfy the organizational needs.**(Principles 21 & 22)** Evaluate if CNIR standards are compatible with SDI standards in Brazil.**(Principles 21 & 22)**
Policies	Develop post implementation or post-development monitoring policies (ensuring continuity of projects between political regimes). **(Principles 22 & 23)**

8.2.5 Access Strategies

The access strategies recommend **how** CNIR should be accessed (i.e., costs, type of advises) and from **whom.** Confidentiality, privacy and liability issues should also be considered at this strategy. For example, the graphical data should be collected only from legally recognized agencies and personal landholder information must be confidential.

Also, at some point, it is understandable that the CNIR system should have copyright/intellectual property. Each collaborating agency should own the copyright of the data produced by them and CNIR system should own the copyright of only the value-added component of the data (e.g., calculated area and parcel layer). Table 8.8 sums-up some strategies for CNIR access.

Table 8.8 – Access strategies for CNIR implementation

Strategies Categories	***Access***
Organizational streamlining	Develop and maintain a web portal for land information where citizens can have some access to the information with free cost. **(Principles 24 to 29)** System access should be via personal login; it should generate individuals' profiles where, for the landholders' entry point, each person has access to his or her own data. Agencies can see all, if the employee is previously registered for this type of access. **(Principle 24)** Access must be traceable by personal identification (e.g, # CPF). **(Principle 24)**
Accountability	Create open access to the system for governmental agencies with different levels of access for the general public. The general public may have read-only access to the CNIR data. Federal agencies with controlled access could download the CNIR database. **(Principles 26, 27 & 28)**
Standards and procedures	Manuals and procedure of the CNIR system must be available to all users. **(Principle 29)**
Policies	There should be a copyright notice for all documents coming from CNIR, it gives notice how owns the data that has been used, since CNIR systemis planned to integrate several database. **(Principle 28)**

8.3 Proposed CNIR Committee

Figure 8.1 explains the proposed CNIR Committee flowchart; it contains four major committees and six working groups. Appendix XII contains more detailed information. Their functions include:

- Develop the phases of implementation of the CNIR system;
- Coordinate activities among CNIR collaborating agencies;
- Develop, streamline and enforce standards and policies for the CNIR;
- Ensure CNIR continuity at long term period by mobilizing federal funding;
- Harmonize sub-committees communication.

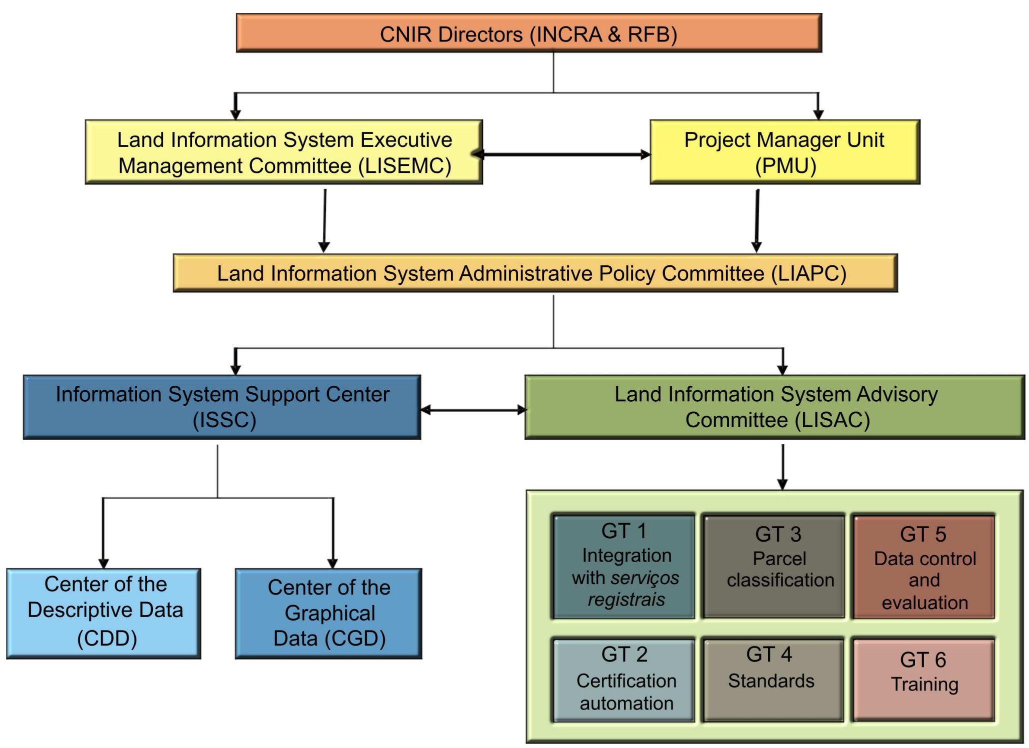


Figure 8.1 – CNIR Committee flowchart

- ***CNIR Directors Board* –** They are the political players within CNIR, besides to contact the coordinators responsable for the current cadastral systems at the collaborating agencies to ensure that the data custodianship and be responsible to sign agreements.
- ***Land Information System Executive Management Committee (LISEMC)* –** This committee has power to make decisions about policy issues.
- ***Project Management Unit (PMU)* –** This unit is responsible to manage the CNIR system, create well define project management and do communication among agencies.
- ***Land Information Administrative Policy Committee (LIAPC)* -** This committee has responsibility to review and to propose administrative statutory changes and to resolve organizational issues.
- ***Information System Support Center (ISSC)* –** This centre is designated to lead if technical issues related to the CNIR descriptive and graphical data.
- ***Land Information System Advisory Committee (LISAC)* –** This committee is responsible to manage a forum represented by all six working groups to propose CNIR data changes, regulations, standards, data quality control and training. It also is used to identify and resolve any issue related to CNIR.

This section proposed principles and strategies for CNIR implementation related to technical, organizational and political issues. Some these issues are easily observed and adjusted for. Others are totally dependent on political decisions. These latter issues might be identified too late in the process to be effectively mitigated if political issues interfere. In general, what CNIR needs is outlined below:

Standardize – In Brazil the land unit concept inside CNIR varies according to the cadastral purpose. The short solution might be to accept this difference and find alternatives for accessing data (e.g., creating a table identifier index). For new data, a common parcel-based sytem should be sought. How to relate the old data to any one uniform parcel system is the biggest challenge that land administrators in Brazil will struggle with at CNIR. The existing land inventory cannot be lost nor does CNIR have enough financial support to start from zero.

Update legislation - Brazil is a civil law jurisdiction. All the policies must be within the civil code. This creates too many inflexible details which make it difficult to follow all the old rules in a new system. Cadastral legislation is also not harmonized and there are many conflicts (such as parcel definition) that need to be resolved. The legislation needs to be reviewed and new regulations need to be developed. The legislative interpretation must be clear to all.

Disseminate knowledge – The CNIR collaborating agencies need to be aware of what is happening worldwide in land management, and how this can impact them (e.g., SDI). Another important fact is the potential of linkage SDI and the cadastral systems in Brazil. The agencies need to understand that this will create institutional and political power because social components (e.g., MDS data) can be added. The lack of research on rural cadastral issues limits evidence of costs and benefits for a National Rural Cadastre in Brazil. For the federal agencies it brings low expectations and for the general public it increases barriers to appreciate CNIR benefits. The lack of tangible demonstrations of CNIR benefits and possibilities limits the ability to promote the idea of a common and integrated rural multipurpose system to the stakeholders and users. Political interest and partnerships are also lost.

***Communicate* –** Lack of communication among these agencies can create a system that is not applicable for all interests; this in turn can also contribute to the lack of commitment from collaborating agencies. A direct consequence of this will be the lack of data maintenance and use of the system.

Adopt a unique reference system – One of the benefits of SIRGAS2000 in Brazil is the possibility having unique topographic mapping that can serve as a primary reference for cadastral surveys. Also the reference framework already contains standards that can be adapted and applied to CNIR. A major problem will be training surveyors who have not had continuous professional development.

Make the system and system development sustainable - Political and institutional instability can reflect on the goals and strategies for implementing and maintaining CNIR. CNIR needs to have a skilled project manager to push its implementation, to be a mediator of existing and potential conflicts and mainly to manage this complex project. It is also possible to see that if CNIR is not flexible enough to be broken into separate and tangible subprojects, then CNIR will fail in the short term. The aim of constructing a non flexible system might result in a never finished project, where funds are lost over time by having intangible goals. Priorities must be raised now at the design phase with the definition of short, medium and long term tasks.

Address data completeness – This is one the biggest challenges for Brazil because it has a large territorial area and a scarcity of funds. It needs to be clear in the CNIR system **how** and **who** can provide the data acquisition and **when**.

Recovering costs – It is understandable that administration costs will be high. How can CNIR be maintained for a long term period? Should citizens or other users have free data access? Will be the federal funds enough? Does CNIR need to seek new partners to subsidize some of these costs? These are questions that need to be analyzed in order to make CNIR a sustainable system. Following the Brazilian free software policy, one of the solutions to give access to all governmental agencies is to use free GIS software. But on the other hand, this might demand more training for the developers and internal users.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 Research Conclusions

The design of a conceptual model for the National Rural Cadastral System (CNIR) was the subject of this thesis; preliminary conclusions and recommendation appear at the end of each chapter and a summary is presented in this chapter. The conceptual model was developed using a multidisciplinary perspective built on an understanding of cadastral systems, spatial data infrastructure, user requirements analysis and system development methodologies using a soft systems approach.

The concept of a multipurpose cadastral system has changed over the years and, in Brazil, the concepts of a multipurpose cadastral system and LIS are the same. As in many other countries, the cadastral data in Brazil is outside the SDI framework, INDE, and interconnection is possible only if there is a common geospatial spatial reference framework. SIRGAS2000 has been helping to harmonize the mapping reference systems in Brazil. This research has described some of the SIRGAS2000 socio-economic impacts studies concerning land regularization that were analyzed through the PIGN project land. In addition, any improvement of the INDE (e.g., the densification of the geodetic network by IBGE because of SIRGAS2000) will directly impact the cadastral data because the primary geodetic survey network is also by law the primary reference for cadastral surveys.

The land regularization PIGN subproject helped to indicate criteria and issues to develop the proposed conceptual model by analyzing several processes of land regularization in Brazil. Improved management of cadastral information has great importance for land administration in Brazil and also provided the motivation for this thesis. The land regularization processes in Brazil directly reflect the history of land administration and political interests. Rural cadastral reform is further complicated, not only by the size of the Brazilian territory, but also by the political involvement in decision making. Unfortunately, the design of CNIR has been constrained by some of these political issues including the fragmentation of information in public and private authorities.

In Brazil there is no judicial tribunal that specializes in land issues; land disputes are treated as civil charges under civil code regulations, and depending on the evidence, they might take years or decades to resolve. In addition, the legal cadastre is separate from the technical and fiscal cadastre, and as a consequence, data is duplicated and inconsistent in these systems. A major impediment to cadastral reform is the fact that the private registry offices have separate systems, yet they have the primary land ownership data which needs to be exchanged with government cadastral agencies. Another impediment is the lack of large scale cadastral mapping for most of the country.

Law# 10,267/2001 came with the hope that some land issues could be solved by having rural properties geo-referenced, and thus, the harmonization of land information in the new CNIR system. This law was established in 2001 and since then, Brazil has been struggling to accomplish what the new land law recommended. On one side there is a lack of skilled professionals to survey the rural properties according to this law. On the other, there is also a lack of infrastructure and procedures from the Land Reform Institute (INCRA) for certifying the rural properties surveyed and to implement the CNIR system together with the Federal Revenue (RFB). It is imperative that this cycle of problems be analyzed, in order to develop a complex system such as CNIR with success. This thesis has reviewed some of these problems.

The primary contributions of this thesis are:

- Description and analysis of the main cadastral systems in Brazil including the private land registration system (see Chapter 3 and Appendix II);
- Evaluation of user requirement analysis methodologies, as well as problem prioritization and analysis of the user requirements for CNIR (see Chapters 5 & 6, and Appendices III, VI, VIII and IX);;
- Description and evaluation of project management methodologies for system development, specifically project management functions and techniques, risk management and principles and strategies for a project implementation (see Chapters 4 & 8). Evaluation was related to:
  - The scoping phase of the project (see Chapter 6) and analysis of the project problems (see Chapter 5);
  - The use of PERT diagrams to indicate the critical pathway and problem prioritization (see Chapters 5 & 7);
  - The use of SWOT analysis to summarize the CNIR strengths, weaknesses, opportunities and threats (see Chapter 8);
  - The closing phase, where principles and strategies were purpose to improve CNIR implementation (see Chapter 8);

- Design of a conceptual model for CNIR using soft systems methodology and based on an analysis of user requirements (see Chapters 5 & 6);
- Development of initial strategies for CNIR implementation (see Chapter 8).

The design process and the analysis of the resulting model were not completed in a vacuum. Rather, it was calibrated through targeted interviews and focus group sessions with government personnel in Brazil. The results of the user requirements analysis have already helped the CNIR managers to identify criteria that were not considered by them when defining their first CNIR model. However, at this point, CNIR managers are still not considering the needs of collaborating agencies in their model. If CNIR is to serve a variety of governmental ministries/agencies and be linked to the serviços registrais, then CNIR development must consider user requirements of collaborating agencies.

From the analysis of the user requirements, it has been concluded that a study must be undertaken as soon as possible to define a common land unit for CNIR. This standard should also include definition of a unique parcel identifier that can interrelate land unit data among CNIR stakeholders. It was also found that CNIR currently lacks data completeness and compatibility the information. There is no official agreement among agencies as yet and legislation is fragmented and outdated. These are priority issues for CNIR development.

The use of project management methodologies was another contribution of this research. In Brazil geomatics research is nearly always technical. The multidisciplinary subjects explored in this thesis showed that many different backgrounds can contribute to geomatics projects. The use of project management components is also a guide for the CNIR managers. It has been shown that, for designing and implementing CNIR, project management will be the key tool in managing all of the information and expectations. Also it shows that the development of a land information system is not just technical; it can benefit from a wide variety of disciplines.

The proposed conceptual model was based on a cognitive approach using soft system methodologies in conjunction with user requirements. The conceptual model contained the following products:

- CNIR problem analysis and prioritization;
- SWOT analysis;
- Flow of the information design;
- Minimum content indication;
- Current collaboration agencies systems description and its data relationship in CNIR system;
- Principles and strategies for CNIR implementation;

The proposed principles and strategies for CNIR implementation are intended to advise CNIR managers about important options which may available but have so far not been considered.

Separate work (coming from PIGN – [PIGN, 2007].) was done in close association with the CNIR implementation agencies to support this research. This included land regularization for *Quilombola* territories in *Pernambuco*, organization of two national workshops on *Quilombola* territories regularization, assessment of the impact of SIRGAS2000 on indigenous reserves, and participation in workshops for CNIR. This cooperation resulted in obtaining much substantive material and opened doors with the collaborating agencies. This gave more authenticity to the results because research could be refined and verified during the process of designing the conceptual model.

The expectations for CNIR implementation from the collaborating agencies' points of view are high, although they know that many challenges will exist for database interconnection. Some of them (e.g., SFB) have already reviewed and changed their cadastral system legislation, and established the possible interconnection with CNIR, as it was intended by the *Law# 10,267/2001*. This is one of the first steps that each of the collaborating agencies will need to work on. The co-operation of SFB shows that the timing is urgent, and that CNIR needs to be implemented soon.

CNIR managers have been working on developing a model for CNIR and it already has had refinements due to this research. However, it needs to be highlighted that decisions may change over time because this is an ongoing project with many political interests. Another positive step taken by the CNIR managers was the creation of a working group. This working group is composed of members of the INCRA and RFB cadastres, IT support and academics from the universities UFPE, UFSC and UFBA who are experts on cadastral systems in Brazil. They have been advising CNIR managers on the best way to implement rural cadastral reform in Brazil with respect to the technical issues.

Unfortunately the *serviços registrais* are not part of this working group. This highlights a major problem concerning lack of contact with *serviços registrais* during the CNIR design phase and therefore a lack of consideration of their needs and constraints. Since the *serviços registrais* ultimately register the legal rights and registration is compulsory to maintain these rights, it is essential that the register matches the physical survey that will be represented at the parcel layer in CNIR system.

9.2 Research Recommendations

Below is a summary of the major recommendations of this thesis for the CNIR design and implementation:

Technical

- Define the standard land unit and its parcel identifier;
- Standardize and integrate descriptive and graphical data;
- Develop a process for completing data;
- Maintain the user requirements evaluation;
- Create sufficient technological support.

Administrative

- Create a strong project management team and structure;
- Sign formal agreements among agencies;
- Create communication among agencies;
- Update legislation;
- Train existing personnel and increase its capacity.

Political

- Make sufficient funds available over a long period of time;
- Manage political interests and commitment effectively.

From a technical perspective, it is recommended that CNIR should have the flexibility to integrate new collaborating agencies in the future. From a short term perspective, it is recommended that agreements between CNIR and IBGE should occur in order to create an official map of the rural/urban zone. The distinction of the urban and rural perimeter will be a big challenge in Brazil because these boundaries are established by decree and tend to change when the dynamic of the urban zone changes.

It is also recommended that the user requirements analysis be continued and expanded during the design, implementation and maintenance phases. This should be a priority for the project management team. User requirements should be also flexible to accommodate all interests and to be open to incorporate new collaborating agencies.

The creation of an official large scale map for the registry office county is another recommendation for CNIR. The map of the county could help the registrars to define and attest to where legal rights are held. Currently registry information is descriptive information and there will be a need to reconcile it with the new CNIR graphical and co-ordinate data. There should also be the development of a unified and simple system through which the registry offices can insert their data for CNIR. One problem is that not all the registry offices in Brazil are computerized. For that, there must be incentives from the federal government to make these entities integrated with CNIR. There is no reason to create a system such as CNIR if the primary legal data is not involved.

Since the academic research about cadastral systems, especially in rural areas, is scarce and marginalized in Brazil, the final recommendation of this thesis is the creation of specific research and scholarship programs at the graduate level to open discussion, generate multidisciplinary studies and bring more solutions for the rural cadastral reform and land administration in Brazil. This should be possible if, through CNIR, universities have agreements to develop research in this subject. Specific areas for further research include:

- CNIR financial sustainability and issues surrounding the costs of data access;
- Integration between old and new data (graphical and descriptive) in CNIR system, depending on the chosen land unit, and without loss of historical information;
- The "best" parcel identifier system for CNIR (and the definition of the criteria necessary to define this);
- Impacts of the legal system within CNIR and information that should have overriding priority;
- Feasibility of integration of the cadastral data with the SDI framework, supported by tangible case studies and how SDI could impact CNIR;
- Lessons learned from international experience in cadastral reform to look for results abroad and how they may be applied to CNIR;
- Models that may be used in other Latin American countries with similar problems and conditions.

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APPENDIX I

SUMMARY OF THE AGRARIAN STRUCTURE IN BRAZIL

(in Portuguese)

Table I.1 - Number of rural properties categorized by area (hectares) in Brazil; report from 2003 [from (DIEESE, 2008)]

Estratos área total (ha)	Imóveis		Área total		Área média
	Nº de imóveis	Em %	Em ha	Em %	(em ha)
Até 10	1.338.771	31,6	7.616.113	1,8	5,7
De 10 a 25	1.102.999	26,0	18.985.869	4,5	17,2
De 25 a 50	684.237	16,1	24.141.638	5,7	35,3
De 50 a 100	485.482	11,5	33.630.240	8,0	69,3
De 100 a 500	482.677	11,4	100.216.200	23,8	207,6
De 500 a 1000	75.158	1,8	52.191.003	12,4	694,4
De 1000 a 2000	36.859	0,9	50.932.790	12,1	1.381,8
Mais de 2000	32.264	0,8	132.631.509	31,6	4.110,8
TOTAL	**4.238.447**	**100,0**	**420.345.362**	**100,0**	**99,2**

Fonte: Incra. II PNRA
Obs.: Situação em agosto de 2003

Table I.2 – Distribution of total area of rural properties in Brazil according to the juridical situation; report from 1998 [from (DIEESE, 2008)]

Brasil e Grandes Regiões	Propriedade	Propriedade e Posse		Posse	Área total	
	Área registrada	Área registrada	Área de posse	Área de posse	Em %	Nºs absolutos (em 1.000 ha)
Norte	76,2	1,3	0,5	21,9	100,0	92.052,8
Nordeste	79,5	2,9	1,4	16,3	100,0	79.068,8
Sudeste	84,0	6,2	2,1	7,6	100,0	65.721,1
Sul	86,5	6,7	1,6	5,2	100,0	44.187,0
Centro-Oeste	87,0	3,4	1,0	8,6	100,0	133.396,2
BRASIL	**82,6**	**3,6**	**1,2**	**12,5**	**100,0**	**414.425,9**

Fonte: Incra. Estatísticas Cadastrais
Elaboração: DIEESE
Nota: (1) O conceito de "imóvel rural" definido pelo IBGE se encontra no glossário
Obs.: O Incra exclui 123.864 imóveis com dados inconsistentes: imóveis cuja soma das áreas registrada, de posse a justo título e de posse por simples ocupação seja maior que 105% ou menor que 95% da área total do imóvel

Table I.3 – List of *Quilombola* communities regularized in Brazil from 2004 to 2007 [from (DIEESE, 2008)]

Regularização de territórios quilombolas	2004	2005	2006	2007
Número de processos (1)	116	212	182	74
RTID (2) publicados (3)	-	27	21	21
Famílias beneficiadas com RTID	54	2.338	3.514	2.496
Área dos territórios com RTID (ha)	3.695	241.243	207.712	58.042
Títulos concedidos	2	4	16	4
Famílias beneficiadas com títulos	54	365	1.528	240
Área titulada (ha)	3.695	9.032	59.859	17.903

Fonte: MDA. PPIGRE
Elaboração: DIEESE
Notas: (1) Foram excluídos do número de processos os que já foram titulados
(2) Relatório Técnico de Identificação e Delimitação
(3) O número de RTIDs inclui aqueles com títulos emitidos

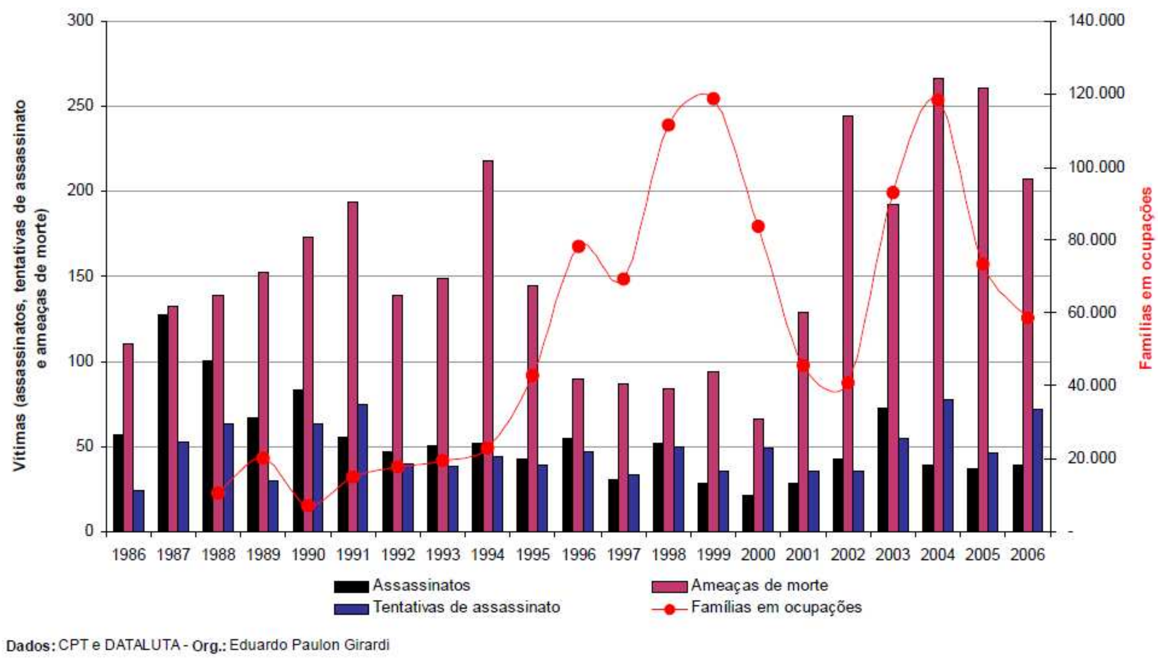


Figure I. 1 – Data of death, tentative of murder and cohesion of murder in Brazil, years from 1986 to 2006 [from (Girardi, 2008)]

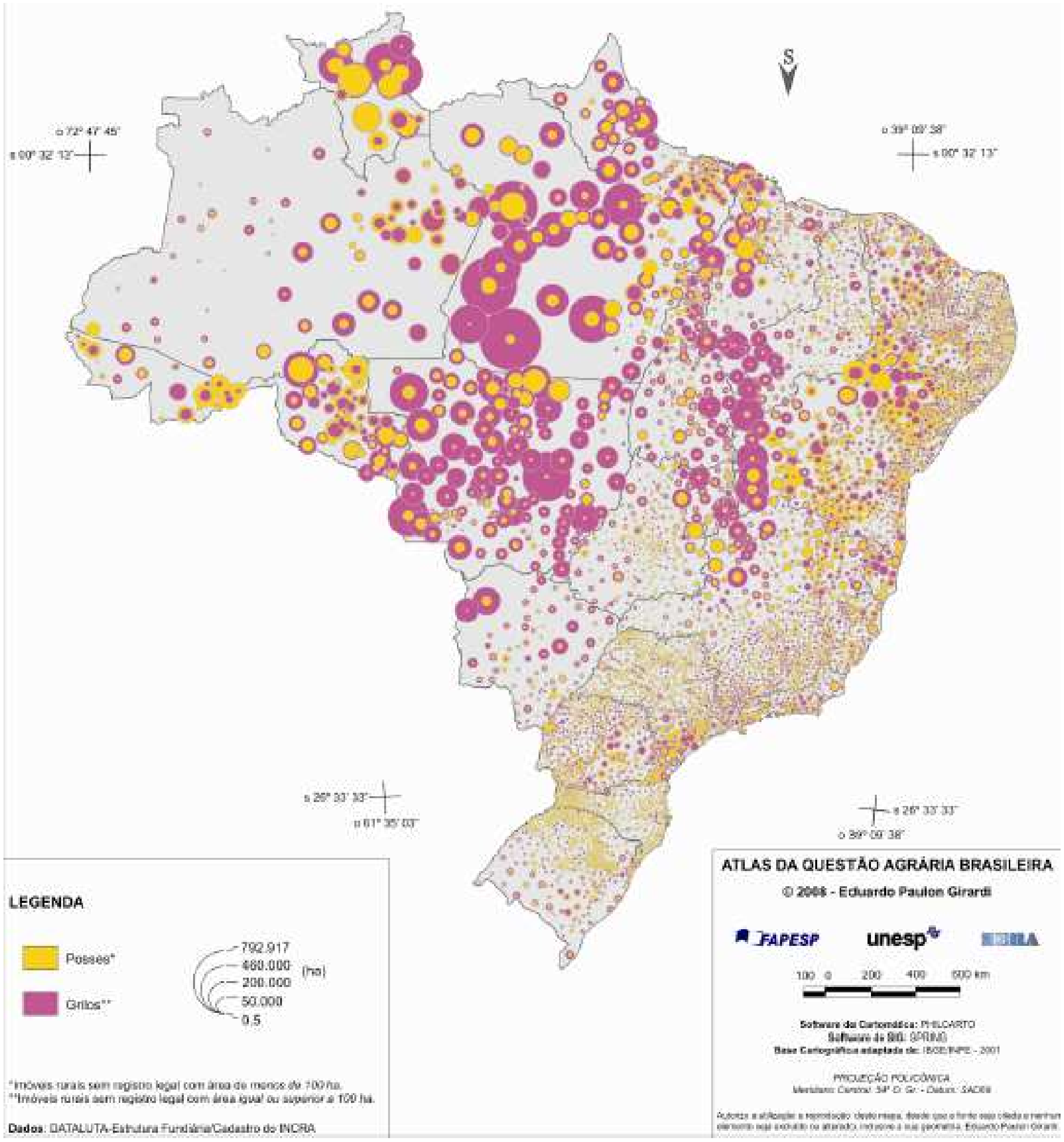


Figure I.2 – Location of land occupation (posse) and potential *grilagem* areas [from (Girardi, 2008)]

APPENDIX II

LAND REGISTRATION IN BRAZIL

II.1 Principles of the Registration System in Brazil

According to Santos [2006] registration principles are rules, criteria and fundamental ideas used as basis for the real estate registration system, unique to each country (and possibly state). Melo [2004] adds that one objective of the principles is to give the citizen maximum security thorough the act of registry. In Brazil the principles follow three main axes where, in each case, some sub-principles are found:

- principles about registration requirements,
- principles about the effects of registration and
- administrative principles of the register.

II.1.1 Principles about Registration Requirements

These principles describe what each *matrícula* should contain. They are subdivided in the following groups, which are further summarized in Figure II.1 [Carvalho, 1997; Diniz, 1992; Moraes, 2001; Pessanha et al., 2003; Santos, 2006]:

- ***Principle of Exclusivity (Rogação)*****:** only the parties involved can registrer rights;

- ***Principle of Information Availability (Disponibilidade):*** this controls the content and the quality of the information on;
- ***Principle of Continuity (Continuidade):*** except in case of new certificates of title (i.e., from land titling) a new registration is not allowed without a previous registration, and every registration requires mention of the original, and successive references (chain of title);
- ***Principle of Legality (Legalidade):*** this obligates the registry office to examine the previous title to give legal force to the transaction;
- ***Principle of Inclusion (Especialidade):*** the property and all of its contents are identified by its unique ID (*matrícula*). Since the *Law # 10.267/2001 matrícula* links the physical description of the parcel (e.g., surveying), cartography by INCRA and the legal description of the rights (e.g., s*erviços registrais*). According to this principle, the property registered at the s*erviços registrais* must be associated with a precisely defined and unique object (i.e., the parcel). This object is defined by the measurement of the property boundaries and corners.
- ***Principle of Uniqueness (Unitariedade):*** this indicates that one parcel should have a unique *matrícula* and each *matrícula* refers to a unique parcel.

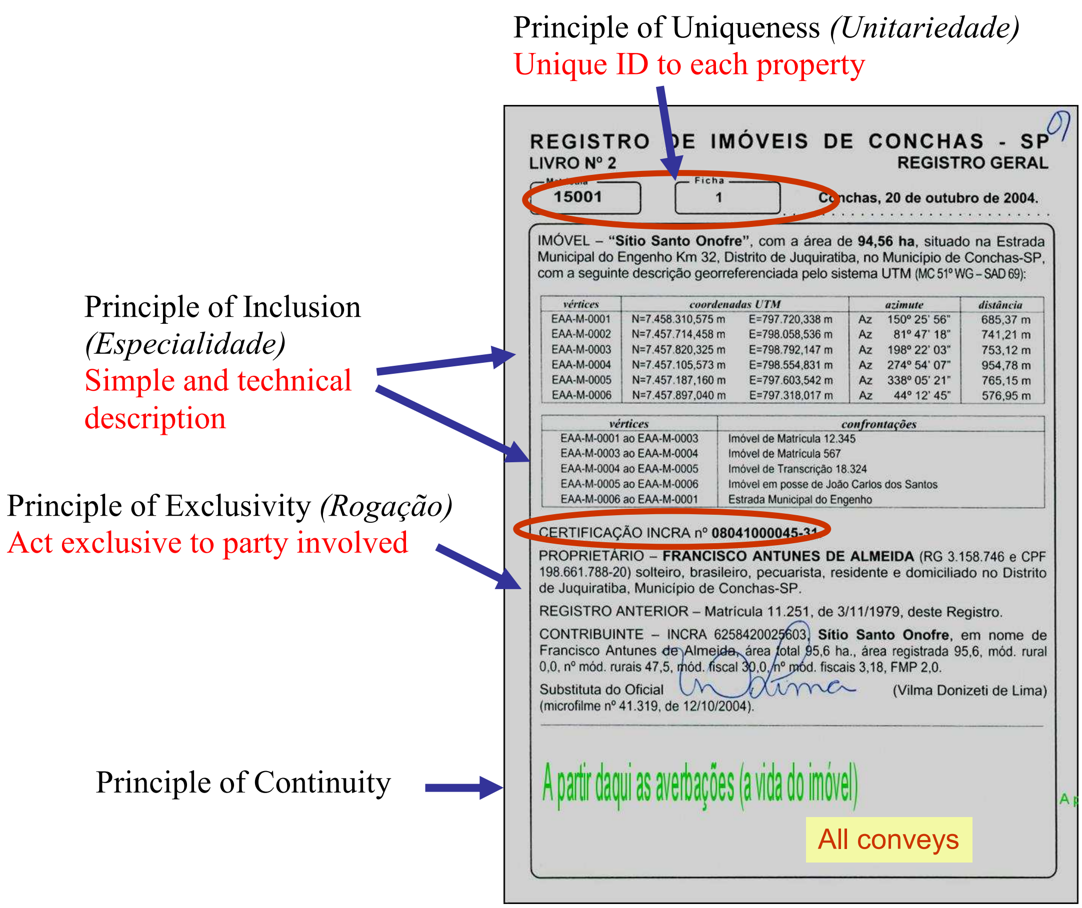


Figure II.1 – Summarized principles contained in each *matrícula* (from Augusto [2005]).

II.1.2 Principles about the Effects of Registration

- ***Principle of Publicity:*** this determines open access to the information in the certificates of titles [Melo, 2004]. It also creates public notice in the media for every transaction and gives notice to the third parties [Balbino Filho, 2001].
- ***Principle of Priority:*** during the registration act, the registration date and time must to be recorded. This principle determines that, in cases of dispute, the priority of the titles registered follows the chronological order of receipt of the documents. Using

the priority principle, no second transaction can be lodged during the following 30 days. In a case of several titles with several dates for the same property, the first registered title has preference [Melo, 2004].

- ***Principle of Inscription***: by this principle the creation, transmission and extinction of the real property rights can only happen by "*inter vivos*" acts through their registration at the registry office [Carvalho, 1997].
- ***Principle of Presumption***: Once the title is registered, the rights refer only to the person to whom it was assigned in registration; this is true for the creation, transfer, and the cancellation of rights [Balbino Filho, 2001].

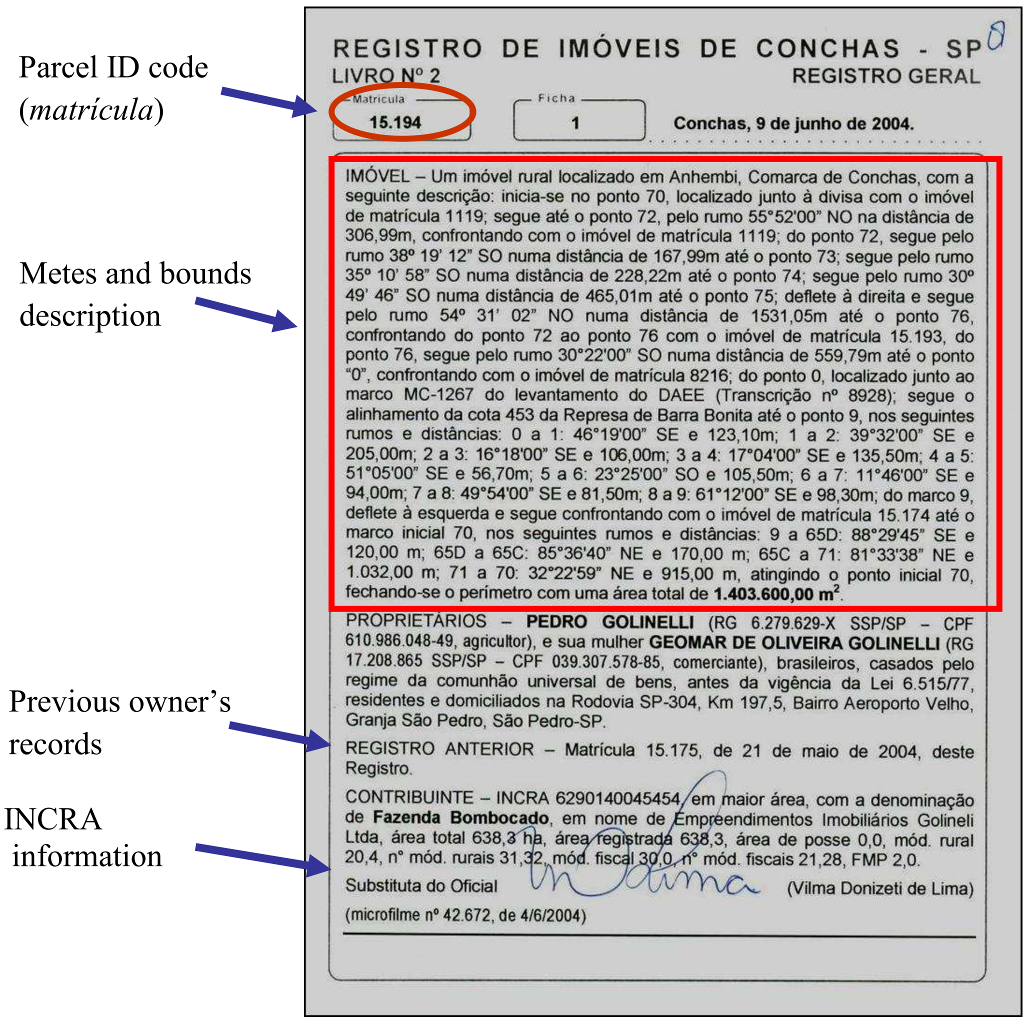
II.2 Parcel Identifiers at *Serviços registrais* (*Matrícula*)

According to Balbino Filho [2001], the system of *matrícula* (both numbers and folio) was created by *Law # 6,015/1973*. *Matrícula* is the unique number assigned to a parcel registered at the registry office. Each parcel can have only one *matrícula* assigned to it and each *matrícula* can only refer to one parcel. The subject of the *matrícula* is (are) the landowner(s), but the object of the *matrícula* is the parcel. One document of a transaction can refer to more than one parcel.

After the new *Law# 10, 267/2001* rural properties should be registered in the General Register Book at the *Serviços registrais* and *matrícula* should contain the following information as shown in Figure II.2 [Augusto, 2005; Carneiro, 2006]:

- The rural parcel ID code number (*matrícula*);

- The parcel metes and bounds description or a table with boundaries corners, co-ordinates in UTM, azimuths and distance, and adjoiners (*confrontantes*).
- Information about the previous owners and their registered *matrícula*; and
- INCRA information about the Certification of the Rural Cadastre (CCIR), area of the parcel and its boundaries.



REGISTRO DE IMÓVEIS DE CONCHAS - SP

LIVRO Nº 2 REGISTRO GERAL

Matrícula 15.194 Ficha 1 Conchas, 9 de junho de 2004.

IMÓVEL – Um imóvel rural localizado em Anhembi, Comarca de Conchas, com a seguinte descrição: inicia-se no ponto 70, localizado junto à divisa com o imóvel de matrícula 1119; segue até o ponto 72, pelo rumo 55°52'00" NO na distância de 306,99m, confrontando com o imóvel de matrícula 1119; do ponto 72, segue pelo rumo 38º 19' 12" SO numa distância de 167,99m até o ponto 73; segue pelo rumo 35º 10' 58" SO numa distância de 228,22m até o ponto 74; segue pelo rumo 30º 49' 46" SO numa distância de 465,01m até o ponto 75; deflete à direita e segue pelo rumo 54º 31' 02" NO numa distância de 1531,05m até o ponto 76, confrontando do ponto 72 ao ponto 76 com o imóvel de matrícula 15.193, do ponto 76, segue pelo rumo 30°22'00" SO numa distância de 559,79m até o ponto "0", confrontando com o imóvel de matrícula 8216; do ponto 0, localizado junto ao marco MC-1267 do levantamento do DAEE (Transcrição nº 8928); segue o alinhamento da cota 453 da Represa de Barra Bonita até o ponto 9, nos seguintes rumos e distâncias: 0 a 1: 46°19'00" SE e 123,10m; 1 a 2: 39°32'00" SE e 205,00m; 2 a 3: 16°18'00" SE e 106,00m; 3 a 4: 17°04'00" SE e 135,50m; 4 a 5: 51°05'00" SE e 56,70m; 5 a 6: 23°25'00" SO e 105,50m; 6 a 7: 11°46'00" SE e 94,00m; 7 a 8: 49°54'00" SE e 81,50m; 8 a 9: 61°12'00" SE e 98,30m; do marco 9, deflete à esquerda e segue confrontando com o imóvel de matrícula 15.174 até o marco inicial 70, nos seguintes rumos e distâncias: 9 a 65D: 88°29'45" SE e 120,00 m; 65D a 65C: 85°36'40" NE e 170,00 m; 65C a 71: 81°33'38" NE e 1.032,00 m; 71 a 70: 32°22'59" NE e 915,00 m, atingindo o ponto inicial 70, fechando-se o perímetro com uma área total de **1.403.600,00 m²**.

PROPRIETÁRIOS – **PEDRO GOLINELLI** (RG 6.279.629-X SSP/SP – CPF 610.986.048-49, agricultor), e sua mulher **GEOMAR DE OLIVEIRA GOLINELLI** (RG 17.208.865 SSP/SP – CPF 039.307.578-85, comerciante), brasileiros, casados pelo regime da comunhão universal de bens, antes da vigência da Lei 6.515/77, residentes e domiciliados na Rodovia SP-304, Km 197,5, Bairro Aeroporto Velho, Granja São Pedro, São Pedro-SP.

REGISTRO ANTERIOR – Matrícula 15.175, de 21 de maio de 2004, deste Registro.

CONTRIBUINTE – INCRA 6290140045454, em maior área, com a denominação de **Fazenda Bombocado**, em nome de Empreendimentos Imobiliários Golineli Ltda, área total 638,3 ha, área registrada 638,3, área de posse 0,0, mód. rural 20,4, nº mód. rurais 31,32, mód. fiscal 30,0, nº mód. fiscais 21,28, FMP 2,0.

Substituta do Oficial (Vilma Donizeti de Lima)

(microfilme nº 42.672, de 4/6/2004)

Figure II.2– Sample of registered rural parcel in a *matrícula* by metes and bounds (from Augusto [2005]).

Important information such as the characteristics of the parcel (boundary description, adjoiners, location, area and types of land use) must be clear and understandable in the *matrícula* to prevent future conflicts. Ideally, a *matrícula* should have information in tables and a graphic representation of the property. The boundary description must also agree with the previous description registered, except in cases when the parcel was subdivided, and a new description is created [Carvalho, 1997]. See Figure II.3.

The previous written description is used again in new transactions even if there has been a new survey.

REGISTRO DE IMÓVEIS DE CONCHAS - SP 01

LIVRO Nº 2 REGISTRO GERAL

Matrícula 15001 Ficha 1 Conchas, 20 de outubro de 2004.

IMÓVEL – **"Sítio Santo Onofre"**, com a área de **94,56 ha**, situado na Estrada Municipal do Engenho Km 32, Distrito de Juquiratiba, no Município de Conchas-SP, com a seguinte descrição georreferenciada pelo sistema UTM (MC 51º WG – SAD 69):

vértices	*coordenadas UTM*		*azimute*		*distância*
EAA-M-0001	N=7.458.310,575 m	E=797.720,338 m	Az	150º 25' 56"	685,37 m
EAA-M-0002	N=7.457.714,458 m	E=798.058,536 m	Az	81º 47' 18"	741,21 m
EAA-M-0003	N=7.457.820,325 m	E=798.792,147 m	Az	198º 22' 03"	753,12 m
EAA-M-0004	N=7.457.105,573 m	E=798.554,831 m	Az	274º 54' 07"	954,78 m
EAA-M-0005	N=7.457.187,160 m	E=797.603,542 m	Az	338º 05' 21"	765,15 m
EAA-M-0006	N=7.457.897,040 m	E=797.318,017 m	Az	44º 12' 45"	576,95 m

vértices	*confrontações*
EAA-M-0001 ao EAA-M-0003	Imóvel de Matrícula 12.345
EAA-M-0003 ao EAA-M-0004	Imóvel de Matrícula 567
EAA-M-0004 ao EAA-M-0005	Imóvel de Transcrição 18.324
EAA-M-0005 ao EAA-M-0006	Imóvel em posse de João Carlos dos Santos
EAA-M-0006 ao EAA-M-0001	Estrada Municipal do Engenho

CERTIFICAÇÃO INCRA nº **08041000045-31**.

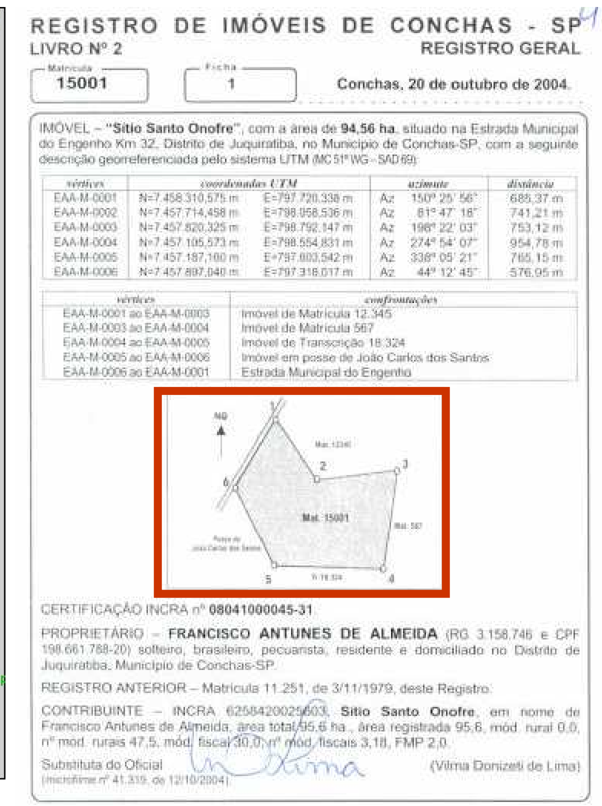
PROPRIETÁRIO – **FRANCISCO ANTUNES DE ALMEIDA** (RG 3.158.746 e CPF 198.661.788-20) solteiro, brasileiro, pecuarista, residente e domiciliado no Distrito de Juquiratiba, Município de Conchas-SP.

REGISTRO ANTERIOR – Matrícula 11.251, de 3/11/1979, deste Registro.

CONTRIBUINTE – INCRA 6258420025603, **Sítio Santo Onofre**, em nome de Francisco Antunes de Almeida, área total 95,6 ha., área registrada 95,6, mód. rural 0,0, nº mód. rurais 47,5, mód. fiscal 30,0, nº mód. fiscais 3,18, FMP 2,0.

Substituta do Oficial (Vilma Donizeti de Lima)
(microfilme nº 41.319, de 12/10/2004).

A partir daqui as averbações (a vida do imóvel)



REGISTRO DE IMÓVEIS DE CONCHAS - SP 01

LIVRO Nº 2 REGISTRO GERAL

Matrícula 15001 Ficha 1 Conchas, 20 de outubro de 2004.

IMÓVEL – **"Sítio Santo Onofre"**, com a área de **94,56 ha**, situado na Estrada Municipal do Engenho Km 32, Distrito de Juquiratiba, no Município de Conchas-SP, com a seguinte descrição georreferenciada pelo sistema UTM (MC 51º WG – SAD 69):

CERTIFICAÇÃO INCRA nº **08041000045-31**

PROPRIETÁRIO – **FRANCISCO ANTUNES DE ALMEIDA** (RG 3.158.746 e CPF 198.661.788-20) solteiro, brasileiro, pecuarista, residente e domiciliado no Distrito de Juquiratiba, Município de Conchas-SP.

REGISTRO ANTERIOR – Matrícula 11.251, de 3/11/1979, deste Registro.

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Substituta do Oficial (Vilma Donizeti de Lima)
(microfilme nº 41.319, de 12/10/2004).

Figure II.3 – Sample of registered rural parcels in *matrícula.* On the left the figure shows the description by table of co-ordinates, azimuths, distances and adjoiners. On the right the figure shows the graphic representation (from Augusto [2005]).

In cases of administrative error, corrections should be made at the registry office without damage to a third party. What happens if it does cause harm to someone – how is this resolved and the injured party compensated? In cases of fraud, a judicial rectification must be made [Carvalho, 1997]. In the judicial process any evidence (maps, aerial photography, satellite imagery, receipts, contracts, pictures of the property and so on) can be used to facilitate the judge's decision [Augusto, 2006].

The landowner is responsible for the information about location and the main characteristics of the property, and the surveyor for the technical data. Both the landowner and surveyor can be judged by civil and criminal law in case of error to a third party. The registrars can also be found negligent if fault on their part is proved [Augusto, 2006].

II.3 Importance of Registry System

Land itself is not property, property describes how the relationships among people with respect to land are defined and enforced [e.g., Nichols, 1993; MacPherson, 1979]. This legal phenomenon, property, produces economic incentives for society that support good governance of land and natural resources. If the property is at risk, these incentives will be diluted. Land registration helps reduce the risk land grabbing that is quite high in Brazil.

Land registration reflects best definition of property rights and provides the opportunity to obtain formal ownership, thus enabling participation in the formal economy. Registered titles are supported by law and can generate investment and secure credit. However, securing property and the benefits of property is not only a question of registration [De Soto, 2000], public policies must also be adopted to have local development [e.g., Jones, 1997; Jones, 2004a; Jones, 2004b; Carneiro, 2003b].

Generally, the registration of titles in the registry offices allow the governmental authorities to identify the owner of the property, where it is located, its size, as well as whether there are debts and the value of these debts associated with the property. The registration identifies who has the rights to access credit from banks or special governmental programs that can provide an improvement to the owner's quality of life. In theory, registration promotes more productive land use and supplies. It supports safe land transfers, program administration (e.g., enforcement of laws, targeting of incentives) and public land management [Carvalho, 1997].

Land title registration should be simple, reliable, prompt, and affordable and well suited to the society it serves [McEwen, 2001]. According to Palmer [1999], registration systems serve two major roles: as information providers and as protection providers.

As an information provider, the registration system should reduce asymmetry of information among the parties in a transaction and can help facilitate good governance by providing an information base for government duties and services. As protection providers, land registration systems serve to protect those who purchase property rights in good faith and to detect those who acquire the rights fraudulently. Ownership is demonstrated through registered title that is evidence against other claimants [Palmer, 1999].

The registration system also can facilitate transactions in land, and to enable land to be used as collateral for a loan. In turn, this collateralized credit could be invested as capital, increasing labor productivity and income [De Soto, 2000]. Registered land titles can also encourage investment by improving the transferability of the parcels and allow households to substitute present consumption and leisure into long-term savings in real property [Galiani and Schargrodsky, 2007].

The primary problem that prevents the democratic and productive access to land in Brazil is the lack of registered property rights. Property rights signify the legitimacy of land occupation through formally recognized land titles.

II.4 Historical Description of the Register in Brazil

The first land registry occurred in 1846, and it was only for mortgaged properties (*Decree # 482/1846*) [Philips, 2008]. As a consequence of Land Law (*Law# 601/1850*) a parish register (*Registro do Vigário*) was created by *Decree# 1,318/1854*. This registry was established for statistics proposes, and did not secure property rights [Balbino Filho, 2001]. This registration was at the county level and gave the priest primary decision-making power, including allocation of land. Without the objective oversight of government and transparent procedures the issue of fraudulent but "registered" documents arose. Jacomino [2006] explains that the parish registers had notorial but not registration characteristics.

The general registry was created by *Law # 1,237/1864*. This law determines that property rights were *inter vivos* occurring with the registration of the title and with onus on the rights holder to register. Inheritance rights also must be registered to have legal effect [Carvalho, 1997; Arruda, 1999; Erpen and Paiva, n.d.].

A system of Torrens title registration was instituted in Brazil in 1890 (*Decree # 451-B*) without much success. Reasons for the lack of success include the fact that citizens did not know about the benefits of state guaranteed title, as well as the high costs and bureaucracy of running the system [Arruda, 1999; Moraes, 2001]. According to Erpen and Paiva (n.d.) Torrens title registration only occurred for rural properties and it was optional.

Under the 1916 Civil Code, *Serviços Registrais* or *Cartórios de Registro de Imóveis* were established to operate real estate registers (by Law of Public Registers (LRP), *Law # 6,015/1973)*. These are private offices run by private notaries, but under governmental regulations. The Law of Public Registers reorganized the books of the notorial registration system and the identification of the parcels by *matrícula;* it is both parcel identifiers and the folio. [Andreade, 2000; Melo, 2004]. As Philips (2008) argues that in the *matrículas* there were only written declaratory boundary descriptions without any standards for quality or precision. As a consequence, there was a high risk of boundaries overlap. Erba and Carneiro (2008) also explain that before the Law of Public Registers, land registration was made by registration consisted of chronological filing of documents. With the establishment of the Law of Public Registers the real property folio system was designated (i.e., conveyances are organized by parcel, see Figure II.4). In practical terms, there are three main characteristics of the real property folio system [Diniz, 1992; Carvalho, 1997; Santos, 2006]:

- The information is indexed by parcel and not by the parcel owner' name;
- The property record contains the entire history of the property; and
- Each *matrícula* corresponds to a single parcel and each parcel has its own record.

As discussed in Section 3.5, a parcel is defined at *serviços registrais* as the concept of real property *(propriedade imobiliária*), which considers ownership.

Figure II.4 – Example of the *matrículas (from [2º Registro de Imóveis de Araraquara/SP*, June 2008], Credit: Fernando Jardim).

According to the 1988 Brazilian Federal Constitution (article 236), registry offices for real estate (s*erviços registrais)* comprise a notarial system (i.e, private rather than state operated). The public registries, including notorial and registry services, are corporate to the public administration, even having a private character. Bona (1996) explains that the term private is connotative because it is related to the financial aspect of the service; the remuneration of the employees and costs with the services are recovered by the taxes collected from the citizen who request the services. On the order hand, the federal government regulates and controls the services.

It also means that the title is created by the notary professional and registered by the registar. But, by *Law# 8,935/1994*, these s*erviços registrais* are controlled by the Ministry of Justice which also creates technical regulations to standardize legal transactions [Carneiro, 2003a]. The 2002 Civil Code (articles 1,245 to 1,247) reinforces the importance of the s*erviços registrais* by establishing that - **property rights do not exist if the property is not registered** [Melo, 2006].

The registration services in Brazil are decentralized by county (i.e., each property must be registered in each county where the property is located) as prescribed Law of Public Registers. An exception exists for properties lying in two adjoining counties; in this case the property should be registered in the county which contains the larger portion [Balbino Filho, 2001; Erpen and Paiva, n.d.].

The Law of Public Registers also subdivides registration services into five different books [Carneiro, 2003a]:

- ***Book 1 - Protocol:*** records the order of general reception of the documents and establishes priority;
- ***Book 2 – General Register:*** records the description of real property rights, including the refernce of the cadastral plan and parcel description of the real estate, and is indexed by ID (*matrículas*);
- ***Book 3 – Auxiliary Register:*** transcribes the documents in the General Register. Even though it is not directly concerned with validating real rights, this book provides public notice of the documents at the registry;
- ***Book 4 - Real Property Index:*** a real estate index where ownership information can be located by ID (*matrículas*);
- ***Book 5 - Personnel Index:*** an index by the owner name used to identify *matrículas.*

In the Federal Constitution of 1988 (Article 5, XXII and XXIII and Articles 184 and 186), property rights are tied to the 'principle of effective use' based on the idea of social function. These articles are regulated by *Law # 8629/1993* which guides the Brazilian Agrarian System. The concept of social function was inherited from part of the Land Statute of 1964 [Ramos Filho and Aly Junior, 2005].

APPENDIX III

DESCRIPTION OF THE CURRENT CADASTRAL SYSTEMS

This appendix describes each current land information systems of the CNIR collaborating agencies in terms of system functionality and description, including data flow process, main data input/output and accessibility of the system; historical factors; related system problems; agencies' expectation for CNIR implementation and their perspective about difficulties for CNIR structural implementation. The CNIR collaborating agencies are listed below. The potential data relationship at CNIR from each particular system is found in Appendix VIII; the cognitive graphics are based on the results of the user requirements.

- ***Environmental agencies* -** IBAMA (ADA cadastral system) and SFB (CNFP cadastral system);
- ***Agrarian agency* -** INCRA (SNCR cadastral system);
- ***Public lands agencies* -** FUNAI (SIT cadastral system) and SPU (SIAPA cadastral system);
- ***Statistical agency* -** IBGE (CNEFE cadastral system);
- ***Fiscal agency* -** RFB (CAFIR)

III.1 Environmental Cadastre

a) ADA - Environmental Declaration Act of ITR (*Ato Declaratório Ambiental*)

Location: General Department of Forest Resources, Brazilian Institute of Environment and Renewable Natural Resources (IBAMA)

1. Respondents

- José Humberto Chaves – General Coordinator of the Forest and Flora Resources Use
- Carlos Fabiano Rozindo Cardoso – Coordinator of the Forest Control
- Renato Gomes Fuscaldi – System Analyst of the Telematics National Center (CNT)

2. Function of the land information system

To get tax reduction by declaring their lands as environmentally protected areas under ADA. Also in theory, ADA stimulates the preservation and protection of forest and any other vegetation form.

3. Responsibility for system

- ***IBAMA local level -*** collect the ADA declaration in analog format and assistance to the landholder;

- ***IBAMA federal level* -** management of ADA database, political decisions and data access control;
- ***Local technology support, National Center of Telematics (CNT)* -** design tools for the software and its contents. The designs and contents must be approved by IBAMA.
- ***Private technology support, Brazilian Telecommunications Company (EMBRATEL)* -** storage and backup the IBAMA's database. Additionally, EMBRATEL implements the tools of the systems and gives technical support to IBAMA.

4. History of the ADA

The Environmental Declaration Act (ADA) is a legal instrument created in 1996 that allows the rural landholder to get tax reductions through the Rural Property Tax Income System (ITR – *Imposto Territorial Rural*) by *Law # 9,393/1996*. The act requires registration, control, and inspection of areas of environmental interest on rural properties.

From January 1st to September 31st of each year, the ADA system is open to the users. It is the same period that RFB opens the ITR system [Normative Instruction 76/2005]. The RFB receives the reports made by IBAMA. This information is for the previous year. By 2008, RFB had received the 2004 report from IBAMA. IBAMA does not receive any information back from RFB.

5. Brief description of the system

The system has just descriptive components. Data is declared by the rural landowner who holds areas of permanent preservation (APP) and areas of limited use such as legal reserve (RL), private reserve of the natural patrimony (RPPN), area of ecologic interest (AIE) and area of forest easements (ASF). These areas must be declared and registered at the *serviços registrais*. Another type of ADA user is the rural landholder who has areas of re-forestry (REF) and sustainable forest management (PMFS).

The applicant can declare ADA directly through the internet or at the local IBAMA office. According to the *Normative Instruction # 76/2005*, the majority of the data is declared in digital format, but analog format has been accepted:

- ***Both systems -*** for the status of people with properties smaller than 100ha;
- ***Digital system*** - for the status of people with properties equal or bigger than 500ha in Northern Brazil and 100ha for other regions in Brazil;
- ***Digital system*** - for juridical persons independent of the area.

At the data control, the declared information is checked and field inspection may occur. ADA also checks an external database called Federal Technical Cadastre (CTF) composed of two cadastres: the potential pollution activities or environmental resources cadastre and the activities and instruments for environmental defense cadastre [*Law #6,938/1981*]. This CTF cadastre is checked to ensure that a rural landowner will not be a beneficiary of the property tax reduction if he is a potential polluter. The collected data is stored in the IBAMA database physically located at EMBRATEL. The RFB has access to this data to authorize the tax reduction. Via access to RFB database, INCRA indirectly updates its SNCR system, as shown in Figure II.1. By sample, IBAMA recalculates the declared areas to check the validity of the total area [*Law # 6, 938/1981*]. The information is available for management use and no report is produced with this data.

The ADA system has its database running in Oracle and its requests are constructed in SQLServer**.** The web service exchanges the information via PHP and currently there is no policy to use XML on IBAMA systems for internet applications.

6. Existing process

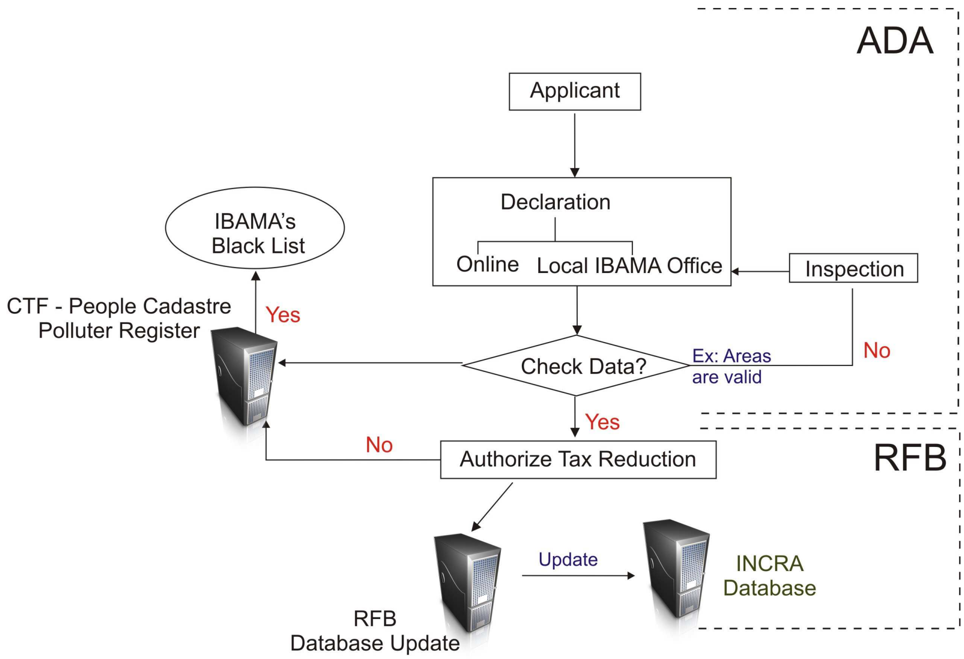


Figure III.1 – ADA existing process

7. Data input/output

The layers of information that could be provided to CNIR include information about:

- Personal identification of the landowner;

- Location of the property and its geographic co-ordinates (lat/long), when collected;
- CTF number - number of the people cadastre registration at the IBAMA;
- NIRF number - number of the property at the RFB;
- Total area of the rural property;
- Area of the Forest:
    - Permanent preserved area;
    - Area of legal reserve;
    - Area of private reserve of the natural patrimony;
    - Area of ecologic interest;
    - Area of forest management;
    - Area of reforestation for natives or exotic plants;

Also the area of the forest has its legal documentation linked, to the name of the *serviços registrais*, number of the property ID (*matrícula*), year, book and pages where the area was registered. Additionally, there is the number of the documentation issued by any environmental entity and the pertinent legislation. There is also information contained at people name cadastre (CTF) that may interest some collaborating agency.

The data output is a summary of the collected data and certificates of the declared forest areas by year recognized under ADA. There is not any description of the ADA systems as a software design project neither as metadata.

8. Access

With the ADA system, each rural property is associated with a NIRF number (RFB) that, as a consequence, must have one declared ADA. There is an internal sequential code to the ADA registration. The NIRF number (at RFB cadastre) or the CCIR number (at INCRA cadastre) can be used for the information request because both exist on the forms. Only the CCIR number is not obligatory to be given in ADA. The CPF, CNPJ, co-ordinate (Lat/Long) are also information that probably can be used as a primary access key.

ADA has internal use at IBAMA and its regional offices. Internally, the team of the General Department of the Forest Resources has full access to the ADA database; they are in charge of selecting who will have access to the system and at which level. The access is made by employee CPF as login and password. When someone enters the system, the history is recorded. External users also can have online access to their own declared land information and also to the certificate of the declaration. To declare under ADA, access is made under the website <http://www.ibama.gov.br/cogeq/index.php?id_menu=76>. The external user must have the # CPF, # CNPJ or # CTF to enter in the ADA system. Database backup is made by EMBRATEL daily.

RFB and INCRA have a technical cooperation agreement with IBAMA. There is also an exchange of information with other environmental entities mainly in the Amazon Region. Until now, there has just been internal use of the ADA information.

9. Problems found at ADA

- ***Low declaration rate -*** The landholders are afraid to give up the environmental information because a property inspection could occur;
- ***Lack of knowledge of ADA -*** There is no massive publicizing about the importance of ADA; the landholders still do not know about the benefits that ADA could bring through tax income reduction;
- ***Lack of institution's local capacity -*** There is no capacity at IBAMA's local level to support the demand of ADA in analogical format;
- ***Electricity instability –*** there is a problem of power supply at IBAMA that disrupts the computer system.

10. Improvements to help solve ADA problems

- ***Publicity dissemination -*** The capacity for publicizing ADA was increased by a INCRA, RFB and Family Agriculture Workers Federation (FETRAP) collaboration in distributing folders and banners to landholders; also the media is starting to advertise the ADA's benefits. Another important step was made by RFB when information about the annual ADA declaration was included in the ITR manual. The RFB also has a field in the ITR system available to put the ADA protocol number.
- ***Data processing –*** In 2003 an online system was created to facilitate the ADA data processing and the growth of the ADA registration.

11. Expectation about CNIR implementation

The General Department of Forest Resources expects to know the rural properties which are not registered at ADA but are registered in other institutions. In their point of view, CNIR will update their record. They also hope that in two more years the institutions will be able to share land information.

12. Difficulties for CNIR structure as explained in Section 5.2

- Heterogeneity of the definition of Rural Property
- Lack of spatial data
- Data incompleteness

b) CNFP - National Cadastre of Public Forest (*Cadastro Nacional de Florestas Públicas*)

Location: Brazilian Forestall Service (Serviço Florestal Brasileiro - SFB), Ministry of Environment (MMA)

1. Respondents

- Gustavo Chaves Machado – Executive Manager
- Luiz Pacheco Motta – Coordinator of the Foresty Identification Service

2. Function of the Land Information System

To determine the area and location of public forests that are under federal, municipal and state responsibility to better designate the use of these areas.

3. Responsibility for System

- ***SFB -*** management of CNFP database, political decisions and data access control; collect the ADA declaration in analog format and provide assistance to the landholder;
- ***Local technology support, National Center of Telematics (CNT) -*** design tools for the software and its contents. The design and content must be approved by IBAMA.
- ***Private technology support, Brazilian Telecommunications Company (EMBRATEL) -*** store and backup IBAMA's database. Additionally, EMBRATEL implements the tools of the systems and gives technical support to IBAMA.

4. History of the CNFP

The CNFP cadastre, created in 2006, has been used to support the use of community forests, to create conservation units and to create forest concessions. Also it offers mapping of the Brazilian public forests to managers of the public administration and to society at large; it classifies the forests that are inside public lands and archives the areas where forests have been lost. The cadastre includes forests which are located on indigenous land, federal conservation units (for restrictive use or sustainable use), forests located in rural or urban areas of federal lands and forests in military areas [Public Forest Law - *Law # 11,284/2006* regulated by *Decree # 6,063/2007*].

5. Brief description of the system

According to the *Decree SFB # 2/2007* which defines the CNFP, the CNFP has been planned to be integrated into CNIR. To better structure the CNFP, SFB subdivides the cadastre into two parts: one is the Cadastre for Federal Forests and the other is the Cadastre for State and Municipal Forests.

With the Cadastre for Federal Forests, both forests which are located in indigenous land and federal conservation units must be recorded. Forests are classified as:

- ***Public forest A (FPA)* –** forests with public dominion and specific use;
- ***Public forest B (FPB)* –** forests with public dominion but without specific use;
- ***Public forest C (FPC)*** – forests defined as property and they were not identified by Brazilian Forestall Service. The inclusion of FPC forest type on the Cadastre for Federal Forests must be communicated to INCRA, SPU and State Land Institutes.

The federal forests must be registered at the s*erviços registrais.* The Brazilian Forestall Service is also in charge of transferring the registration content to the *matrícula* issued by the s*erviços registrais* to the forest's managing agency.

Cadastre for State and Municipal Forests has state administration, and it may differ from state to state inside Brazil. The information about the forest classifications are detailed and inputted by local agencies. According to the *Decree SFB # 2/2007* the information must be based on:

- *Matrícula* number - number of the property at the s*erviços registrais* and respective s*erviços registrais*' information;
- Location of the forest (municipality and State);
- Geo-referencing perimeter;
- Type of biomass;
- Reference of studies done on public forests related to removable natural resources or non- removable;
- Use of public forest;
- Indication of land possession in the public forest area;
- Indication of land or social conflict in the public forest area;
- Legal documentation such as certificates, normative, acts or any administrative contract related to the forests;

As a new cadastre, the Cadastre for State and Municipal Forests contains information about the north of Brazil, mainly Amazônia, Amapá, Acre and Pará. This system has a descriptive and graphical component which is updated by federal and local agencies. The basis for the graphical data is the topographic maps produced by IBGE and Military Service (DSG) at scale 1:250,000 or smaller. Also the type of vegetation and the forest characteristics follow the IBGE definition [*Decree SFB # 2/2007*].

CNFP has the database running in Oracle. There is not metadata or any standard being used. For GIS they are using ArcGis from ESRI.

6. Existing process

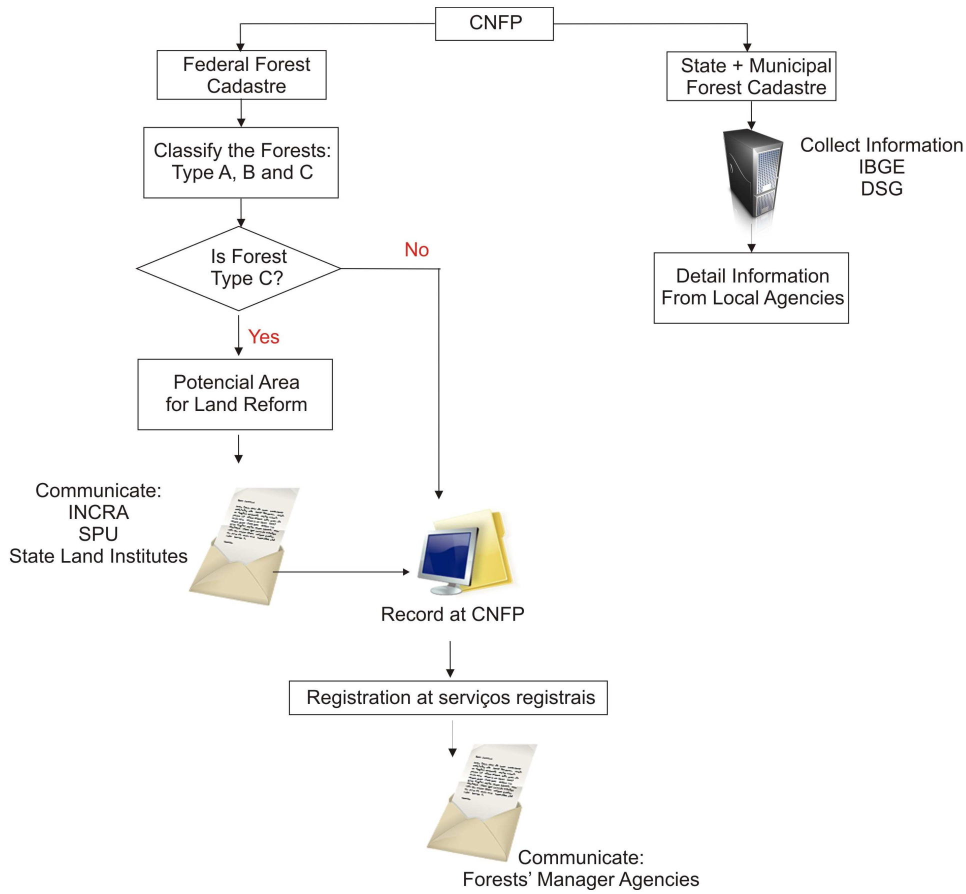


Figure III.2 – CNFP existing process

7. Data input/output

The data input is a mix of graphical and descriptive information. CNFP cadastre contains satellite images that are used to delineate forest areas and information related to forest management. Spatial data is from SIVAN (Amazon), IBGE and DSG, all of them with SAD-69 as datum. To complement the database, other land information was collected from FUNAI (Indigenous Lands), IBAMA (Federal Conservation Units - UCs) and INCRA (settlement projects and land without use).

CNFP contains the following information:

- Location of the forest;

- CNFP number - number of the public forest at MMA;
- Type of public forest and its use;
- Total area ;
- Information acquired by other agencies
    - Name of the institution;
    - Name of the land;
    - Number of the Legal documentation;
    - Percentage of the land that belongs to the institution's cadastre;
- Type of Biomass

The output is an on-line summary of the collected data and certificates of the CNFP registration. A GIS system is also provided under MMA's website based on free software. The link to the interactive map is found at the website < http://mapas.mma.gov.br/i3geo/aplicmap/geral.htm?o1j15opqj24d669s6nh4e4edt4 >. There is not any description of the CNFP systems as either a software design project or as metadata.

8. Access

The code to identify the public forest is created by computer and is associated with the centroids of each polygon by geographic co-ordinates (GMS). The code itself is 3 characters for the type of the public forest (A, B or C), and other characters for the geographic co-ordinates (e.g., FPA-5534967W-451436S). The data is available to users by intranet and internet, but with different access permission to the portal. For the Federal level, CENAFLOR (MMA) has open access. For the state level, just the data that each region works with can be modified, even though all data can be consulted. The verification of the user access can be made by the history of the transactions that are kept.

Any user can consult the CNFP database online at the website < http://www.mma.gov.br/applications/intermanager_internet/index.php?ido=florestaPublica.exibe&idEstrutura=95 >. There are multiple searches choices, including by municipality, type of biomass, type of forest use and type of public forest. Database backup is made by EMBRATEL daily. Although CNFP collects data from IBAMA, FUNAI and INCRA, there is not a formal agreement for that.

9. Problems found at CNFP

- ***Data Inconsistency*** **–** because area is calculated from maps from different institutions using different map projections and methods, information about area may be inconsistent.

10. Improvements to help solve CNFP problems

- During the delineation stage, the polygons are drawn carefully on satellite images to minimize the distortion of the area value.

11. Expectation about CNIR implementation

The Forest Service aims to have aggregated land information acquired from many other institutions to know more about the characteristics and dynamics of the rural lands.

It will help them to identify what could be public land or not. In reality, this kind of information is unknown by INCRA.

12. Difficulties for CNIR structure as explained in Section 5.2

- Lack of operational support;
- Access to the information;
- Potential inconsistency of data (compared with other sources)
- Different map scales and precision;
- Politics

III.2 Agrarian/Land Regularization Cadastre

c) SNCR - National System for Rural Cadastre (Sistema Nacional de Cadastro Rural)

Location: General Coordination of the Rural Cadastre (DFC), National Institute of Colonization and the Agrarian Reform (INCRA)

1. Respondents

- Luciméri Selivon – General Coordinator of the Rural Cadastre
- José Kleber Costa Pereira– Manager of the Cadastral Statistics Studies Nuclei
- Josias Vieira Alvarenga – Manager of the Foreign Owners Department
- Regina Coeli Cunha Craveiro - Manager of the SNCR Cadastre

- Otávio de Almeida Fernandes – Technical Assistante
- João de Abreu Filho - Technical Assistante

2. Function of the Land Information System

To manage land information for land reform and agrarian land management.

3. Responsibility for System

- ***INCRA local level*** - collect the rural property declaration (DP) in analog/digital format and assistance to the landholder;
- ***INCRA federal level -*** management of SNCR database, political decision and data access control; management of the graphical SNCR data.
- ***Public technology support linked with Ministry of Finance, Federal Service of the Data Processing (SERPRO - Brasilia) -*** design tools for the software and its contents. Storage, maintenance and backups of the SIAPA database.

4. History of the SNCR

In 1972, the National Rural Cadastre System (SNCR) was created by *Law# 5.868/1972* with a declaratory description for fiscal proposes. The purpose was to get information about the use and occupations land. In 1978, the information in the cadastral system was updated by a new declaration processes, which permitted developing some indicators of the social - economic situation of the rural peasants [Costa and Loch, 2004; Carneiro, 2003a; INCRA, 2000]. According to Carneiro [2003a], SNCR is important to meet the following specifics objectives:

- Collect data for microeconomic analysis, for technical and credit orientation and for systematic survey;
- Have a real knowledge of the land temporary use;
- Guide line for national and regional land reform programs;
- Have knowledge about effective land distribution and land concentration, as well as, land occupation (*posse*);
- Help the systematic survey of the public lands (federal, provincial and municipal).

Even the SNCR attributions designated by INCRA were [INCRA, 2000]:

- To record descriptive data of the rural properties and its relationship;
- To record the land use to classify rural properties;
- To grant rural property certificates (*Certificado de Cadastro do Imóvel Rural* – CCIR);
- To support activities to acquire rural properties and its subdivision.

5. Brief description of the system

SNCR data flow starts when a landowner or a land occupant fills out the declaration for rural properties record (*Declaração para Cadastro de Imóveis Rurais – DP*). This declaration contain forms that were created by INCRA normative # 08/2002, they are [Carneiro, 2003a]:

- ***Structure form*** **–** area, juridical situation, location of the property;
- ***Land use form*** – type of the land use, and;

- ***Personal form*** – relationship between the land occupants and the properties, their personal identification.

DP declaration forms must be delivered at the local INCRA office (*Unidades Municipais de Cadastramento - UMC).* Each UMC is responsible for analyzing the processes and sending them to the INCRA regional office in each capital. Each regional department is in charge of processing and storing the SNCR database at SNCR/WEB applicative via intranet [TCU, 1999].

During the data processing, critical analyses of the SNCR data are made. It is limited to confirming internal coherence and the completeness of the information declared at the DP (For example: personal identification of the occupant and the total area of the property with all parcels that it contains). The data is subdivided into descriptive and graphical data. The graphical produced on maps verify the information. At the same time the descriptive data is typed.

If the information is complete and confirmed then INCRA issues the rural property certificates (CCIR). CCIR was constituted by *Law # 5,868/1972* and regulated by *decree # 72,106/1973*, includes all the data on a given property in terms of its physical features, geographic location, use of the land, and information on the persons in occupation of the property [Carneiro, 2003a].The certificate is a legal prerequisite for any change in the rights to a property, including mortgage, sale, or leasing, and must be registered in the *serviços registrais*according to the *Law # 10,267/2001*.

At INCRA, there is also mobility of the SNCR system. The SNCR/PGD application enables the INCRA's mobile notebook user to download some specific software or download property records at the SNCR/Portal and to work at SNCR when the system is offline. This is possible because of the Declaration Program (PGD - *Programa Gerador* *de Declaração*). Once the notebook is connected again to the internet, then data can be sent to the SNCR/Portal. At SNCR/PGD there is a local validation system which confirms if the declaration was accepted by INCRA. The INCRA employee can also go to the field with a personal data assistant (PDA) and use the PGD mobile. Once the PDA is connected on the notebook, then the data can be again uploaded.

The Federal Revenue Service (*RFB*) can consult the SNCR/Portal to obtain information contained at the DP declaration to generate the property taxation (*Imposto sobre a Propriedade Territorial Rural – ITR*), according to the *Law # 8,022/1990*. There is a communication between RFB and *serviços registrais* under the declaration for real estate operations form (called DOI) to exchange data of fiscal events.

SNCR was first developed in 1992 by SERPRO using Natural programming and ABADAS as database architecture. In 1997, the database was migrated to Oracle and SQL Server where descriptive and graphical data were part of the SNCR structure. INCRA uses Geomedia (Intergraph) to publish the geospatial data. The system runs at the commercial time. The backup is made every day, weekly and annually. The data is copied simultaneously in to two different databases; one that cannot be edited and another that allows modification.

6. Existing process

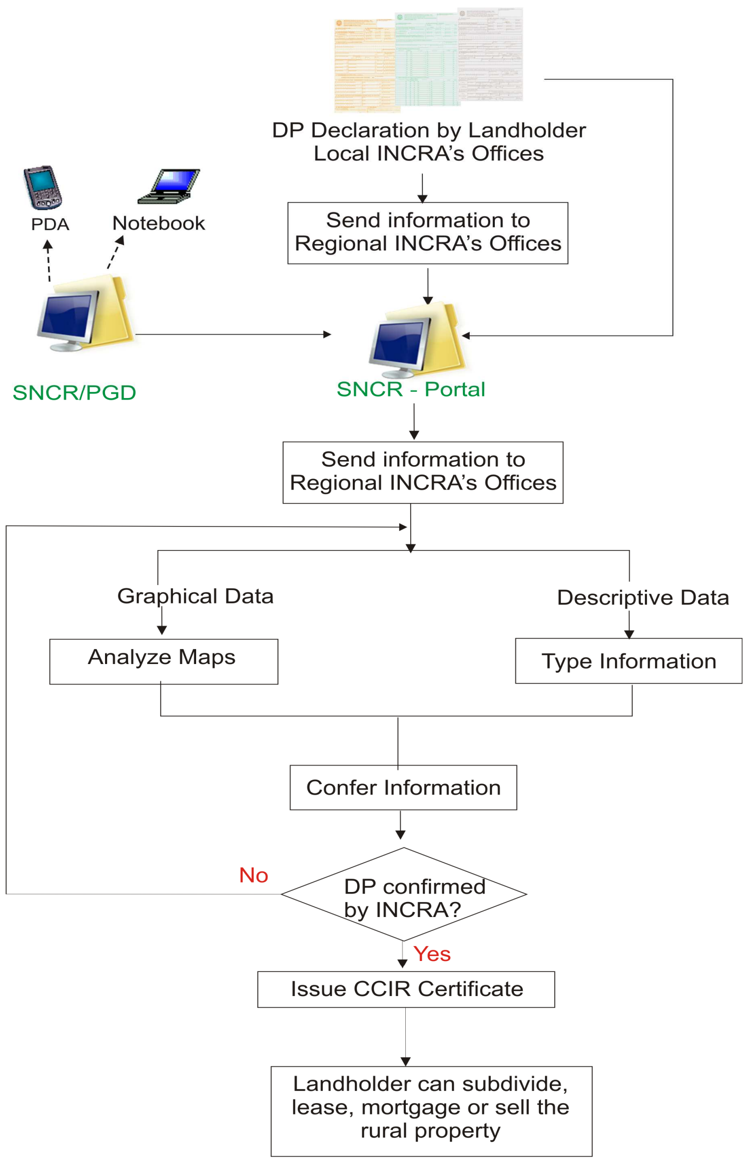


Figure III.3 – SNCR existing process

7. Data input/output

The descriptive data contained in SNCR reflects the three forms that compose the Declaratory Rural Property Cadastre (*DP - Declaração para cadastro de Imóvel Rural*). In general, the information is:

Land relationship form:

- Personal identification of the landowner or juridical person;

- CCIR number - number of the rural property certificates at the INCRA;
- Information about the ownership status;
- Main exploration activity and its legal status.

Land use form:

- Location of the property;
- Information about the crop product in isolated and rotative area;
- Information about the animal exploration;
- Area of the restrictive area:
    - Area of legal reserve;
    - Area of permanent preserved area;
    - Unuseful area;
    - Area of Atlantic forest;
    - Area of protect forest;
    - Area of ecological interest;
    - Area with restrictions.

Land structure form:

- NIRF number - number of the property at the RFB;
- Code of the property subdivision/joiner and its area;
- Juridical situation of the property
    - Information about *Serviços registrais* location;
    - *Matrícula* number - number of the rural property registered at *Serviços registrais*;
    - Number of the book and date of the registration;

- Area of the registered;
- Type of occupation;
- Number of families resident;
- Number of formal and informal workers;
- Land Market:
  - Property value;
  - Value of the property improvements;
  - Value of the crops and cultures;
  - Value of the crude land.

The data output is a summary of the collected data for land use to support land reforms programs and the rural property certificate (CCIR). Based on INCRA's needs, SERPRO developed the Capability Maturity Model (CMM) to aid the definition and understanding of the SNCR organization processes. SERPRO has been customizing the program for the Brazilian reality. The macro view of the INCRA's needs is described in a main document without many details. With this document elicitation requirement is created. It is composed of uses cases and business rule solutions where the format and validation of the tools are determined by INCRA's managers. The SNCR's Distributed Resource Sharing Software (DRSS) is also created to identify which requirements can or cannot be functional in the SNCR system. The migration is helped by metadata ETL/ETC (extract, transform, load).

8. Access

The Property ID in the SNCR system is the CCIR number composed of 13 characters generated by the computer. The data can be available to the users by intranet (INCRA's internal users) and internet (worldwide user). The worldwide user and INCRA have different access permission levels to the SNCR/Portal. There is a public area, where the information is open to all users because the data is aggregated, and there is the restrictive area, where the user must to be registered at INCRA to have access to the information. Everybody must be assigned to level of responsibility because confidential issues. External users just have access to the SNCR Portal under the website <http://www.incra.gov.br>.

The access is controlled by the SNCR/ADM system that is also connected with the Revenue Service (RFB) to verify the taxpayer personal identification number (CPF). The verification of the users' access can be made by history of the transactions where the # CPF, # IP address, time of the access and the used time are kept. Actually INCRA has agreements with City Halls, State Land Institutes (*OTE – Institutos Estaduais de Terra*) and Tributary Controller Ministry (*CGU - Controladoria Geral da União*). There will also need to be formalized agreements with FUNAI, IBAMA, Retirement Institute (*INSS - Instituto Nacional do Seguro Social*), Ministry of the Integration (responsible for the Sao Francisco River diverting project). INCRA also receives land information from RFB and IBGE through formal agreements.

9. Problems found at SNCR

- ***Lack of spatial information -*** The spatial information should be improved because there is not an agrarian map at cadastral scale; also sufficient rural properties have been surveyed according to the *Law #10.267/2001* with 0.50m of precision.

- ***Integration tool -*** The integration system is still in development; it will provide the possibility of exchange of information with other institutions.
- ***Data validation*** **–** There is a need to implement better verification in the system to minimize errors of spelling and accentuation.

10. Improvements to help solve SNCR problems

- ***New technology*** **–** There are two tools in development at SNCR system: the Data warehouse and an integration system which will allow the interoperability among other systems in/out of INCRA.

11. Expectation about CNIR implementation:

To INCRA, the implementation of CNIR has brought many expectations:

- ***Data duplication*** **–** CNIR will eliminate isolated land cadastres which have common information; once it has been integrated it will minimize or eliminate inconsistent information that is declared at all institutions by the landholder;
- ***Data update*** **–** Ideally there is a need to use data from the agrarian census (IBGE) to update INCRA's database.
- ***Data integration*** **–** From RFB, INCRA wishes that with CNIR there will be cross validation of the INCRA database with the RFB database to determine unknown rural properties. From the *serviços registrais*, CNIR is expected to help them to have more knowledge about *Law# 10,267/2001*. The connection with the *serviços registrais* will also help INCRA to identify better the nationality of the landowners. From the other institutions such as RFB and IBAMA and so on,

INCRA expects to optimize and to control land certificates issued by them. Even inside INCRA, there are some sub-systems that should be linked at CNIR, such as the Land Reform System (*SIPRA- Sistema de Informação para Projetos de reforma Agrária*). This gives support to the land settlements programs. All settlements should be at the SNCR, but there is no connection between the systems.

12. Difficulties for CNIR structure as explained in Section 5.2

- Heterogeneity of the definition about Rural Property
- Lack of spatial data
- Lack of operational support
- Lack of technical support

III.3 Public Lands Cadastres

d) SIT - Indigenous Land System (*Sistema de Terras Indígenas*)

Location: Indigenous Demarcation and Protection Land Department, National Indian Foundation (FUNAI)

1. Respondent

- José Antonio de Sá – General Coordinator of the Demarcation and Protection

2. Function of the Land Information System

To support judicial and administrative processes of indigenous land demarcation, land regularization, land controlling and land planning.

3. Responsibility for System

- ***FUNAI local level -*** regional support to resolve indigenous claims;
- ***FUNAI federal level -*** management of SIT database, political decisions and data access control;
- ***Private consultant -*** design tools for the software and its contents;
- ***FUNAI technological support -*** storage and backup the SIT database.

4. History of the SIT

SIT was planned to work with an official and unique list of indigenous land. It is a system that is updated by different departments into the Indian Settlement Office (DAF-*Diretoria de Assuntos Fundiários*). To ensure that there is no more need for data input in any of these departments, the land process is closed when the indigenous land receives the title.

5. Brief description of the system

When there is an indigenous land claim, a process is open. Descriptive and graphical information is input by three offices which give the data support input to SIT: Demarcation Office, Identification Office and Settlement Office. Each office is responsible for updating (inserting/excluding) and controlling the data referred to in their department. But all offices can see all of the information in SIT.

The data is stored on a FUNAI server even though a private consultant gives technical support to FUNAI. Once the process is closed, the community receives the title that must be registered at the *serviços registrais* and SPU (Secretary of Federal Assets) as federal land. Data is again entered into the SIT system.

The spatial data is processed with Microstation, Arcgis and Geomedia programs and the database is developed in access and SQL servers.

6. Existing process

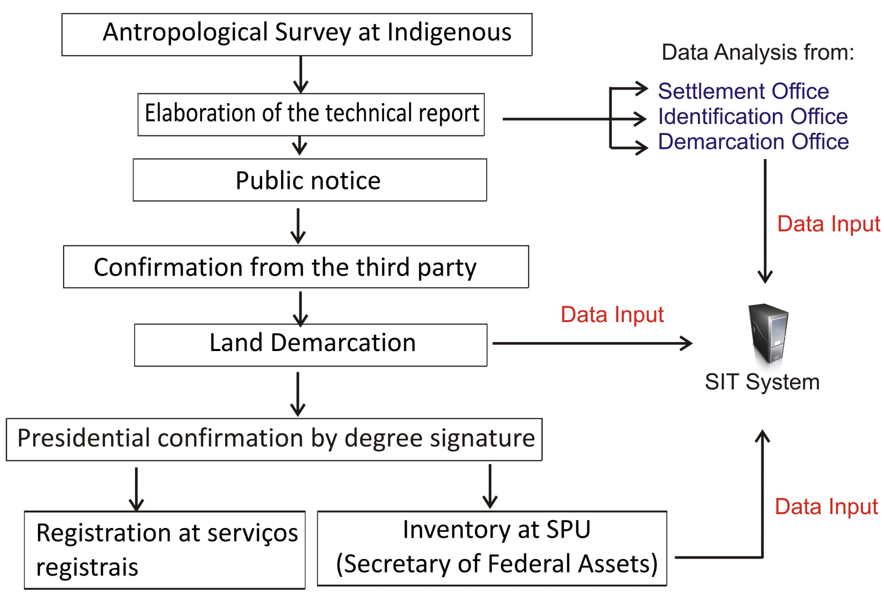


Figure III.4 – SIT existing process

7. Data input/output

SIT is composed of two components: the graphical, where the Geomedia software is used to locate areas and the descriptive where documents related to the indigenous land processes are stored.

The descriptive information contained at SIT is:

- Indigenous identification:
    - Name of the indigenous land according to the official documentation;
    - Indigenous group name and population.
- Location and area of the land
- Type of land and its legal documentation:
    - TI – Traditional land occupation;
    - RI – Indigenous Reserve;
    - DI – Indigenous Dominion – It is the land title named to an indigenous or group ethnic;
    - AD – Donated land or purchased land;
- Map of the demarcation;
- Juridical situation of the indigenous land:
    - Dates of the land confirmation;
    - *Matrícula* number - number of the rural property registered at s*erviços registrais*;
    - Number of the book and date of the registration at s*erviços registrais* and at SPU;
    - Area of the registered land;
    - Decree which confirms the boundary description (geographic co-ordinates, azimuth and distances);
    - Any other legal or administrative documentation related to the open process.

The cartography map base is from 1:100.000 to 1:300.000, depending on the size of the area. The descriptive information is collected from judicial and administrative processes. This includes regulations, decrees and laws. A simple metadata structure was developed by the consultant, but there is no pattern followed. The output is a map in PDF format and a summary report.

8. Access

FUNAI uses the name of the indigenous land as a primary key. This can sometimes bring problems because of the spelling. Indigenous names normally have a number of special characters and accents.

Access is given at several levels:

- ***Internal STI –*** For those who directly work with the process control. They have specific access to control the flow of the information. At this level the data checking and the triage of the problems are solved. Some of the data is confidential such as the anthropological report, so only managers have access.
- ***Internal FUNAI –*** Specific access for all FUNAI employees
- ***External –*** public access on the FUNAI web site with indigenous lands and the documentation associated with it. All the information is available in PDF format and by request. The indigenous information must have a declaratory regulation and decree to be a public source.

The system itself was created just to store documents. The information at SIT has intranet access. To control the access, there is a tool to show the pending action for each office. SIT runs 24 hours per day. Outside FUNAI, it is possible to access data, but alterations can no be made. Officially, there is not data exchange with other institutions, even though indigenous land that has been considered as a public land and must be registered at SPU.

9. Problems found in SIT

- ***Lack of land classification* –** This can be caused by missing documentation that is supposed to help recognize and to classify the land or by complexity in determining where the land is located.
- ***Unclear recognition* –** The interpretation of the indigenous territory may be unclear. It depends on the documentation or the technical point of view to define if the land title will be named to an indigenous group.
- ***Dynamic of the indigenous' groups names* -** There is no uniformity of indigenous group names. They can change during the process of self identification which can complicate the research of the process;
- ***Lack of data update* -** Information about indigenous population is not permanently updated. The map is just updated when a modification of a registered land or a new land is included; it can take more than 6 months to be updated. The surveys have not fully accomplished under the *law #10.267/2001* and INCRA's regulations. If there is alteration of the area during the revision process, the increased area or decreased area will not appear in the system;
- ***Recognition of the customary law* -** Federal roads, which cross an indigenous land, should subdivide the land into different parts, but the indigenous customary

law does not recognize this subdivision. This is a problem when land is registered at the *serviços registrais.*

10. Improvements to solve SIT problems

To improve the graphical component of the SIT a new manual to demarcate and to monitor the indigenous land has been reviewed. It aims to use *Law# 10,267/2001* and INCRA's regulations.

11. Expectation about CNIR implementation

The Indigenous Demarcation and Protection Land Department aims to obtain information from other institutions about deforestation, preserved forest areas, road locations, forest fires and so on, and to cross reference these with the FUNAI database. Also they would like to have access to a complete agrarian map with the adjoiners, showing which portion of the indigenous lands was trespassed upon. It will facilitate monitoring and inspecting of the indigenous land.

12. Difficulties for CNIR Structure as Explained in Section 5.2

- Absent metadata standard;
- Difficult access to the information;
- Lack of technical support;
- Lack of spatial data;

e) SIAPA - Integrated System for Patrimonial Management (*SIAPA – Sistema Integrado de Administração Patrimonial e SPIUnet - Sistema de Patrimônio Imobiliário da União*)

Location: Public Lands Characterization Department, Secretary of Federal Assets - Ministry of Planning (SPU)

1. Respondents

- Eliane Hirai – National Director of the Characterization
- Claudia de Souza Barreira
- Dulce Vidigal do Amaral – General Coordinator of the Inspection and Identification

2. Function of the Land Information System

To locate federal properties and identify the occupancy situation to better manager and distribute federal assets.

3. Responsibility for System

- ***SPU local level -*** regional support to attend citizens;
- ***SPU federal level -*** management of SIAPA database, political decisions and data access control;
- ***SERPRO technological support -*** design tools for the software and its contents, besides storage and backup the SIAPA database.

4. History of the SIAPA

The Integrated System for Patrimonial Management (SIAPA) contains all federal properties, their utilization, and associated financial events. To help the SIAPA, the Secretary of Federal Assets (SPU) created the System for Patrimonial Federal Properties (SPIUnet). SPIUnet was created to mange federal properties under special uses. The main idea is to maintain the updated cadastre to easy evaluate federal assets at any time.

5. Brief description of the system

The main functions described for SIAPA and SPIUnet are the following:

SIAPA:

- To control the federal property occupancy and its legal right;
- To update property value mapping;
- To designate federal property uses;
- To convey federal property by selling, exchange, donation or special concession;
- To support juridical actions in defence of federal interests.

SPIUnet

- To support juridical actions in defence of federal interests;
- To formalize the use of concessions for federal functional properties and to control their occupancy;
- To manage the use conditions of the federal functional properties, including information about maintenance and reparation.

SIAPA is integrated with RFB by the taxpayer personal identification (CPF) and juridical identification (CNPJ).

All verification, such as, rules of valid fields, contents and cross validation, is made by SERPRO, which also develops, maintains and stores the database. Backups are done daily, weekly and monthly by SERPRO. There is no geographic information. The database is developed in SGBD Oracle and to process the information at the Data Warehouse, Microstrategy Server has been used. There is a model for the metadata that is available on the internet under www.**spu**.planejamento.gov.br/arquivos_down/**spu**/SSD_Manual.pdf. Also there are formal agreements with city halls to update the information by municipalities.

6. Data input/output

The data contained at Siapa and SPIUnet are listed as follows. Data output is made by the internet via # RIP.

1. Basic Information

- RIP number – number of the property at the SPU;
- Location of the property and city hall
- Situation of the area
  - Type of land regularization
  - Area of the social interest declared by the city hall;
- Technical characteristics
  - rural or urban
  - total area and federal area;
- Information of the landholder
  - CPF

    - Name
    - Address
- Type of use and its situation

2. Terrain Information

- Legislation of the incorporation
- Number of the DC – Cadastre Document
- Number of the administrative process
- Number of pages of the registration process
- Number of the municipal inscription
- Number of the map of the area
- Type of terrain
- Quantity of aero photos
- Number of the cartography at SPU
- Coordinate UTM
- Garbage collection
- Water system
- Drainage system
- Sewage
- Type of road
- Public lighting
- Actual property use
- Description of the property in total
- Description of the Federal Property

- Description of the Used Area

3. Improvements Information (Benfeitorias)

- Identification
    - Situation and denomination of the property
- Technical data
    - Privative area
    - Projected constructive area
    - Any other area
    - Total area of the improvement (benfeitorias) and type
    - Year of the construction
    - Main use
    - Type of construction, cover material and structure
    - Number of floors and rooms
    - Improvement in condos
- Description of the property improved

4. Information about special grantee

5. Responsible

- CPF
- Name
- Nationality
- Date of birth
- Civil status
- Personnel ID (RG)

- Profession
- Address
- Number of dependants
- Median of month Income (R$)
- Total of familiar Income (R$)
- Median of familiar Income (R$)
    - Bolsa familia program

6. Utilization

- Regime
- Tax
- Used area
- Situation

7. Debit

- Debit identifier number
- Year of the debit
- Date for the base deadline
- Value of the debit
- Situation of the debit

8. Credit

- Credit identifier number
- Year of the credit
- Value of the credit
- Type of the credit

9. History of the property transaction occurrences

10. Any notification about the cadastre

11. Possessory chain

- Landholder
- CPF/CNPJ
- Date of the start of occupation
- Date of the ended of occupation

7. Access

The property is identified by Patrimonal Property Registration Code (*Registro Imobiliario Patrimonial - RIP*). It contains 13 characters composed as following: 4 characters for the SRF municipality code + 7 sequential numbers + 2 verification code. All information is available monthly at a data warehouse (DW) when the users have a filtered access via internet. The data access does not have public access; new entrance or only landholder with registered CNPJ, CPF, or RIP code could have access to the information.

The user must to be registered with # CPF and password to access the SPIUnet under the website < https://spiunet.spu.planejamento.gov.br/Default.asp >.

8. Expectation about CNIR implementation

The Lands Classification Department expects to have CNIR to help them to identify federal lands and to control their properties and as consequence contribute to improve the land regularization in Brazil.

9. **Difficulties for CNIR structure as explained in Section 5.2**

   - Duplication of the land information;
   - Inconsistent database;

III.4 Statistical Cadastre

f) CNEFE - National Cadastre of the Address for Statistical Purposes (Cadastro Nacional de Endereço para Fins Estatísticos)

Location: Agrarian Census Department, Brazilian Institute of National Statistics and Geography (IBGE)

1. **Respondents**

   - Wolney Menezes – Coordinator of the CNEFE
   - Marcelo de Moraes Duriez – Coordinator of the Analysis and Agrarian Planning
   - Dulce Santoro Mendes – Coordinator of the Territorial Structure

2. **Function of the Land Information System**

   To help IBGE statistical surveys by locating the rural establishments.

3. **Responsibility for System**

   - ***IBGE local level -*** collect and process data on site and contact with partners to manage data collection;

- ***IBGE federal level -*** management of the CNEFE database, political decisions and data access control;
- ***IBGE technology support -*** design tools for the software and its contents, storage and backup the CNEFE database.

4. History of the CNEFE

The National Cadastre of the Address for Statistical Purposes – CNEFE was created in 2005 using the addresses produced during the 2000 census to support assessors (*recenseador*) during their fieldwork, planning and supervision of the census data collection. It also guides several of IBGE's research projects. The association of CNEFE graphical data started in 2007 in small provinces with up to 20.000 inhabitants. According to the CNEFE coordinator, as of December 2008, CNEFE has around 60.000.000 addresses registered at several levels. This happens because in rural areas there is inconsistency of addresses due to non existence of a formal address. The residents describe where they live and it might differ from person to person.

5. Brief description of the system

The CNEFE system has descriptive data, but the module for the graphical information is still in development. The database has data input from IBGE and external partnerships. Everything is stored on an IBGE server. The data validation is made during the data collection. IBGE also is constructing a data warehouse (DW) to permit internal data availability. Database backup is done daily.

IBGE uses Oracle to build its database. For GIS, CNEFE uses the Municipal Maps Semi-Automatic Elaboration System – SisCart. It was specifically developed for IBGE in Visual Basic 6.0 with MicroStation/MGE, from Bentley/Intergraph as graphic platform and Access, from Microsoft as alphanumerical platform. The SisCart facilitated the construction of the municipal map, contemplating the homogenization of projection and scale. Also it validates and helps the geometric treatment of features when joining sheets, cropping sheets, and adding the framework and footnote data composition [IBGE, 2007]. CNEFE has metadata created according to international standards using GDF (Geographic Data Files). GDF is the standard created to describe and to transfer Geographic Data [BURITY et al, 2002]. “It is much more than a generic GIS standard, as GDF gives rules on how to capture the data, as well as how the features, attributes and relationships are defined “[SAFE, 2008].

6. Existing process

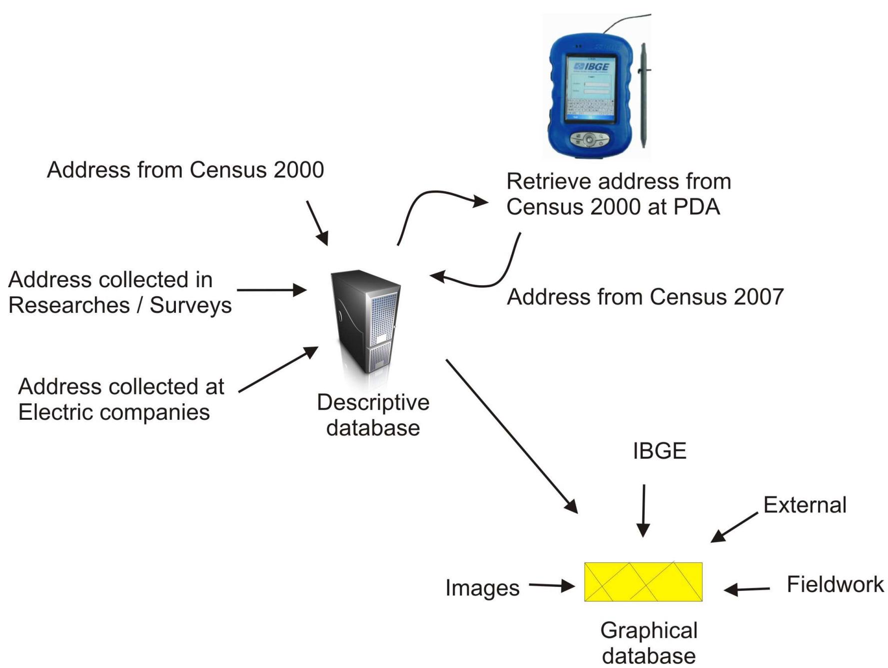
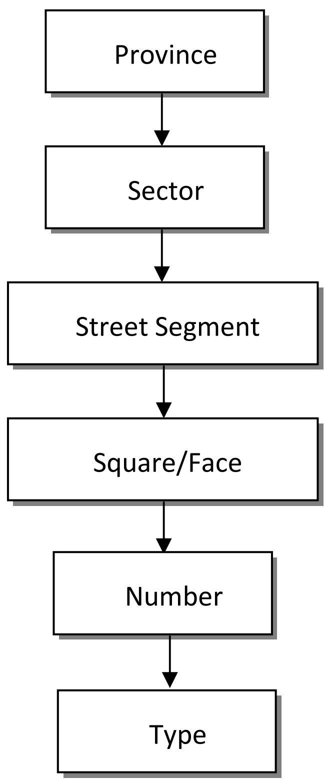


Figure III.5 – CNEFE existing process

7. Data input/output

CNEFE contains the complete address of each establishment in the urban or rural areas collected during the census and for specific research projects. CNEFE has received support from electric companies to update addresses. In the rural areas, the geographical coordinates of the rural properties and religion, health and education establishments are collected. How the CNEFE address is standardized (Figure III.6) is described below.



Address format:

Type of the street

Title of the street

Name of the street

Location

Postal Code

Number and Complement

Geographical Co-ordinates

Point of reference

Name of the landholder

Type of establishment

Figure III.6 – Address format

At data output, the CNEFE can identify the location of the establishment by categories of occupancy and can represent the dynamic of occupation in rural areas.

8. Access

At CNEFE the establishment is identified by the Geocode composed of the following characters: Federation Unity (2) + IBGE Municipality code (4) + District (2) + Sub-District (2) + Questionnaire number (4). The collected information is confidential, i.e. the landholder should not be identified; only aggregated data are available. The regional offices have access to some of the information, which is restricted for IBGE use. There is no request for access online.

9. Problems found at CNEFE

- ***Lack of data validation*** **–** There are limitations to completely cross check the data input at the personal digital assistant (PDA) during the census interview. The analysis of the census data takes almost one year to be finalized.
- ***Lack of software update*** **–** Census maps are produced via SISCART; they need to be updated to eliminate bugs in the system.
- ***Lack of data update*** **–** There is missing system for data update. It happens occasionally under IBGE statistical research and by electric companies.
- ***Timeless*** **–** There is inefficiency in processing all collected data in the available time.

10. Improvements to solve CNEFE problems

- ***New technology -*** The use of PDAs eliminates the digitalization of the paper work and has real time control. In addition, it helps the systematization of the electronic questionnaire that allows the previous answers to appear and to answer the obligatory fields avoiding null fields by mistake.

- ***Exchange of information* –** The exchange with electric companies helps CNEFE to be updated. Also, IBGE adopted the software SAS to validate the addresses.

11. Expectation about CNIR implementation:

The Agrarian Census Department at IBGE wishes to refine their address database, once the agrarian census data collection is made each 10 years, and CNIR can estimate the data during this absent survey period. Also they want to use a reliable agrarian map.

12. Difficulties for CNIR structure as explained in Section 5.2

- Heterogeneity of the definition of Rural Property
- Lack of spatial data
- Difficult access to the information

III.5 Fiscal Cadastre

g) CAFIR - Rural Property Cadastre for the Revenue Income (*Cadastro de Imóveis Rurais da Receita Federal*)

Location: Cadastre Management Department, Federal Revenue Service (RFB)

1. **Respondents**

- Andre Felipe Camara Salvi – Special Coordinator of the Cadastre Management
- Ana Paula Sacchi Kuhar – Acting Chief of the Cadastre
- Ivana Bandeira da Silva – Fiscal Auditor of the RFB

2. **Function of the Land Information System**

To inventory fiscal information of the rural properties.

3. **Responsibility for the System**

- ***RFB local level -*** to manage data changes and update, to give support to local department;
- ***RFB federal level -*** to manage CAFIR database, political decisions and data access control.
- ***Public technology support linked with Ministry of Finance, Federal Service of the Data Processing (SERPRO) -*** to design tools for the software, its contents and integration with other systems; storage, maintenancee and backups of the CAFIR database.

4. **History of the CAFIR**

Until 1990, the Rural Property Taxation (ITR) was administrated by the Land Reform Institute (INCRA). After this period, RFB was in charge of operating and managing the fiscal information [*Law # 8,022/1990*]. During period from 1992 to 1997 the ITR had problems in its implementation. For the first time, in 1992, RFB issued the

ITR. There was no property identification code (# NIRF) and duplicity of data occurred. In 1993 there was no obligatory ITR declaration, but the system was open to data update or records of new properties. NIRF became be used by RFB in 1994 when a simplified declaration was required. The on-line ITR declaration occurred only in 1995. The taxation in 1995 and 1996 occurred based on the information declared in 1994. Finally in 1997, the RFB used the taxpayer's numbers (#CPF and #CNPJ) linked to NIRF.

To improve the declaration of the Rural Property Taxation (ITR), RFB created Rural Property Cadastre for the Revenue Income (CAFIR system). Since 2001 it has been used to locate, classify and characterize rural properties. Areas of preserved forest on the rural properties are also indicated for discounts in the taxation. The registration at CAFIR under RFB does not signify legal rights to the land in any circumstances. CAFIR has an annual period for the declaration of users. Actually the Department of Cadastral Management (Cocad) manages CAFIR under the Technology and Information Security Department (Cotec) supervision. Cotec has power to approve all the changes in CAFIR.

5. Brief description of the system

CAFIR is a declaratory and descriptive inventory. CAFIR is updated annually by the landholders when they declare their data for the property tax (ITR). It is made via the form of the Declaration of the Property Tax - DITR (*Declaração do Imposto Territorial Rural*). DITR is composed of forms called Fiscal Information for the Property Tax – DIAT (*Documento de Informação e Apuração do ITR*) and Cadastral Information for the Property Tax – DIAC (*Documento de Informação e Atualização Cadastral do ITR*).

DIAC has the cadastral information about the rural property and its landholder. The auxiliary forms are the forms to register in RFB inventory, to cancel and to communicate any conveyances. But if there are special needs to update cadastral data, then the update can be done by the FACIR form. DIAT has the fiscal propose. This form contains the taxable and non-taxable information about area within the rural property. Non-taxable areas are the ones which contain environmental preservation. This information must match with the preserved environmental areas that were declared at the Environmental Declaration Act of ITR (ADA System – *Ato Declaratório Ambiental*) under IBAMA. If the information ADA/DIAT/DIAC is confirmed then the landholder receives discounts in the property tax. These forms are processed by SERPRO.

Public property, small rural property or rural properties settled by land reform programs are rural properties without taxation. They only need to be registered at the DIAC. The conception of small rural properties is related to size of the property and its location:

- 100ha if it is located at Occidental part of Amazon, Pantanal, South of Mato Grosso;
- 50 ha if it is located inside the drought area of the Northeast of Brazil or at Oriental part of Amazon;
- 30 ha, if it is located in any other part of Brazil

SERPRO does daily, weekly and annually backups. The data is copied simultaneously into two databases, at a fixed and a mirror database. The data mirror is modified all the time. It is made also by. CAFIR system was developed in Visual Basic with ADABAS database. The database access is made by SQLda.

6. Existing process

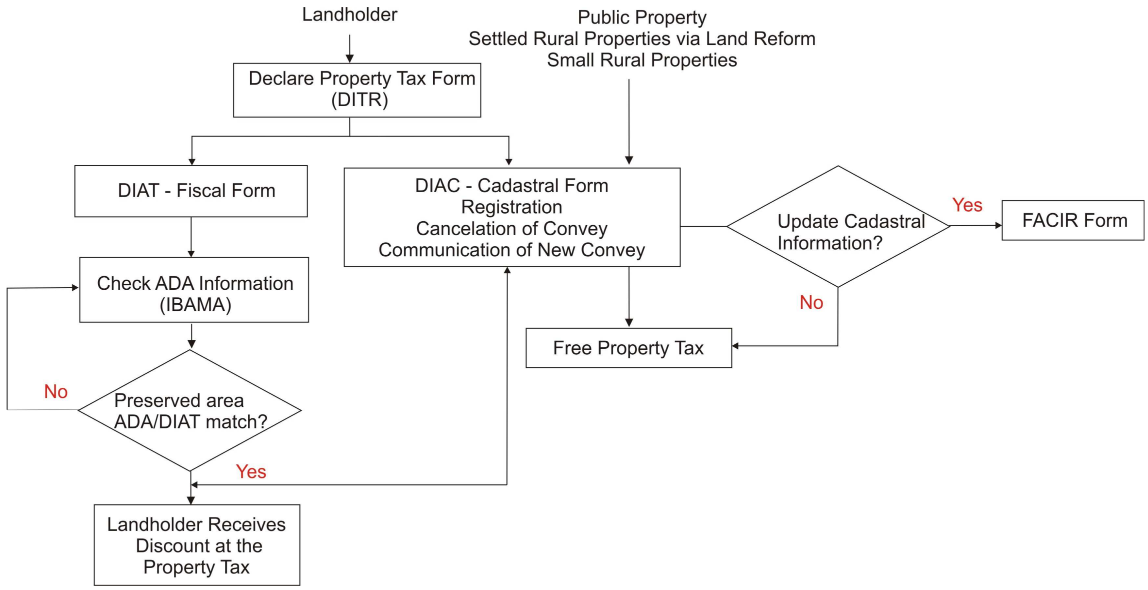


Figure III.7 – CAFIR existing process

7. Data input/output

CAFIR has three forms that are used to record and cancel rural property declarations, communicate exchange of ownership and update the information.

Registration forms are used to register:

- acquisitions of partial area or addition of adjoining areas that result in a new property;
- acquisitions of partial or total rural properties by public institutions or private institutions that are exempt from the ITR taxation;
- when there is expropriation, partial or total area of the rural property can be registered by needs or social interest, including for agrarian reform proposes.

The cancelation form is used when a rural property has been transformed to an urban property, or when there is duplication of cadastral registration at CAFIR or when the acquisition/expropriation of the total area of the rural property is already registered at CAFIR. Additionally, the cancelation form is used for judicial determination.

The communication form is used to notify the exchange of ownership, including the notification of the partial or total expropriation of the rural property by needs or social interest. According to the Normative Instruction *RFB #830/2008* the forms contain following information:

- Property identification (#CCIR – INCRA code and #NIRF – RFB code);
- Location of the rural property and area;
- Type of condominium, who acquired and with percentage;
- Personnel information of the landholder, mainly the taxpayer's numbers (# CPF or # CNPJ);
- Cause of the cancelation and equivalent NIRF;
- Information of the CPF/CNPJ of the person who acquired/expropriated land, date, area and equivalent # NIRF;
- Information of CPF/CNPJ of the expropriate or land ownership exchanged exempt of the ITR, date, legal act, area and equivalent #NIRF;

Data standardization is related to the system validation. CAFIR also offers to landholders' access to research the cadastral situation of the rural property.

8. Access

The Property ID in the CAFIR system is the code composed of 7 characters and 1 certificated character all generated randomly by the computer, it is called NIRF – *Numero do Imovel na Receita Federal.*

Access to the CAFIR is restricted to RFB; however, indirectly INCRA managers have access to the RFB data through the ITR database by specific login which allows tracking the history of the transactions. The #CPF, IP address, time of the access and the used time are logged. To make a CAFIR declaration, the user needs to have # NIRF. This is done at the website http://www.receita.fazenda.gov.br/Aplicacoes/ATSDR/Cafir/Consulta_Situacao_Cadastral.asp >.

Actually RFB has agreements with City Halls (according to *Law # 11,250/2005* the municipalities will be in charge of issuing and collecting the tax), IBAMA (because of the ADA declaration) and INCRA (because of SNCR system).

9. Problems found at CAFIR

- ***Absent records* –** There is no cross validation between the INCRA database and RFB database. One of the consequences is that there are many properties that are registered at CAFIR, but are not registered at SNCR/INCRA;
- ***Digital format -*** CAFIR was created based in analog format that needed to be later digitized. Some information found is invalid or missing (e.g., taxpayers' number # CPF and #CNPJ;

- ***Data duplication -*** duplication of the declared information can be found, mainly when the landholder re-declares the property and the system does not access that it is already registered.

10. Improvements to help solve CAFIR problems

- ***New technologies -*** CAFIR has a digital data input made by the landholder. Just 3% still is made in analog forms. The system itself has been updated and many automation improvements were implemented.

11. Expectation about CNIR implementation:

The Cadastre Management Department hopes to match the INCRA database with RFB database. The concise data can be used to minimize agrarian conflicts. CNIR can also be used to confirm the land information, because all data will be kept in the same system. As a result, it may promote land titling and access to credit for the landholder. Another advantage of the CNIR is that it will minimize duplicity of land information and administrative work.

12. Difficulties for CNIR structure as explained in Section 5.2

- Heterogeneity Rural Property definition
- Financial aid to implement CNIR
- Incompatible PID
- Absentee standard to descriptive data

APPENDIX IV

INFORMATION SYSTEMS DEVELOPMENT

This appendix gives literature review of the models for information systems development and highlights the advantages and disadvantages of each model. They are guide for CNIR managers; the choice of a particular model for CNIR is related to what is expected for CNIR. This thesis, for example, chooses the cognitive tools of soft systems to develop the conceptual model; this was seen as an opportunity to implement external political and cultural factors to CNIR and being a participative process.

Before designing any system and describing how it will be developed and which product/services will be delivered to the users, it is important to clarify the concept of what an information system is and to understand its life cycle development, it is seen in Section IV.1 and IV.2. Section IV.3 presents the systems development commandments. They serve to show the important elements to avoid design weakness. Section IV.4 presents the CMM and ISO parameters to evaluate processes of the information systems development.

IV.1. Information System Development Processes

According to Murawski [1995, p.28] “information is derived from the assembly, analysis or summarizing of data into a meaningful form”. According to Wasson [2006], every system has a mission and objectives within its institutional domain; it is what will determine the specific tasks to deliver a product/services. An information system captures and manages data to produce useful information to the institution as a whole, including its employees, stakeholders and users [Whitten et al., 2004]. It satisfies information requirements and decision-making needs at all levels of management, as well as satisfying users' needs [Burch and Grudnitski, 1989].

Figure IV.1 illustrates what is the knowledge hierarchy: data is the logical element contained in the record and describing an attribute; information is processed and summarized data; knowledge is the interpreted, compared and analyzed cumulative information and wisdom is the collection of lessons and trends learnt over time [Bellinger et al., 2004; Whitten et al., 2004; Warnest, 2005; Paixao et al., 2008].

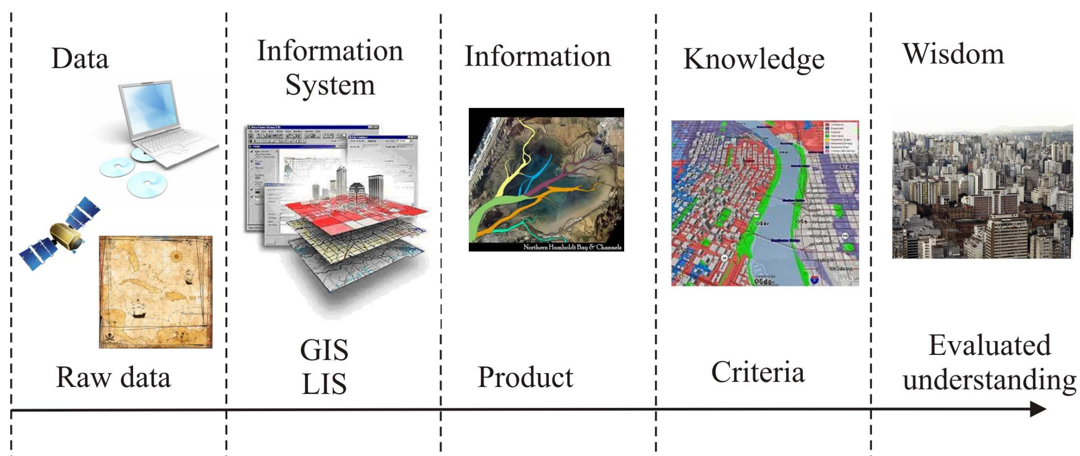


Figure IV.1 – The knowledge hierarchy: data to wisdom (after Tomlinson [2007, p.2])

IV.1.1 Information System Development Phases

To create an information system, there are certain processes that need to be employed such as system initiation, analysis, design and implementation. They are described bellow (see Figure IV.2).

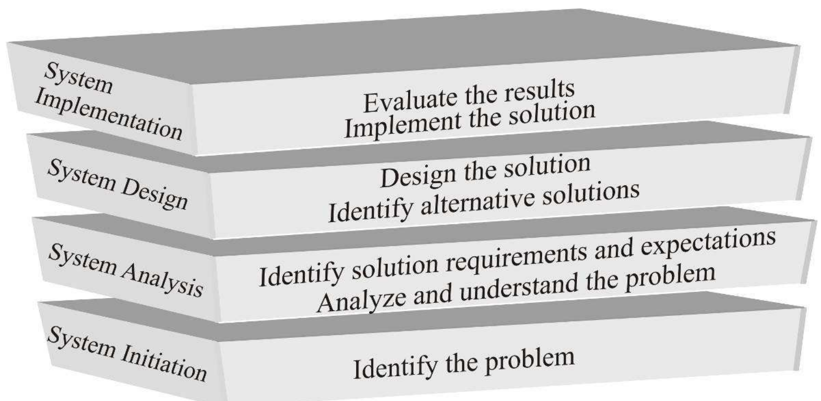


Figure IV.2 – Information system development processes (after Whitten et al. [2004]).

Phase 1 - System Initiation or Planning: This is the first phase of the system development life cycle. It is where the information needs are initially examined and general ways to meet these needs are identified. A system initiation project should be carefully planned in order to solve existing and future problems, since the primary problems stated are generally vague. Also in this phase the economic and organizational impact of the system is determined [Valacich et al., 2001]. Problems and opportunities are also addressed in order to establish the project scope, objectives, schedule and budget [Whitten et al., 2004].

Phase 2 - System Analysis: This phase is used to study and understand the problem domain well enough to analyze the problems and opportunities that are primarily concerns about the system owners' and system users' views of the existing systems. Clarifying terminology, Whitten et al. [2004] defined that a problem as a situation that results in an undesirable side effect and opportunities are actually situations that are identified as possible areas for improvement, despite not being specific problems. Wasson [2006, p. 137] complements saying that, "technically a problem does not exist until the hazard that poses a potential risk occurs".

The goal of this second phase is also to do system analysis to eliminate redundancies and to generate alternatives to initiate the system design, which includes the analysis of the user and system's requirements that were addressed at the Section 4.2 [Valacich et al., 2001].

Phase 3 - System Design: During the system design, the alternative solutions found in Phase 2 are now described in system specifications. System specifications are both logical (e.g., from input and output data to reports, database, processes, etc) and physical (e.g., which programming language the system will be written in, which database will be used, which hardware platform, operating system and network environment the system will run under) [Valacich et al., 2001; Whitten et al., 2004].

Phase 4 - System Implementation: This is the final phase that turns the system specifications into a working system that, once tested, can be used. It includes coding, testing and installation. The system implementation may also include activities such as finalization of the documentation, training materials and user assistance [Valacich et al., 2001].

IV.2 Process Models for Software Development

The reliability of information systems such as geographic information systems (GIS) is related to how well the processes, data, operations and applications meet the requirements. The development of these dynamic and adaptable systems requires methods to analyse, model, design evaluate and redesign the system [Morales et al., 2002 and Morales, 2004]. The development of the systems also goes through lifecycle models, which establishes the criteria to determine what should be done to proceed from one task to the next in developing the system [McConnell, 1996]. Lifecycle models present well defined phases that might be subdivided to provide management control with linkages to the operational performance. It helps to define, for example, the technical work, the deliverables, who is involved and how things are controlled [Project Management Institute, 2004].

There are many approaches for systems development using lifecycle models. The lifecycle model choice should be one which can streamline a system development project and can help to ensure that the subsequent steps converge to the project goals. Basically the choice will depend on: the project request for improvement of the development speed; the improvement of quality and control; minimize risk exposure; improve stakeholder relationships; the level of complexity and uncertainty; the size of the project; the familiarity of the technology, etc. [Gasson, 1995; McConnell, 1996]. There is no one best model, basically because there is no one correct way to develop an information system. These models can be applied in parallel or overlapping [Gasevic et al., 2006].

Rosenau [1998] highlighted some factors that might make the project improvements interdependent. Once these parameters are well-defined the system development can be planned:

- Knowledge of the actual situation of the system;
- Knowledge of what the system is to accomplish;
- Definition of how to get from the existing situation to what needs to be accomplished.

The life cycle framework can be categorized as linear, interactive or evolutionary, and incremental. The linear framework has a sequential system construction. It is based on stages that are only carried out once, i.e., after each stage the deliverables are met, and they will not usually be changed. Interactive development, or evolutionary, delivers a full system at the beginning, but changes of the functionalities can be made at each new release, while the incremental blocks are constructed and added as the functions are tested [Burg, 1998; Pfleeger and Atlee, 2006; Wasson, 2006].

In some system development models the steps are fully used (e.g., waterfall model), partially used in order to obtain faster delivery of the system project (e.g., prototype model), or in other cases there is a repetitive use of the steps each time that an interaction is done (e.g., spiral model). These approaches are listed bellow with respective model examples [McConnell, 1996; Bell, 2000; Pfleeger and Atlee, 2006; Anon., 2008]:

- Linear: Waterfall Model;
- Evolutionary: Prototyping;

- Evolutionary and Incremental: Spiral Model, Agile Model (AM), Model Driven Architecture (MDA), Framework for Application of Systems Thinking (FAST) and Soft Systems (SSM).

Waterfall Model - Developed in the 1970s, the Waterfall Model is defined as sequential stages followed in time from the initial system conception to the final system testing; often there is no overlap in these stages [McConnell, 1996; Hamilton, 1999]. Wasson [2006, p.293] says that in the Waterfall Model "users' needs are determined, requirements are defined, and the full system is designed, built and tested for ultimate delivery at one point in the time". A variation of the Waterfall Model has a V format, in which analysis and design are on the left and testing, maintenance and design verification are on the right side. The linkage between both sides implies that if problems are observed in the verification and validation, then the left side can be re-executed to fix or mitigate the problems before the right side is recreated. While waterfall focuses on documents and functions, the V model focuses on activity and correctness [Pfleeger and Atlee, 2006].

Prototyping - The idea of prototyping is to break the complexity of the systems into several comprehensive and simple parts and to ensure that all of these parts fit together as previously planned; these parts are also subsequently refined to attend to end-user or market expectations [Carr and Verner, 1997 ; Yu, 2008]. It includes implementation of a few functions that were tested by the user and it is then improved. With prototypes, additional user requirements can be implemented throughout the project. All these cycles continue until the product is finished [Pomberger and Weinreich, 1994]. It might not be a complete system, maybe just part of it, but it works [Bell, 2000].

Incorporated in the 1990s, Rapid Application Development (RAD) is considered an umbrella of the rapid prototyping because it gives faster system development [Hamilton, 1999]. RAD practices are associated with speed and intensive interactions; it uses low-to-moderate levels of change. It works well when teams are small, dedicated and collated [Highsmith III, 2000].

Spiral Model - Published in the 1980s the spiral mode was designed to have stages with overlaps and feedback loops into previous stage that help improve the system in development [Hamilton, 1999]. This model applies the idea of incorporates risk analysis into the process and also allows the process to be stopped to add new requirements. These risks include poor understanding of the requirements, architecture and performance problems, and underlying technology issues and so on [McConnell, 1996].

In the spiral model, the entire system is not defined in detail; just the highest priority features are first implemented. After that, successive interactions can be defined and more features can be implanted [Hamilton, 1999]. The difference from the incremental model is that the spiral model does not fully form users' needs at the beginning of the development and all the requirements are not initially defined [Wasson, 2006].

Agile Model - The Agile Models were created in the late 1990s with the goal to satisfy users by having early and continuous deliveries [Pfleeger and Atlee, 2006]. As Ambler [2002] says that agile modeling is not a prescriptive process; it does not define detailed procedures for how to create a model, instead it provides advice for how to be effective as a model. Ambler [2002] also identifies some principles of agile modeling. They are based on:

- how interactively the team can exchange their ideas with no main ownership level;
- how clearly these ideas can be represented, aiming to satisfy the user needs, by gradually incrementing tools to the system or constructing a parallel prototype;
- how simply the system can be constructed and displayed to the users, including simple tools where the users can increase the functionality of the system;
- how an effective system can be an original matrix for new systems; it is only possible by keeping all design documentation and codes.

Model Driven Architecture (MDA) - MDA analyzes systems by constructing models and by transforming these models into other models. It gives developers the ability to better describe problems and also helps them to have an entire understanding of the system in development [Gasevic et al., 2006]. Using the MDA approach, the resulting system model will serve as documentation for any change that might be needed during the operational stage and support of the life cycle [Whitten et al., 2004].

Framework for Application of Systems Thinking (FAST) - According to Whitten et al. [2004] FAST provides alternative strategies to accommodate different types of projects, technology goals and developer skills during the information system development. FAST advocates the value of documentation, where it is accumulated after each phase.

The users are more likely to receive the system they really need because of the opportunity to experiment with requirements and design options [Baker et al., 2008].

There are 8 phases necessary to develop a FAST framework: scope definition, problem analysis, requirements analysis, logical design, decision analysis, physical design, testing and installation and delivery [Project Management Institute, 2004; Rosenau, 1998; Sommerville, 2000; Whitten et al., 2004].

Soft Systems (SSM) - SSM deals with human issues such as organizational, political, and cultural aspects of the systems. It addresses fuzzy problems with unclear and multiple objectives; several different perceptions of the problem are guided by intervention meetings [Herlea, 1996; Presley et al., 1998; Staker, 2001]. SSM also recognises that system ideas can be helpful in understanding the problem and the situation [Schmidt, 2006]. It is a process for managing, which in this context means achieving organised action. The output of the soft systems is the learning aspect which leads to actions, knowing that this will lead not to the solution, but to a changed situation and new learning [Yurtseven, 2000].

Table IV.1 – Advantages and disadvantages of the development models (after Pomberger and Weinreich [1994]; McConnell [1996]; Carr and Verner [1997]; Bell [2000]; Yurtseven, 2000; [Stojanovic et al. [2003]; Whitten et al. [2004]; Schmidt [2006]; Baker et al. [2008]; Anon.[2008]).

Models	***Advantages***	***Disadvantages***
Waterfall Model	- Helps to find errors in the early, low-cost stages of the project. - Minimizes planning overhead. - Easy and early track of complexity. - Eliminates midstream changes that cause potential errors. - Ideal for less experienced project teams, stages are straight forward. - Divides a complex task into smaller, easy to manage tasks. - Produces a well-defined deliverable at each stage.	- Provides tangible results in the end of the lifecycle. - Lack of full requirements specifications at the beginning of the first project. - Lack of flexibility. - Identifies missing or wrong requirements when the system is tested. - There is no turning back at any stage. - Produces excessive documentation.
Prototype	- Provides high degree of user evaluation which affects requirements, specifications and design. - Shows the system working before it is completed. - Supplies early visualization of the product and early user testing. - Requires minimal effort for flexible modifications. - Intensifies feedback to users. - Helps to clarify confusing functions and missing functionality. - Provides quick implementation of an incomplete, but functional application. - Can be used for training purposes before the final system is delivered. - Appropriate for large projects with many users, interrelationships, and functions.	- Designers may prototype too quickly, without regard for the stakeholders' expectations. - Prototypes may not have sufficient checks and balances incorporated. - Makes it difficult to manage the project if unknown iterations are added to budgets and schedules. - Changes the requirements; it might not be easily accepted by the designers.

Table IV.1 – Advantages and disadvantages of the development models (Continued)

Models	***Advantages***	***Disadvantages***
Spiral Model	- Can be combined with other lifecycle models as interactions are implemented. - Provides good management control with check points at the end of each interaction. - Identifies risks in early phases.	- Needs knowledge management because of the model complexity. - Difficult to set up objectives and ensure that the next layer can be added.
Agile Model	- Provides agility and effectiveness in the modeling. - Provides sufficient details, accuracy and consistency. - Focuses on documentation	- Might be too simple. - Might miss important detail. - Requires highly trained professionals.
Model Driven Architecture (MDA)	- Models provide clear and unambiguous definitions of behaviour, capability or design. - More effective translation of user needs into program requirements via models, easy validation. - Results can be available continuously throughout the program. - Focuses on documentation.	- Requires highly trained process and tool experts who are well versed in the methodology. - Very time-consuming. Takes time to collect facts, draw and validate models. - Models are dependent on the understanding of users' requirements.
Framework for Application of Systems Thinking (FAST)	- Focuses on documentation. - Uses of the requirements during each phase. - Designs of each phases is well defined.	- Relies on correct phases to go to the next stage. - Keeps too much documentation that might be hard to update.
Soft Systems Methodology (SSM)	- Relevant actors take part in the problem situation and interact with the analyst. - Can be used in combination with a hard method. - Allows the developer and stakeholders to learn about the system as an iterative process. - Relies on being a participative process where knowledge and results can only be gained through debate.	- Relies too much on individuals' perceptions. - SSM is fuzzy, lacking in rigour and not easily applied in practice. - Can be seen to neglect some of the forces that interact in society, such as social constraints and group norms. - Can limit scope by having the worldview definition affected by interpretation. - Inherently conservative.

IV.3 Software Development Commandments

Many authors have created a list of the main commandments that software development needs to follow; they are essential to avoid design flaws. Even though these commandments were created for formal methods of software development, they are important for any method of software development. Table 4.2 lists the software development commandments and explains why they are important. Most of the commandments were explained in the previous sections. This section will present the importance of each as it relates to managing a project.

Table IV.2 - Software development commandments (after Purba et al. [1995]; Cleland [1998]; Hamilton [1999]; Whitten et al. [2004]; Bowen and Hinchey [2006]; Ribeiro [2007])

Commandments	*Why?*
Start development with software requirements	Software requirements help to organize ideas and processes and to measure the success of the development effort. Without good requirements that state precisely what a software program needs to accomplish, it is difficult to complete the project, much less judge the application's success.
Open communication	Communication skills include the ability to capture and analyze data, document the results and provide feedback to the users to ensure that there is an understanding of the tasks. Constant and direct communication with stakeholders and users will ensure that their requirements are correctly understood. Poor communication might involve errors in or misinterpretation of the project design.
Get the system users involved	The engagement of the stakeholders helps to minimize the idea of the system being perceived as owned by the technical support.
Establishment of phases and activities	Well define phases helps the management of the project and indicates problem-solving process.

Table IV.2 - Software development commandments (after Purba et al. [1995]; Cleland [1998]; Hamilton [1999]; Whitten et al. [2004]; Bowen and Hinchey [2006]; Ribeiro [2007] - Continued)

Use a problem-solving approach	A system development methodology should guide the study, and include understanding of the problem, definition of requirements, and indication of the best solution, design, implementation and evaluation of the solutions.
Divide and conquer	Dividing the system into subsystems and components that are more easily manageable pieces that can have a simplified problem-solving process.
Design system for growth and change	Needs and priorities change. Information system should be able to scale up and adapt to the business.
Establish standards	These serve to direct the technology solution and information system to a common configuration. Detailed metadata, for example, is essential to manage the databases and it also helps the interoperability of several systems. Metadata is important to assist in the understanding of the data and quality assurance.
Document throughout development	Documentation enhances communication and acceptance, reveals strengths and weaknesses of the system. At the same time, it also stimulates user involvement and reassures management about progress. Formalizing the documentation leads to less ambiguity and thus less likelihood of errors.
Manage the process and project	Process management ensures that an organization's chosen process or management is used constantly on and across all projects. It also defines and improves the chosen process or methodology over time.
Justify information system as capital investments	The idea the needs to be sold is that there is an add value information that will be available after the system be implemented. Software is only the tool to create this capital.
Do not be afraid to cancel or revise scope	Projects can be partially cancelled if they are no longer feasible, costs and schedule can be revaluated and adjusted if the project scope increases or decreases.
Change of requirements	Requirements might grow beyond the original scope to improve the description of the users' needs or to add new elements or functions.

IV.4 Evaluating Processes of Software Development

"A quality management system can be defined as the managing structure, responsibilities, procedures, processes, and management resources to implement the principles and action lines needed to achieve the quality objectives of an organization" [CERCO, 2000]. According to CERCO [2000], a quality management system can be used, for example, to:

- improve users' satisfaction;
- improve quality of products and services;
- increase commitment of the organization;
- have better management and a more effective organization;
- review goals, and assess how well the organization is meeting those goals;
- identify processes that are unnecessary or inefficient, and then remove or improve them;
- review the organizational structure, clarifying managerial responsibilities;
- improve internal communication, and business and process interfaces;
- improve staff morale by identifying the importance of their output, and by involving them in the review and improvement of their work.

Every project is composed by a series of processes, each one designed to meet a particular goal. During the process of the system development, the processes need to be evaluated to ensure the final quality of the product in place. From many types of process assessment, this research will briefly describe the CMM method and ISO 9000.

IV.4.1 Capability Maturity Model (CMM)

The Capability Maturity Model (CMM) is a framework that describes the key elements of an effective software process. Its foundation is the continuous process of improvement for productivity and quality gains [Hall, 1998]. The idea of CMM is that the more mature the process used to develop a system is, the better the system will be. The rank of maturity varies from 1 (low level) to 5 (high level). It means that "organizations need to assess their maturity then introduce process changes which will enable them to progress up the maturity within the 5 levels" [Sommerville and Sawyer, 1997, p.19]. The maturity levels are described as [Sommerville and Sawyer, 1997; Pfleeger and Atlee, 2006]:

Level 1, initial level – there is not too much organization of the system development process. It is left up to the organization to decide how to manage the process and which technique should be used. Normally the inputs to the process are ill-defined and comprehensive measurements are difficult to define.

Level 2, repeatable level – organizations have a budget and schedule to be followed. Inputs and outputs of the system are defined, and constraints are indicated. In this level there are primary management activities that help to understand the actions and outcomes of the process.

Level 3, defined level – organizations have the system process documented and standardized under the organization standards and can be served for everybody. Early product measures can be useful indicators of the later product measures. This early correction of problems helps not only to control quality, but also to improve productiveness and reduce risks.

Level 4, managed level – there is a detailed measurement of the process and product quality used to control the whole process. This means that feedback from early project activities can be used to set priorities for current and later activities, because facts can be compared and contrasted and the effect of changes in one activity can be tracked in the others.

Level 5, optimizing level – there are continuous process improvement strategies for the system. New tools and techniques are tested and monitored to show how they affect the process and products. Assets of the ongoing or completed projects may lead to a refined different development process for the future projects.

Since the CMM does not include the system requirements in its asset of the maturity process, Sommerville and Sawyer [1997] indicates 3 levels of the requirements process maturity model:

Level 1, initial level – organizations have not defined the requirements processes. In consequence they fail to produce good quality requirement documents under a determined budget and schedule.

Level 2, repeatable level – organizations have defined standards for requirement descriptions and have introduced policies and procedures for requirement management. Their requirement documents are more likely to be delivered on time.

Level 3, defined level – organizations have sediment requirement processes based on good practices, and the organizations are able to implement an improvement process based on new methods.

IV.4.2 International Standards Organization (ISO)

The International Standards Organization (ISO) measures standards that collectively are known as ISO 9000. This specific standard demonstrates the level of expertise in designing and building a product. If an organization has a requirement for ISO conformance, then it has requirements for risk management. Hall [1998] explains that corrective actions should plan to deal with problems identified as risks and, at the same time, which the contract should be reviewed to ensure that possible contingencies can be identified. This developed plan should be divided in phases and the design or implementation process should not proceed until all known deficiencies are satisfactorily resolved or the risk is known.

ISO 9001 is applicable as the way to develop and maintain software, including a quality manual, plans, procedures and instructions [Sommerville and Sawyer, 1997]. ISO 9001 focuses on users' satisfaction and processes. It requires less documentation and a more significant quality management system, with an actual commitment to continuous improvement [CERCO, 2000]. It also recommends corrective action to eliminate the causes of the noncompliance issues and preventive actions to eliminate the causes of potential nonconformity [Hall, 1998].

ISO 13407 is related to user-centered design. It begins with a thorough understanding of the needs and requirements of the users. The benefits of the ISO 13407 includes increasing productivity, enhancement of work quality, reductions in support and training costs, and improvement of user satisfaction [Bevan, 2002].

Table IV.3 – Contrasts CMM and ISO 9000 (from Vitharana and Mone [2008])

	CMM	ISO 9000
Strengths	- Widely accepted in the industry. - Continual evolution in software development. - Highlights intra-organizational strategy (e.g., costs and data inventory) to quality management	- Internationally accepted standard for quality. - Pays particular attention to agreements. - Highlights inter-organizational approach (e.g., agencies relationships) to manage quality
Weaknesses	- The theoretical basis for CMM practice is generally lacking. - Considerable up front investment is needed to implement CMM in software quality improvement initiatives.	- Defines the minimum qualification needed to achieve the certification, and hence lacks support for continuous improvement. - Takes a more inter-organizational focus that emphasizes contractual obligations in quality management (as the expense of critical factors such as process, management commitment, etc.). - Similar to CMM, considerable up front investment is needed to implement ISO 9000 software quality improvement initiatives.

APPENDIX V

SPATIAL DATA SHARING AND INTEROPERABILITY

This appendix brings the literature review of data sharing and interoperability. These are technical specifications that will be primary guide for CNIR data sharing. Interoperability is the ability of different systems, or components of a system, to interoperate in a way that users and producers of information can recombine disparate information and apply it in new, unforeseen ways to any number of applications. It is done through a mutual understanding of request and response mechanisms [Groot and McLaughlin, 2000; Hamilton, 2005; Kralidis, 2009]. Interoperability can be for the hardware, software or the data formats [Cömert, 2004].

From the cadastral perspective, the benefits of the interoperability might be, for example, that data sources can be incorporated in inventories, increasing the accuracy and currency of analyses and bringing significant savings in federal funds [Hamilton, 2005]. Stoimenov and Djordjevic-Kajan [2002] state that the advantages of successful information integration are obvious for many reasons:

- Quality improvement of data due to the availability of large and complete data.
- Improvement of existing analysis and application of the new analysis.
- Cost reduction resulting from multiple use of existing information sources.
- Avoidance of redundant data and conflicts that can arise from redundancy.

Section V.1 will bring the methods to implement geospatial data sharing. Section V.2 presents the international standards organizations and their specific spatial standards. ISO standards, defined Appendix IV, are also applied in this section for spatial data. At last, this section will bring a summary of spatial web service interoperability.

V.1 Technical Implementation of Spatial Data Sharing and Interoperability

Wang et al. [2007], Gong et al. [2008] say that there are three methods to implement geospatial data sharing. They are data exchange mode, database direct access mode or common interface mode:

Based on data exchange mode – This method turns certain other data format into internal data format through transformation (i.e., using spatial data exchange software based on files). Some data exchange formats are used in different countries such as DLG and STDS in the USA, ASDTS in Australia, NTF in the UK, DIGEST with NATO, CNSTDF in China, and so on. Data Exchange Mode can be only used for data integration and cannot provide real-time data sharing at the feature level. It is very useful in the field of data processing before importing data into a spatial database and providing digital map products according to the requirement of the users.

Based on direct access – this occurs when the package can directly access multiple databases using different data formats. Direct access not only avoids the fussy course of data exchange, but also allows users to obtain online data by accessing another database directly. It is likely considered to implement spatial data sharing and interoperability through a local intranet.

Based on a common interface - by constituting the common interface function form and parameters, different GIS software packages can directly access each other's database. This can be implemented when the data access interface of a GIS directly uses the standardized interface function or when a GIS has defined its own data access function based on XML (eXtensible Markup Language).

Mohammadi [2008] explains that from the heterogeneous spatial data acquisition to its integration there are few steps which are costly and time-consuming processes: first is the effort and time to investigate the data to find out the characteristics of the data (including spatial and descriptive accuracies) and inconsistency with other data sets. Then, guidelines or standards should be created to finally be able to properly perform data manipulation and integration. Figure V.1 shows these steps.

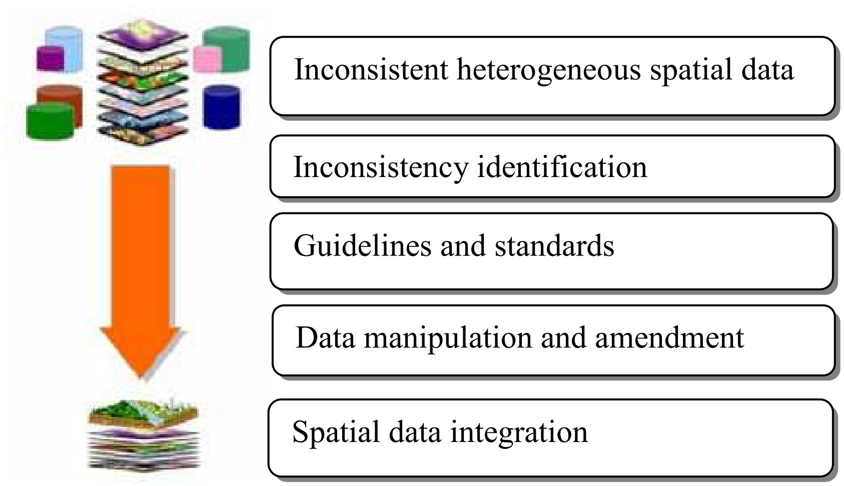


Figure V.1 - Steps for spatial data integration (from Mohammadi [2008])

V.2 International Standard Organizations

Standards can be defined as a document or collection of documents that establish a common language, terminology, accepted practices and levels of performance. They can also be considered as technical requirements and specifications used for development and use of products, services and systems. For spatial data, the benefits of standards are based on conservation of time and effort by removing the need for reinventing approaches to discover, evaluate, access and visualize the data [Kralidis, 2009].

Important organizations including government organizations (e.g., FGDC), industry associations (e.g., W3C and OGC) and international standard bodies (e.g., ISO) are creating standards and specifications to achieve geospatial data interoperability [Zhao et al., 2007]. They are providing standards which lessen the complexity of software development and allow for independent technology, data and information to interact with one another more transparently [Kralidis, 2009].

W3C (World Wide Web Consortium) provides many standards for presentations and delivery of information across networks. The W3C was created to lead the Web to its full potential by developing common protocols that promote evolution and ensure interoperability [Kim and Jang, 2006].

FGDC (Federal Geospatial Data Committee) develops geospatial data standards that facilitate the development, sharing, and use of geospatial data in cooperation with State, local, and tribal governments, the private sector, and the academic community [NIST, n.d].

OGC (Open GeoSpatial Consortium) is a voluntary consensus standards organization that envisions that everyone can benefit from geographic information and services made available across any network, application, or platform, based on implementation specifications. OGC covers a broad range of service types: catalog/registry services, data access services, portrayal and display services, data transformation services, and location-based services [Reed III, 2004; Hamilton, 2005; Di et al., 2008].

ISO/TC211 (International Organization for Standardization Technical Committee 211) has created a complete suite of standards for vector-based GIS which integrate all major developments in this field. It is one of many other ISO technical committees. ISO/TC211 includes standards for: reference model, feature definition, spatial and temporal schema, coordinate reference system, encoding, quality and metadata [Kresse, 2004].

V.2.1 Spatial Data Standards

Below are reviewed examples of standards related to the spatial data:

W3C **-** Among many other specifications such as CSS (Cascading Style Sheets), DOM (Document Object Model), and SMIL (Synchronized Multimedia Integration Language) W3C supports the open standard Scalable Vector Graphics (SVG) [Biuk-Aghai, 2005]. SVG describes two-dimensional graphics and graphical applications in XML that supports vector graphic shapes, images and text [W3C, 2002; Kralidis, 2009]. It is designed to be interactive (event-based) and allows scripting. Because SVG is fully transparent to the DOM, every single element, attribute and property within the SVG graphics may be changed with scripting or programming. SVG is also well integrateable with other XML-based W3C standards.

FGDC **-** FGDC established one metadata standard called the Content Standard for Digital Geospatial Metadata (CSDGM). A similar (and mostly compatible) ISO 19115 standard for geographic information metadata is also widely used [Scofield, 2007]. CSDGM establishes a common set of terminologies and definitions for the documentation of the digital geospatial data, including metadata for the following seven types of information: identification, data quality, spatial data organization, spatial reference, entity and attribute information, distribution and metadata reference [Breitman et al., 2007; Shekhar and Xiong, 2008].

OGC - Some of the OGC specifications are the basis standards of the ISO (e.g., ISO 19125, ISO 19128, and ISO 19136). The fundamental ones include OGC Web-services specifications: WMS, WFS, WCS and CSW implementation specifications. Figure 4.10 indicates the type of features the OGC Web-services specifications. They allow seamless access to geospatial data in a distributed environment, regardless of the data format, projection, resolution, or the archive location [Wang et al., 2007; Di et al., 2008]:

- Web Map Service (WMS) produces portrayal of geographic information as a digital image file suitable for display on a computer screen. It is generally rendered in a pictorial format such as PNG, GIF or JPEG, or occasionally as vector-based graphical elements in Scalable Vector Graphics (SVG) or Web Computer Graphics Metafile (WebCGM) formats [Reed III, 2004; Wang et al., 2007]. As displayed in Figure V.2 by Reed III [2004], WMS utilizes an HTTP request structure that packages a request to one or more servers that understand a WMS request. These servers could provide access to a database. The server processes the WMS request and sends back a geo-registered picture to the client. Since the WMS allows the client to specify a coordinate reference system, all picture images are returned to the client in the same reference system, allowing the overlap.

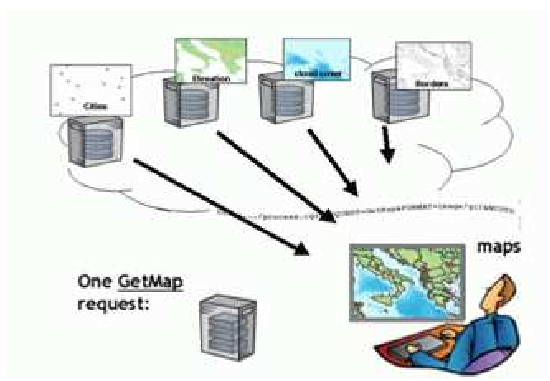


Figure V.2 – WMS map access (from Reed III [2004])

- Web Feature Service (WFS) consists of a description of query or data transformation operations that are to be applied to one or more features in the target repositories; the features come back defined as GML. The features that are returned are selected by tests on values within the properties of a feature as specified in the query filter [Reed III, 2004], see Figure V.3. The WFS is written in XML and uses GML to represent features, but the database can be in any format [Peng and Zhang, 2004].

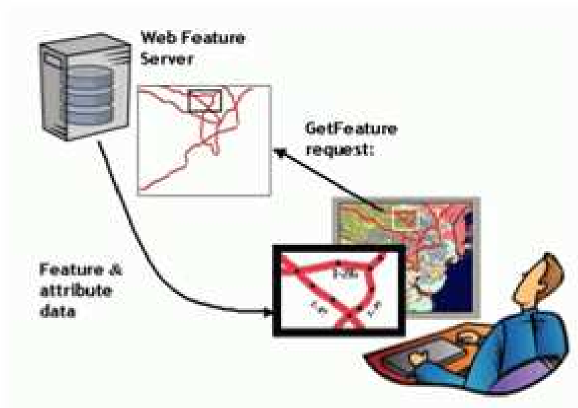


Figure V.3 – WFS application (from Reed III [2004])

- Web Coverage Service (WCS) supports electronic interchange of geospatial data as raster coverages, in contrast with a WMS that only returns images. [Wang et al., 2007; Di et al., 2008]. Coverage contains values or properties of spaced locations, and is returned as grid values (e.g. a GeOTIFF file). As Shengyu and Huayi [2008] exemplify, many satellite imagery viewers, such as Google Earth and Microsoft Virtual Earth, integrate satellite imagery and aero photography, and implement the rapid, multi-resolution display of massive amounts of spatial data that are WCS.
- Catalog Service for Web specification (CSW) defines common interfaces to discover, browse, and query metadata for geographic data, services, and other potential resources [Yue et al., 2006; Di et al., 2008].

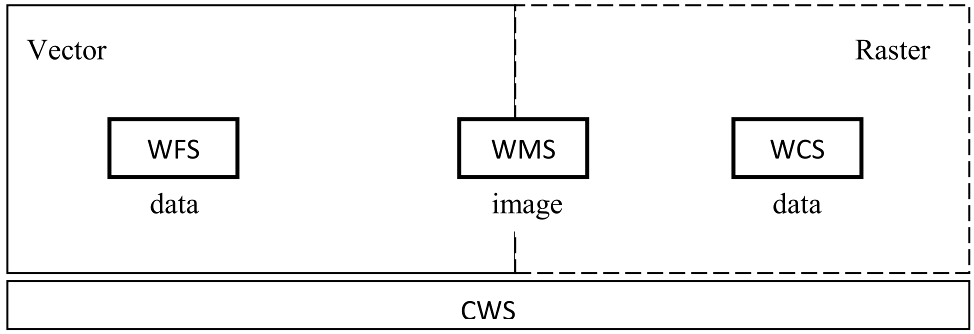


Figure V.4 - OGC Web-services specifications and type of features

WCS and WFS together cover all geospatial data (Figure V.4). They form the foundation for OGC Web-based interoperable data access. OGC WMS defines interfaces for assembling maps from multiple sources over the Web. The OGC WCS, WFS, and WMS specifications allow users to specify the requirements for the data they want in terms of format, projection, spatial/temporal coverage and resolutions. In the end, the users obtain the data that exactly matches their requirements in both content and structure. [Di et al., 2008].

ISO - The standards developed by the ISO/TC 211 are often called the ISO 19100 family. Kresse and Fadaie [2004] explain that the core standards to develop a GIS are:

- Data Capture – ISO 19113 (Quality principles), ISO 19114 (Quality evaluation procedures) and ISO 19115 (Metadata).
- Data Storage – ISO 19109 (Rule for application schema), ISO 19107 (Spatial schema), ISO 19111 (Spatial referencing by coordinates)
- Data Exchange – ISO 19118 (Encoding)
- Coverage - ISO 19123 (Coverage geometry and functions)

Gong et al. [2008] explains that besides ISO 19107 and ISO 19123 which define the spatial characteristics and coverage, the core of the geometry standards are the ISO 19125-1 that provide an implementation specification for the features access in SQL environment and ISO 19136 that uses Geography Markup Language (GML) for the transport and storage of geographic information. GML is an XML encoding for the modeling, transport and storage of geographic information including both the spatial and descriptive properties of geographic features [Wang et al., 2007].

ISO 19100 is one of the most important series of standards to enable geospatial datasets to interact between different data models and different applications. The more geospatial datasets that exist with different data models and different levels of quality the more important it is that the user is aware of where and how the datasets can be used in an application [Jakobsson and Giversen, 2009]. These guidelines might also be useful for any organization that produces geographic information, or for users who want to better understand the approaches taken by producers of geographic information, or who are invited to design specifications in collaboration with producers. Table V.1 complements related standards in the ISO 19100 family.

Table V.1 – List of some GIS standards – ISO/TC211 (from Jakobsson and Giversen [2009]; ISO [2009]).

Phase	Goal	ISO Standard	Guidance
Data Specification	Quality Model	ISO 19113	Quality principles
Production	Logical consistency tests	ISO 19114	Quality evaluation procedures
	Producing metadata	ISO 19115; ISO 19113	Metadata
	Quality measures for database	ISO 19113; TS 19138 ; ISO 19115	Data quality measures
	Product specifications	ISO 19131	Data product specifications
	Spatial characteristics and coverage	ISO 19107; ISO 19123	Spatial schema and coverage functions
Quality Evaluation	Quality tests	ISO 19114; ISO 2859-4 ISO 19105	Quality evaluation Conformance and testing
Metadata	Reporting quality	ISO 19115	Metadata (Extensions for imagery and gridded data)
Storage		ISO 19109; ISO 19107; ISO 19111; ISO 19112	Rule for application, spatial schema, and spatial referencing by coordinates and geographic identifiers
		ISO 19136	Storage and transport of information via GML
Exchange	Metadata catalogues	ISO 19139	Metadata (XML schema implementation)
	Encoding	ISO 19118	Encoding upon XML
Representation	Standard representation	ISO 6709	Standard representation of geographic point
		ISO 19128	Web map server interface
Access	Features access	ISO 19125-1	Specifications for SQL environment

V.2.2 Spatial Web Service Interoperability

Web Services is where every different system or provider offers some "services" for certain user groups over the Internet [Cömert, 2004]. When used for geospatial information, Web Services refer to the use of technology to manage, analyze, and distribute spatial information. It also allows the user search through the data geospatial characteristics, such as location, area, neighborhood, and any other spatial features [Zhao et al., 2007].

Zhao et al. [2007] points out that the advantages of Web Services varies from real-time data access, customized information delivery, value-added composition to easy integration. From the technical point of view, the advantages of using Web services can be summarized as:

- enabling the sharing of hardware, software, and data/information across the organization boundary;
- easy to maintain since the modularity of Web Service allows partial updating and change to existing systems;
- independent from platforms and operating systems since they interact with other Web services through standard messages; and
- independent from programming languages;

Figure V.5 illustrates an example of Web Service interoperability. On the left it is possible to observe services interaction layers that are going from connectivity to interoperability levels. On the right are their connections to specific technology [OGC, 2003].

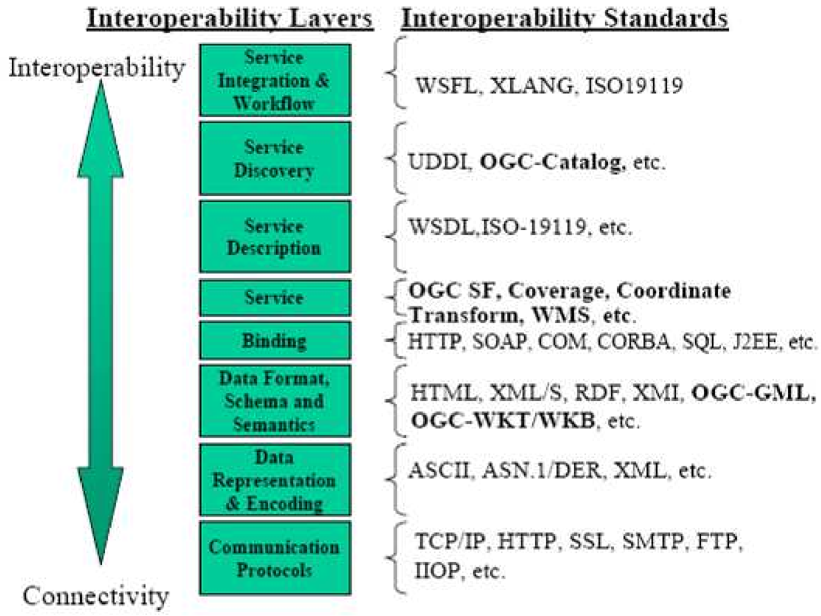


Figure V.5 - Web service interoperability (from OGC [2003])

OGC and ISO/TC211 are the major players in standardizing geospatial Web services. OGC specifications focus on developing implementation standards while ISO/TC211 is concentrating on developing standards for specific methods, tools, and services for acquiring, processing, analyzing, accessing, presenting, and transferring spatial information between different users, systems, and locations [Kim and Jang, 2006;.Zhao et al., 2007].

Béjar et al. [2002] states that in a real situation, vector cadastral information is accessed by a WFS that delivers the requested features (e.g., parcel lines, parcel centers, others) for a specific geographical extent, or associated to a cadastral identifier (e.g., numeric or alphanumeric). Other WFS is used to retrieve, for example, environmental data from the existing official register. A WMS is responsible for providing the graphical representation of the ortho-photographs and the raster cadastral data.

Interaction with a coverage server is needed when a scanned map is requested, it will be provided by WCS, since this information is required to make the following requests to the WMS.

Wang et al. [2007] adds that there is also the Web 3D Service (W3DS). It merges different object types into a single scene graph, providing a visual representation of the basic 3D geodata. The semantic characteristics and relations are not contained in a scene graph. Reed III [2004], Wang et al. [2007], Scianna et al. [2008] and Zhao et al. [2008] also points out that for 3D data in the GIS applications there are standards such as LandXML/LandGML and CityGML:

- LandXML/LandGML: is a specialized XML/GML standard for civil engineering, land management, surveying and cadastre used in land development, transportation and pipe networks. It is executed by OGC. The goal of LandXML/LandGML is to automate the flow of civil engineering and land survey data directly into GIS applications and back again using XML-based open standards, allowing land development, transportation and GIS professionals to exchange high precision design data throughout the entire lifecycle of a project.
- CityGML is the OGC standard for representing 3D city objects in a spatio-semantic coherence data model. CityGML provides support for five levels of detail: Digital Terrain Model (DTM); block models, without any roof structures or textures; buildings with differentiated roof structures and textures and maybe vegetation objects; detailed architectural models with wall and roof structures, balconies, bays and projections and “walkable” architecture models.

- There is also the Web Terrain Service (WTS). WTS specification defines a standard interface for requesting 3D terrain scenes from a server capable of their generation. WTS is an OGC standard similar to WMS but provides a static 3D rendered image of a dataset instead of data itself (i.e., WMS creates 2D visualizations and WTS provides an image depicted of 3D data) [Lupp and Poth, 2008]. The WTS specification is issued by OGC as 'companion specification' to the WMS specification. In both cases the output is a raster image (a bitmap). [Vries and Zlatanova, 2004].

APPENDIX VI

USER REQUIREMENTS STRUCTURED INTERVIEW AT THE CNIR COLLABORATING AGENCIES

(*in Portuguese*)

Conhecimento das Necessidades nas Instituições

CONTATO:

1. Nome Completo do participante: ____

*2. Celular:*_____________________________________

*3. Email:*____

4. Cargo que ocupa: ____

5. Endereço: ____

6.Telefone: _____________________________*7. Fax:*__________________________

1. General Questions Applied to all agencies

Informações gerais da Instituição

1. Qual o cadastro territorial existente? _____________________________________

2. Qual é o objetivo desse cadastro? ____

3. Qual a(s) área(s) de atuação que seu sistema pode ser utilizado?

- ☐ Suporte a infra-estrutura rural
- ☐ Planejamento/zoneamento rural
- ☐ Regularização Fundiária rural
- ☐ Assentamento de trabalhadores rurais
- ☐ Assistência Técnica e Extensão Rural
- ☐ Pesquisas
- ☐ Administração de Terras Públicas
- ☐ Assistência legal aos trabalhadores rurais
- ☐ Monitoramento ambiental

☐ Desenvolvimento Sustentável
☐ Formulação de Políticas públicas rurais
☐ Formulação de regulamentações
☐ Licença ambiental
☐ EIA/RIMA
☐ Demarcação de terras de quilombos
☐ Regularização de terras de quilombos
☐ Demarcação de terras indígenas
☐ Regularização de terras indígenas
☐ Demarcação de terras de tradicionais
☐ Regularização de terras de tradicionais
☐ Capacitação de técnicos e trabalhadores rurais
☐ Vistoria e avaliação de imóveis rurais

4. Das funções atuais do seu sistema, quais dessas funções você acha necessário existir para o CNIR?____
   4.1 Quais dessas funções deveriam ser melhoradas? ________________________

5. Existe algum relatório periódico para monitoramento e avaliação de metas cumpridas? ☐Sim ☐Não
   a) De que forma?_______ ____
   b) Freqüência? ____
   c) Para quem esse relatório é desenvolvido?_______________________________
   d) O que contêm neste relatório? Amostra

6. Que níveis de informação seu sistema poderia produzir para o CNIR?___________

Relacionamento com outras entidades

7. Cite algumas expectativas que você tem com relação a implementação do CNIR? __

8. Sua instituição tem capacidade atual de trocar de um grande volume de dados com outras instituições? ☐Sim ☐Não Como isso é feito?______________________
   8.1 Existe alguma política para essa trocar de dados (ou previsão para esta política) ? Com quem e por quê? ☐ Sim ☐Não
   a) Instituições que regularmente fornecem dados ao seu sistema
      ☐ formal ☐ informal
   b) Instituições planejadas (futuro) para fornecer dados ______________________
   c) Instituições que regularmente recebem dados do seu sistema
      ☐ formal ☐ informal
   d) Instituições planejadas (futuro) para receber dados ________________________

9. Existe alguma integração do seu BD? ☐Sim ☐Não
   ☐ Entre todas as sedes de uma maneira geral
   ☐ Entre a sede nacional e a sede estadual

☐Com a da sede estadual e as unidades regionais
☐Com o INCRA ou com o OET
☐Com órgãos Federais? ________________________________
☐Com Secretarias Estaduais?__________________________________
☐Cartório

10. Como é o acesso a informações é realizado em sua instituição?
☐ Não restrito – público acesso ☐ Apenas uso interno
☐ Informal ☐ Pedidos individuais no local
☐ Limitado por uma política de uso dos dados ☐Disponível on-line no site
Outro ……………………………………

11. Existe algum custo aplicado ao acesso dessas informações? ☐Sim ☐Não ______

12. Com o CNIR, você acha que o acesso dos dados deveria ter a mesma política de acesso que a aplicada atualmente? ☐Sim ☐Não Porque?_____________

Informações sobre o sistema atual

13. Quais são os formatos dos dados de entrada? Exemplo.
☐ Formulários (digital/papel) ☐ Mapas (digital/papel)
☐Tabelas (digital/papel) ☐ Relatórios (digital/papel)
☐ Certificado (digital/papel)

14. Quais são os formatos dos dados de saída ? Exemplo.
☐ Excel/ banco de dados/tabelas (digital/papel) ☐ Mapas (digital/papel)
☐ Resumos de Relatórios (digital/papel) ☐Gráficos (digital/papel)
☐ Certificados (digital/papel)

14.1 Quem faz o controle de qualidade/ revisão dos dados?
entrada de dados: ☐ Sim ☐Não
processamento: ☐ Sim ☐Não
saída dos dados espaciais: ☐ Sim ☐Não
saída dos dados descritivos: ☐ Sim ☐Não
14.2 Qual a periodicidade dessa revisão?__________________________

15. Para controle interno da sua instituição, os dados disponíveis são devidamente documentados? ☐Sim ☐Não

16. Existem diferenças de níveis de acesso dos dados para os usuários internos e externos? ☐ Sim ☐Não
16.1 Com quem? ____
16.2 Por quê? ____
16.3 E Como?____

17. O público em geral está recebendo as mesmas informações/detalhes que uma entidade colaboradora recebe? ☐Sim ☐Não

18. De acordo com as etapas de gestão da informação, em que formato seu dado se encontra?
   a) *Armazenamento* ☐ Analógico ☐ Digital ☐ Internet
   b) *atualização* ☐ Analógico ☐ Digital ☐ Internet
   c) *Disponibilidade a terceiros* ☐ Analógico ☐ Digital ☐ Internet
   d) Transferência interna ☐ Analógico ☐ Digital ☐ Internet
   e) *Troca de dados com outras entidades* ☐ Analógico ☐ Digital ☐ Internet

19. Em que rapidez o Usuário interno e externo pode acessar seu sistema?
   ☐ 5 segundos ☐ menos de 30s ☐ menos de 1min ☐ quase 5 min
   ☐ quase 10 min ☐ quase 15 min ☐ quase 20min ☐ mais de 30min

20. Qual a formação educacional das pessoas que trabalham em seu departamento?
   ☐ Doutorado ( ) ☐ Mestrado ( )
   ☐ Graduado ( )
   ☐ Técnico ( ) ☐ Treinado pelo departamento sem diploma ( )

21. Em que periodicidade sua equipe é treinada?
   ☐ bimestral ☐ trimestral ☐ uma vez no ano
   ☐ cada 3 anos ☐ cada 5 anos ☐ nunca

22. Sua equipe é suficiente para a demanda do seu sistema? ☐ Sim ☐ Não
   22.1 Quantos membros mais seriam necessários?

23. A infra-estrutura do seu departamento suporta a demanda de dados? ☐ Sim ☐ Não
   ☐ computadores ( ) ☐ impressoras ( ) ☐ plotter ( )
   ☐ No-breaks( ) ☐ router ( ) ☐ scanners ( )
   ☐ mesa digitalizadora( ) ☐ leitor de microfilm ( ) ☐ xerox ( )
   ☐ rede de internet ( )

24. Qual a freqüência de backup dos seus dados?
   ☐ Todos os dias ☐ 1 semana ☐ 2 semanas ☐ 1 mês
   ☐ Menos de 3 meses ☐ Nunca

25. Que procedimentos são adotados para garantir a segurança dos dados armazenados? _______

26. Qual o sistema operacional do seu sistema?
   ☐ Mac OS X ( ) HD________
   ☐ Microsoft Windows ( ) HD________
   ☐ Solaris ( ) HD________
   ☐ Linux ( ) HD________

27. Qual o banco de dados do seu sistema? (Frequência de uso, S = Sempre, F= Frequentemente,R= Raramente)
☐ Excel (   ) ☐ Firebird (   ) ☐ Oracle (   )
☐ FileMaker (   )
☐ Ingres (   ) ☐ Informix (   ) ☐ Access (   )
☐ SQL Server (   ) ☐ PostgreSQL (   )
Outro____

28. Como é estabelecido o código de identificação do imóvel? ________________
28.1 Você considerado esse identificador adequado para um sistema compartilhado como o CNIR?____
28.2 Esse código é utilizado por outras instituições para acesso aos dados do imóvel? Quais? ____

29. Seu sistema tem metadados? Anexe um exemplo ☐Sim ☐Não

30. Seus dados seguem algum padrão? Qual? ☐Sim ☐Não
☐ Internacional ☐ Federal ☐Local

☐Organizacional

31. Que programas de SIG a sua instituição possui (SNCR-Geo)?
a) Open Source Software
☐ MapServer ☐ GeoNetwork ☐ GeoTools ☐ MapGuide
☐ PostGIS ☐ Quantum GIS ☐ TerraView ☐ GRASS
☐ SPRING ☐ TerraLib

b) Comercial
☐ Autodesk (MapGuide,AutoCAD)
☐ Intergraph (GeoMedia, GeoMedia Profesional, GeoMedia WebMap)
☐ ESRI (ArcView 3.x, ArcGIS, ArcSDE, ArcIMS, and ArcWeb)
☐ ERDAS IMAGINE
☐ IDRISI
☐ MapInfo (MapInfo Professional and MapXtreme)
☐ CARIS
☐ Safe Software (FME, SpatialDirect and the ArcGIS Data Interoperability Extension)
☐ ENVI

c) Visualizador gratuito
☐ArcExplorer

32. Qual a base cartográfica utilizada?____

33. Você usa alguma ferramenta de conversão em combinação com seu SIG?

Segurança do sistema

34. Quem é autorizado para atualizar/alterar os dados do sistema do seu sistema?___

35. Essa alteração dos dados é notificada pelo sistema ao usuário interno?

36. Um grupo de usuário interno tem permissão de ver informações, e não atualizar/alterar eles? ☐ Sim ☐ Não
Quem?____

37. É necessário permitir que uma função X do seu sistema seja disponível apenas para um grupo seleto de usuários internos? Quem? Por quê?_________________

38. Existe algum controle do acesso de entrada de dados, processamento, saída dos dados ou backup por um usuário interno? ☐ Sim ☐ Não
38.1 Quem é responsável por definir o controle de acesso ao seu sistema internamente?____
38.2 A execução desse controle de acesso é feito pela mesma pessoa/ departamento que definiu o usuário?____

39. Existe algum problema com relação a transferência de dados? ☐ Sim ☐ Não

40. Para quem e porque os dados são transferidos? Por que meio de transferência?____

41. No seu sistema existe alguma forma para detectar ou corrigir erros? ☐ Sim ☐ Não

42. Qual o grau de confiança do seu sistema?
☐ Não confiável ☐ pouco confiável ☐ sem opinião
☐ muito confiável ☐ confiável

43. No caso de queda do seu sistema que causa indisponibilidade dos dados, qual o período de tempo que as funções são restauradas?
☐ segundos ☐ menos de 30min ☐ 30min-1hora
☐ menos de 4 horas
☐ 1 dia ☐ 2 dias ☐ 1 semana ☐ em 1 semana

44. Quando existe um problema técnico (hardware, BD, ou software), qual o período de tempo que as aplicações são restauradas?
☐ segundos ☐ menos de 30min ☐ 30min-1hora
☐ menos de 4 horas
☐ 1 dia ☐ 2 dias ☐ 1 semana ☐ em 1 semana

45. Existe um tempo específico que o seu sistema é disponível aos usuários? Que dia da semana e horário?____

46. Em caso de auditoria, quanto tempo seu sistema retêm informação para:
Documentação __________ registro das auditoria __________
registro dos dados modificados __________ registro dos acessos __________

47. É possível o auditor descobrir quem fez as mudanças, quando elas foram feitas e o que eles fizeram?

2. Specific Questions

a) Entrevista na RFB sobre CAFIR system

Informações gerais da Instituição

1. Quais os usuários atuais e potenciais do CAFIR que você identifica e quais as suas necessidades?

2. Quais tipos de imóveis rurais são exclusos do CAFIR? (posses, terras devolutas???)

3. O que acontece se o imóvel está localizado em mais de um município?

4. Das funções atuais do seu sistema, quais dessas funções você acha necessário existir para o CNIR?____
   4.1 Quais dessas funções deveriam ser melhoradas? _______________

5. Existe algum relatório periódico para índice de consistência entre os dados de imóveis rurais no CAFIR e no Cadastro do INCRA? ☐Sim ☐Não
   a) Procedimento ?____________________________________
   b)Freqüência? ______________________________________
   c)Para quem esse relatório é desenvolvido?____________________
   d) O que contêm neste relatório? Amostra
   e) Problemas encontrados? ______________________________

6. Que níveis de informação seu sistema poderia produzir para o CNIR?__________

7. Existe algum relacionamento entre o INCRA e a RFB? ☐Sim ☐Não

De que forma? _______________________________________

8. Qual o processo para emissão do DITR (Declaração de imposto sobre Propriedade Territorial Rural)?____

9. Qual o significado de área contígua de um imóvel rural para a RFB? ___________

Relacionamento com outras entidades

10. Quais dados são de interesse da RFB oriundo:
    a) INCRA____
    b) Cartório____
    c) CNIR?____
    d) outro

11. Que limitações (ou dificuldades) e oportunidades (ou facilidades) você identifica para a implementação do CNIR?
    a) Legais
    b) Técnicas
    c) Políticas
    d) Administrativas

12. Na sua opinião, como deve ser o gerenciamento compartilhado do CNIR, entre INCRA e RFB, conforme determina a Lei 10.267/01? ________________________

13. A atual estrutura de gerenciamento do CAFIR seria utilizada para o CNIR ou você acha que será necessária outra organização ?_________________________

14. Que instituições deveriam participar da estrutura do CNIR? Quais dados dessas instituições seriam relevantes ao CNIR? ________________________

15. Quais os recursos necessários ao INCRA e RFB (pessoal, tecnologia, procedimentos, regulamentações) para viabilizar a estruturação do CNIR? _______

16. Sua instituição tem capacidade atual de trocar de um grande volume de dados com outras instituições? ☐Sim ☐Não Como isso é feito?____

17. O código do cadastro do imóvel rural é dado por imóvel (1 imóvel:1detentor) ou por detentor (1 detentor: N imóveis)? _____________________________________
    17.1 Esse código é informado ao INCRA? De Que forma? ☐Sim ☐Não

b) Entrevista no SERPRO sobre IT support

1. Qual o papel do SERPRO junto ao INCRA e RFB? ___________________________

2. Como a autorização do sistema para atualizar/alterar os dados é concebida?_______

3. Como o controle do acesso é dado ao usuário:
   a)Do INCRA:________________________________
   b)Entidades externas:__________________________

4. Quem é responsável por definir o controle de acesso o sistema internamente?_____

5. Como é dada a certificação de:
entrada de um novo usuário:______________________________________
alteração dos dados:____

6. No sistema existe alguma forma para detectar ou corrigir erros? ___________

c) Entrevista nos Cartórios de Registro de Imóveis

1. Procedimentos para o registro de imóveis rurais

1. Qual a abrangência da circunscrição do cartório sob sua responsabilidade (bairros, municípios, distritos)? Quais são eles? _________________________

2. Qual o processo (etapas) para o registro de uma documentação de terras particulares? Fluxograma e tempo das etapas____________________________________

3. Qual a demanda pelo registro de terras públicas?_____________________________

4. Existe demanda para registro de terras coletivas ou comunitárias (quilombolas, ribeirinhas)? __________

5. Qual o procedimento para fazer a cadeia dominial? Fluxograma.

6. Como o fluxo das informações sobre imóveis rurais poderia ser melhorado em seu cartório? _____________

7. Quais os documentos necessários ao registro de imóveis rurais?____________

2. Atenção ao cumprimento da Lei 10.267/2001 e legislação associada

8. Você se considera suficientemente esclarecido sobre a aplicação da Lei 10.267/2001 e seus regulamentos? ☐ sim ☐ não

9. Qual sua opinião sobre a implementação dessa lei?__________

10. Este cartório recebe alguma orientação da ANOREG ou IRIB a respeito do Registro dos Imóveis Rurais segundo a Lei 10.267/2001 ou normas do INCRA? ☐ sim ☐ não

11. Que limitações (ou dificuldades) e oportunidades (ou facilidades) você identifica para a implementação da conexão entre cartórios e o cadastro de imóveis rurais segundo a Lei 10.267/2001?
    a) Legais
    b) Técnicas
    c) Políticas
    d) Administrativas

12. Na sua opinião, que ajustes são (ou foram) necessários, no funcionamento do cartório, para atender ao disposto na Lei 10.267/01 e seus regulamentos? _______________

13. Esse cartório já recebeu algum processo de registro de imóveis segundo a Lei 10.267/2001? ________

3. Fluxo da Informação

14. Como as informações no seu cartório são disponibilizadas?
a) para o público em geral ☐ Meio analógico ☐ Meio digital ☐ Internet
b) para o INCRA em atendimento à Lei 10.267/01 ☐ Meio analógico ☐ Meio digital ☐ Internet

15. Existe demanda para a retificação de matrículas de acordo com o estabelecido na lei 10.931? _____

16. Existe demanda de informações sobre o procedimento a ser adotado, de acordo com o R.I, para o atendimento à Lei 10.267/2001? ☐ sim ☐ não

5. Informações sobre o sistema atual

17. Quais são os títulos levado a registro nesse cartório?
☐ hipotecas legais, judiciais e convencionais
☐ penhoras, arrestos e seqüestros de imóveis
☐ usufruto e do uso sobre imóveis e da habitação ☐ servidões
☐ contratos de compromisso de compra e venda ☐ cédulas de crédito rural
☐ sentenças declaratórias de usucapião ☐ contratos de penhor rural
☐ transferência, de imóvel a sociedade ☐ loteamentos rurais
☐ sentenças declaratórias da concessão de uso especial
☐ permuta
☐ contrato de concessão de direito real de uso de imóvel público
☐ doação entre vivos

☐ contrato de bens de partilha
☐ escrituras

18. Que tipo de averbação é mais comum neste cartório?
☐ cancelamento, da extinção dos ônus e direitos reais
☐ contratos de promessa de compra e venda
☐ Termo de Securitização de créditos imobiliários
☐ cédulas hipotecárias
☐ decisões, recursos e seus efeitos, que tenham por objeto atos ou títulos registrados ou averbados
☐ extinção da concessão de uso especial
☐ cessão de crédito imobiliário
☐ reserva legal
☐ servidão ambiental.

19. Neste cartório, em que caso existe a exigência da planta para o registro do imóvel?
☐ Loteamento ☐ Lei 10.267/2001 ☐ Registro Torrens

20. Existem diferenças de níveis de acesso de dados dos imóveis rurais dentro do seu cartório?
☐ Sim ☐Não Com quem? Por quê? E Como?___________________

21. Qual a formação acadêmica das pessoas que trabalham em seu cartório?
☐ predominantemente fundamental ☐ predominantemente médio ☐ predominantemente superior

22. Sua equipe tem recebido algum treinamento ou realizado cursos de aperfeiçoamento/atualização?
☐ sim ☐ não Caso afirmativo, com que freqüência? ______________________

23. Sua equipe é suficiente para a demanda do seu sistema?
23.1 Quantos membros mais seriam necessários para que se tenha um trabalho eficiente?_________
23.2 Na sua opinião, seriam necessários outros profissionais para seu cartório atender as exigências da lei 10.267/2001? ☐Sim ☐ Não

APPENDIX VII

LIST OF CURRENT AND POTENTIAL CNIR AUDIENCE AND EXPECTATIONS FOR CNIR IMPLEMENTATION

a) Academics and Research Centers (Universities, EMBRAPA and NEAD)

- Subsidizing rural properties studies in Brazil by having a general idea of the rural cadastral situation;
- Helping to develop sustainable programs for rural cadastres and agricultural development programs by having concise land tenure information;
- Providing research about land tenure information management, land administration and land uses;
- Providing research and advice for land reform and land redistribution programs.

b) Environmental Agencies (IBAMA, SFB and DNPM)

- Knowledge of the location of the parks, biological reserves, and units of conservation relative to the location of rural properties and their uses;
- Monitoring pollution and exploration in preserved areas by having data about land uses, capability and ownership;
- Knowledge of the location of public and traditional lands and their characteristics and possibilities to be transformed into environmental protected areas;
- Locating and monitoring mineral resource exploitation inside the rural areas;
- Identifying the rural/urban and municipal/state limits.

c) Fiscal Agency (RFB)

- Knowledge of the subject of taxation (i.e., location and characteristics) related to the existence of preserved areas and location within public or traditional lands;
- Locating and estimating the value of rural properties;
- Appling fair property taxation by having land information concur with the real situation, not only as based on citizen declaration;
- Identifying the rural/urban and municipal/state limits.

d) Land Policy Agencies, Consultants and International Aid (MDA, MAPA, MDS, PNUD, IICA and FAO)

- Gathering general information about rural properties (e.g., geometry and uses) and their landholders (e.g., socio-economic aspects and statistics of legal status) to subsidize rural development programs in Brazil;
- Development and implementation of public policies using general land information;
- Identifying land conflicts and helping the decision-making of the land disputes by having the location of private, public and traditional lands;
- Generating new core data and indicating the location of existing core data sets in other user agencies.

e) Land Regularization Agencies and Land Institutes (INCRA and State Land Institute)

- Identifying the landholders and general information about rural properties;
- Characterizing the rural properties in their geometric and socio-economic aspects to allocate land for agrarian reform and land regularization;
- Identifying rural land use and overlaps between private and the locations of public and traditional lands to identify potential areas for expropriation and also making decisions in case of land disputes or *grilagem*;
- Identifying parcel IDs (*Matrículas*) that compose each rural property, and verifying the legal status of the rural property;
- Cross checking citizen declarations with the available and reliable geometric features of the rural property;
- Locating protected areas with restrictions;
- Relocating areas for land reform based on the land use of the rural properties;
- Identifying the rural/urban and municipal/state limits.

f) Legal Rights Agencies (*Serviços registrais*)

- Knowledge of the legal status of the parcel by having its location, description and size;
- Locating the *serviços registrais'* county jurisdiction;
- Researching the location of the estimated rural property value and comparing this with values in the surrounding area;
- Researching the location of the protected area and areas with restrictions and checking their information through the *matrículas*;
- Identifying the municipal/state limits.

g) National Defense Agencies (CDN and ABIN)

- Collecting information related to land acquired by foreigners, especially in regions near the Brazilian border;
- Having access to updated land information for monitoring land occupation. This may reduce *grilagem* in the public lands and avoid agrarian conflicts.

h) Social Agencies and Movements (INSS, FEBRABRAN, MST, CONTAG and FETRAF)

- Collecting information about rural properties and landholders (e.g., personal data and location and duration of the occupied land) for retirement grants and to facilitate acquisition of bank credit;
- Identifying rural lands that should be expropriated by knowing the location of the public and traditional lands and protected areas;
- Improving processes of land regularization for fair land distribution among the landless in Brazil as a whole and enforcing their rights;
- Updating their land inventory to identify areas for future occupations.

i) Statistics Agencies (IBGE)

- Improving statistics cadastral services by having rural property location and personal landholder information;
- Researching land use and land capability in rural areas;
- Identifying the rural/urban and municipal/state limits.

j) Technical Assistance Agencies (EMATER)

- Collecting information about landholders and their rural properties to give support to the rural extension and technical assistance;
- Helping to develop rural programs by having rural property locations and information about land use;
- Identifying the real needs for technical assistance and determining their location by having the position of the rural lands.

k) Traditional and Public Lands Agencies (SPU, FUNAI)

- Knowledge of traditional lands (e.g., who occupies them, their use, location and what are the land improvements in cases of compensation) to ensure the preservation of indigenous reserves from outsiders;
- Knowledge of public lands (e.g., who occupies them, their use, location) to ensure the preservation of national patrimony and to determinate the lands appropriate for redistribution for the landless;
- Verifying the location of neighboring landholders help monitor trespass onto public and traditional land;
- Researching legal information about public and traditional lands to regulate these areas and to prevent use by illegal private occupants;
- Having an inventory of the public lands in Brazil, that is currently unknown;
- Identifying the rural/urban and municipal/state limits.

APPENDIX VIII

RELATIONSHIP OF THE DATA IN THE CURRENT CADASTRAL SYSTEMS

VIII.1 Environmental Cadastre

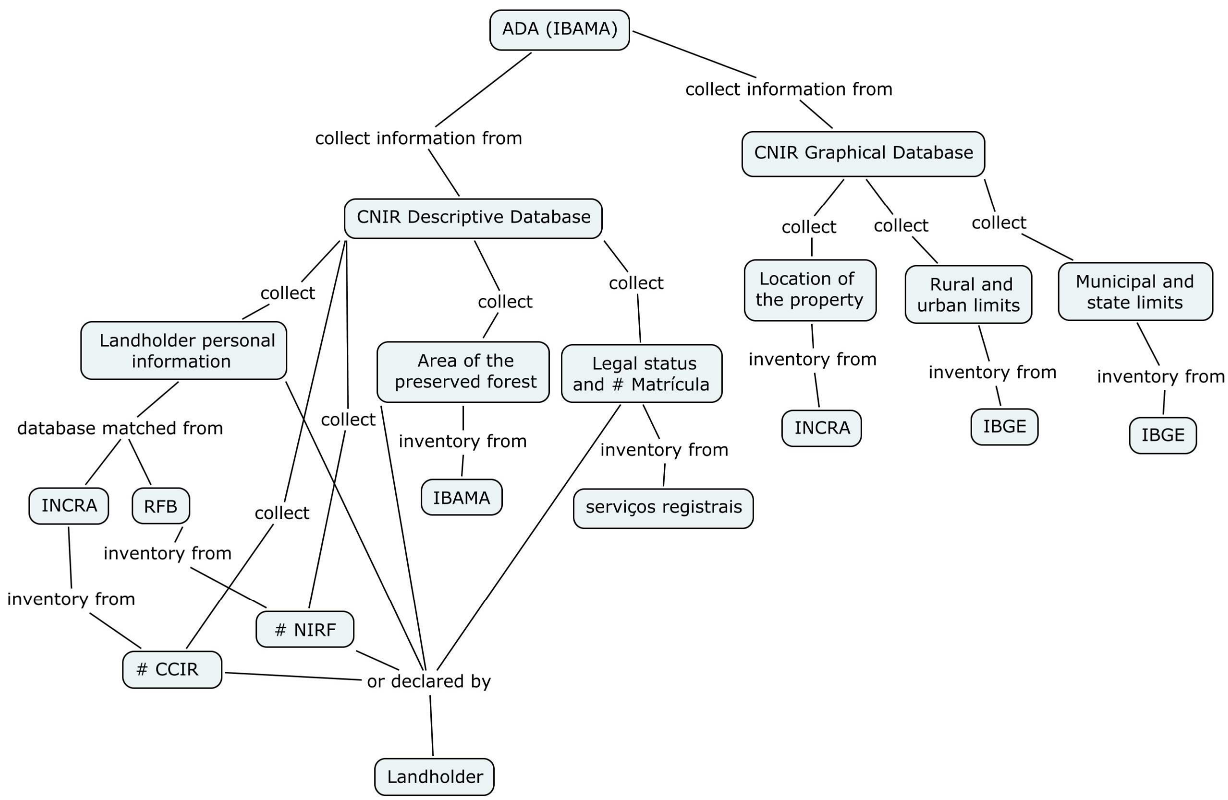


Figure VIII.1 – ADA system data relationship

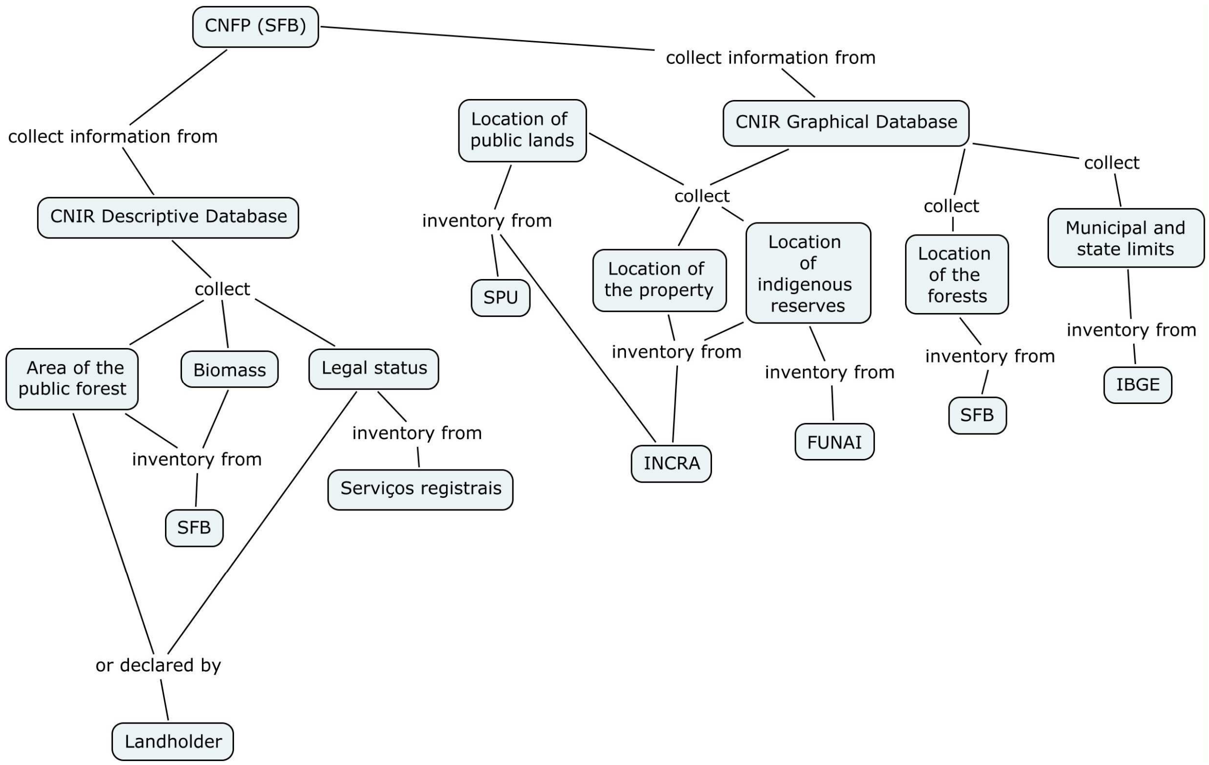


Figure VIII.2 – CNFP system data relationship

VIII.2 Agrarian/ Land Regularization Cadastre

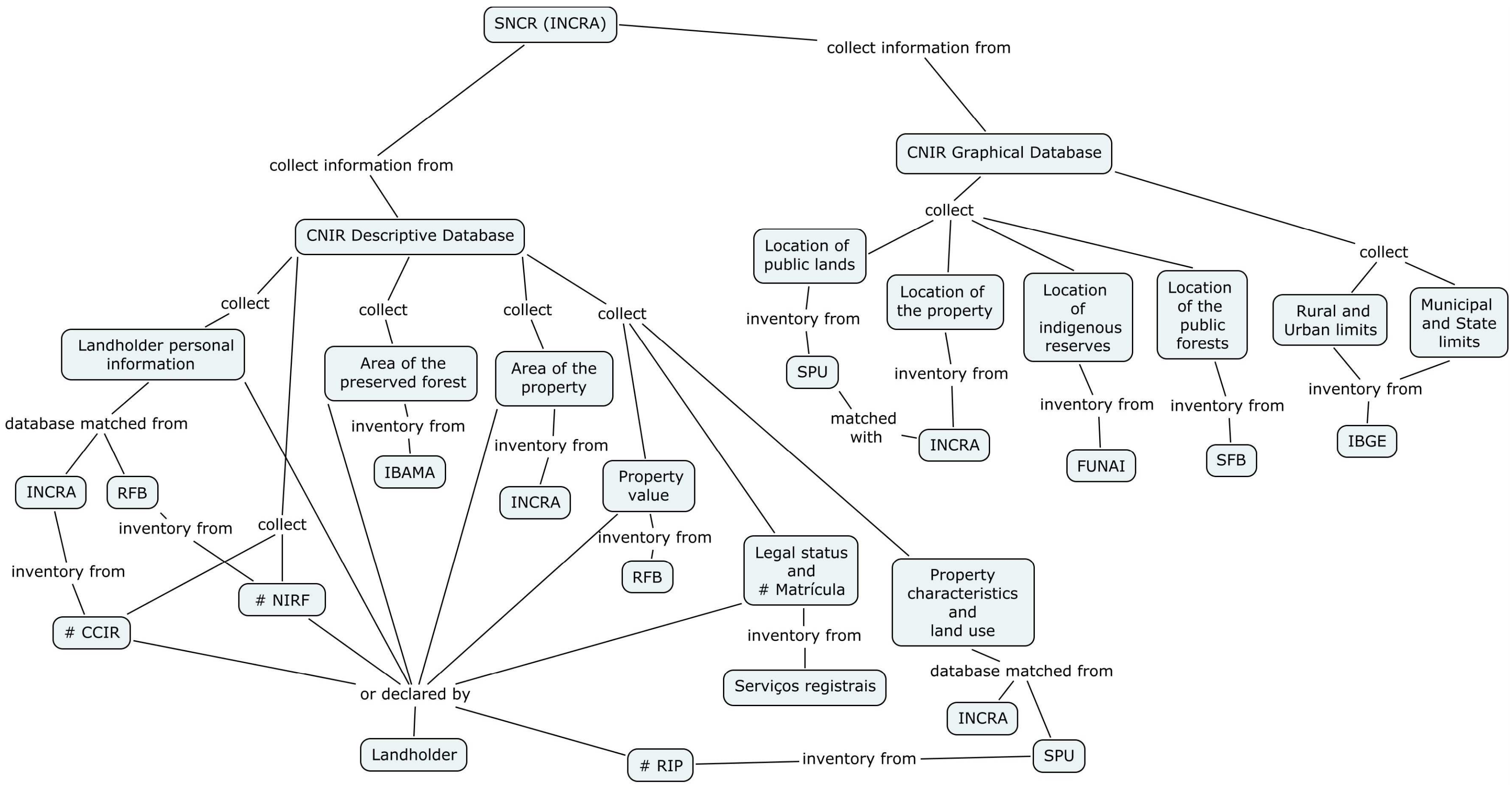


Figure VIII.3 – SNCR system data relationship

VIII.3 Public Lands Cadastre

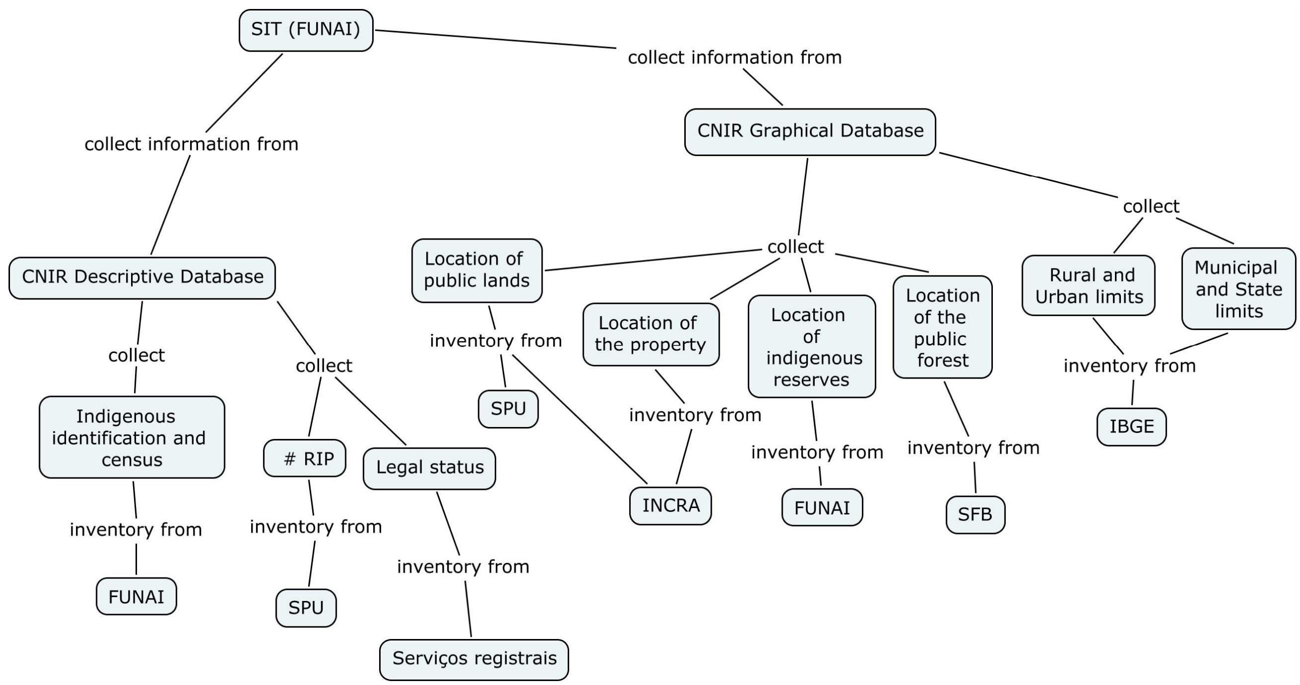


Figure VIII.4 – SIT system data relationship

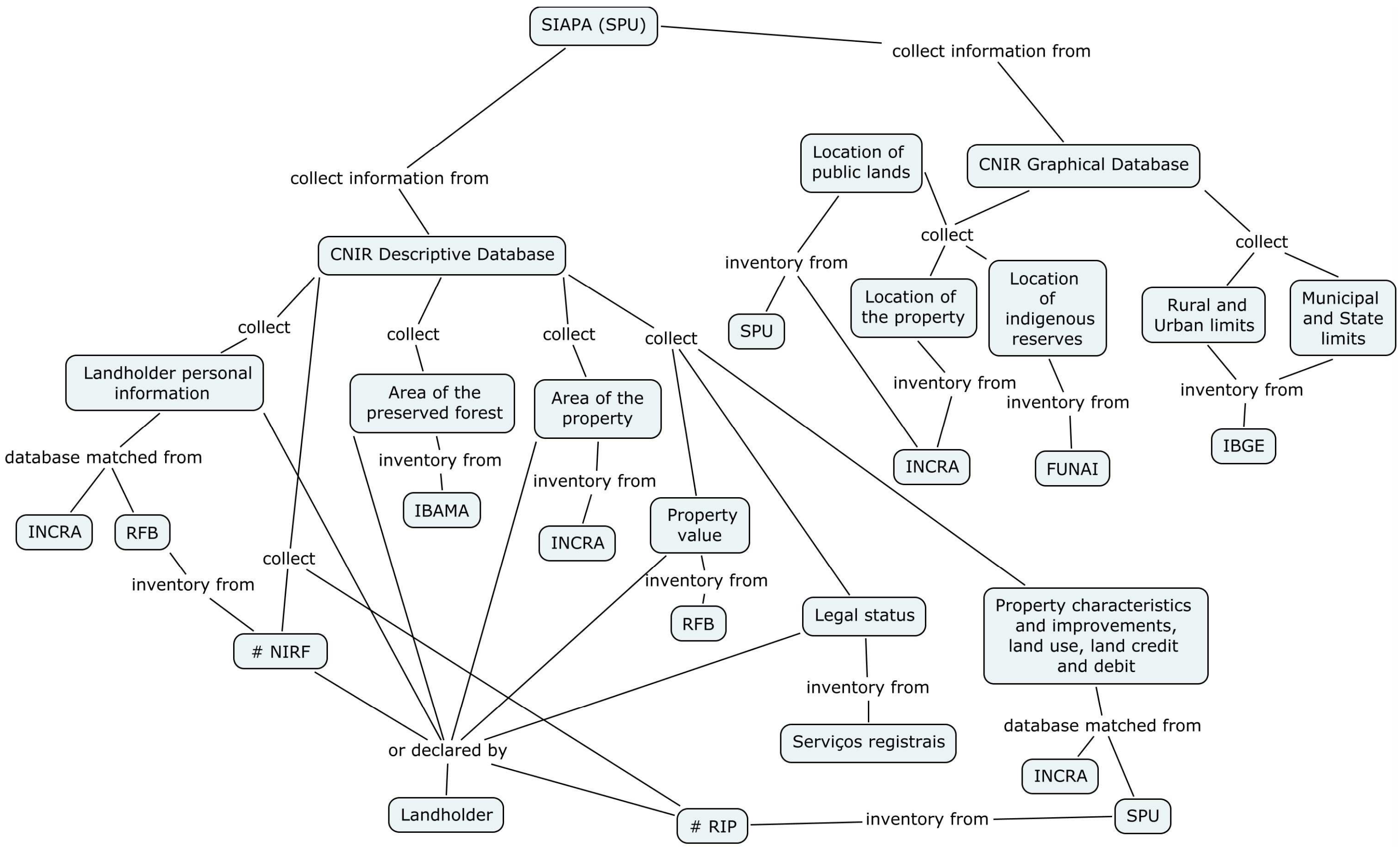


Figure VIII.5 – SIAPA system data relationship

VIII.4 Statistical Cadastre

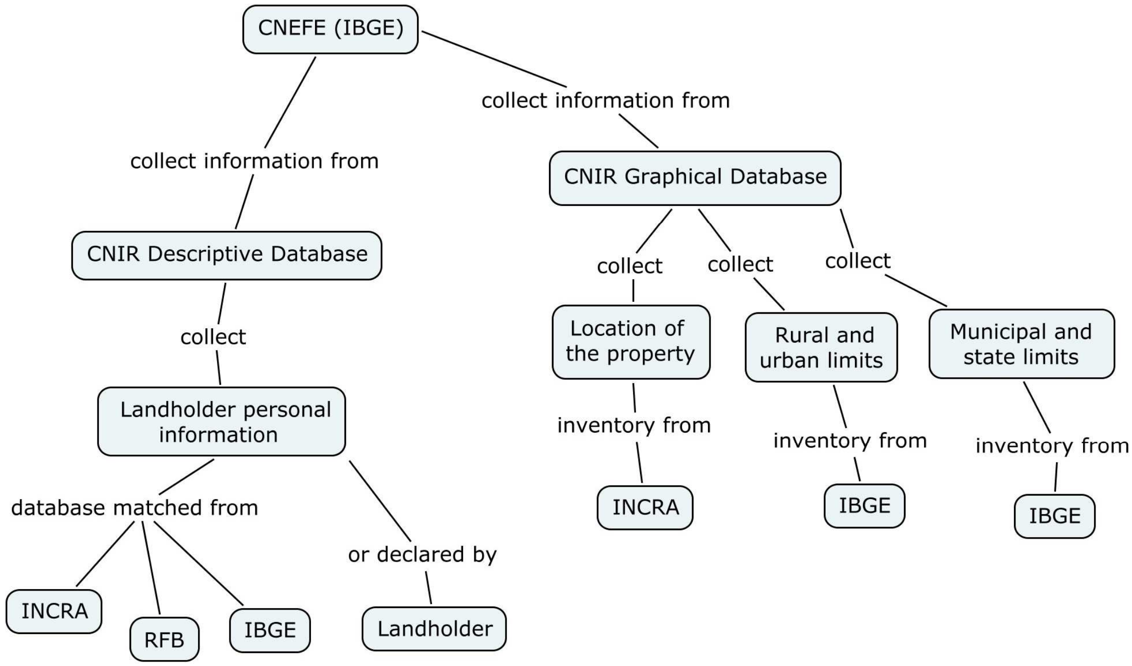


Figure VIII.6 – CNEFE system data relationship

VIII.5 Fiscal Cadastre

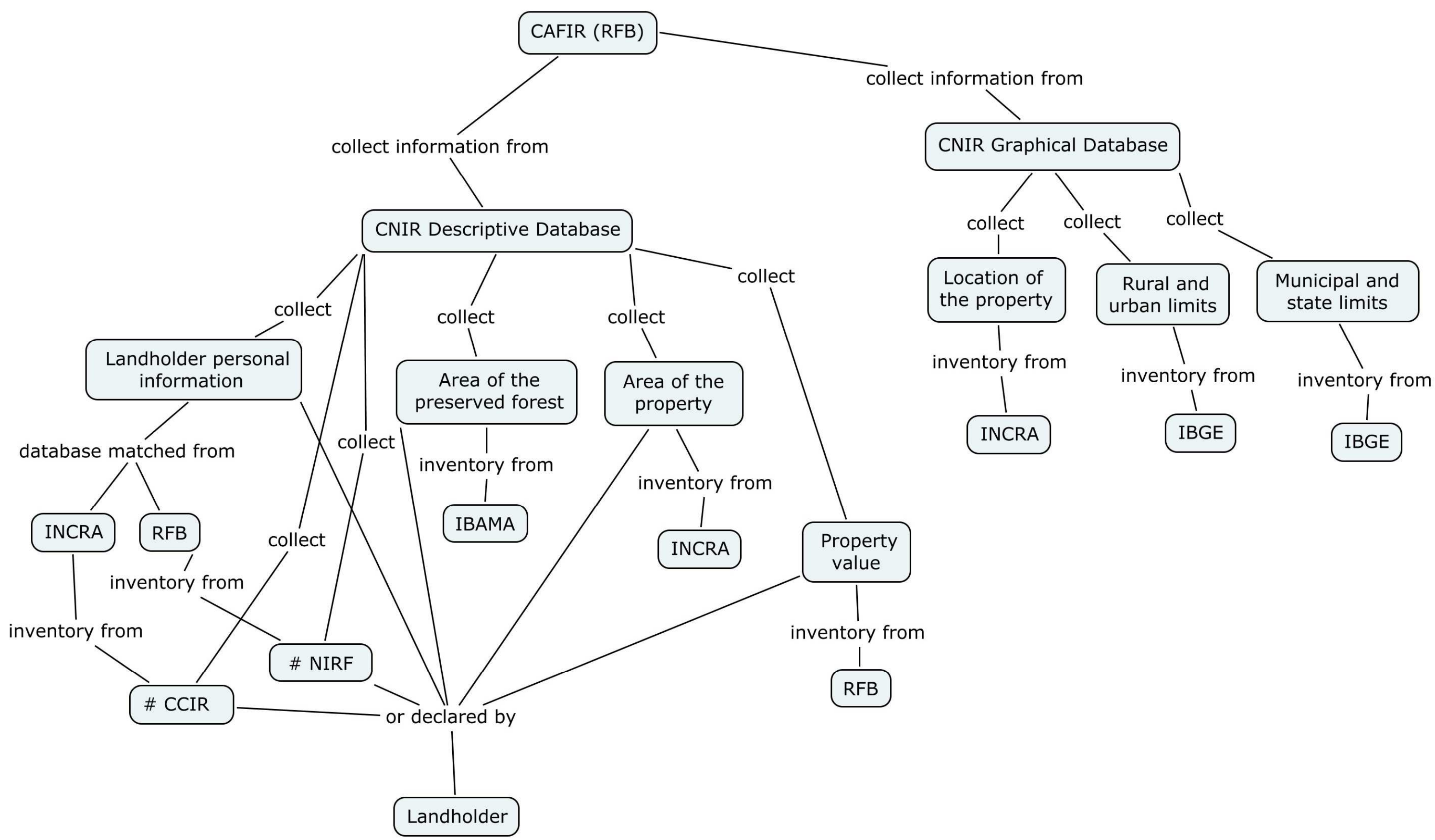


Figure VIII.7 – CAFIR system data relationship

VIII.6 Legal Cadastre

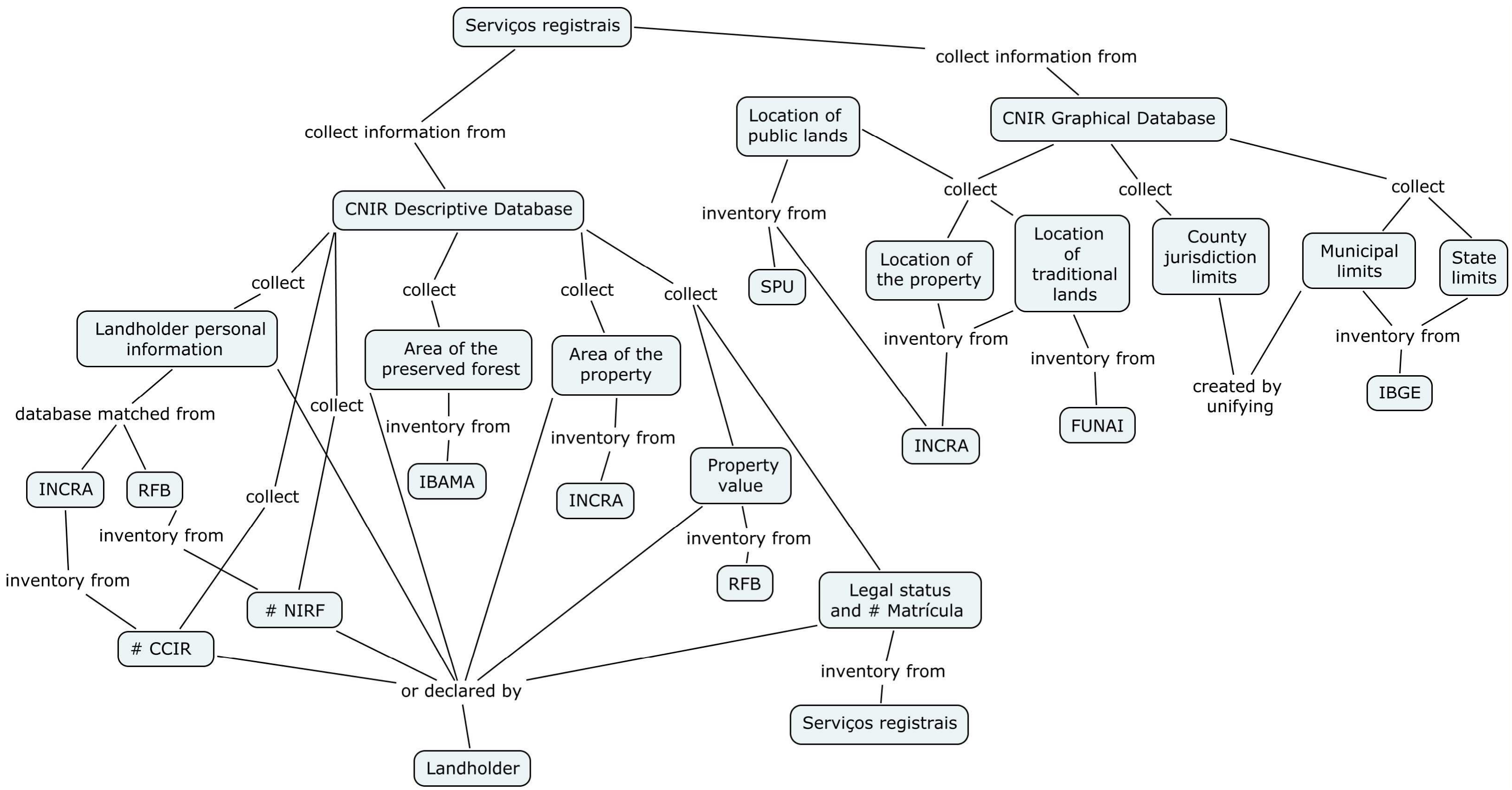


Figure VIII.8 – *Serviços registrais* data relationship
Since there is no *serviços registrais* cadastre and its integration with above systems. The data relationship is hipotetical.

APPENDIX IX

USER REQUIREMENTS AND CONCEPTUAL MODEL

EVALUATION QUESTIONNAIRE

(in Portuguese)

Validação do Modelo Conceitual – INCRA, RFB e SERPRO

☐ INCRA ☐ RFB ☐ SERPRO

1. Prioridade dos Problemas de Implementação do CNIR

1. Por favor classifique com um X cada critério de problemas de implentação do CNIR de acordo com:

Completude – Informação não mais precisa ser adicionada ou o processo está completo.
Confiabilidade – Capacidade do sistema ou processo performe uma requerida função, sobre uma condição específica num intervalo de tempo.
Eficiência- é a medida da produtividade relacionada com alcançar os objetivos com recursos mínimos. Focus no processo.
Consistência – é uma coerência lógica entre dados ou processos
Efetividade – medida de qualidade ou melhoria do sistema. Focus nos dados de saída.

Critérios	**Completo**	**Confiável**	**Eficiente**	**Consistente**	**Efetivo**
Consistência dados de entrada e saída					
ntegração entre os sistemas com outras agências					
Controle de qualidade dos dados					
Fácil atualização					
Sistema de fácil uso					
Fácil acesso do CNIR com outras instituições					
Fácil geração de dados de saída					
Treinamento de profissionais					

Padronização dos dados/ metadados					
Controle de acesso do usuário					
Disponibilização do CNIR ao usuário interno					
Disponibilização Web					
Flexibilidade de agregar novos sistemas					

2. Você acha que esses critérios representam o universo de problemas para implementação do CNIR?

☐ sim ☐ não Caso escolha não, que outros críterios você sugeria?

____

3. Você concorda com a prioritização dos problemas de implementação do CNIR de acordo com:

☐ sim ☐ não

1. Treinamento de profissionais
2. Padronização dos dados/ metadados
3. Integração entre os sistemas com outras agências
4. Uso da intranet para disponibilização do CNIR ao usuário interno

Caso não, indique abaixo 4 problemas em termos de sua prioridade.

2. Modelo Conceitual Proposto

4. Você concorda com o fluxo de informação proposto no modelo conceitual apresentado?

☐ sim ☐ não

Caso não, que modelo conceitual você idealiza? ______________________________

5. Você concorda com o modelo do conteúdo mínimo apresentado?

☐ sim ☐ não

Caso não, em que precisa ser melhorado? ____________________________________

APPENDIX X

DESCRIPTION OF CNIR MODEL DEVELOPED BY INCRA, RFB, SERPRO AND ACADEMICS FROM UFPE, UFSC AND UFBA

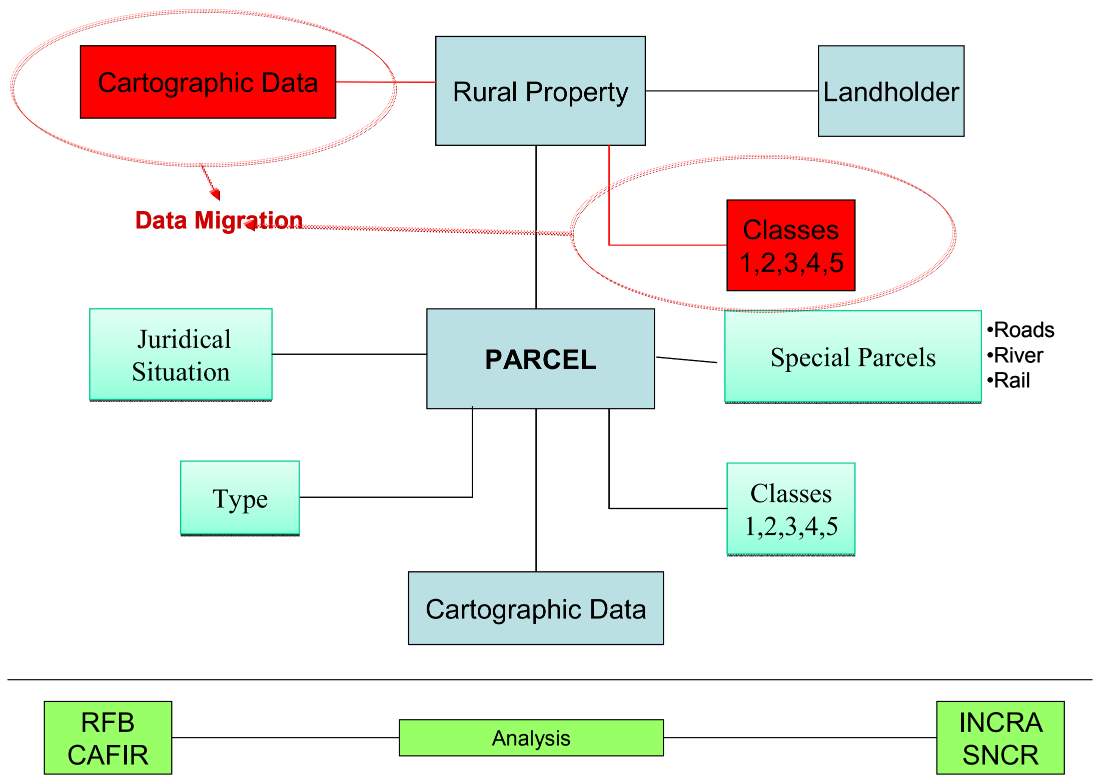


Figure X.1 – CNIR model proposed by CNIR managers

X.1 Description of the CNIR minimum content proposed by the CNIR Managers (INCRA, RFB and Academics)

Identificação - Rural properties are identified through a code attributed by INCRA in the SNCR system. PID will be later on assigned.

Location- Parcels will originate from five groups of sources; depending on the situation that georeferenced data is applied or not. This data is separated into different quality classes, from higher to lower precision, which will compose the CNIR minimum content, as described below.

- **Class 1** – georeferenced rural properties, certified by INCRA according to *Law# 10,267/2001.* Indicate the uncertainty of the measurement;
- **Class 2** - georeferenced rural properties, probably according to *Law# 10,267/2001* (certifiable). Indicate the uncertainty of the measurement;
- **Class 3** – georeferenced realty with indication of the methodology used, which can be altered when applied to the previous conditions. Indicate the uncertainty of the measurement;
- **Class 4** – non-georeferenced rural properties, but possessing some geometric information that might be incorporated into the system, and which can be altered when applied to the previous conditions. Estimate the uncertainty of the measurement;

- **Class 5** – rural properties without geometric information which will be incorporated into the common CNIR database, with only descriptive information. They are result of the matched data from SNCR and CAFIR.

Dimension - Class 1 and 2 parcels will be necessarily georeferenced, therefore description of their geometry and area, with corresponding uncertainties, will be linked to the coordinates. Size of Class 3, 4 and 5 parcels will be defined according to the available information, and when applicable the corresponding uncertainties must be indicated (estimated).

Ownership – This contains the data of the person who possesses the rights and its obligations. This should include: name, CPF or CNPJ, nationality, address, type of relation to the rural properties.

***Legal Situation* -** The following situations must be indicated:

- **Property –** these are the rural properties taken from public estate and registered under the registry office. The owner has complete hold (direct and use).
- **Possession with title –** these are the rural properties that have a title (which can be registered) even if it has not been taken to the registry office.
- **Occupation possession –** these are the rural properties that are occupied without any titling document or without any document that can be registered under the registry office.
- **Public land** – these are the parcels that represents for example, hydrology and roads. These are federal lands.

Land types – This is characterized by the nature that the rural properties

Type 1: rural are;

Type 2: urban area;

Type 3: road;

Type 4: bodies of water;

Type 5: navy lands;

Type 6: native lands;

Type 7: quilombola1 lands;

Type 8: conservation units; etc.

Parcel history - The original parcel code and the way it was constituted (splitting, recombination or inclusion) must be indicated.

Administrative limits - To take into consideration the institutional needs in the formation of the rural properties from the parcels, it is necessary to indicate administrative limits, such as state, city, county, urban area, and rural area. These limits will be taken into consideration when making the parcel.

X. 2 Data resource for CNIR minimum content proposed by the CNIR Managers (INCRA, RFB and Academics)

Class 1 – The source is the data analyzed by the National Certification Committee and INCRA Cartography Coordination.

[1] *Quilombolas* are residents of *Quilombos* in Brazil, they descend from ex-slaves who founded communities named *Quilombos*.

Class 2 – The primary priority 1 is the data from INCRA (regularization, settlement project, Quilombolas territories). The second priority is the data from other agencies (e.g., IBAMA, FUNAI, and SPU).

Class 3 – The primary priority 1 is the data from INCRA (regularization, settlement project, surveys). The second priority is the data from other agencies (e.g., IBAMA, FUNAI, and SPU).

Class 4 – The primary priority 1 is the data from INCRA and the second priority is the data from other agencies.

Class 5 – It contains the descriptive data from SNCR and CAFIR databases.

APPENDIX XI

PROPOSED CNIR COMMITTEE

Figure XI.1 explains the proposed CNIR Committee flowchart. Each committee is below described as:

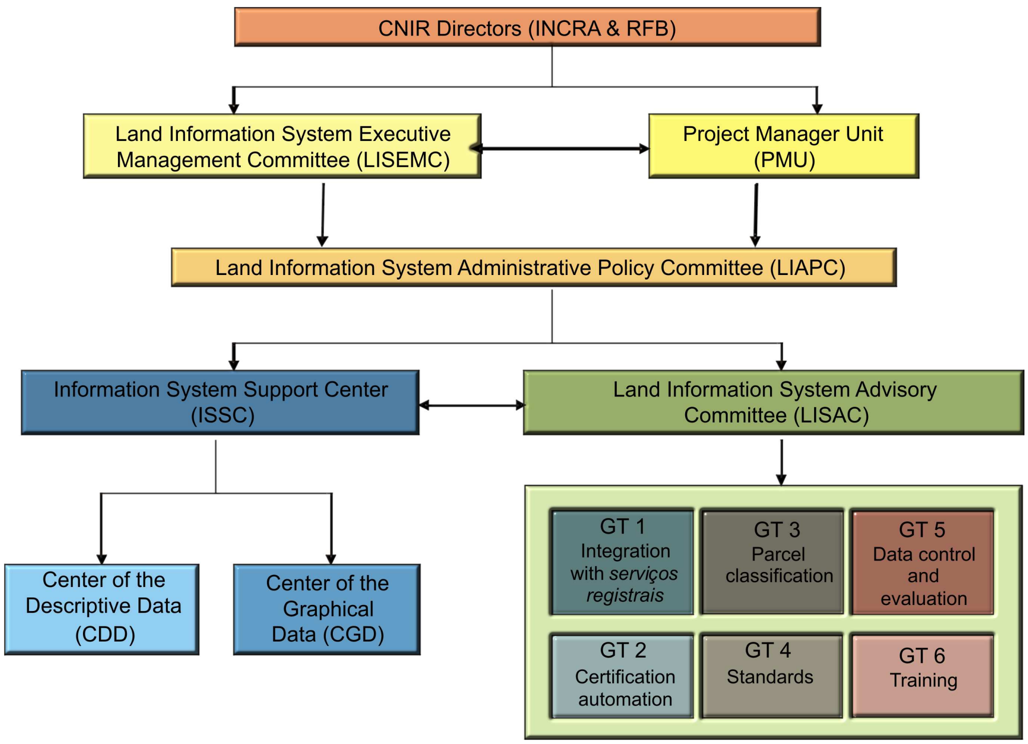


Figure XI.1 – CNIR Committee flowchart

CNIR Directors Board - CNIR Directors have the responsibility to play the politics within CNIR. They are the ones who need to contact the heads of the collaborating agencies to ensure that the data custodianship and data update will be maintained in from each current cadastral system. They are also responsible to sign agreements. The CNIR directors also have direct access to INCRA and RFB the general directors of

INCRA and RFB. The final policy decisions recommended by any of the subordinate committees need to be signed by them. CNIR directors should be the general coordinators of the INCRA and RFB cadastral departments.

Land Information System Executive Management Committee (LISEMC) - LISEMC has the power to make decisions about policy issues recommended by LIAPC. It also has direct connections with CNIR directors (from INCRA and RFB). LIAPC should be composed of the general coordinators INCRA and RFB cadastral departments and coordinators of the collaborating agencies current cadastral system.

Project Management Unit (PMU) **–** Working in parallel to the LISEMC, the PMU is responsible to manage the CNIR system at all levels (i.e., implementation of the system, management of the data quality and communication). This unit should be composed of a team of project managers with different backgrounds (e.g., cartographic engineering, business, lawyer, computer science). They are in charge of the following tasks:

- Update the CNIR project management, which includes reviewing the user requirements;
- Create a well defined workplan;
- Trace system requirements and documentation for further update;
- Support information system management and do system quality control evaluation;
- Support all created working groups and ISSC;
- Do CNIR internal and external communication.

Land Information Administrative Policy Committee (LIAPC) - LIAPC is created to manage both, ISSC and LISAC. Also this committee has responsibility to review and to propose administrative statutory changes and to resolve organizational issues. LIAPC should be composed of one representative of the ISSC and LISAC, the general coordinators of INCRA and RFB current cadastral systems, the general coordinator of INCRA and RFB cadastral departments and the project manager. Some tasks would be:

- Provide for CNIR implementation of all legal aspects.
- Identify/inventory existing related legislation and regulations related to all current cadastral systems at collaborating agencies.
- Review existing copyright and privacy laws and create news regulations if there is need.
- Provide relevant regulations to guide full realization of CNIR system (including updating and creating new legislations).
- Provide funding strategy for CNIR activities (e.g., data collection, update, storage, interoperability and training) and attract new funding to ensure CNIR sustainability.

Information System Support Center (ISSC) - The ISSC is the Center of CNIR Descriptive and Graphical Data general coordination. The ISSC should be composed of the manager of the INCRA cartography department, the manager of the RFB fiscal cadastre system, IT support and a project manager.

The Center of CNIR Descriptive Data (CDD) is used to manage the descriptive data, to manage the processes for classification triage and to manage the information that needs to be changed because of the physical changes. The Center of CNIR Graphical Data (CGD) is used to manage the graphical data, to manage the processes for the separation and classification triage, to manage the information that needs to be changed because of the descriptive changes and implement standards for new maps from other sources outside CNIR.

The CDD should be composed of the coordinators of the INCRA and RFB current cadastral systems and SERPRO specialists. For the CGD, the composition should be from INCRA's cartographic specialist and SERPRO technical specialists.

The main ISSC responsibilities are:

- Coordinate CNIR databases.
- Assist the CNIR collaborating agencies to process their data according CNIR standards.
- Ensure the availability of the CNIR data from the collaborating agencies.
- Resolve conflict of data interests.
- Develop new and improved data classification in CNIR together with GT3 and GT5 (see below).
- Ensure the communication between Center of CNIR Descriptive Data and Center of CNIR Graphical Data and interoperability between these centers.
- Ensure communication between the Information System Support Center and the Land Information System Advisory Committee to maintain all the problems and solutions updated.
- Review at intervals the list of minimum content for possible modifications of the list, based on user requirements.

- Obtain approval of custodianship from each collaborating agency.
- Identify/inventory existing graphical and descriptive data resources.

Land Information System Advisory Committee (LISAC) - The LISAC is the general committee that is represented by members of the implementing agencies, SERPRO, *serviços registrais* and the project manager. LIASC is responsible to manage a forum represented by all six working groups to propose CNIR data changes, regulations, standards, data quality control and training. It also is used to identify and resolve any issue related to CNIR. Besides, LISAC should ensure that all the collaborating agencies are aware of any issues related to CNIR and also ensure that all needs continue to be met for all agencies. If necessary, via project manager or a member of each working groups, the coordinator of each current cadastral system can be directly contacted. LISAC is composed of six working groups, described as:

- ***GT1 (Integration with serviços registrais) -*** this is responsible to create strategies for the integration of the *serviços registrais* within CNIR and to arise problem related to this integration. GT1 should be composed of the *serviços registrais,* INCRA and RFB representatives, and SERPRO specialists.
- ***GT2 (Certification Automation) -*** this is responsible to create standards for the process of parcel certification issued by INCRA at national level, including development of the procedures, guides and training material. GT2 should be composed of the members of the parcel certification department and members of the national certification committee under INCRA.

- ***GT3 (Parcel Classification) -*** this is responsible to manage the parcel classification and decide when data can be upgraded as improves and to create standards for the classification process. GT3 should be composed of *serviços registrais,* INCRA and RFB representatives. These representatives might have direct communication with the coordinators of the current cadastral systems to ensure that all needs are met.
- ***GT4 (Standards) -*** this is responsible to propose standards for CNIR, to monitor the use of the standards created by the GT4 and by others working groups and to communicate with the coordinators of the current cadastral systems to ensure that the agencies are aware of the standards that they need to input their own data. If there is need, GT4 can ask the GT6 to develop special training packages for the collaborating agencies. GT4 should be composed of members of the CDD and CGD. GT4 should be composed of the coordinator of the current cadastral systems from all collaborating agencies. The main tasks of the GT4 are:
    - Create an inventory and review/evaluation existing standards at all agencies.
    - Compile existing standards in one common standard in conformity with ISO used at the SDI in Brazil.
    - Publish CNIR national standards.
    - Develop with GT6 guidelines to provide advices on the application of standards.
    - Promote the benefits of using the CNIR standards
- ***GT5 (Metadata, Data Control and Evaluation) -*** this is responsible for ensuring that the descriptive and graphical data have quality control during the triage process. GT5 also evaluates cases when the graphical data is change to upper level. GT5 needs to work synchronized with GT4, because any decision taken in GT4 will

direct affect GT5 and vice versa. GT5 should be composed by one member of GT4 and one member of the each current cadastral system. GT5 tasks include:

- Produce detailed metadata for CNIR implementation.
- Develop with GT6 guidelines to provide advices on maintenance and use of metadata.
- Promote the CNIR metadata to the existing and potential agencies in order to maintain the commitment of the collaborating agencies and gather new partnership.
- Identify, catalogue and evaluate information sources (graphical and descriptive data).
- Develop conformance and testing tools for CNIR dataset.
- Create rules for tolerance errors at graphical data and for mismatch of descriptive data.
- Control the data access at several levels in CNIR.

- ***GT6 (Training) -*** this working group is responsible to assist all the others GTs. GT6 is available to elaborate procedures, manuals, and training material for the collaborating agencies and the citizens. GT6 can create its own material, or use materials developed by each GT. It should be composed of one representative of each GT, and communication department within INCRA and RFB. Other GT6 tasks would be:
  - Encourage basic training on CNIR system and its components (e.g., metadata development, data sharing and use of the system).

- Promote research on CNIR application helping to showcase the benefits of CNIR.
- Promote awareness on the importance of CNIR for policy and decision makers, to ensure CNIR remains strong in the long term period.
- Promote institutional reforms in geo-information to facilitate assimilation of CNIR by the agencies.
- Promote mandatory continuous workshops to update the knowledge of relevant professional in geo-information subjects (e.g., SDI and interoperability) in order to maintain strong the CNIR conception.
- Promote general awareness on CNIR system using various media (e.g., print and electronic media, newsletter publication, Internet website and conferences) using simple and direct language that can be understandable by the general public.

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