Masters
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in Geospatial
Technologies

PARTICIPATORY MAPPING IN THE DESIGN PROCESS OF A SPATIAL DATA INFRASTRUCTURE (SDI)

A case study in the Biosphere Reserve Rio Platano (Honduras)

Alberto Olivares Colás

Dissertation submitted in partial fulfilment of the requirements
for the Degree of *Master of Science in Geospatial Technologies*

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Dissertation supervised by

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ABSTRACT

In the recent years, the major production of cartographic information and the advancement of new Information Technologies (IT's) has brought with it the need to develop new storage and management tools, making access in a simpler way either alphanumeric or vector information.

Since the 60s, the processing, analysis and visualization of cartographic data has been carried out using GIS as desktop software, installed on a single computer. The advantage of this system was the possibility of combining different cartographic information thereby facilitating decision-making.

The need to share data, mainly cartographic information, between agents who are working in the same area has been the basis for the creation of Spatial Data Infrastructures (SDI) at global, national, regional ,local, or corporative level.

Several resources for managing, classifying, sharing, exchanging, combining and accessing geographic data through internet connection have been developed together with the implementation of all levels of SDI's. The resources can be classified as: software for publishing cartographic data (maps servers), publication standards, metadata, legal framework, agreements among organizations, and the possibility to create different user levels.

Therefore, the aim will be to have cartographic information updated and available for all the involved agents who are working in the same territory, which will result in sharing efforts and costs.

Nevertheless, the development of new technologies has had an effect where the cartographic data producers have less direct contact with the field, ignoring somehow the people living in it who are the ones with best knowledge of the territory.

In remote areas, where it is difficult to access such as the Rio Platano Biosphere Reserve Region (Honduras), it is indispensable to create an SDI for managing and sharing cartographic information by the involved agents in the territory.

It is important that the information offered by the indigenous communities is not left aside because they have a direct relation with the field. In the case of Rio Platano, they are scattered along the territory.

The basis of this thesis is to create the SDI for the Rio Platano region and the methodology to combine the different cartographic information published by different organisms. Also, it will be important to include in the SDI structure the information regarding the cadastral boundaries and socio environmental indicators obtained from the indigenous communities. It will require the design of participative pictograms using Participatory Mapping techniques.

PARTICIPATORY MAPPING IN THE DESIGN PROCESS OF A SPATIAL DATA INFRASTRUCTURE (SDI)

A case study in the Biosphere Reserve Rio Platano (Honduras)

ABSTRACT (Spanish)

El incremento en la producción de información cartográfica y el avance de las nuevas Tecnologías de la Información (IT´s) en los últimos años ha llevado aparejado la necesidad de desarrollar nuevas herramientas de almacenamiento y gestión, con las que acceder de una forma sencilla tanto a la información alfanumérica, como a la vectorial de la misma.

El tratamiento, análisis y visualización de la información cartográfica se ha venido realizando, desde la década de los 60, mediante la utilización de los Sistemas de Información Geográfica como software de escritorio, instalado en un único ordenador. Este sistema ofrecía como ventaja la posibilidad de combinar distinta información cartográfica facilitando de este modo la toma de decisiones.

La necesidad de compartir información, ya sea cartográfica o de cualquier otra materia, con agentes que estén trabajando en un mismo territorio, ha sido la base para la creación de las Infraestructuras de Datos Espaciales (IDE), tanto a nivel global, como nacional, regional, local, o corporativa.

Aparejados a la implementación de las IDE´s a todos los niveles, se han desarrollado diversos recursos para gestionar, clasificar, compartir, intercambiar, combinar y acceder a los datos geográficos a través de internet. Podemos clasificar

dichos recursos como: software de publicación de datos cartográficos (Servidores de mapas), estándares de publicación, metadatos, marco legal, acuerdos entre organizaciones y creación de niveles de usuarios.

La finalidad, por tanto, será disponer de una información cartográfica lo más actualizada posible, accesible por todos los agentes que trabajan en un mismo territorio, compartiendo esfuerzos y costos.

Sin embargo, este desarrollo de nuevas tecnologías ha producido que los generadores de información cartográfica tengan menor relación directa con el territorio, obviando en ciertos momentos, que las personas que mejor lo conocen son los que habitan en cada lugar.

En áreas remotas y de difícil acceso como la Región de la Biosfera Rio Plátano (Honduras), se hace indispensable la creación de una IDE para gestionar y compartir información cartográfica por los agentes que trabajan en la misma. En la definición de la IDE se ha optado por no dejar de lado la información ofrecida por aquellos que conocen mejor el territorio, dominado por la presencia de pequeñas comunidades indígenas dispersas.

La base de esta tesis es la creación de los recursos de la IDE para la Región de Rio Plátano y el establecimiento de la metodología para combinar información cartográfica publicada por distintos organismos con la información a tiempo real de uso del territorio con el objeto de definir los límites catastrales e indicadores socio-ambientales. Dicha información a tiempo real será la proporcionada por las comunidades indígenas a través de pictogramas participativos mediante la técnica conocida como Mapeo participativo.

KEYWORDS

Participatory Mapping

Participatory Pictogram

Indigenous Communities

Spatial Data Infrastructure (SDI)

Spatial Database Management System (SDBMS)

Map server

Geographic Information System (GIS)

Cadaster

Socio-environmental indicators

KEYWORDS (Spanish)

Mapas Participativos

Pictogramas Participativos

Comunidades Indígenas

Infraestructura de Datos Espaciales (IDE)

Sistema de Gestión de Bases de Datos (SGBD)

Servidor de Mapas

Sistemas de Información Geográfica (SIG)

Catastro

Indicadores Socio-ambientales

ACRONYMS

CONPAH – National Confederation of Indigenous People of Honduras

CSW – Catalogue Service for the Web

DCMES – Dublin Core Metadata Element Set

EU – European Union

FETRIPH – Confederation of Pech Indigenous communities of Honduras

FGDC – Federal Geographic Data Committee

GIS – Geographic Information System

GPS – Global Positioning Systems

GSDI – Global Spatial Data Infrastructure

HTTP – Hypertext Transfer Protocol

ICDE – Colombian Spatial Data Infrastructure

ICF - National Institute for Forest Conservation and Development, Protected Areas and Wild Life

ICTs – Information and Communication Technologies

IFAD – International Fund for Agricultural Development

IGN – National Geographic Institute

IK – Indigenous Knowledge

IP – Institute of Property of Honduras

IP – Internet Protocol

ISO – International Organization for Standardization

IT – Information Technology

LADM – Land Administration Domain Model

MASTA – Moskitia Alsa Takanka

MDGS – UN Millenium Development Goals

MOPAWI – Moskitia Pawisa

NAD – Noth American Datum

NGOs – Non-Governmental Organization

NSDI – National Spatial Data Infrastructure

OFRANEH – Honduran Black Fraternal Organization

OGC – Open Geospatial Consortium

OSGEO – Open Source Geospatial Foundation

PRA – Participatory Rural Appraisal

PAFID – Philippine Association for Intercultural Development

PGIS – Participatory Geographic Information System

PROTEP – Land Use Planning and Environmental Protection Project

P3DM – Participatory 3-D Modelling Mapping

RDBMS – Relational Database Management Systems

RHBRP – Reserve of the Man and Rio Platano Biosphere

SDBMS – Spatial DataBase Management System

SDE – Spatial Database Engine

SDI – Spatial Data Infrastructure

SEGEPLAN – Secretariat of Planning and Programming of the Presidency

SEPLAN – Ministry of Planning and External Cooperation

SIMONI – Integral Monitoring System

SINAPH – National Protected Areas System of Honduras

SINIT – National Land Information System

SNIF – Forest National Information System

SLD – Style Layer Descriptor

SQL – Structured Query Language

SURE – Unified Registry System

UK – United Kingdom

UML – Unified Modelling Language

UN – United Nations

UNESCO – United Nations Educational, Scientific and Cultural Organization

USA – United States of America

VGI – Volunteered Geographic Information

WCS – Web Coverage Service

WFS – Web Feature Service

WGS – World Geodetic System

WMS – Web Map Service

WPS – Web Processing Service

WSIS – World Summit on the Information Society

WWW – World Wide Web

XML – Extensible Markup Language

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1. INTRODUCTION

1.1. Theoretical Framework

''Geospatial data'' means information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth. This information may be derived from, among other things, remote sensing, mapping, and surveying technologies. Statistical data may be included in this definition at the discretion of the collecting agency (Presidential Documents Executive Order 12906, 1994).

This document was the first to talk about the cooperation between the different agencies in the U.S.A. regarding "Geospatial data" and the way of obtaining it. It was the basis for developing the Spatial Data Infrastructure of the country.

The term Spatial Data Infrastructure (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and the application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general (Global Spatial Data Infrastructure, 2004).

The Region of Rio Platano is a huge extension of forest composed of five municipalities. The low level of development of the whole region, where communication is through unpaved roads, is the main cause of the isolation of the area from Tegucigalpa (capital of Honduras).

Furthermore this situation is exacerbated by the lack of coordination among organizations working in the study area. Municipalities and ICF offices *"National Institute for Forest Conservation and Development, Protected Areas and Wild Life"* in the Region, and other organizations work in isolation without maintaining communication between them. Also, the difficulty of access to some areas causes the minimum spatial knowledge of those territories.

In these cases, the relationship between the municipal technicians and the indigenous communities who are living in the remote areas of Rio Platano becomes important. The role of the citizens is vital to feed Geospatial data to those remote areas, since they are the ones with the best knowledge of the territory.

Therefore, it is important to obtain relevant cartographic information from different sources in all levels of knowledge from the International cartographic servers to the small communities. The ideal situation would be that all the organizations working in the Region were well organized, and the Geospatial data were obtained from all the different levels of the society.

This Thesis will be framed within the *"Land Use Planning and Environmental Protection Project"* (PROTEP) in Rio Platano. This project has been developed through bilateral cooperation between Honduras and Germany, and is executed by the ICF. The KfW-Entwicklungsbank is the funding organization for the project and the GFA-Consulting group provides technical assistance.

PROTEP's activities are directed towards improving the management and protection of natural resources in the "Río Platano Region" Reserve and its buffer zones. The project implementation began in May 2010 as a continuation of a previous process of land tenancy regulation and cadastral establishment in the reserve. The project emphasizes their actions in the framework of support for land management at the community level.

Rio Platano is a protected area, where small isolated indigenous communities are scattered throughout the territory. As previously mentioned, the information obtained from these communities will be of vital importance to feed the Spatial Data Infrastructure of the Region with cartographic information.

In the last years there has been an explosion of interest in using the Web to create, assemble, and disseminate cartographic information provided voluntarily by individuals, e.g. Wikimapia and OpenStreetMap. Anyone with an internet connection can edit entries, and provide it with a description (Goodchild, M., 2009). These modern tools, known as Volunteered Geographic Information (VGI), are very

popular in developed countries. Nevertheless, how can indigenous communities, provide cartographic information without an internet connection?

There are different tools used in the obtaining of data from the indigenous communities, but the most used one is "Participatory mapping"; which is in its broadest sense, the creation of maps by local communities – often with the involvement of supporting organizations including governments (at various levels), non-governmental organizations (NGOs), universities and other agents engaged in development and land-related planning (International Fund for Agricultural Development (IFAD), 2009).

The methodology used in order to obtain cartographic information from the indigenous communities using Participatory mapping and the inclusion of that information to the structure of the SDI of Rio Platano will be the backbone of this thesis.

1.2. Motivation

The great amount of cartographic information generated by all the different sources has provoked a hardship in maintaining all this information in a well-organized fashion. The organizations in the study area must coordinate and share all sorts of information, mainly cartographic data. This is the base for the progress and development of the projects carried out, focusing on the global knowledge and better planning of the region.

Rio Platano Region is a vast area, where communication is difficult, due to the terrain since it is very abrupt and the roads are not in a good condition. This structure of the area causes that the information between different organizations and people working in the study area to not flow easily.

Establishing communication between the inhabitants of the region, such as indigenous communities, and the different organizations in the area is a key factor for the territorial knowledge and planning.

The methodology used to obtain relevant information from indigenous communities with participatory mapping processes is considered an important point for obtaining a good real knowledge of the area. Their contribution using maps with pictograms, showing the different aspects of the territory, will be necessary to feed the cartographic data of the Spatial Data Infrastructure of the Rio Platano Region.

Therefore, obtaining such information from indigenous communities and its conversion to digital format using Geographic Information System (GIS) is essential for the establishment of cadastral boundaries and socio-environmental information with a great relation to the ground physical level.

This research proposes to develop a methodology to include the information obtained from the indigenous communities regarding cadastral boundaries and socio-environmental information using Participatory mapping tools aiming to feed the Spatial Data Infrastructure proposed for the Rio Platano Region, and coordinate it with the information related to the other organisms.

1.3. Research Objectives

The different objectives of the thesis after studying the necessities of the project are:

- ❖ Design the methodology to obtain information from the indigenous communities.
- ❖ Design the methodology for the extraction of the cadastral information in the indigenous areas.
- ❖ Design the methodology for the extraction of the information regarding socio-environmental aspects.
- ❖ Methodology of the digitalization to include the obtained information in the structure of the PROTEP cartography.
- ❖ Global structure of the SDI Rio Platano Region including all the available information taking into account the multi-scale interoperability (PROTEP

office, ICF offices, Municipalities, other agencies in the area, inhabitants and indigenous communities).

❖ Design the methodology to share all the available information with the different agents and all the people interested in the Rio Platano Region.

1.4. Research Questions

1. How can we include the information of the people who have better knowledge of the territory (indigenous communities)?
2. How is it possible to measure the quality of this information?
3. How can the obtained information from the indigenous communities be important to acquire a better knowledge of the territory?
4. How can all the available information in PROTEP project be organized in a SDI?
5. How can PROTEP project share the available information with the different municipalities, ICF offices "National Institute of Forest Conservation and Development, Protected Areas and Wild Life", and the people interested in Rio Platano Region?

1.5. Thesis Structure

This thesis is divided in nine chapters. The first chapter is a general description of the actual scenario in the Rio Platano Region regarding the availability of the cartographic information and the motivation of creating a SDI in the region including the information obtained from the indigenous communities using Participatory mapping techniques.

Chapter 2. State of the Art, is an overview of the actual situation in Participatory mapping technics and Spatial Data Infrastructures, reviewing different key documents, books, publications and articles, and the relation established between both concepts. A relation and a comparison of the different software used to develop a map server is also included.

Chapter 3. Conceptualisation. Necessities of the project. After several interviews with the people who are working in the project, it is possible to gather the weak points from the actual situation for sharing cartographic information. Analysing that information obtained from them; the Geoportal interaction prototype of the Spatial Data Infrastructure of the Rio Platano Region with the different services is developed. In addition to the design of the main page, the necessity to include the information obtained from the indigenous communities is considered essential for the good knowledge of the territory after the interviews with the people selected for the interviews in the PROTEP project.

Chapter 4. Study Area and Data, is a brief geographic description of the Rio Platano Region and an overview of the available data published by different agencies which are working in the area and its characteristics of production.

Chapter 5. Indigenous communities Cartographic integration process. Designing the methodology to include the information from the indigenous communities in a Geographic Information System. After several meetings with the selected people in each community a few number of pictograms for the collection of different information as boundaries for the cadastral registration and biological aspects are designed (hunt areas, fishing areas, agriculture areas, etc.) in QuantumGIS. Also, the first steps of the methodology for feeding the SIMONI (Integral Monitoring System) which is being developed in this moment in the PROTEP project are designed.

Chapter 6, Spatial Database Management System (SDBMS), is a description of the different databases created for the management of the digital cartography. It is included the data model designed for the use in PostgreSQL/PostGIS regarding cadastral and socio-environmental information and the definition of the different user levels for accessing to the cartographic information.

Chapter 7. Design process of the SDI. Gathering the information from the indigenous communities is the first step to share information in Rio Platano Region. In this chapter, a Geoportal with connection to the different services of a standard

SDI is designed. The Geoportal is the reference of the Rio Platano Region regarding the cartographic information. It is possible to check all available cartographic information from the different involved agents in the area. Besides, the potential clients of the Geoportal obtain information from all level and with the sources, from indigenous communities to an international map server such as Google or OpenStreetMap. From this platform, it is possible to obtain general information from the Rio Platano Region and PROTEP project, contact with all the agents working in the area and consult the metadata, agreements and laws regarding the cartographic information.

Chapter 8. Evaluation. Describes the situation in the region after the deployment of the platform with the inclusion of cartographic information from the indigenous communities. The level of cartographic knowledge of the area has improved. The relationship between all agents is the key for sharing and increasing the cartographic value of this remote protected area.

Chapter 9. Conclusion. This final chapter is focused on taking a look back in the thesis to know if it has reached the objectives marked in the first point. It includes a final consideration of the evolution of the Rio Platano Region SDI.

2. STATE OF THE ART

2.1. Why participation of the indigenous communities?

The major reasons for emphasizing participation of the indigenous communities are as follows (Narayanasamy, N., 2009):

- ❖ Participation results in better decisions.
- ❖ People are more likely to implement the decisions that they made themselves rather than the decisions imposed on them from above.
- ❖ Motivation is frequently enhanced by setting up of goals during the participatory decision-making process.
- ❖ Participation improves communication and cooperation (Locke, E., 1968).
- ❖ People may learn new skills through participation; leadership potential may be readily identified and developed (Heller et al., 1998).

2.2. Participatory Mapping

"Maps are more than pieces of paper. They are stories, conversations, lives and songs lived out in a place and are inseparable from the political and cultural contexts in which they are used." (Warren, 2004).

Participatory mapping is, in its broadest sense, the creation of maps by local communities – often with the involvement of supporting organizations including governments (at various levels), non-governmental organizations (NGOs), universities and other actors engaged in development and land-related planning (International Fund for Agricultural Development (IFAD), 2009).

The participatory mapping recognizes the cognitive spatial and environmental knowledge of local peoples and transforms this in more conditional forms (Herlihy and Knapp, 2003). All this type of information obtained from the indigenous communities in a specific area is known as Indigenous Knowledge (IK) according to the World Bank definition.

2.2.1. Indigenous knowledge

Herbal medicine is a good example of Indigenous Knowledge. It is the basis for local decision-making in agriculture, health, natural resources management and other activities. Indigenous Knowledge is unique to a particular culture and society (World Bank, 1998).

The knowledge of the Indigenous communities is crucial to understand the territory where they are located. Learning from them in an investigating process will provide us important information about what they have and what they know.

The integration process of this knowledge obtained from the indigenous communities is essential for sharing information in the Rio Platano Region. The process for including it is composed by different steps according to the World Bank:

Step Number	Step Name	Definition
1	Recognition and Identification	Identification by external observers.
2	Validation	Assessment of Indigenous Knowledge significance and relevance.
3	Recording and Documentation	Is the major challenge, because of the tacit nature of Indigenous knowledge (typically exchanged through personal communication).
4	Storage	It is not limited to text document.

5	Transfer	Include the testing of the knowledge in the new environment.
6	Dissemination	Share the information to other communities.

Table 1. Adaptation from the World Bank document

2.2.2. Participatory Rural Appraisal. A bit of History

Mapping is a fundamental way for displaying human spatial cognition. The representation of the territory by local people has been done in different ways since prehistoric societies. Some remarkable examples are shown in the delightful book "Maps are Territories" (Turnbull, 1989). The earliest is a wall painting dating to 6,200 BC, from Catal Huyuk (Chambers, 2006).

The participatory mapping started in the late 1980s during the evolution of the "Participatory Rural Appraisal" (PRA) using Sketch mapping tools and scale mappings. The situation changed in the 1990s, with the diffusion of Geographic Information Systems (GIS), Global Positioning Systems (GPS), and the open access to data via internet (Rambaldi, 2004).

By the early 1990s, three core components had emerged which can be said to constitute PRA: methods, behaviour and attitudes, and sharing (Mascarenhas et al, 1991). PRA methods are *"visual and tangible and usually performed by small groups"* and the maps created can be *"social or census, showing people and their characteristics, resource maps showing land, trees, water and so on, and mobility maps showing where people travel* for services" (Chambers, 2008).

By the late 1990s, methods and techniques were applied in policy research, participatory government and rights-based development work. The spread and application of PRA to a wide variety of fields led to a change in the nomenclature from PRA to "participatory learning and action". Methods and techniques of PRA

were used to monitor and evaluate the projects. It has been known as participatory monitoring and evaluation (Narayanasamy, N., 2009).
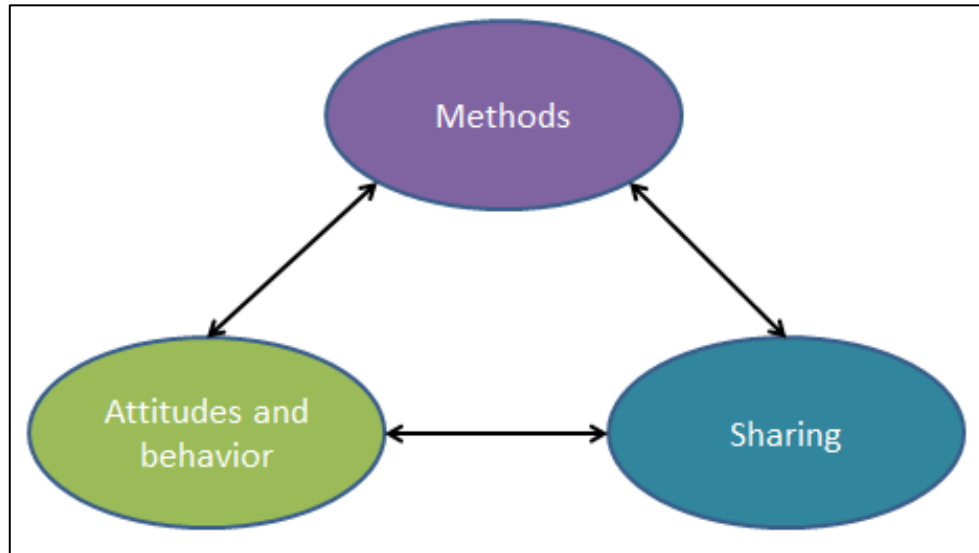
Figure 1. Three pilars of PRA. (Chambers, 1997)

Indigenous and peasant societies in Latin America and the social scientists working with them began to harness the powers of mapping in the 1990s. Nongovernmental organizations (NGOs) became widespread actors in indigenous regions in the previous decade, but by 1990 indigenous organizations had begun to organize national-level movements throughout the region (Brysk, 2000; Dean and Levi, 2003; Maybury-Lewis, 2002).

2.2.3. Participatory Mapping projects in Rio Platano Region

The mapping project was born in 1992 to map the land use of the indigenous Miskito, Pech, Tawahka, and Garífuna communities of the Honduran Mosquitia (South of the Rio Platano Region). Over the two preceding years, geographer Peter Herlihy had collaborated with the NGO Moskitia Pawisa (MOPAWI) and their associated Tear Fund volunteer environmentalist Andrew Leake on the establishment of the Tawahka Biosphere Reserve in the Mosquitia rain forest corridor of Honduras (Herlihy 1997; Herlihy and Leake 1990).

Funded by the Honduran and German governments, a geographer of the University of Kansas, Peter Herlihy and a team of researchers and local surveyors used participatory mapping to design a zoning and management system for the residents of the Rio Platano Biosphere Reserve in 2001 (Herlihy and Knapp, 2003).

Figure 2. Land use for the indigenous communities in Rio Platano Region (P. Herlihy, 1998)

These were the pictograms used for describing the land use of the different indigenous communities in the Rio Platano Region:

Pictogram	Land Use
	Agricultural
	Trees for canoes
	Hunting
	Collection of fruits, medicines and craft
	Eggs collection
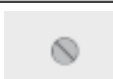
	Material construction/Wood
	Wood for sale
	Natural Area for protection
	Fish area
	Sacred site
	Touristic Place

Table 2. Pictograms used in the Land Use study (P.Herlihy, 1998)

This document was the basis for the design of the Participatory Mapping methodology for the definition of the cadastral boundaries in the PROTEP project, this information will be included in the future in the Rio Platano Geoportal after the approval of the *Institute of Property* (IP). The methodology for obtaining these limits is explained in section 5. "Indigenous communities cartographic integration process" of this master´s thesis.

2.2.4. Purposes and Uses

Participatory mapping has been developed for different purposes. Some examples are (International Fund for Agricultural Development (IFAD), 2009):

❖ Land use planning: Describes a participatory land use planning process initiated in a number of villages in Mae Hong Song province, Thailand (Puginier ,2001).

❖ Historical mapping: Mapping ancestral domains in Northern Mindanao (a PAFID-IPAD project).

❖ Cultural mapping: Project developed for the International Fund for Agricultural Development (IFAD) in Peru where the indigenous communities express their perceptions of the past, present and future of the local environment and surrounding areas.

- ❖ Social mapping: Create census using participatory mapping.
- ❖ Health mapping: Using participatory mapping to show the location and concentrations of breast cancer for women.
- ❖ Mobility mapping: Maps showing the functional habitat of the indigenous communities. Who goes where for what and how often?
- ❖ Education: Showing the variation in didactic styles.
- ❖ Water and sanitation: Mapping areas of open defecation.
- ❖ Farm mapping: Study of the soil conditions within the farm.

This relation is only a small list of possible purposes and uses, but it could be extended further. The *International Fun for Agricultural Development* (IFAD) identifies six broad purposes for initiating a participatory mapping project:

1. To help communities articulate and communicate spatial knowledge to external agencies.
2. To allow communities to record and archive local knowledge.
3. To assist communities in land-use planning and resource management.
4. To enable communities to advocate for change.
5. To increase the capacity for sharing ideas within communities.
6. To address resources-related conflict. Participatory mapping can be used to manage conflicts between a community and outsiders and to address internal conflicts.

2.2.5. Methodology

In the incredible book "Rural development – Putting the last first", written by Robert Chambers in 1983, the author identifies six methods which define with the term "Reversals in learning" (Chambers, 1983):

1. Sitting, asking, and learning
2. Learning from the poorest
3. Learning indigenous technical knowledge:
    - 3.1. Glossaries of local terms

3.2. Games, quantification and ranking

4. Joint Researcher and communities in their fields and under their conditions

5. Learning by working

6. Simulation games

The methodology to obtain cartographic information from the indigenous communities has changed over the past years to start incorporating new technologies. In the next sections it is possible to identify some of them described by the IFAD in the publication "Good practices in participatory mapping" (International Fund for Agricultural Development (IFAD), 2009):

❖ Ground Mapping: A basis mapping method that involves community members drawing maps on the ground from memory using any available materials, such as plants, rocks, or household tools. The final product is kept for a short time only.

❖ Sketch mapping: They are drawn on large pieces of paper and from memory. The represent the land from a bird´s eye view. They involve drawing key community-identify features. They do not rely on exact measurements, and do not use a consistent scale and geo-referencing.

❖ Transect mapping: A spatial cross-section community, depicting geographic features (e.g. infrastructures, local markets, and schools) as well as land use types and vegetation zones observed along an imaginary line.

❖ Scale mapping – drawing information on existing scale maps: This method is commonly used where accurate and affordable scale maps are available. Local knowledge is gathered in conversation around a map and is then drawn directly upon the map. The position of features is determined by looking at their position relative to natural landmarks (e.g. rivers, mountains, lakes).

❖ Scale mapping – making scale map using survey techniques: Where scale maps are not available but are required by the purpose of participatory mapping initiative, they can be made from scratch using a range of equipment including compass and GPS tools. The final map can then be

used to incorporate and communicate local spatial knowledge. This is often a last resort measure because the time and energy required to create a scale map from scratch is considerable.

❖ Participatory 3-D modelling mapping: P3DM are stand-alone scale relief models created from the template of a cartographic maps. Pieces of cardboard are cut in the shape of the contour lines and pasted on top of each other. Geographic features are depicted on the model using pushpins (for points), coloured string (for lines), and paint (for areas).

❖ GPS mapping: Use to capture and store geographic coordinates related to local features (e.g. boundaries or point locations) and then locate these points on accurate scale maps.

❖ Aerial and Remote sensing images: Good format to communicate community information to decision-makers because it uses cartographic protocols. The problem is that it can be expensive and images are not readily available.

❖ Multimedia mapping: Interactive, computer-based maps that link digital video, photos and written text with maps. This method is expensive for many communities and training is needed to understand the equipment as well as cartographic protocols.

❖ Participatory Geographic Information System (PGIS): Participatory GIS are computer-based systems that capture, manage, analyse, store and present geo-referenced spatial information. This method is also expensive for many communities and training is needed to understand the equipment as well as cartographic protocols.

❖ Internet-based mapping: It is the newest arena for participatory mapping initiatives. These interactive maps allow users to click on map features in order to access other multimedia information. This method requires high speed internet access. This remains a challenge for many developing countries outside of urban area.

The next images show different examples of the explained methods extracted from the document of the IFAD:

Ground Mapping	Participatory 3-D modelling mapping
Sketch Mapping	Aerial and Remote sensing images

Figure 3. Images of participatory map methodologies

2.2.6. Relation between GIS and Participatory mapping

It is fairly evident that geographic information systems (GIS) and geospatial technologies has become an important decision-making tool for local communities. For example, geospatial visualization techniques can be used to show the current and future situations of the communities in a more intuitive and realistic way (Pleizier et al, 2004).

The spatial analytical capabilities of GIS can assist local committees in understanding the nature of community issues and making better decisions. However, it has been well recognized that "traditional GIS methodologies often exacerbate the marginalization of community stakeholders who lack access to GIS technologies" (Evans et al, 1999).

An important recent development in community-based GIS has been the recognition of the need and the power to enlarge the level of community involvement in spatial decision-making processes (Barton et al., 2005) since "the complexity of modern society cannot be managed – even at the local level – without the direct involvement of all the components of the society" (Yu and Cai, 2009).

Recent decades have seen significant changes in both local and global development planning efforts. Community-based organizations and advocacy groups around the world have advanced the concept of "environmental justice" and issued calls for more inclusive dialogues among planners and local stakeholders. At the same time, research on sustainable practices has emphasized the importance of "resident experts" in implementing environmentally-sound development decisions.

In response to this concurrent international emphasis on stakeholder consensus and indigenous knowledge, public and community participation have moved to the forefront of both large- and small-scale development and environmental agendas (Stiglitz, 2002).

The transformation of development priorities and practices has drawn widespread attention to a variety of information and communication technologies (ICTs) for their potential to facilitate participatory development that is both inclusive and environmentally-sensitive. The international demand for these technologies is evident in initiatives, such as the UN Millennium Development Goals (MDGs) and the World Summit on the Information Society (WSIS), which emphasize that effective development depends on equitable information access and global knowledge sharing (United Nations, 2000; WSIS, 2003).

The theoretical framework to share cartographic information obtained by participatory mapping and using GIS is based on three key "dimensions". Figure 4 illustrates how the balance between 1) spatial and social objectives, 2) accuracy and precision in map displays, and 3) representativeness and comprehensiveness of spatial information collectively define the fundamental attributes of different mapping methods and their resulting maps. Each of the attributes on the left side of

the three dimensions focus primarily on the issues surrounding *how* people live and are connected more strongly to participatory mapping. The dimensions on the right side characterize *where* people live and are more strongly associated with GIS. The combination of GIS and participatory maps into participatory digital mapping at the center of the figure seeks to balance these attributes and create a dynamic equilibrium across all three dimensions (Vajjhala, 2005)
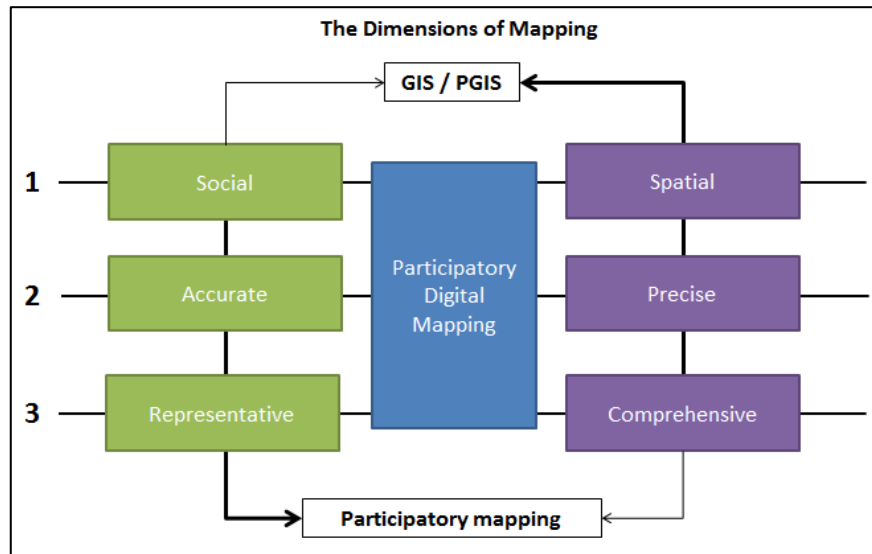
Figure 4. Diagram of the three dimensions of paired attributes shared by GIS and participatory mapping (Vajjhala, 2005)

2.3. Spatial Data Infrastructure (SDI)

The need of geographic information for almost every human activity has led to an enormous struggle for its recording, storage, treatment, analysis and visualization. Cartography, and its most known product, maps, has been the traditional answer to the disposition of an idea, in smaller scale, of the reality that occurs in a territory (Rodriguez and Bernabé, 2012).

It is possible to check in section 1.1. "Theoretical Framework" of this thesis the definition of "Spatial Data Infrastructure" (SDI) by the Global Spatial Data Infrastructure (GSDI).

2.3.1. SDI around the world

The **Presidential Document of the U.S.A. "Executive Order 12906 of April 11, 1994"** pointed the necessity to create a coordination of the Geographic Data. The aim of this order was *"to implement the recommendations of the National Performance Review; to advance the goals of the National Information Infrastructure; and to avoid wasteful duplication of effort and promote effective and economical management of resources by Federal, State, local, and tribal governments"* (Presidential Documents Executive Order 12906, 1994).

The **United States National Spatial Data Infrastructure (NSDI)** started in 1994. It is considered the first SDI concept created from the basis of the Presidential Document. *"The NSDI is seen as the technology, policies, criteria, standards and people necessary to promote geospatial data sharing throughout all levels of government, the private and non-profit sectors, and academia. It provides a base or structure of practices and relationships among data producers and users that facilitates data sharing and use. It is a set of actions and new ways of accessing, sharing and using geographic data that enables far more comprehensive analysis of data to help decision-makers choose the best course(s) of action"* (Federal Geographic Data Committee, 2013).
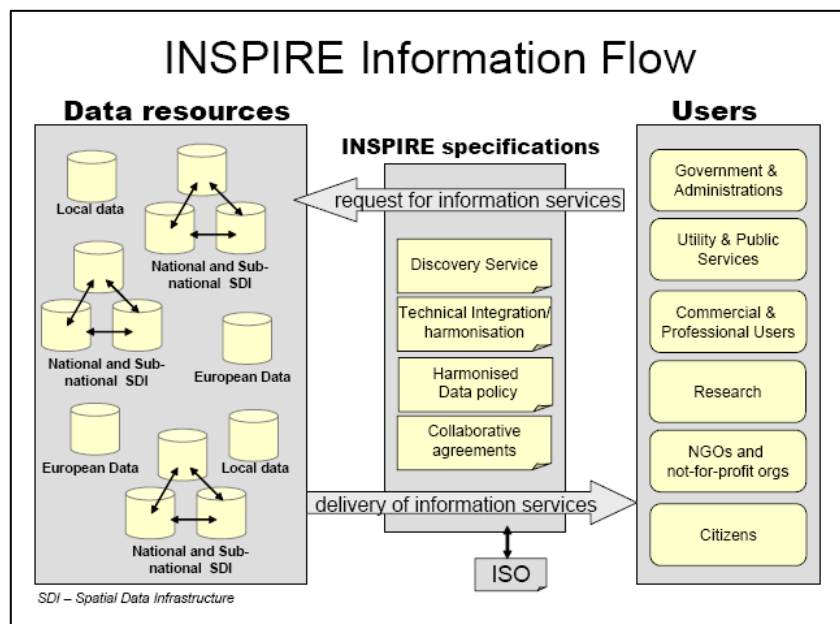
Figure 5. Diagrammatic View of the INSPIRE Vision (Inspire, 2013)

In Europe **INSPIRE** was the initiative which developed the idea of SDI. The INSPIRE directive came into being on May 15 2007 and has been implemented in several stages, with full deployment required by 2019. The INSPIRE directive aims to create a European Union (EU) Spatial Data Infrastructure, enabling the sharing of environmental spatial information among public sector organizations and to better facilitate public access to spatial information across Europe. The European Spatial Data Infrastructure allows assistance in policy-making across boundaries and agencies. Therefore the spatial information considered under the directive is extensive and includes a great variety of topical and technical themes. INSPIRE is structured in seven chapters: 1) General provisions 2) Metadata 3) Data interoperability 4) network services 5) harmonization and data reuse 6) coordination and complementary measures and 7) final dispositions (INSPIRE, 2013).

Colombia was the first country to develop a SDI in Latin America. The **Colombian Spatial Data Infrastructure-ICDE** began in 1996 as a mechanism to coordinate efforts of producers and users of geographic information, with the aim of optimizing their production, managing all the data, and accessing through the use standards and information technology. In 2000, eight institutions came together to create the Basic Agreements for establishing and promoting the development of ICDE as the sum of policies, standards, organizations and technology resources that facilitate the production, access and use of the geographic information in all the country. Services available from the ICDE include location services, map view services, and download services, transformation services and service access to spatial data. The services agree on the international standards established in the ISO TC211 Committee and the OGC (Colombian Spatial Data Infrastructure, 2012).

In the **Eighth Regional Cartographic Conference of the United Nations from America on 2005**, the methodology to define the SDI was proposed. That idea was developed in different documents and publications, taking into account the wide digital differences between the countries of the area, regarding the environmental, social, cultural and economic information.

Regarding Central America, Guatemala is the country with the most developed SDI. The initiative to create the **SINIT "National Land Information System"** was developed based on the Land Use Planning law of 2009. In this law, SINIT was defined as the instrument that contains and organizes all alphanumeric and cartographic information. SINIT published different topographic, agricultural, statistical and thematic information managed by **SEGEPLAN "Secretariat of Planning and Programming of the Presidency"** (SEGEPLAN, 2013).

2.3.2. Components of the SDI

In any spatial and thematic area of a SDI (besides of **the geographic component** that consists of data, data descriptors -metadata-, and services), a key part is the "organization". It is responsible for ordering and defining the structure and harmonizing the rest components of a SDI in order to work in an efficient way. The organization includes a **political component**:

- ❖ Creating a collective organism, composed of all the involved actors in the project.
- ❖ The adoption of an appropriate legal framework.
- ❖ The definition of agreements, alliances and partnerships necessary for the availability of spatial data and services.
- ❖ Establishing agreements between the producers to coordinate the generation and maintenance of geographic information.

A **technology component** should be defined, which will be able to:

- ❖ To establish standards and regulations necessary for the interoperability.
- ❖ To coordinate tools and mechanisms for searching, consulting, and using geographic data.

Finally, the **social component** must be emphasized (e.g. data producers, service providers, developers, brokers), each of them with competencies, and specific roles in a collaborative community (Sanchez et al., 2012).

2.3.3. Standards and Regulations for management of Geographic Information

2.3.3.1.   Interoperability

Interoperability is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units (ISO 2382-1, 1993).

In a SDI, interoperability is the definition for the communication among the involved agencies in a coordinated way and using the same semantic. The interoperability enables the involved agencies to be able to share in a coordinated form: Business Agreements, Policy Framework, Incentives to cooperate, Business Models, Infrastructure, Networks, Support for multiple (Languages, Customs, Views, Data Formats, Projections, Datums), Shared Best Practices, Metadata and Standards.

In the GIS field, it is possible to find some organizations that are developing software and standards to help in the process of sharing cartographic information:

- ❖ The Open Geospatial Consortium (OGC) is an international industry consortium of 482 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC Standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications (Open Geospatial Consortium (OGC), 2013).
- ❖ The Open Source Geospatial Foundation (OSGeo) is a not-for-profit organization whose mission is to support the collaborative development of open source geospatial software, and promote its widespread use. The foundation provides financial, organizational and legal support to the broader open source geospatial community. It also serves as an independent legal entity to which community members can contribute code, funding and other resources, secure in the knowledge that their

contributions will be maintained for public benefit. OSGeo also serves as an outreach and advocacy organization for the open source geospatial community, and provides a common forum and shared infrastructure for improving cross-project collaboration (Open Source Geospatial Foundation (OSGeo), 2013).

2.3.3.2.   *Metadata*

A metadata record is a file of information, usually presented as an Extensible Markup Language (XML) document, which captures the basic characteristics of a data or information resource. It represents the *who, what, when, where, why* and how of the resource. Geospatial metadata commonly document geographic digital data such as Geographic Information System (GIS) files, geospatial databases, and earth imagery but can also be used to document geospatial resources including data catalogs, mapping applications, data models and related websites. Metadata records include core library catalog elements such as Title, Abstract, and Publication Data; geographic elements such as Geographic Extent and Projection Information; and database elements such as Attribute Label Definitions and Attribute Domain Values (Federal Geographic Data Committee, 2013).

There are significant benefits to use metadata in the generated cartography (Global Spatial Data Infrastructure, 2004):

- ❖ Metadata helps organize and maintain an organization's investment in data and provides information about an organization's data holdings in catalogue form.
- ❖ Coordinated metadata development avoids duplication of effort by ensuring the organization is aware of the existence of data sets.
- ❖ Users can locate all available geospatial and associated data relevant to an area of interest.
- ❖ Collection of metadata builds upon and enhances the data management procedures of the geospatial community.

- ❖ Reporting of descriptive metadata promotes the availability of geospatial data beyond the traditional geospatial community.
- ❖ Data providers are able to advertise and promote the availability of their data and potentially link to on line services (e.g. text reports, images, web mapping and ecommerce) that relate to their specific data sets.

The most used metadata standards are the developed by the ISO and the Dublin Core:

- ❖ ISO 19115: The 211 ISO technic commit developed the international norm ISO 19115:2003 "Geographic Information. Metadata". This norm provides a model and establishes a common framework of terminology, definitions, and procedures of application for describing the obtained Geographic Information. The norm presents a metadata model described in a Unified Modeling Language (UML) where each package defines different metadata entities.

    The Core of the ISO 19915 is formed by the next elements defined by Compulsory (C), Optional (O) and Conditional (Co):

Set Data Title (C)	Spatial Representation type (O)
Data Reference Date (C)	Reference System (O)
Responsible of the data (O)	Lineage (O)
Geographic location (Co)	Metadata file identification (O)
Data language (C)	Metadata Norm name (O)
Character set data (Co)	Metadata norm version (O)
Category of data issue (C)	Metadata language (Co)
Data Resolution (O)	Character set of the metadata (Co)
Data Summary (C)	Contact point of the metadata (C)
Distribution format (O)	Creation Data of the metadata (C)
Additional information (O)	

Table 3. Metadata Core ISO 19115.

- ❖ ISO 19139: provides the XML implementation schema for ISO 19115 specifying the metadata record format and may be used to describe, validate, and exchange geospatial metadata prepared in XML.
- ❖ Dublin Core: This metadata initiative was born in 1995. It is an organization dedicated to the promotion and diffusion of metadata interoperability norms and the development of specialized vocabulary for

the description resources helping the user to find in an easy and efficient way the information of the data (Duval et al. 2002). The Simple Dublin Core Metadata Element Set (DCMES) consists of 15 metadata elements:

1. Title	2. Creator
3. Subject	4. Description
5. Publisher	6. Contributor
7. Date	8. Type
9. Format	10. Identifier
11. Source	12. Language
13. Relation	14. Coverage
15. Rights	

Table 4. Metadata Element Set. (Dublin Core, 2013)

2.3.3.3.   *Geo-services*

The Open Geospatial Consortium has defined different Geo-services standards for delivering the Cartographic Information (Open Geospatial Consortium (OGC), 2013):

❖ Web Map Service (WMS): provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc) that can be displayed in a browser application. The interface also supports the ability to specify whether the returned images should be transparent so that layers from multiple servers can be overlain.

❖ Web Feature Service (WFS): defines an interface for specifying requests for retrieving geographic features across the Web using platform-independent calls. The WFS standard defines interfaces and operations for data access and manipulation on a set of geographic features.

❖ Web Coverage Service (WCS): defines a standard interface and operations that enables interoperable access to geospatial "coverages". The term "grid coverages" typically refers to content such as satellite images, digital aerial

photos, digital elevation data, and other phenomena represented by values at each measurement point.

❖ Web Processing Services (WPS): provides rules for standardizing how inputs and outputs (requests and responses) for geospatial processing services, such as polygon overlay. The standard also defines how a client can request the execution of a process, and how the output from the process is handled. It defines an interface that facilitates the publishing of geospatial processes and clients discovery of and binding to those processes. The data required by the WPS can be delivered across a network or located on the server.

3. CONCEPTUALISATION. NECESSITIES OF THE PROJECT

3.1. Context scenario

The study of the Biosphere Reserve Rio Platano (Honduras) involves many different agents to be considered: agency which develops the cadastral and the main environmental information, municipalities, different agencies regarding environmental and social aspects, inhabitants and indigenous of the study area. Also the involved agents are composed by different services which developed an important library of information. This information can be divided in 4 different groups: Cartography, agreements, laws, and metadata.

This kind of project develops an important collection of cartographic information divided in different categories: cadastre, environment, hydrology, transportation, land use, digital images, etc. For the agencies involved in the project the availability of information about the study area is important for knowing the territory and making good decisions.

Also, The *Land Use Planning and Environmental Protection Project"* (PROTEP) is developing the "Integral Monitoring System" (SIMONI), which is a comprehensive monitoring system whose main objective is to provide a platform that can measure the management effectiveness of the Reserve of the Man and Rio Platano Biosphere (RHBRP). The final objective is to contribute to the sustainable use within the RHBRP.

The SIMONI has three strategic objectives:

Strategic Objective 1: Systematize and integrate different monitoring approaches, development of indicators and data collection and information aimed at RHBRP and incorporate relevant elements to SIMONI.

Strategic Objective 2: Create a monitoring system with the ability to measure the state, pressure, response and impacts within the socio-cultural and biological-ecological aspects in five different eco-regions of the RHBRP.

Strategic Objective 3: Create a monitoring system that integrates the needs of beneficiaries RHBRP, as decision makers, NGOs, scientists and technicians in order to promote a comprehensive vision which establishes a series of coordinated actions that contribute to the sustainable management of RHBRP.

3.2. Necessity to share information

Through a complete interview with two members of the agency (Annex 1) in which the PROTEP project is developing, it was possible to take a general overview of the process to access the cartographic information and the different aspects to be considered for the decision making.

The main points from the interviews, which are included below explain the necessity to create a platform for sharing information between all the involved agents whom are working in the Rio Platano area. This also includes the information obtained from the indigenous communities:

"In this moment is very difficult to share information between the project office and the municipalities. Our people travel to the study area at least twice per month but their task is not to bring the updated information. So, the actual situation is not ideal, because municipalities don´t have the updated information."

"For me, it would be important that I and all the people involved in the project could have access to all the available information in an easier and more accessible way. Also, we have to find the way to include the information obtained from the indigenous communities in the project."

"We are defining the web page of SIMONI. We have designed a web page where it is very easy to feed the SIMONI with socio-environmental indexes and incidences which occur in the area. However, the problem is we cannot show that

information in a map for making decisions. Also, we have to find a solution for sharing this information with the ICF (National Institute of Forest Conservation and Development, Protected Areas and Wild Life) offices in the area, the municipalities and other agencies which are developing projects in Rio Platano."

"To feed the SIMONI is important the information provided by different agents, municipalities, ICF agencies, inhabitants of the area, and the indigenous communities of Rio Platano.".

3.3. Necessities of the new Platform

The process of creating information is more than simply collecting and storing data on a hard drive. The process needs to include the knowledge to create a good data model, where the information will be structured and it will be possible to retrieve information about this data (i.e. metadata). The proposed platform should enable the user to select the information needed by filtering information that defines the different aspects of the project.

To clarify, the first aspect is to know what information is available and its location. Then it will be necessary to organize such information. The benefit of the platform will provide the consulting user with all the available information for decision making including all the existing variables.

Regarding the SIMONI, the application has been designed for incorporating alphanumeric information. SIMONI tries to define a number of socio-environmental indexes, which may be obtained with existing information of the study area.

SIMONI also has the possibility to incorporate incidences about the good or bad practices of the territory. Example of these incidents could be: registration of a wildfire or death of a jaguar in a particular point. The proposed platform should enable the user to check the information created in SIMONI related to the cartographic information of the project, and to incorporate new information related to incidences via internet.

The benefit of the platform will be for the consulting user which will be able to provide all the available information for decision making with all the existing variables.

- ❖ Accessing to cadastral, environmental and socio economical information.
- ❖ Share information obtained from the indigenous communities.
- ❖ Consulting information on-line.
- ❖ Aggregating information.
- ❖ Downloading the information.
- ❖ Consulting the information of the data (metadata).
- ❖ Consulting the agreements between the different agencies.
- ❖ Consulting the laws regarding the study area.
- ❖ Consulting the information regarding other projects or agencies.
- ❖ Creating maps with the available information.
- ❖ Creating different users.
- ❖ Adding incident information (punctual and polygonal incidences) in SIMONI application.

3.4. Conceptual development

The figures in Annex 1 present prototype interfaces of the GEOPORTAL created for the deployment of the Spatial Data Infrastructure in the Rio Platano Region. This was developed after a Usability Test with two members of the agency.

The presented figures are sequential; the user starts with the first interface and continues by clicking the selected button to be forwarded to the second interface and so forth. Initially, the invention allows checking general information of the project and offers the possibility to check the information at the bottom of the page. The system shows with big buttons the services that Geoportal offers. By clicking the different buttons, the user will be able to call the different services: Map server, metadata service, SIMONI, agreements, and laws.

Also included in Annex 1 are the interviews with two members of the agency for developing the Geoportal of the Spatial Data Infrastructure in Rio Plata Region.

4. STUDY AREA AND DATA

4.1. Study Area

The study area is the "Rio Platano Reserve" declared "Heritage of Man and the Biosphere" by UNESCO in 1982. Located within the watershed of the Rio Platano, the reserve is one of the few remaining tropical rainforest areas in Central America with an abundant and varied plant and wildlife. In its mountainous landscape sloping down to the Caribbean coast, are over 2.000 indigenous people whom have preserved their traditional way of life (UNESCO, 2013). The area of the reserve is 900.000 hectares with a population of approximately 150.000 inhabitants.
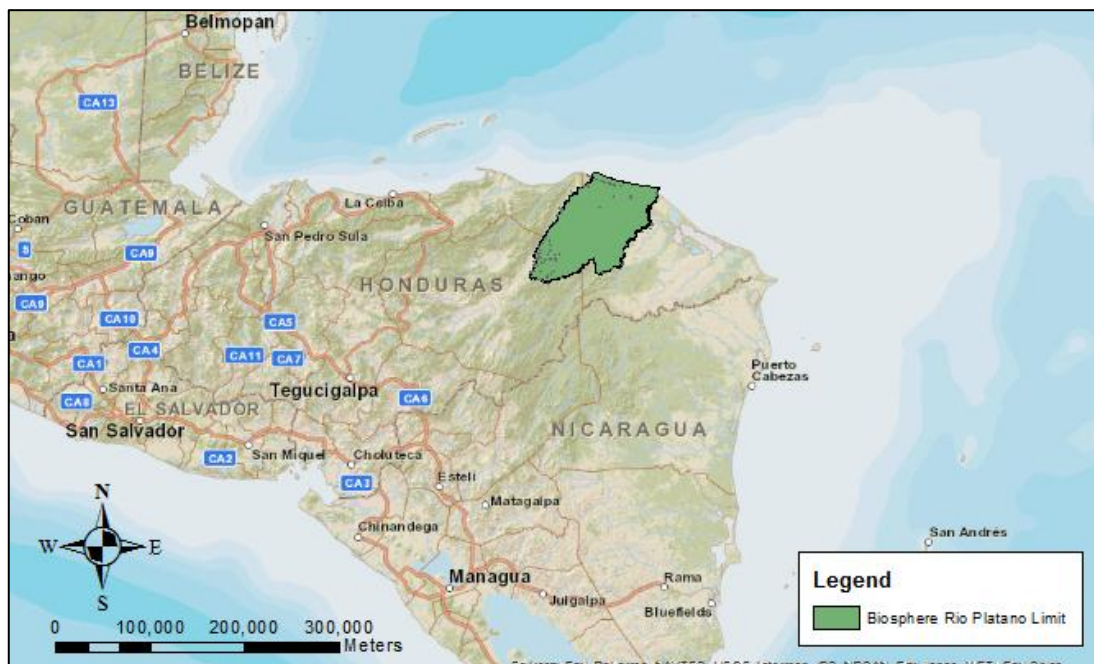
Figure 6. Location of the project

The Biosphere Reserve of Rio Platano is located within the boundaries of six municipalities (Iriona, Brus Laguna, Juan Francisco Bulnes, Ahuás, Wampursirpe, Culmí). Figure 7 shows the location of the municipalities.
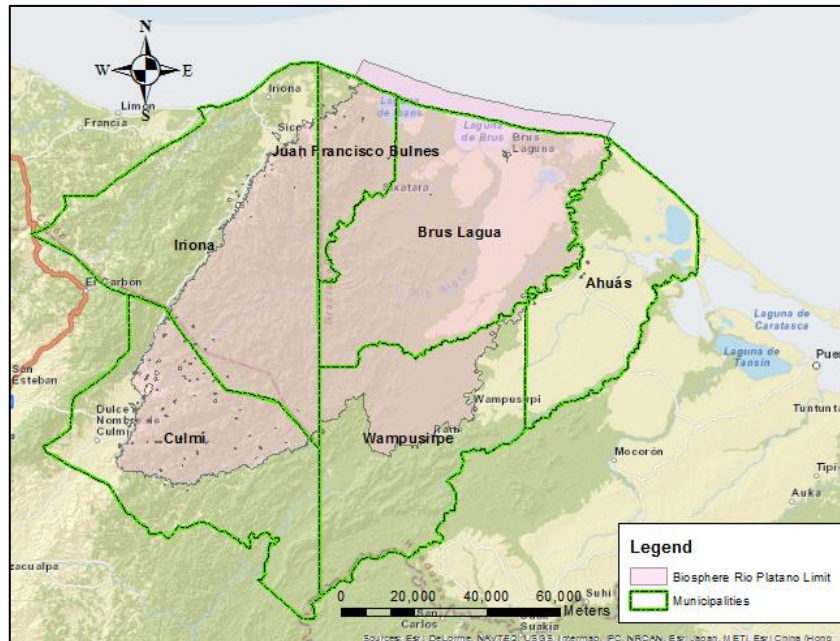
Figure 7. Municipalities in Rio Platano

The area is also populated by indigenous communities; Miskitos, Pech, Garífunas and Ladinos. Miskitos and Garífunas live close to the coast, in the area of the big lakes (Ebano lake and Brus lake), where there are good conditions for fishing activities. The Miskitos are progressively conquering the inland zones through the channels of the major rivers in the area (Platano River and Patuca River).
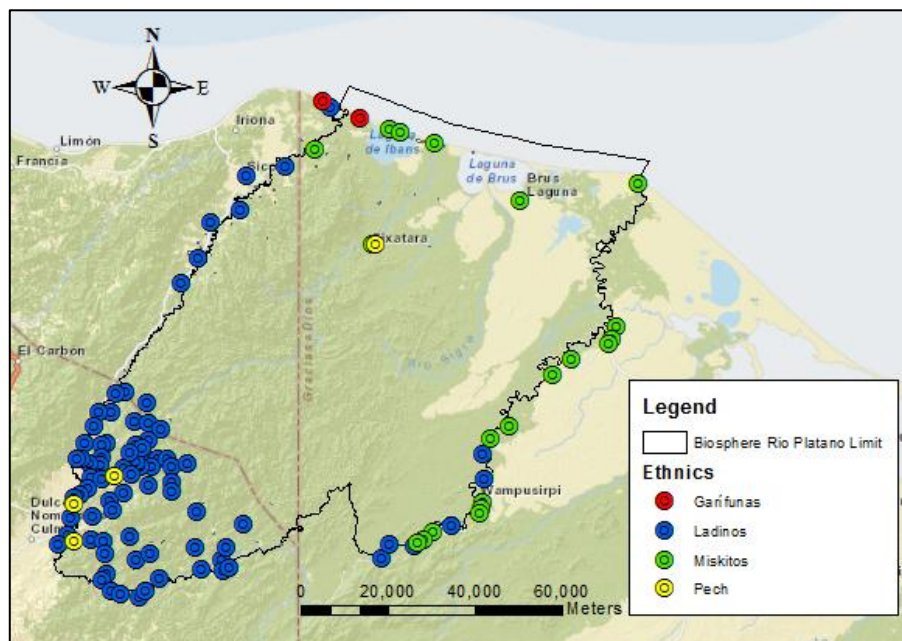
Figure 8. Distribution of the ethnics

The main inland areas of the reserve are inhabited by the Ladino and Pech communities. They reached the limits of the reserve from the south and west crossing the mountains of Dulce Nombre de Culmí area.

The distance between the capital of Honduras (Tegucigalpa) and the south-west limit of the Biosphere Reserve (the closest one) is 250 kilometres and the needed time to reach the limit from there is approximately 4 hours. Dulce Nombre de Culmí is the last large village (4.000 inhabitants) located exactly in the border of the Reserve. This area is populated by Ladinos and Pech communities. After this village the communication is more difficult, provoking a slow paced travel are to unpaved roads which increases the travel time.

In the coastal area and along the rivers the economy is mainly based in agriculture and fishing activities with a low level of development. This small-scale agriculture is easily made sustainable. However, conflicts over land rights involve non-native people invading and threatening indigenous land owners, which at the time are forcing them to move on from their historical lands. This migration is shifting the land use of these areas to the control of drug traffickers.

The climate of the area is tropical with precipitation values between 3.000 and 4.000 mm per year. This is important for the maintaining of the wet forest and the agriculture of the area. It is possible to define two seasons (rainy and dry), with huge differences in the value of precipitation. During the rainy season, tropical storm can occur with the consequence of big floods, overflows and landslides.

The reserve is mostly mountainous excluding the lower watershed where the rivers lead to the Caribbean Sea. This area is an alluvial plain with the presence of a large amount of lakes. The most important mountains in the area are Pico Dama (giant granite formation), and Punta Piedra, with its highest peak at 1.326 meters.

4.2. Data

4.2.1. Digital Cartography

The ICF is the agent which executes the national law regarding the "Forest management, protected areas and Wildlife" with the faculty to develop programs, projects and plans; also it is the organization which is in charge of creating the technical administration units that comply with the goals of this law. Its mission is to *"Ensuring the conservation and sustainable use of ecosystems, through the application of policies and regulation and encouraging investment and participation"* (National Institute for Forest Conservation and Development, Protected Areas and Wild Life, 2013).

The ICF has developed a Forest National Information System (SNIF), a transversal tool to manage the administrative and technical information. This software is capable to handle cartographic information. Currently, the SNIF is technically supported by the Information Technology (IT) department, but it is only a prototype without a real agreement by the institution, and it is only used by the technicians of the IT department.

The only way to obtain digital information published from the ICF is through the *"National Protected Areas System of Honduras"* (SINAPH) where it is possible to download the limits of the protected areas in shapefile format. Currently, ICF does not have procedures and protocols for the exchange of cartographic information with other national institutions. Therefore, the only way to share cartographic information is informal and using physical copies.

ICF has different cartographic information in shapefile format developed by their technicians regarding protected areas, land coverage, conservation targets, management plans, road networks and hydrology of the whole Honduran territory.

PROTEP is a project which is developed in the ICF compound using a single building of the ICF property. It could be an ideal situation where the communication

between the two organizations were easy, however there exists a technological wall where the communication for sharing cartographic information is broken. PROTEP and ICF have two different cartographic databases with no connection between them.

One of the main tasks with the PROTEP project is developing the cadastral information. During the last five years the project has been working in the regularization of land tenure in the municipalities (Iriona and Dulce Nombre de Culmí), and legalising the land of the indigenous communities in the study area of the project. In this moment the project is working with municipalities and the *"Institute of Property"* (IP), which is the organism that gives the final resolution to the owners of each party and the inclusion in the *"Unified Registry System"* (SURE).

The Cadastral Spatial Database of the project is composed by 23 sub-sectors in the two named municipalities which are in continuous update.

Also, PROTEP is working with indigenous communities to define the cadastral boundaries in the region. This is a complicated task due to the importance of the communications of the selected sources of information between the community and the assigned anthropologist. The result is a set of paper maps with different versions of the same area, showing the evolution of the boundary limits. These maps are obtained using Participatory mapping processes with the different indigenous communities.

Moreover, the project has produced different cartography about the region regarding threats in the wetlands, threats in relation with the communities, ecosystems, limits of the three sub-zones of the Region (Core zone, Cultural zone and Buffer zone), (see Figure 9), and a land use change project between the years 2002 and 2005.

Regarding the cartographic information published by the National Government there are several institutions which are producing cartographic information. The actual problem is the accuracy and the possibility to access to that information in digital format by other organisms.
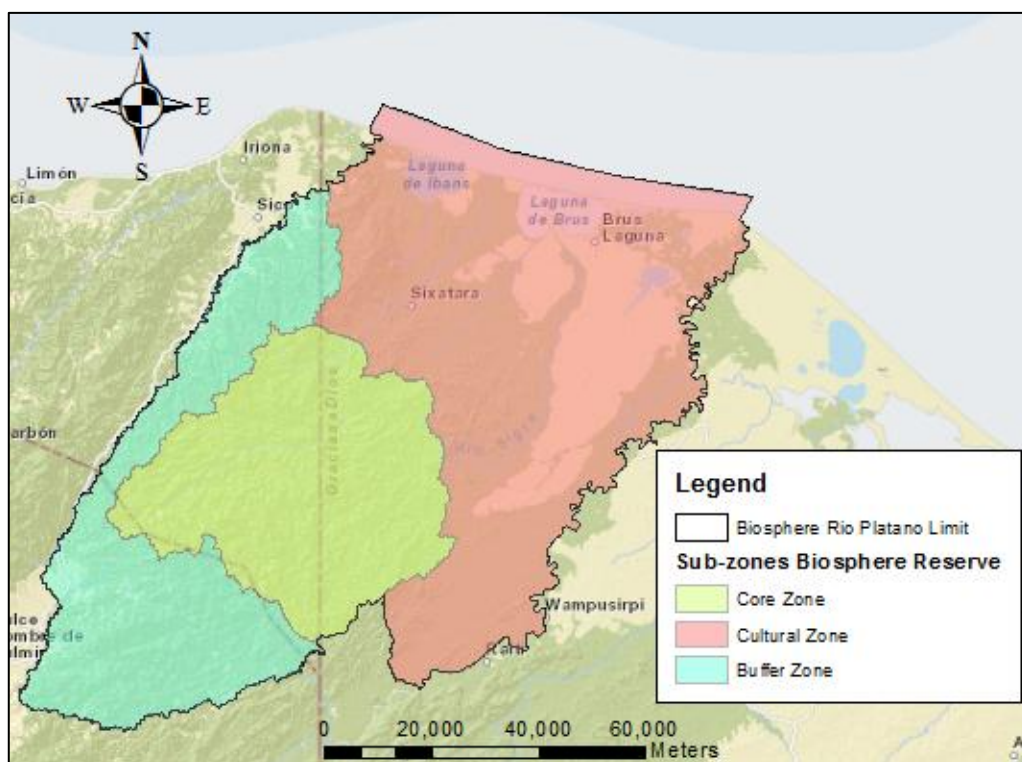
Figure 9. Sub-zones Biosphere Reserve

The *"Ministry of Planning and External Cooperation"* (SEPLAN) of Honduras is the organization in charge of the implementation of the National SDI in Honduras. This process is in the first steps of establishing communications between the different ministries of Honduras on the basis for sharing and publishing cartographic information.

The topographic maps (scale 1:50.000) are currently in process of being digitized for the entire country. Rio Platano Region will probably be the last area to be included on the list because it is the least inhabited area and has worst communication network.

The actual printed topographic maps of the Rio Platano area are published by the *"National Geographic Institute"* (I.G.N.), using aerial photography taken in 1956, 1960 and 1961. These maps were updated by sending technicians to the field in 1988. In PROTEP there are scanned copies of the different topographic maps, with a scale of 1:50.000, which are in .sid and .tiff format with unknown origin.

Table 1 in Annex 2 is a summary of the different digital cartographic information of the Rio Platano Region.

4.2.2. Metadata and Reference system

The availability of metadata is low in Honduras, because it is very difficult to acquire information regarding the general conditions about the available data.

Honduras adopted the "WGS84" reference system (Datum) in 1984. However, the most used reference system in the country is the NAD27. In the different institutions people are unaware that there is an official reference system and almost all of them are using NAD27, and this is the reason why all the available cartography is generated based on this reference system.

5. INDIGENOUS COMMUNITIES CARTOGRAPHIC INTEGRATION PROCESS

5.1. Cartographic integration process of the land use rights

5.1.1. Indigenous communities land rights

In the past two decades, the northern coast of Honduras and the Mosquitia have suffered economic and population pressures. This erosion of the indigenous communities land rights is reflected in several phenomena such as:

1. Land grabbing by third parties, via informal and/or extra-legal methods.
2. Invasion of private third actors extracting the natural resources of the area in detriment of the rights and interests of the communities.
3. Imposition of a new legal framework and system of land management in ancestral community areas without incorporating the rights and interests of communities.
4. Some practices of community members are non-consistent with the rights and communal control of their lands.

Simultaneously, the Honduran government has undergone a democratic opening, part of which has been the enactment of laws and ratification of conventions that guarantee the land rights of indigenous people who have traditionally occupied these areas. In this context, the Miskito, Pech and Garifuna communities, who are ancient inhabitants of these regions, have suffered incursions on their land by other people known as Ladinos. The communities have claimed for their legal and political rights of these lands.

At this point, PROTEP's activities are directed toward improving the management and protection of natural resources in the "Río Platano" Reserve and its buffer zones. The project emphasizes in the framework of support for land management at the indigenous community level.

5.1.2. Indigenous communities organizations

It is necessary to have a previous knowledge of the structure of the indigenous communities to understand their way of living and working. This structure is essential to create a good network of agents working in the area to contribute to the Rio Platano Region SDI.

Within the limits of the Biosphere Reserve three different ethnic groups are settled in an important number of small communities. The "National Confederation of Indigenous People of Honduras" (CONPAH) is the organization in charge of integrating all the indigenous communities in the country. The structure of the indigenous communities in the region is explained in the next chart:
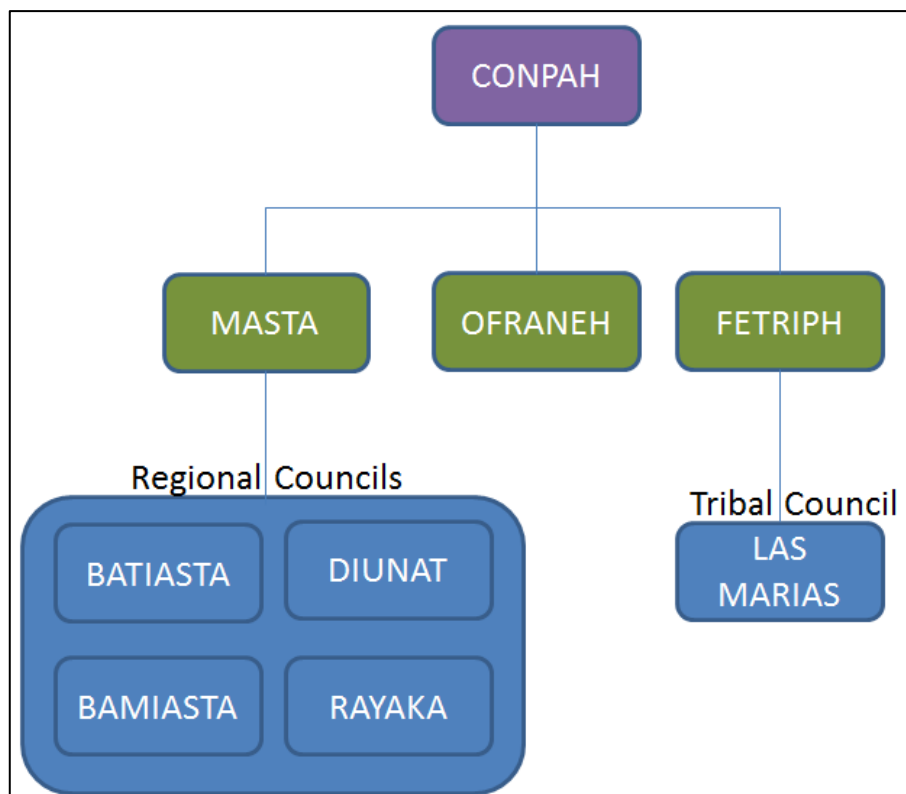

Figure 10. Indigenous communities organizations in Rio Platano

❖ "Indigenous Peoples Confederation of Honduras" (CONPAH): Is a multinational and multicultural association. The aim of the association is the claiming of the ancestral rights of indigenous communities in Honduras. Their board is made up by the leaders of each member of the federation.

❖ <u>MASTA:</u> Association which defends the land rights of the Miskito communities.
❖ <u>"Honduran Black Fraternal Organization" (OFRANEH):</u> Association which defends the land rights of the Garifuna communities.
❖ <u>FETRIPH:</u> This organization represents 3800 Pech indigenous tribes in 10 departments of Olancho, Colón and Gracias a Dios.

In the future, the Cadastral titles will be extended to the indigenous communities; however it will be the territorial councils (i.e. Regional and Tribal councils) who will assume the land management.

5.1.3. Methodology process to obtain indigenous communities cadastral boundaries

One of the PROTEP components is the "Regularization of the land tenure". The indigenous territories will be defined through their indications after a process of free consultation. The final purpose is to issue cadastral titles for the indigenous people by the "Property Institute" (IP) of Honduras.

The anthropologist who is working with the PROTEP project, Jorge Federico Travieso, has developed the methodology to obtain the cadastral limits from the indigenous communities using Participatory mapping techniques in the Rio Platano Region. He considers that it is necessary to include all information obtained from indigenous communities regarding cadastral boundaries in a GIS program. The availability of this information in a digital format facilitates the inclusion of the ideas from the indigenous communities into the decision making process.

He also requested the inclusion of the cadastral limits and other information obtained from the indigenous communities, in the future Rio Platano Geoportal as a part of the Spatial Data Infrastructure of the region. Travieso believes the indigenous communities are the ones who have better knowledge of the territory due to their more direct contact with the field. Therefore indigenous communities are an important information source that the process of implementation of the Rio Platano SDI cannot ignore.

The methodology to obtain the cadastral limits of the indigenous communities is based on two concepts:

- ❖ Right to Use: It is defined by the Functional Habitat of the indigenous community. The Functional Habitat is the area that the community uses to supply their basic needs.
- ❖ Ownership Right: It is the legal term which defines the property of a piece of land.

Table 5 shows the different steps to obtain the final limits of cadastral boundaries using Participatory Mapping techniques. This was developed after several meetings with the indigenous communities:

Step	Activities
1. **Preparation**	1.1. Bibliographic review of the principal aspects of the indigenous community 1.2. Selection of the most influential people of the group. It will be people with the best knowledge of the territory. - Criteria: Age, Activity (hunter, fisherman, …). 1.3. Analysis of the legal framework.
2. **Field Work (Participatory Mapping)** **Functional Habitat Map**	2.1. Meeting with the selected people. 2.2. Drawing the "Functional Habitat": - A cartographic map scale of 1:50.000 is used as a Base Map. - Set of pictograms which describe the Land use of the territory to define the Functional Habitat.
3. **Validation (Participatory Mapping)** **Consolidated Functional Habitat Map**	3.1. Validation process between the elder people and the information groups of the community. 3.2. Final cartographic definition of the "Consolidated Functional Habitat". Quality process of the information.

4. Functional Habitats comparison	4.1. Using the same map drawn by neighbouring communities, it is possible to compare the Functional Habitats and examine the overlapped areas. 4.2. Definition of "ownership rights" limits using as a base map the Cartographic Map (scale 1:50.000). 4.3. The base map is used to define the limits according to the natural breaks in the area.
5. Meetings between neighbouring communities	5.1. Final definition of the "ownership rights". This limit will be agreed after several meetings with the Territorial councils of the communities. 5.2. Depending on the conflict level it will be necessary more or less meetings with the indigenous communities.
6. Parcel Title	6.1. Public view with the proposed limits in the city council. 6.2. Final Title issued by the "Property Institute" (IP).

Table 5. Methodology to define the cadastral boundaries

The aim of the cadastral process is not only about establishing the parcel limits; the objective is more related to the land management. After the definition of the limits, concepts of "Right to Use" and "Ownership Right" will be present. Each indigenous community will have "Ownership Rights" in a defined area, and depending on the "Functional Habitat", another area with "Right to Use" where they will be able to use those lands as they are doing in this moment.

5.1.4. Participatory Mapping Process

The next points show the process to convert the information obtained from the indigenous communities to digital cartography regarding the "Right to Use" and "Ownership Right" concepts.

1. Preparation: The analysis of the general aspects of each indigenous community is needed: hierarchy, associations, etc…
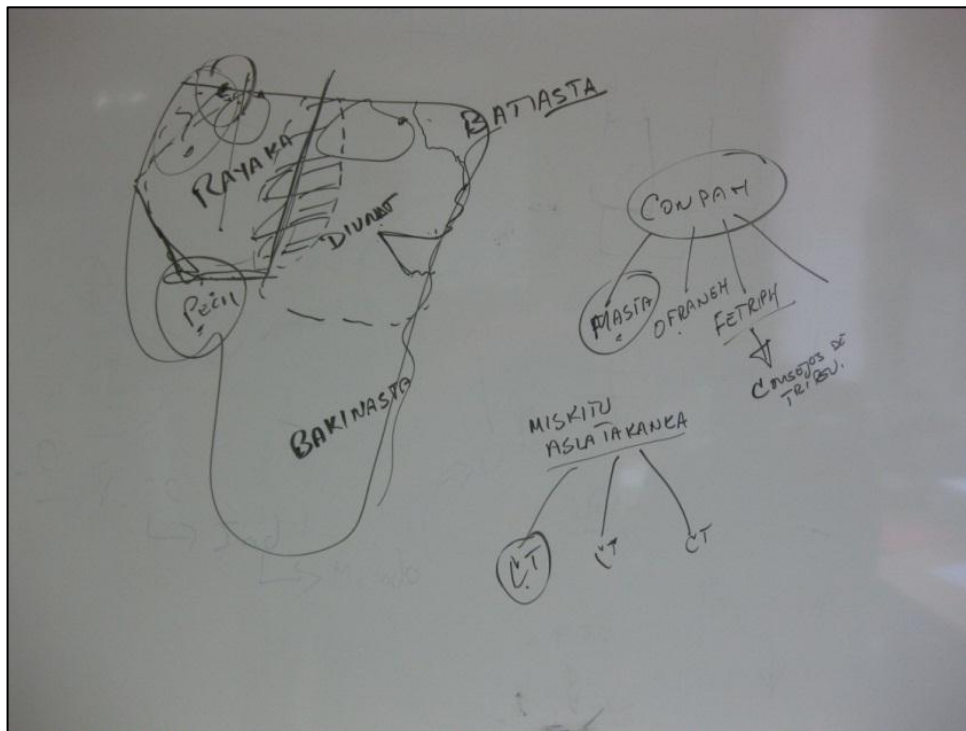
Figure 11. Preliminary study about the indigenous community hierarchy

After a previous visit to the community the most influential people of the group are defined. The criteria to determine who is influential are age and territorial knowledge.

A study of the legal framework regarding the cadastral and land management aspects is also needed.

2. Functional Habitat definition: It is a Participatory mapping process between the selected people of the indigenous communities and the anthropologist of the PROTEP project, where they draw the area that the community uses to supply their basic needs. The base map is the Topographic map, scale 1:50.000, published by the "National Geographic Institute" (I.G.N.) of Honduras.

| Functional Habitat map | Draw Process |
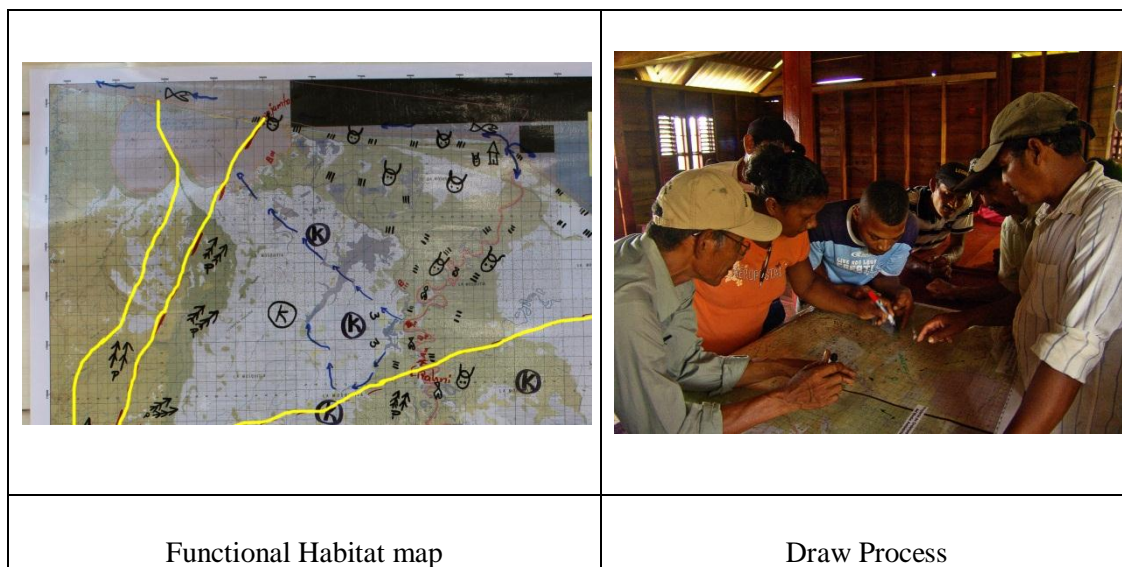
Figure 12. Functional Habitat design. Draw Process

3. <u>Validation process:</u> It is developed between the elder people and the information groups of the community to establish the "Consolidated Functional Habitat". It is a process for defining the quality of the obtained information.

Figure 13. Validation process

4. <u>Meetings between neighboring communities:</u> After the Habitat Functional definition, the "Right to Use" and the "Ownership Right" limits need to be established after several meetings between neighboring communities.

Figure 14. Meeting to establish the Cadastral boundaries

5.1.5. Conversion process from Participatory Mapping to Digital Cartography

The conversion from Participatory Mapping to Digital Cartography is one of the bases of the thesis. In the present, the PROTEP project is defining the cadastral limits of some areas within the Biosphere Reserve Rio Platano, but it also works in the outside limits.

Figure 15 shows the provisional digital cadastral limits established by the PROTEP project excluding the areas dominated by indigenous communities. The methodology to obtain these limits is not based on the Participatory mapping process due to the fact that these areas are dominated by Ladinos.
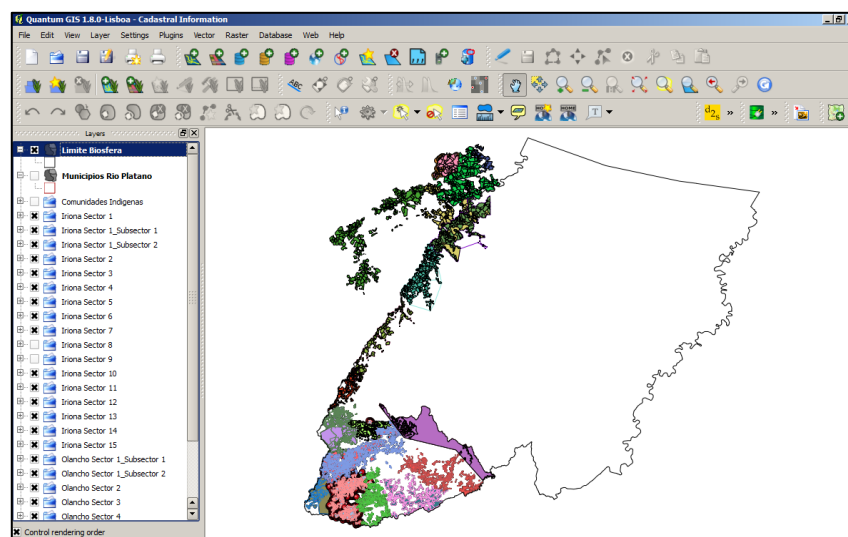

Figure 15. Provisional Cadastral limits in the area not dominated by indigenous communities

The transformation from paper cadastral limits to digital cartography is developed using QuantumGIS, which is a GIS open source software, where it is possible to digitalize topographic maps, cadastral limits and land use of the area settled by indigenous communities. The final purpose is to feed with this type of information into the Cartographic Database of the Rio Platano Region which is stored in PostgreSQL/PostGIS format (see section 6 about the Spatial Database Management System of the project).

5.1.5.1. *Digital Land use management participatory pictograms*

"the preparation of the legend, particularly the selection of features to display and the way they are depicted and textually defined, assumes a key role in determining its final intellectual ownership, its resulting message, and its usefulness in the process" (Rambaldi , 2004). This sentence shows the importance to define good pictograms to establish the communication between the researchers and the indigenous communities, but it also reflects the importance to include these pictograms in all levels of the project including the conversion to digital cartography. The design of "participatory pictograms" to define the land use management of the territory facilitates the communication between the people of the communities.

Table 6 shows the list of participatory pictograms designed to define the Functional Habitat of each indigenous community:

Pictogram	Land Use
林	Forest area
₱	Pine area
ℂ	Colour wood (mahogany tree,…)
⚲	Human settlement
Ⓚ	Hunting area
⅄	Livestock area

⋈	Fish area
←	Access route
‖‖	Crops area
ろ	Invaders (Ladinos)

Table 6. List of digital participatory pictograms

5.1.5.2. _Conversion to GIS symbology_

To convert digital participatory pictograms to QuantumGIS icons, it is necessary to transform the image format from .tiff to .svg, which is the format used by QuantumGIS to show symbology.

After the conversion to .svg format the participatory pictogram is included in the list of available symbols in QuantumGIS using the Symbol property menu.
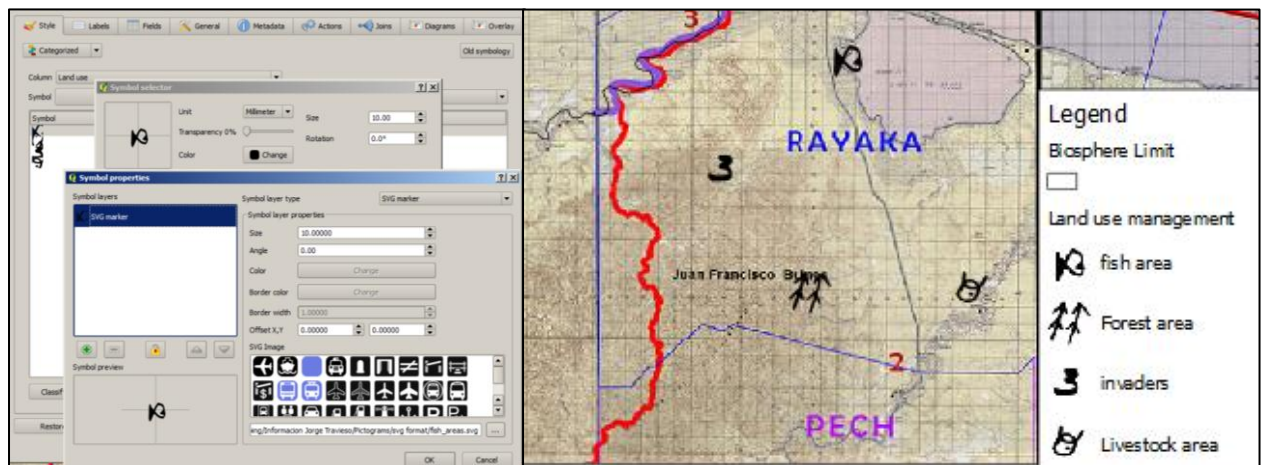
Figure 16. Add "fish area "Participatory pictogram to QuantumGIS icons

5.1.5.3. _Digital Cartographic limits extracted from the Participatory mapping consensus_

Figure 17 show an example of the process to convert the obtained information from the indigenous communities to digital cadastral limits in GIS software. Image a) of the figure 17 shows the Rayaka community (Garifuna community) and Pech

community "Functional Habitat" limits. Both limits are sharing area, so a dialogue process was necessary to define the final cadastral limits of the communities.

The Functional Habitat limits define the "Right to use", but the "Ownership Right" has to be drawn after several meetings between both indigenous communities. At this moment, the process is not finished yet and the PROTEP project, represented by the anthropologist Jorge Travieso is working with both communities for the definition of the final limits.

Image b) of the figure 17 shows the actual negotiation limits. It is important to keep in mind that the negotiations sometimes are held among more than two communities. In particular cases, this negotiation is a very difficult process where the role of the intermediary is very important to help all the involved communities reach a general agreement.
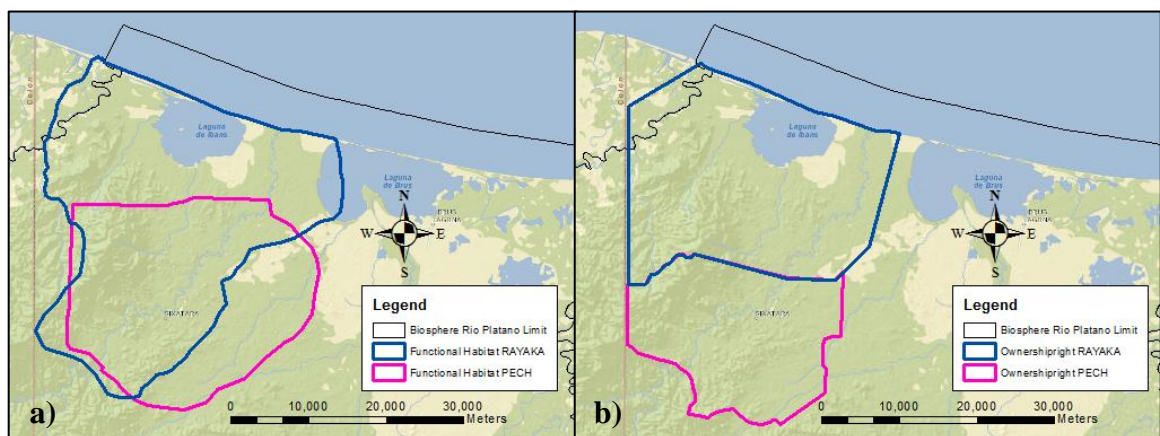
Figure 17. a) Functional Habitat of two neighbouring communities.
b) Provisional cadastral limits in the negotiation process between Rayaka and Pech communities

5.2. Cartographic integration process in the SIMONI "Integral Monitoring System"

The "Integral Monitoring System" (SIMONI), which is a comprehensive monitoring system whose main objective is to provide a platform that is able to measure the management effectiveness of the Reserve of the Man and Rio Platano Biosphere (RHBRP). SIMONI is a project which will be managed by biologist from the *"National Institute for Forest Conservation and Development, Protected Areas*

and Wild Life" (ICF) obtaining information from the indigenous communities of the area and other involved agents.

The cartographic information extracted from the communities will be divided in two types:

1. Socio-environmental aspects: capturing cartographic information regarding socio-environmental aspects to develop indicators for measuring the state, pressure, response and impacts in the region.
2. Incidences: about the good or bad practices in the territory. The purpose is to have a real knowledge of the practices that the communities are performed in the area.

The methodology is based on the definition of the cadastral limits explained in the previous section 5.1. "Cartographic integration process of the land use rights". Participatory mapping techniques will be used with the indigenous communities taking advantage of the contacts of the previous land management project.

The next points summarize the methodology to obtain this information:

1. Selection of the most influent people of the group. It will be people with the most knowledge of the territory. Criteria: Age, Activity (hunter, fisherman, …).
2. Meet with the selected people.
3. To draw in a Base Map (cartographic map scale 1:50.000) the defined socio-environmental aspects and the good or bad practices in the territory (incidences) using participatory pictograms in a meeting between the anthropologist and the selected people.
4. Validation process between the elder people and the information groups of the community. Process to measure the quality of the information.

At present, the technicians are defining the indicators to feed the SIMONI software. However, it is possible to use the pictograms exposed in the section 5.1.5.1. "Digital Land use management participatory pictograms" of this thesis to obtain the

Functional Habitat limits. It will be also necessary to establish new "participatory pictograms" to describe new socio-environmental aspects which will be included in the Quantum GIS symbology.

Table 7 shows a list of possible "incidence participatory pictograms" that would be registered in SIMONI and including in the Quantum GIS symbology or as polygon:

Pictogram	Incidence	Type
	Burnt areas (dry period)	Polygon
	Flood areas (rainy season)	Polygon
	Jaguar killing	Point
	Iguana Killing	Point
	Natural deforestation	Polygon
	Human deforestation	Polygon
	Over-fishing	Point
	Artificial barriers created by man	Point

Table 7. Possible "incidence participatory pictograms" in SIMONI

This cartographic information will be added with QuantumGIS software in the same way that it was previously done for the introduction of the cadastral information from the indigenous communities. The gathered information will be created in a PostgreSQL/PostGIS database. Figures 18 and 19 show an example of incidence participatory information included in GIS software:
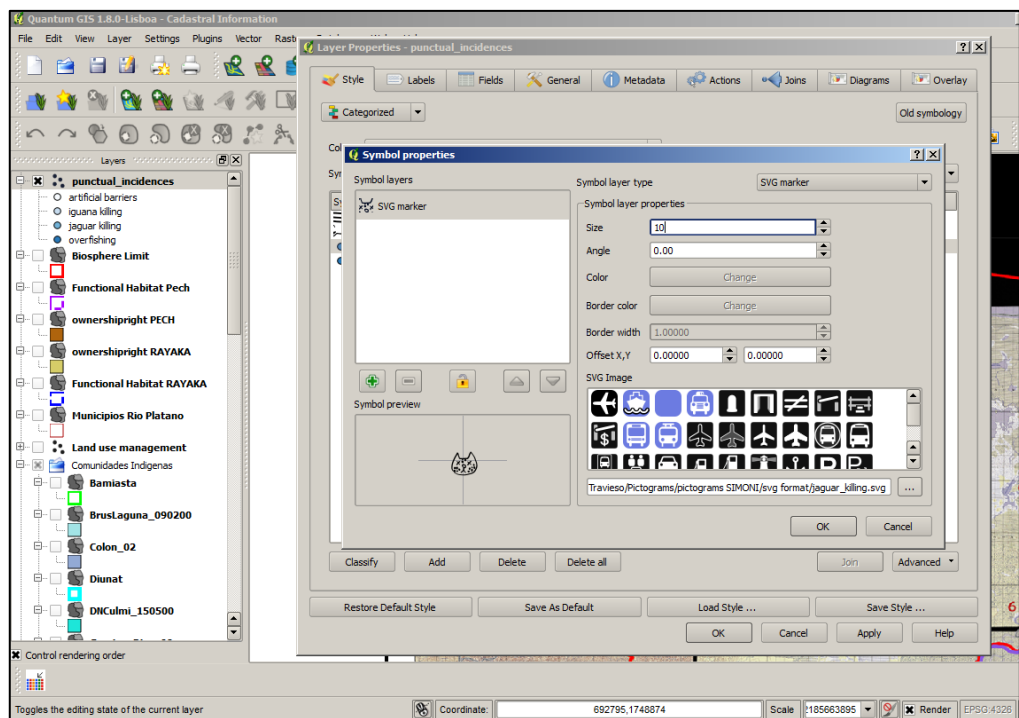
Figure 18. Add "jaguar killing" pictogram to QuantumGIS icons
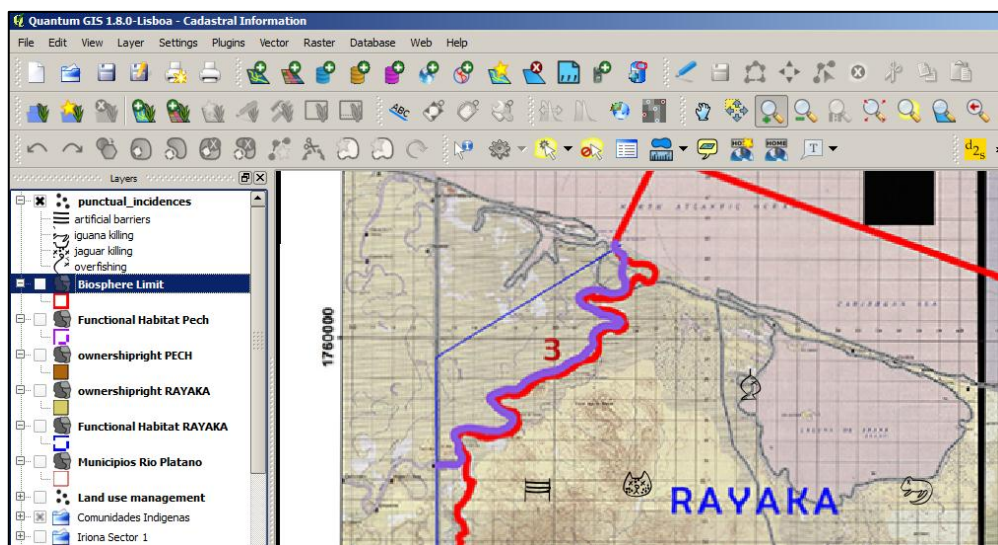
Figure 19. QuantumGIS view with punctual incidence icons

6. SPATIAL DATABASE MANAGEMENT SYSTEM (SDBMS)

A collection of data related to objects of known spatial location is called Spatial Databases (Barriga et al., 2012). This database is a model of reality that fits to a certain phenomenon.

The design of a database is a complex process which requires the following configuration management:

1. To define the main purpose.
2. To establish the potential users.
3. To identify available data sources.
4. To define the organizational structure or data model.

The different databases have been designed using POSTGRESQL with the spatial extension POSTGIS.

PostgreSQL: is a powerful, open source object-relational database system. It is fully ACID (Atomicity, Consistency, Isolation, Durability) compliant, has full support for foreign keys, joins, views, triggers, and stored procedures (in multiple languages). It includes most SQL:2008 data types, including INTEGER, NUMERIC, BOOLEAN, CHAR, VARCHAR, DATE, INTERVAL, and TIMESTAMP. SQL language is a special-purpose programming language designed for managing data in relational database management systems (RDBMS) (PostgreSQL, 2013).

PostGIS: adds support for geographic objects to the PostgreSQL object-relational database. In effect, PostGIS "spatially enables" the PostgreSQL server, allowing it to be used as a backend spatial database for geographic information systems (GIS), much like ESRI's SDE or Oracle's Spatial extension. PostGIS follows the OpenGIS "Simple Features Specification for SQL" and has been certified as compliant with the "Types and Functions" profile. (PostGIS, 2013).

6.1. Purpose of SDBMS and available data sources

The main purpose of the architecture of the Rio Platano Spatial Database Management System is to share cartographic information of the area among all involved agents in the structure of the Rio Platano Spatial Data Infrastructure. The cartographic information is organized into three distinct databases:

1. Cadastral information registered in the "Cadastral Information Database"
2. Socio-environmental information registered in the "Socio-environmental information Database"
3. Indicators for measuring the state, pressure, response and impacts in the region and territorial incidences trough SIMONI application registered in the "SIMONI Database".
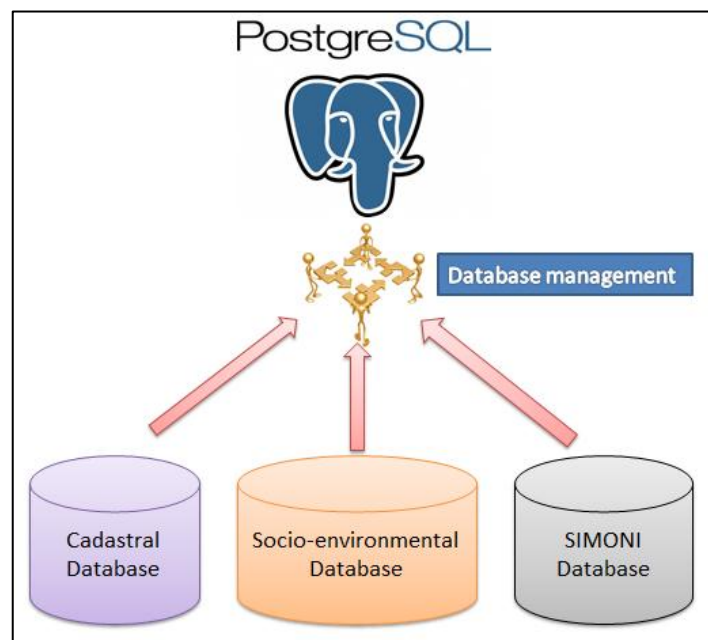
Figure 20. Database management

6.2. Potential Users

It will be necessary to define different users for each database with different permissions (only read or write and read). Tables 8, 9 and 10 show the defined users and the access permissions for each database:

User	Cadastral information	
	Read	Read/Write
Administrator		X
PROTEP workers		X
Municipality Technicians	X	
Other People	X	

Table 8. Users and Permission in the Cadastral Database

User	Socio-environmental information	
	Read	Read/Write
Administrator		X
PROTEP workers		X
Municipality Technicians	X	
Other People	X	

Table 9. Users and Permission in the Socio-environmental Database

User	SIMONI	
	Read	Read/Write
Administrator		X
PROTEP workers		X
ICF workers		X
Other entities	X	
External People	X	

Table 10. Users and Permission in the SIMONI Database

The administrator is also in charge of managing the structure of the Database. To create the user accounts with their passwords in PostgreSQL the next SQL statements were developed in order to provide different roles in the spatial databases previously created:

❖ Superuser/Administrator:

```
CREATE ROLE admin SUPERUSER PASSWORD 'protep2012';
```

❖ Write/Read permission user:

```
CREATE ROLE protep PASSWORD 'protep#2012#';
GRANT UPDATE ON pg_tables TO protep;
GRANT SELECT, INSERT, UPDATE, DELETE, TRUNCATE,
REFERENCES, TRIGGER ON pg_tables TO protep;
```

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❖ Read only permission user:

```
CREATE ROLE munic PASSWORD 'protep@2012@';

GRANT UPDATE ON pg_tables TO protep:

GRANT SELECT, ON pg_tables TO protep;
```

6.3. Organizational structure or data model

6.3.1. Cadastral Database

The cadastral data model is based on the LADM, "Land Administration Domain Model" described by ISO 19152 ISO / TC 211.
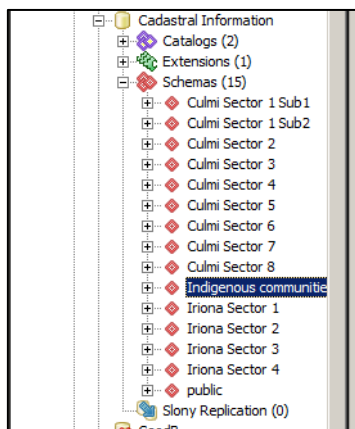
Figure 21. Cadastral Database schemas

The core of LADM is based on the classes related to the three fundamental elements in land management: 1) the subject has a right to a portion of the land, or land parcel known, 2) the basic unit of ownership is the cadastral parcel, and 3) legal relations: Rights, Restrictions and Responsibilities.

The Cadastral database is structured in PostgreSQL scheme dividing the whole cadastral area in different sectors. A scheme for the indigenous communities is also included where it will be defined the different tables with the "Functional Habitats" and the "Ownership land rights".

It is possible to consult the structure of the SDBMS for the Cadastral information based on the LADM in the Annex 2 of this thesis.

6.3.2. Socio-environmental Information Database

The socio-environmental database is comprised of a set of tables without any relation due to the source of each element being different. This database is a

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recompilation of thematic information gathered from PROTEP project and ICF informatics department.

It is possible to consult the table structure of the Socio-environmental information database for thematic cartography and attributes in Annex 2 of this thesis.

6.3.3. SIMONI Database

The SIMONI database has been designed to define several socio-economic indicators using information obtained from the people who live in the Rio Platano Region, as well as with the information from other entities.

To feed the SIMONI Database with data from the indigenous communities, communication is needed between the technicians (i.e. biologist who are developing the indicators) and the decision group of the communities through the methodology explained in the section 5.2 of this thesis. One of the main objectives of the platform is to include the incidences which occur in the territory where the indigenous communities are settled using QuantumGIS software. These incidences will be an important element in the definition of some socio-environmental indicators.

The SIMONI database is also designed in PostgreSQL with the spatial extension PostGIS as the previous designed databases. The incidences have been classified as punctual or polygonal and each category represents a table in the structure of the SIMONI database. Figure 3 in Annex 2 shows the structure of the SIMONI incidences Database.

7. DESIGN PROCESS OF THE RIO PLATANO REGION SPATIAL DATA INFRASTRUCTURE (SDI)

7.1. Rio Platano SDI as a Regional Nodo

Rio Platano Region SDI has been designed as a platform for sharing cartographic information among all the involved agents who are working in the area. The definition of the Rio Platano SDI as a regional node is justified because it is a specific area in Honduras which has been declared "Heritage of Man and the Biosphere" by UNESCO. All the agents which will be included in the structure of the SDI have a real contact in many ways with the region.

Figure 22 shows the different structure of the SDI node levels. The ideal situation would be an advanced structure where there were "horizontal relations" between the nodes in the same level (i.e. different forest regions in Honduras) and also "vertical relations" between nodes in different levels.
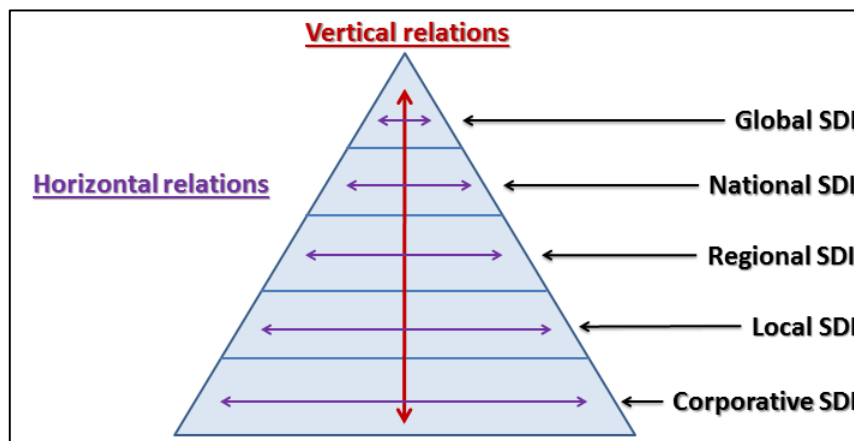
Figure 22. Nodo structure in SDI levels

Rio Platano Region SDI has been designed simultaneously to the Honduras SDI. The National project for sharing cartographic information is in the first steps of the design process (Mid 2013 is the expected date to launch the project). In the moment that Honduras SDI creates the structure of a National level, the Rio Platano

Region SDI will be adapted to the particular specifications designed in a superior node.

However, the Rio Platano Region SDI will be an important starting point for future projects in other regions in the country.

7.2. Components of the SDI

The different components of the SDI have been designed following the structure explained in the section 2.3.2. "Components of the SDI" of this thesis. Figure 23 shows the components in the Rio Platano Region SDI:
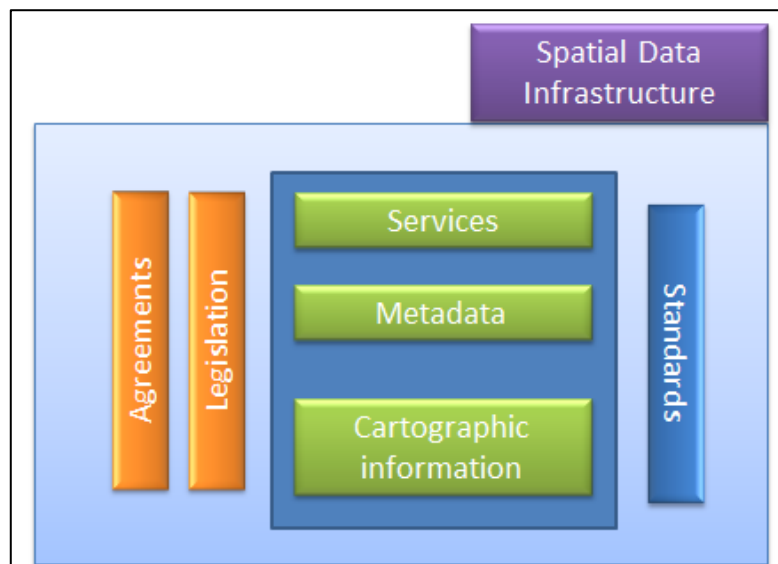
Figure 23. Rio Platano SDI components

7.3. Client-Server Model

The SDI is based on the informatics model called client-server. In an informatics point of view, the client is a software running in a local computer and a server is a software running in a remote computer; both communicate through the Internet/Intranet protocol. A server is able to communicate to clients at the same time and is responsible for consulting and processing the information according to the clients request.
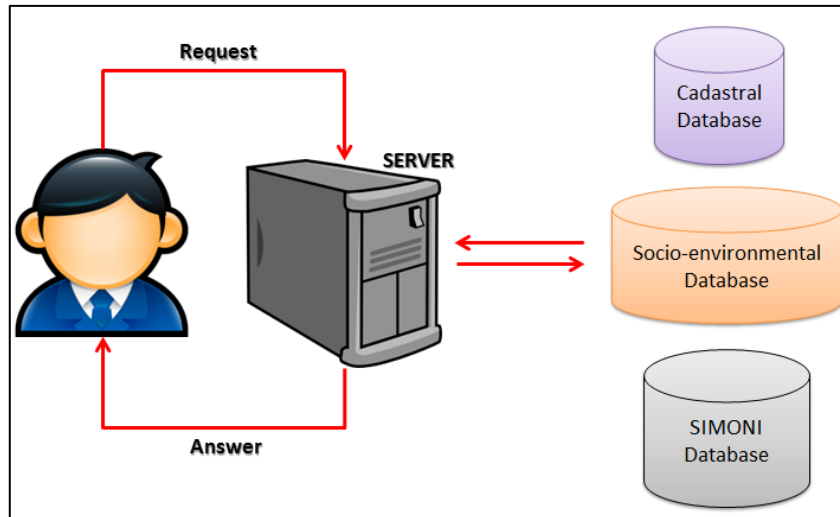
Figure 24. Architecture Model Client/Server

7.4. Geoportal Design. Service Structure

A Geoportal is a web site that presents an entry point to geographic content on the web, or more simply, a web site where geographic content can be discovered (Tait, 2004) and where it is possible to access to associated geographic services (display, editing, analysis, etc.) via Internet. Geospatial web services can be categorized by the functions they provide: map services, data services, analytic services and metadata catalog services. (Fu and Sun, 2011)

The purpose of developing the Geoportal is to facilitate effective and innovate collaborative working within a multi-disciplinary research group. The essence of the Geoportal is to permit a distributed group of researches access to integrated geo-spatial (and non geo-spatial) socio-economic metadata and data for the Rio Platano Region. (Berry et al, 2010).

Moreover, the platform to connect different services in the Rio Platano Region SDI with multiple clients is a Geoportal. From the technical point of view, the Geoportal is accessible via internet through a web server. The web server is a computer which has a specific, publically accessible internet address called IP and specialized software which communicates with clients through the HTTP protocol. To find a specific web server is necessary also link a domain name to the IP address.

For instance, the IP address 190.109.199.227 is linked to the name http://www.icf.gob.hn/.

The Rio Platano Region SDI Geoportal has been launched in the PROTEP website, but is currently waiting until the Rio Platano Regional office has the infrastructure necessary to assume the platform.

The Geoportal has been designed following the requirements indicated by technicians who are working in the project. Figure 1 in Annex 4 shows the main page of the Geoportal from where it will be possible to access to all different services (i.e. Mapserver, Metadata service, SIMONI, Agreements and Legislation).

7.5. Involved agents. From the Global one to the indigenous communities

There are several actors involved in the definition of a SDI. The users will be the ones who will determine the success or failure of the platform. We can make a difference among the various users. They can be classified as follows:

1. Public administration.
2. Companies.
3. Universities and research centres.
4. External people.

All of these users have to be considered in the SDI definition so that it can reach a larger number of users in the most effective possible way.

Also, it has to be considered the international organizations which are in charge of creating standards as Open Geospatial Consortium (OGC), or the Open Source Geospatial Foundation (OSGeo) as well as the big international map servers which will provide base cartography of the area to the Geoportal. There are several world cartographic services such as Google, Bing or OpenStreetMap which offer free base maps through WMS services. Both kinds of actors have contributed cartographic information to the different services that have been implemented.

Table 1 in Annex 3 shows a relation of the involved agencies which have been included in the structure of the SDI for sharing cartographic and non-cartographic information through the Geoportal.

From the contact link in the Geoportal website it is possible to access to the different webpages of the organizations. Each organization has a user name and a password to login in the Geoportal and the different services of the SDI.

7.6. Policies and Agreements

The Geoportal is also a useful tool to share non-cartographic information. The Geoportal allows consulting and downloading a list of legislation in a National, Regional or Local level in .pdf format. The platform also includes a list of agreements among the different agencies of the Region. It is possible to consult all this information from the service included in the main page of the Geoportal. (See Figure 2, Annex 4).

7.7. Rio Platano Region Map server

7.7.1. Definition

A map server is the brain of any web GIS application. It provides specific traditional GIS functions which include: spatial analysis, spatial and attribute queries, geo-coding, geoprocessing and generating dynamic maps to the client based on user requests. The map server can generate output in two broad forms (Rao and Vinay, 2010):

1. Feature info as a result of a spatial query, such as feature selection or geo-processing that is sent to the client application for further user manipulation.
2. A graphical image as a response to feature filtering/search capabilities or a simple GetMap request etc.

Some of the main ideas of the Map serves are:

❖ Specific GIS software is not necessary. The user does not have to install anything in the computer.
❖ Little to no skills in GIS technology are not needed.
❖ Improve the collaborative work among the agents involved in a specific web meeting point.
❖ Real time information updates.
❖ The map server is independent to the configuration of the device used.
❖ Map server applications can be personalize using libraries such as Openlayers.
❖ It is possible to combine cartography with other elements such as video, pictures and audio.

7.7.2. Map server software comparison

In the open source community there are several programs that provide us with the technology to create a map server. The different solutions are divided in categories, depending on a specialized way of looking at the projects, allowing understanding, of their aims and scopes (Carrillo, 2012).

❖ Libraries: Expose classes and functions to allow building applications at a higher level of programming.
   Ex: Openlayers, Flexlayer, Ka-Map, Mapbuilder.
❖ Wrappers: According to the Free On-Line Dictionary of Computing, a wrapper "[...] acts as an interface between its caller and the wrapped code. This may be done for compatibility, e.g. if the wrapped code is in a different programming language or uses different calling conventions, or for security [...] The implication is that the wrapped code can only be accessed via the wrapper."
   Ex: GWT-Openlayers, MapQuery.
❖ Toolkits: "more modular and easily integrated into a custom application." (Ramsey, P., 2007).

Ex: GeoExt, ReadyMap Web SDK.

❖ <u>Frameworks</u>: According to the OGC glossary, a framework is "[...] a reusable software template, or skeleton, from which key enabling and supporting services can be selected, configured and integrated with application code.". "Are more suitable for customization than integration." (Ramsey, P., 2007).

Ex: Cartoweb, Chamaleon, GeoMoose, MapBender.

❖ <u>Clients:</u> This category comprises viewers and ready-to-use Web mapping applications.

Ex: Geoide, GisClient, i3Geo.

7.7.3. OpenGeo suite

OpenGeo suite software has been used for the development of the Map Server. It is a software package integrated by a set of components described in the next table:

POSTGIS	Premier open source spatial relational database—fast, robust, full-featured. PostGIS "spatially enables" the PostgreSQL open source relational database. The database can then be used to store and query spatial data (points, lines and polygons).
GEOSERVER	Map and feature server providing standardized web access to GIS data sources.
GEOWEBCACHE	Web map accelerator, intelligently caching and serving tiles to make maps scale.
OPENLAYERS	Industry-standard Javascript map controls for viewing and editing data from multiple sources.

	Rich user interface controls for the geospatial web.

Table 11. OpenGeo suite software package (OpenGeo, 2012)

The decision to choose this package was based on the possibility to have different open source software packaged in an easily deployable manner: the Spatial Database Management (PostgreSQL/PostGIS) and the Map server (Geoserver software) which is in charge of managing the different layers that the project wants to publish. Geoserver also supports a set of standards that provides the Map server with plenty of possibilities regarding the different publication formats:

- ❖ Implements OGC services including Web Map Service (WMS 1.1.1 and 1.3.0), Web Feature Service (WFS 1.0.0 and 1.1.0), WFS-Transactional (WFS-T 1.0.0), and Web Coverage Service (WCS 1.0.0 and 1.1.1)
- ❖ Java J2EE application, works with Jetty, Tomcat, WebLogic, WebSphere, JBoss.
- ❖ Support for many back-end data formats (ArcSDE, Oracle Spatial, DB2, SQL Server, shapefile, GeoTIFF, MrSID, JPEG2000).
- ❖ Multiple output formats (GML, shapefile, KML, GeoJSON, PNG, JPEG, TIFF, SVG, PDF, GeoRSS) plus Google Earth integration.
- ❖ User- and role-based security subsystem based on Spring Security

The OpenGeo suite also offers GeoExplorer which is a JavaScript-based mapping framework. In the words of OpenGeo, it "brings together the spatial capabilities of OpenLayers with the user interface power of ExtJS." The goal of GeoExplorer is to assemble a browser based mapping application with functionality traditionally found in the desktop GIS world.
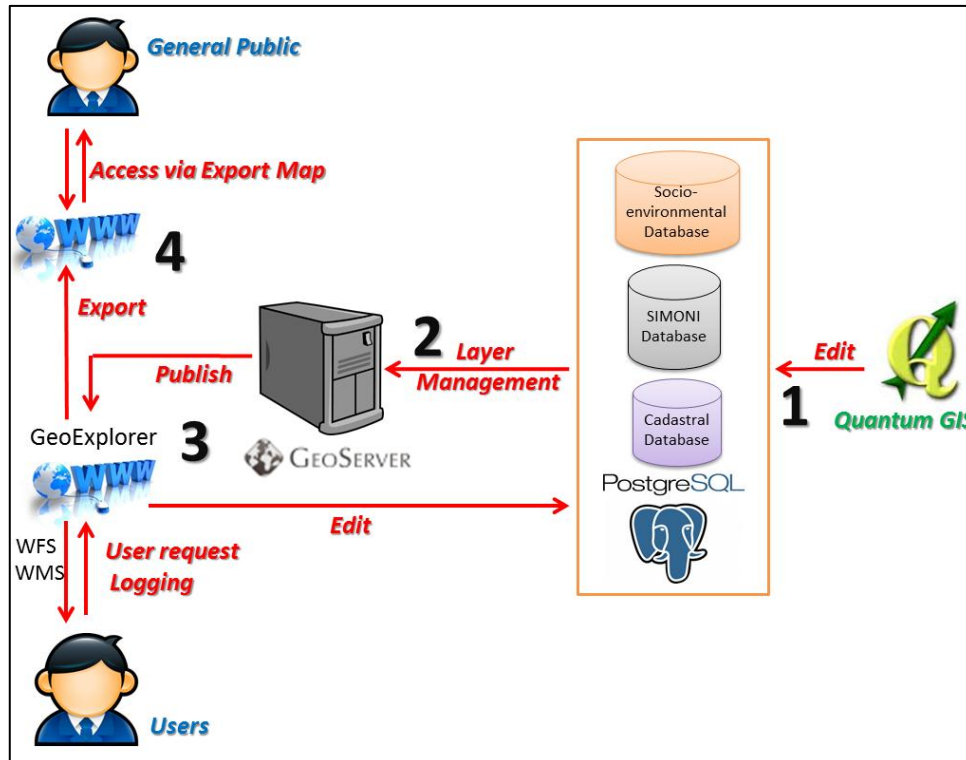
Figure 25. Publishing process through Geoserver

Figure 25 shows the process to publish cartographic information in Geoserver through the OpenGeo suite. The steps are as it follows:

1. Editing: Edit (create, delete, modify, etc.) features in the Spatial Databases created in PostgreSQL/PostGIS format through QuantumGIS software.

2. Management: The administrator of the Geoportal, using Geoserver, is in charge of managing the published layers.

3. Editing/Publishing/Downloading: Through Geoexplorer different users have access to the published layers and depending on their permissions, they are able to read or write/read in the Spatial Databases. The authenticated users can query the data using the WMS service and download the cartographic information in different file formats such as shapefile.

4. Access via Web: The people interested in the cartography of Rio Platano Region are able to query the information recorded in the Spatial Database through the map created by Geoexplorer through the WMS format.

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Depending on the user´s permissions in the Spatial Databases and in Geoexplorer, they can also edit features in the Spatial Databases. The different users of Geoserver and Geoexplorer can gain access through their "user name" and "password" to the applications. If the user has read-only permission to the database, a message will appear in Geoexplorer denying them write access. Figure 3 in Annex 4 shows a user with write permission, while the user in Figure 4 in Annex 4 has read-only access in the database.

Geoexplorer offers different tools to the users for managing the cartographic information:

- ❖ <u>User access:</u> The user access to the map through his/her own account.
- ❖ <u>Map view:</u> 3D view, Pan Map, Zoom by dragging a box, Zoom In, Zoom Out, Zoom to previous extent and Zoom to next extent.
- ❖ <u>Layers management:</u> Add layers, Upload layers, Remove layers, Layer properties and Layer styles.
- ❖ <u>Other tools:</u> Save map, Publish map, Print, Identify element (show information recorded in the Database), Query, Measure and edit elements (create and modify).

The option "Addlayer" permits the user to incorporate cartographic information from other sources. It is possible to incorporate information by including the URL of the service, but by default the MapQuest Layer, OpenStreet map Layers, Google Layers, Bing Layers and Mapbox layers are available.

With the option "Export map", it is possible to embed the map in an external web page created to share the cartographic information with interested people without having any relation with the agencies which are involved in the definition of the SDI. This functionality does not require a user name or password. The external user can access different tools such as Add layers, Print, Pan map, Identify, Measure, Zoom In, Zoom out, Previous zoom,ext zoom, Map extent, Legend, Combine with Google Earth.

Figures 5 and 6 in Annex 4 show exported maps embedded in the Rio Platano Region map server web page and the SIMONI map server web page.

7.7.4. Publishing Indigenous communities cartographic information

Once the cartographic information from the indigenous communities has been included in the Spatial Database (PostgreSQL/PostGIS) and edited using The QuantumGIS software, it is possible to share this information in the same way as how it was obtained from other sources.

The information represented by polygons is published through Geoserver incorporating the layers which represent the "Functional Habitat" and "Ownership rights" of the different indigenous communities. (See Figure 7, Annex 4).

The information related to socio-environmental aspects and incidences for feeding the SIMONI application is represented by points in QuantumGIS symbology.

Geoserver has the possibility to import the symbology through a SLD standard format which is based on the XML language. The SLD has been previously exported in QuantumGIS. The Annex 5 shows the XML code to import the symbology in Geoserver.

Figure 8 in Annex 4 shows the participatory pictograms defined with the indigenous communities integrated in the symbology of the Map server. With this process the participatory pictograms and therefore the ideas of the indigenous communities have been used in all levels of cartographic information being a crucial element for the decision making process in the region.

7.8. Metadata Service

The aim to have a metadata register is that the users can consult the location and characteristics of the data produced in the region. Access to the metadata has to be efficient by allowing different criteria for searching by spatial (location) or attribute (organization, data, keyword, etc…) terms.

The metadata service has been created using GeoNetwork following the objectives of the project to develop all services using free and open source software.

GeoNetwork is a catalogue application to manage spatially referenced resources. It provides powerful metadata editing and search functions as well as an embedded interactive web map viewer. The software provides an easy to use web interface to search geospatial data across multiple catalogs, combine distributed map services in the embedded map viewer, publish geospatial data using the online metadata editing tools, and optionally the embedded GeoServer map server. Administrators have the option to manage user and group accounts, configure the server through web based and desktop utilities and schedule metadata harvesting from other catalogs (GeoNetwork, 2013).

The methodology to consult the metadata of the different cartographic information is shown in Figure 26. The information is required through a CSW service receiving the answer in a metadata file created in XML language.

❖ <u>CSW:</u> Catalogue Service for the Web. It is an Open Geospatial Consortium standard to consult the metadata of the cartographic data.

❖ <u>XML:</u> Extensible Markup Language. It is a W3C standard that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.
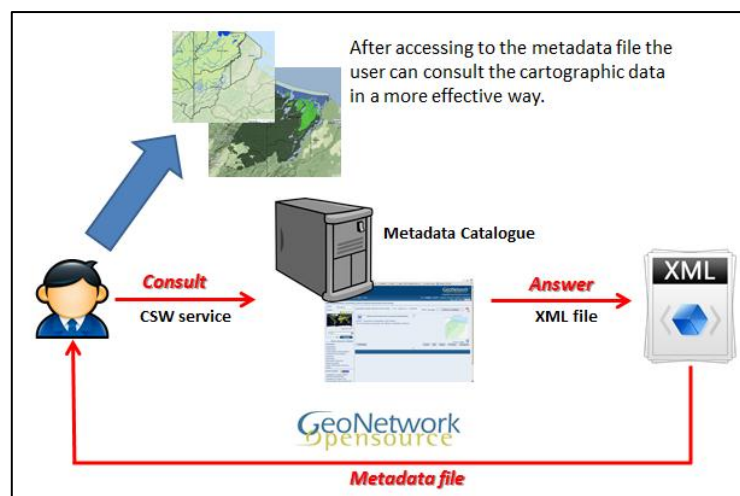
Figure 26. Schema for accessing to the metadata information

7.9. Rio Platano Region metadata service

The metadata register is not designed at the National level yet. Currently, Honduras is in process of defining the structure of the SDI for the country. Therefore, the characteristics of the metadata will be designed in a near future. At that moment, the structure of the metadata created for the Rio Platano Region SDI will be adapted to the new conditions of the Honduran legislation.

GeoNetwork permits to create metadata files using different standard templates, such as ISO19139, Dublin Core and FGDC. ISO19139 has been the standard selected in the Rio Platano Region SDI. The SO19139 provides a XML implementation schema for ISO 19115 specifying the metadata record format which will be filled with information that describes the *who, what, when, where, why* of each layer created by the different agencies involved in the project.

Figure 1 in Annex 6 shows an example of the search results from the "What?" tool included in the GeoNetwork. This tool uses the keywords included in the metadata file.

GeoNetwork produces a XML document where it is possible to query the layer and its characteristic of production. GeoNetwork and Geoserver are connected in order to consult the metadata from the Map server software and in the opposite direction. (See Figure 2, Annex 6).

8. EVALUATION

Biosphere Reserve Rio Platano is an isolated area located in the southeast of Honduras. Communications within the area are complicated due to mountainous terrain and unpaved roads. It is populated by indigenous communities with a lack of communication between them. Also, the communications among other agents who are working in the study area, such as municipalities, government statements, NGO´s, etc… are difficult as well.

Invasion of private third party agents and land snatching by third parties in the area was the reason that the PROTEP's activities were directed toward improving the management and protection of natural resources. The project emphasizes a framework to support land management at the indigenous community level.

The lack of communication and isolation of the area has made the process of obtaining cartographic information very difficult. Therefore, it is necessary to share all information among the agents who are working in the territory to reduce cost and effort.

Consequently, the most important source in the area to obtain information about the usage of the territory regarding to the cadastral boundaries and other socio-environmental aspects is through the relation between the technicians of the different projects and the indigenous communities of the area.

After several interviews, the necessity to create a platform for the sharing of information being developed and obtained in the Rio Platano Region Spatial Data Infrastructure was considered. Nevertheless, this platform would be useless without inclusion of the information obtained from the indigenous communities, who possess the best knowledge of the territory.

The methodology to include the information from the indigenous community was developed in section 5. "Indigenous Communities Cartographic Integration Process" of this thesis.

The policy of the PROTEP project is to only use free open source software. Therefore; only this kind of products were considered for developing the services of the Geoportal. The next list shows the software used for building a SDI regarding the minimum services needed (Steinger and Hunter, 2012):

1. A software client - to display, query, and analyze spatial data (this could be a browser or a Desktop GIS): Quantum GIS and Geoexplorer.
2. A catalogue service - for the discovery, browsing, and querying of metadata or spatial services, spatial datasets and other resources. GeoNetwork.
3. A spatial data service - allowing the delivery of the data via the Internet. WMS (Query) and WFS (Download layers) via Geoserver.
4. Processing services - such as datum and projection transformations. Geoserver
5. A (spatial) data repository - to store data, e.g. a Spatial database. PostgreSQL/PostGIS.
6. GIS software (client or desktop) - to create and update spatial data. Quantum GIS and Geoexplorer.

9. CONCLUSION

This last section of the thesis is focused on analysing the proposed objectives for this research to see it the thesis addressed the specific objectives. This section will be divided into two discussions; Research objectives and Research Questions.

A final point describing the next steps of the Rio Platano SDI as an essential tool in the process of sharing cartographic information in the area is also included.

9.1. Research Objectives

The idea of sharing cartographic information in the area was the basis to define the objectives of the thesis. In the recent years, two important terms have had a big burst in this process: Spatial Data Infrastructure (SDI) and Volunteered Geographic Information (VGI).

However, both terms have difficulties in being implemented in this area due to the lack of organization and structure regarding cartographic information in the country and the difficulties of the inhabitants of the area towards internet access.

VGI refers to the idea of providing cartographic information voluntarily by individuals. Nevertheless, the structure of the population dominated by the existence of isolated indigenous communities, make it difficult to process.

Accordingly to this situation, it was not possible to set aside the information offered by the ones with the most direct relation to the field. This process is not strictly voluntary, and a different way of communication is needed; like Participatory mapping technics. Therefore, the combination of SDI and Participatory mapping in areas where the conditions are not suitable is the objective of this project.

The design of the methodology to use the information obtained from the indigenous communities in cadastral and socio-environmental aspects was developed in section 5 of this thesis. It is a methodology which starts by the use of Participatory

mapping technics using participatory pictograms and ends with the inclusion of this information in the map server created for the sharing of such cartographic information.

The study of all the agents who are working in the area and the deployment of the platform used to share all the available information among them was developed in section 7 of this thesis. It was also included the information gathered from the indigenous communities.

Thereby, the final result is a platform in which all the agents are connected, sharing organized cartographic information obtained from all available sources (i.e. Google maps, OpenStreetMap, national organizations, regional organizations, NGOs, inhabitants and indigenous communities).

9.2. Research Questions

The next points are the answers of the questions that were elaborated in the beginning of the thesis:

1. Using Participatory mapping technics and developing participatory pictograms makes it possible to communicate with the indigenous communities and extract information related to different aspects of the territory.
2. To measure the quality of the information, the analysis of the social structure of the community is necessary; having access to the most influential people of the group. Moreover, it is necessary to be in touch with the elders and the information groups of the community, since they will confirm the quality of the previously obtained data.
3. People who are living in the area are the ones with better knowledge of the territory. Therefore, their information is the most important in order to know what is happening there.
4. It is necessary to have a good structure of the spatial databases created by the organization classified in different topics. PROTEP spatial information

is divided in cadastral, socio-environmental information and SIMONI databases. After that, a process to select which information is candidate to be published in the created platform is necessary.

5. A platform was created to share cartographic information composed by different services (agreements, legislation, map server, metadata service, SIMONI) for the use of all the involved agencies in the project.

9.3. Future in the Rio Platano Region SDI

The next efforts in the developing process of the SDI have to be focused on the four components of a SDI definition described in the point 2.3.2. "Components of a SDI" of this thesis:

- ❖ Geographic component: Classifying and integrating all new cartographic information obtained from the different sources using the developed services (PostgreSQL/PostGIS, map server and metadata service).

- ❖ Social component: Involving all the agencies which are producing cartographic information of the area in the new platform through different agreements for sharing cartographic information.

- ❖ Technology component: Developing new tools or designing a personalized map server or Metadata service. It also has to be considered the possibility to use mobile devices, such as tablets, laptops and PDA´s for producing and consulting cartographic information, even developing a mobile application. However, the conditions are not good enough regarding internet connection, including UMTS and GPRS technologies. Therefore, the only way would be through satellite connection (very expensive) or saving the information in the mobile device and downloading after in the office.

- ❖ Political component: It is necessary that the Honduran Government gets involved in the process of publishing a SDI for the country. Designing laws and procedures for sharing cartographic information between the agencies which are working in the area.

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Annex 1. Prototype design and interviews

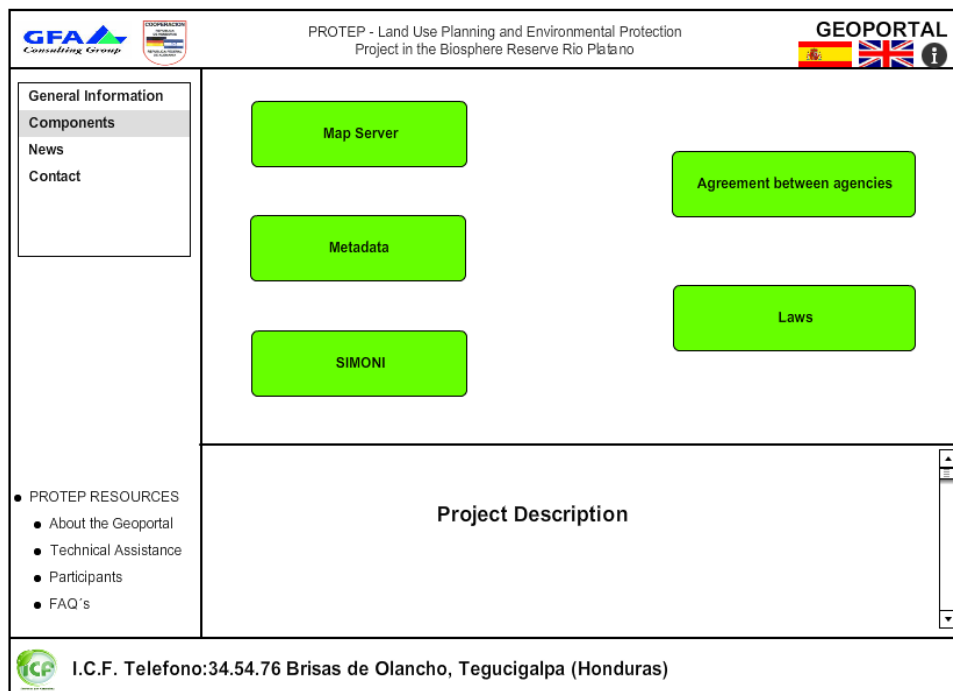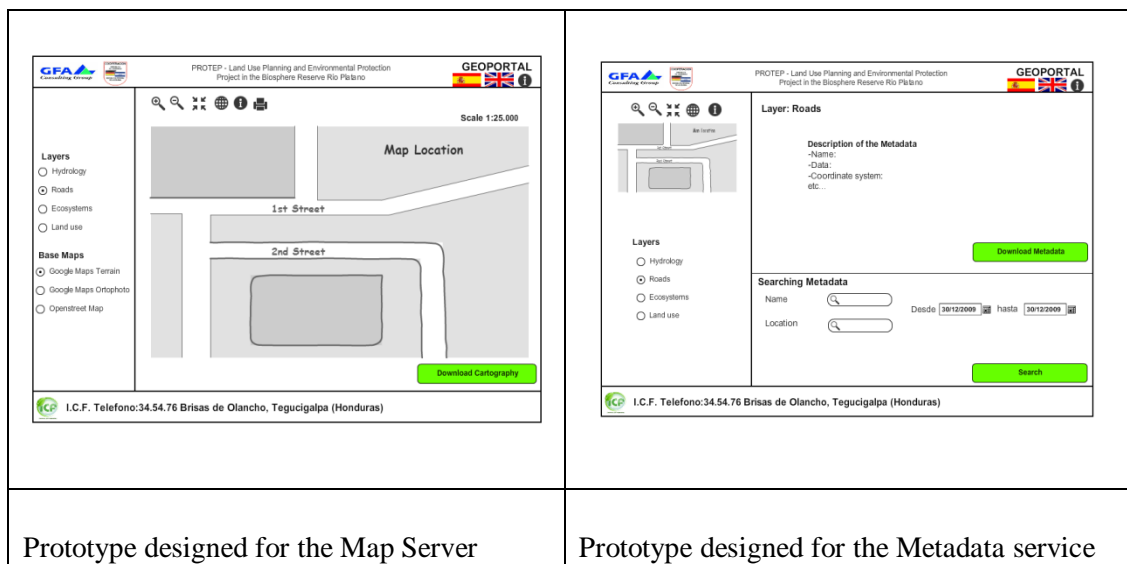**Figure 1. "Rio Platano GEOPORTAL" prototype. The user will be able to select the different services to check**

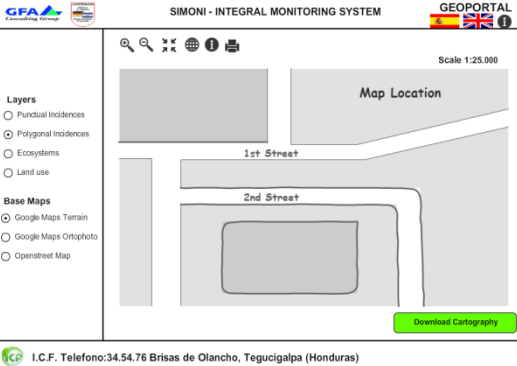| Prototype designed for the Map Server | Prototype designed for the Metadata service |

| Prototype designed for the Laws and Agreements download service | Prototype designed for the SIMONI Map server |

Figure 2. Recompilation of the prototype Services in the Rio Platano Geoportal

Project: Sharing information of the PROTEP project
User group: Technicians
Interview number: 1
Interviewee: Technician of the PROTEP project.
Interviewer: Alberto Olivares
Date: 25.09.2012

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
Introduction			
1	Describe in one or two sentences what you are doing.	What is your task in the project?	In summary, I try to manage the different aspects of the project focusing on the people, who work in each area, do their jobs.
2	Which major tasks (time-consuming, often, important) belong to that? Which of them should be supported by system?	Which are your main tasks in the projects? which of them should be supported by system?	As I said before my main task is to manage the different aspects of the project and to have in my head a complete analysis of it. Also, I have to make decisions about all the aspects of the project. For me, it would be important that I and all the people involved in the project could have access to all the available information in an easier and more accessible way. Also, we have to find the way to include the information obtained from the indigenous communities in the project.
3	How is work organized (e.g. mixed work, fixed sequence, monotonous single task)?	How do you decide then? You have so many things that you know…	I try to collect as much information as I can. I check the actual situation of the information with the different technicians. This can take time. Sometimes it's hard to decide even knowing all this information and it´s when we have meetings with the different departments of the project.

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
Prerequisites			
4	Necessary qualifications (subject-related, system)? Knowledge missing?	Do you think it is very important to have a good knowledge of the information of the project?	For sure, having a good knowledge of the territory is needed, because the Land use Planning project is based on it. If you are going to make decisions you should know about the different involved variables. In this project is an important point to obtain the information of the indigenous communities of Rio Platano. They are who have better knowledge of the territory.
5	Who/what determines what to do when?	Who makes the decisions in the project? What aspects are important?	The decisions are always made by all the agents involved. For example, regarding the cadastral information we need inputs from the municipalities and the inhabitants, but also for the socio-economical information we need inputs that they can facilitate to us or vice versa. In the end, the most important point is that all decisions we make will be agreed upon by all the agencies involved and with the knowledge of all the technicians who work in the project.
6	Which tools are necessary? Which are missing? Which are desired in addition?	What kind of tools do you use for decision making? Are these tools useful? Which are missing in this moment?	The most important point is that the project has the policy of only using free software. So, we have installed UBUNTU, OpenOffice. For working with the cartography information we use QuantunGIS and PostgreSQL, and PostGis. These tools are very useful, because they gave us all the solutions that we needed. The only tool that I miss is the possibility to share our information with all the agencies involved in the project, because the distance between Tegucigalpa (*location of the project´s offices) and the municipalities is at least 6 hours by car.

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
Usual execution			
7	Which steps are necessary?	How are you sharing information in this moment?	In this moment is very difficult to share information between the project office and the municipalities. Our people travel to the study area at least twice per month but their task is not to bring the updated information. So, the actual situation is not ideal, because municipalities don´t have the updated information. Also, the first step to do that will be to organize all the information in our office and decide which information is useful for them and which information we can provide.
8	Which steps reoccur often? Automation desired/necessary?	What do you always check before taking the decision?	We have a server in the project which makes checking the cadastral information possible. We also have to consult other information, but it´s true that we often have to find them in all the information available in the server. Sometimes this task is easy, but other times this task lasts at least one or two days.
9	Which steps are automated? Can the user interfere?	Are there any automated tools?	No. We need to create information from zero. We have people who digitalize the cadastral information that it was obtained in the field with the municipalities and inhabitants of the area. However, we receive information from other statements related to hydrology, protected areas, roads, etc.
10	Do several people have to work with an object (e.g. document) simultaneously?	Do all the information use the same tools?	No, we use QuatumGis to analyze some information, but we also use PostgreSQL. In the municipalities we don´t know exactly which one they use. Now, we are creating an Environmental monitoring system "SIMONI" which we wish all agencies can use.

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
11	Is there a fixed sequence of steps? Flexibility reasonable/necessary?	What is the sequence in your search?	1) Obtaining the cadastral information in the field. Survey work. 2) Check the cadastral information connecting PostgreSQL with QuantumGIS. 3) If it´s necessary I cross check other information regarding environmental and socio-economic aspects in QuantumGIS. 4) I talk with the people involved in the solution. 5) We make a decision.
12	Which (partial) results? How further used?	How do the results look like?	If it´s necessary to create a dynamic map we show the information in QuantumGIS. But we also produce alphanumerical information on tables, and paper maps if it´s necessary to consult.
13	Which feedback regarding results and impact of work?	So what would you expect of these agencies involved or what kinds of results would be more useful?	It´s important that other agencies provide us with cartographic information that we can use to make decisions in our project. This information can refer to different aspects like hydrology, land use, transportation, etc.
Specifics with execution			
14	Interruptions? Why? Of which kind (organizational, social, technical)?	So as far as I understand, you create information but you also depend on other agencies?	Absolutely. Sometimes, we have to make an analysis but the information needed is not provided for us. So, we have to get in contact with other agencies.
15	How are errors reported and corrected?	How do you communicate with the other agencies if some information is not proper?	In this moment the way of communication with the Municipalities or other agencies is via e-mail or letter. Sometimes, it is difficult to know if we are talking about the same thing. Also, we have technicians who visit the small indigenous communities to extract information related cadaster, and socio-environmental aspects.

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
16	Important special cases to be considered (e.g division of labor, collaboration)?	In the cases that you are not in the ICF (agency of the project) how do you check the information?	Ufff. In this case it is impossible. The only way is if you have previously printed the information. The most horrible case is when you are in a municipality 5 hours away from the office and you need specific information about some theme and you have not brought it with you.
Organisational framework			
17	Measures of performance enhancement/control? Which? Necessary?	How and when do you know if the information is correct?	It's difficult to say. I think for this aspect it would be interesting to know the information related to the information. By what means was the information and data regarding: author, date, coordinate system, etc… obtained.
18	Which task results/steps directly affect third parties (e.g. customers)? Consequences?	In case you forget something, has this ever happened? Does this affect any of the other agencies?	Yes, we have had problems in which we don´t remember exactly the information we have. So, it´s important to deal with this problem. Of course, this situation affects a lot, because we don´t give a good service for all the involved parties.

Project: Sharing information of the PROTEP project
User group: Technicians
Interview number: 2
Interviewee: Biologist who has developed the SIMONI application
Interviewer: Alberto Olivares
Date: 26.10.2012

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
Introduction			
1	Describe in one or two sentences what you are doing.	What is your task in the project?	I´m defining the Conceptual Model and the structure of SIMONI.
2	Which major tasks (time-consuming, often, important) belong to that? Which of them should be supported by system?	Which are your main tasks in the projects? which of them should be supported by system?	My main task is to define the tools of SIMONI. Defining also the biological aspects of the final product. I think it is very important that all my thoughts are included in the final product.
3	How is work organized (e.g. mixed work, fixed sequence, monotonous single task)?	How do you decide then? You have so many things that you know…	I´m defining all these aspects according to similar studies regarding to the Environmental Information Systems, and following the biological aspects defined by the Honduran Government and other agencies. I try to extract the singularity of those aspects regarding Rio Platano area.

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
Prerequisites			
4	Necessary qualifications (subject-related, system)? Knowledge missing?	Do you think it is very important to have a good knowledge of the information of the project?	No. It´s possible that you need to have a good knowledge of the territory for including biological information, but we need information of the incidences that occur in Rio Platano and for this it is not necessary to have a wide scope of knowledge, but it helps.
5	Who/what determines what to do when?	Who makes the decisions in the project? What aspects are important?	At this moment, I decide all the aspects in the project. But in the future, the local technicians will define the structure and will feed the SIMONI project. To feed the SIMONI is important the information provided by different agents, municipalities, ICF agencies, inhabitants of the area, and the indigenous communities of Rio Platano.
6	Which tools are necessary? Which are missing? Which are desired in addition?	What kind of tools do you use for decision making? Are these tools useful? Which are missing at this moment?	We are defining the web page of SIMONI. We have designed a web page where it is very easy to feed the SIMONI with socio-environmental indexes and incidences which occur in the area. However, the problem is we cannot show that information in a map for making decisions. Also, we have to find a solution for sharing this information with the ICF (National Institute of Forest Conservation and Development, Protected Areas and Wild Life) offices in the area, the municipalities and other agencies which are developing projects in Rio Platano.
Usual execution			
7	Which steps are necessary?	How are you sharing information in this moment?	The product is not available yet. We are defining the usability of SIMONI. We need to launch the product and later to feed it with the information provided by the technicians of the ICF, municipalities and the inhabitants of the area.

| #	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
8	Which steps reoccur often? Automation desired/necessary?	What do you always check before making the decision?	In the future, we would have to be capable to define the solutions for the problems that we will find in the area. The SIMONI will be a tool for decision making, with the ability to show the information in the easiest way possible to solve problems quickly.
9	Which steps are automated? Can the user interfere?	Are there any automated tools?	We need the user to be able to introduce information in two ways: one way is by following the screens and filling the information regarding the area of study. We need that information to be registered in the SIMONI database. The second one, will be similar to the first one but by filling the database through the cartography of the area.
10	Do several people have to work with an object (e.g. document) simultaneously?	Does all the information use the same tools?	We need all the information in POSTGRESQL database. I don´t have computer skills but the informatics told me that we are working using this tool for registering the project data.
11	Is there a fixed sequence of steps? Flexibility reasonable/necessary?	What is the sequence in your search?	For the incidences, I will have: 1) Register the incidence in my mind. 2) Register in the SIMONI webpage. 3) Fill the incidence following the instructions of SIMONI.
12	Which (partial) results? How further used?	How does the results look like?	In the end, we need to show the information in tables to extract conclusions, but we need also to show this information in a map.
13	Which feedback regarding results and impact of work?	So what would you expect of these agencies involved or what kinds of results would be more useful?	At first hand, we need them to know the tool. Later, We need to get them and the people who live in the area of Río Platano involved in the project. We need all these inputs for creating a useful tool.

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
Specifics with execution			
14	Interruptions? Why? Of which kind (organizational, social, technical)?	So as far as I understand, you need to create information but you also depend on other agencies?	Yes, as I said before we need the inputs of the other agencies which work in the territory of the project. But the most important is to involve the people who live in the area.
15	How are errors reported and corrected?	How do you communicate with the other agencies if some information is not proper?	We need to create a useful tool; we also need to define the quality criteria according the technicians of the project.
16	Important special cases to be considered (e.g division of labor, collaboration)?	In the cases that the people who will work in the project will be not in the office, how will the information be included in SIMONI?	We need to include the information via internet somehow. It´s an important aspect of the project. It´s the way to connect all the involved parties.
Organisational framework			
17	Measures of performance enhancement/control? Which? Necessary?	How and when do you know if the information is correct?	We´ll see. First, we need to launch the prototype. And then, check with the ICF offices in the area, and the other agencies on how the SIMONI is working to create quality criteria aiming to develop a useful tool for the area.

#	Guiding questions	Adaptation of guiding questions / comments	Answers of interviewee
18	Which task results/steps directly affect third parties (e.g. customers)? Consequences?	In case you forget something, has this ever happened? Does this affect any of the other agencies?	Yes, of course!!! We need to work all together and with the same criteria. We need coordination between the ICF agencies in the territory, but we also need coordination with the municipalities and the other involved parties.

Annex 2. Digital Cartography List and Spatial Database Management System (SDBMS)

| DATA	ORGANISM	VECTOR TYPE	AREA
Ethnics	PROTEP project	Points	Rio Platano Region
Communities	PROTEP project	Polygon	Rio Platano Region
Villages	PROTEP project	Polygon	Rio Platano Region
Protected Areas	ICF	Polygon	Honduras
Land Cover	ICF	Polygon	Honduras
Conservation targets	ICF	Polygon	Rio Platano Region
Management plans	ICF	Polygon	Rio Platano Region
Road network	ICF	Lines	Honduras
Hydrology	ICF	Lines	Honduras
Lakes	ICF	Polygon	Rio Platano Region
Threads in the wetlands	PROTEP project	Points	Rio Platano Region
Threads in the communities	PROTEP project	Points	Rio Platano Region
Ecosystems	PROTEP project	Polygon	Rio Platano Region
Sub-area limits	PROTEP project	Polygon	Rio Platano Region
Land Use year 2002	PROTEP project	Polygon	Rio Platano Region
Land Use year 2005	PROTEP project	Polygon	Rio Platano Region
Changes between 2002-2005	PROTEP project	Polygon	Rio Platano Region
Cadastral Boundaries	PROTEP project	Polygon	23 subsectors in Region
Topographic Maps (scale 1:50.000)	National Geographic Institute		Rio Platano Region

Table 1. Relation of digital cartographic information

Figure 1. LADM structure (PROTEP cadastre database)
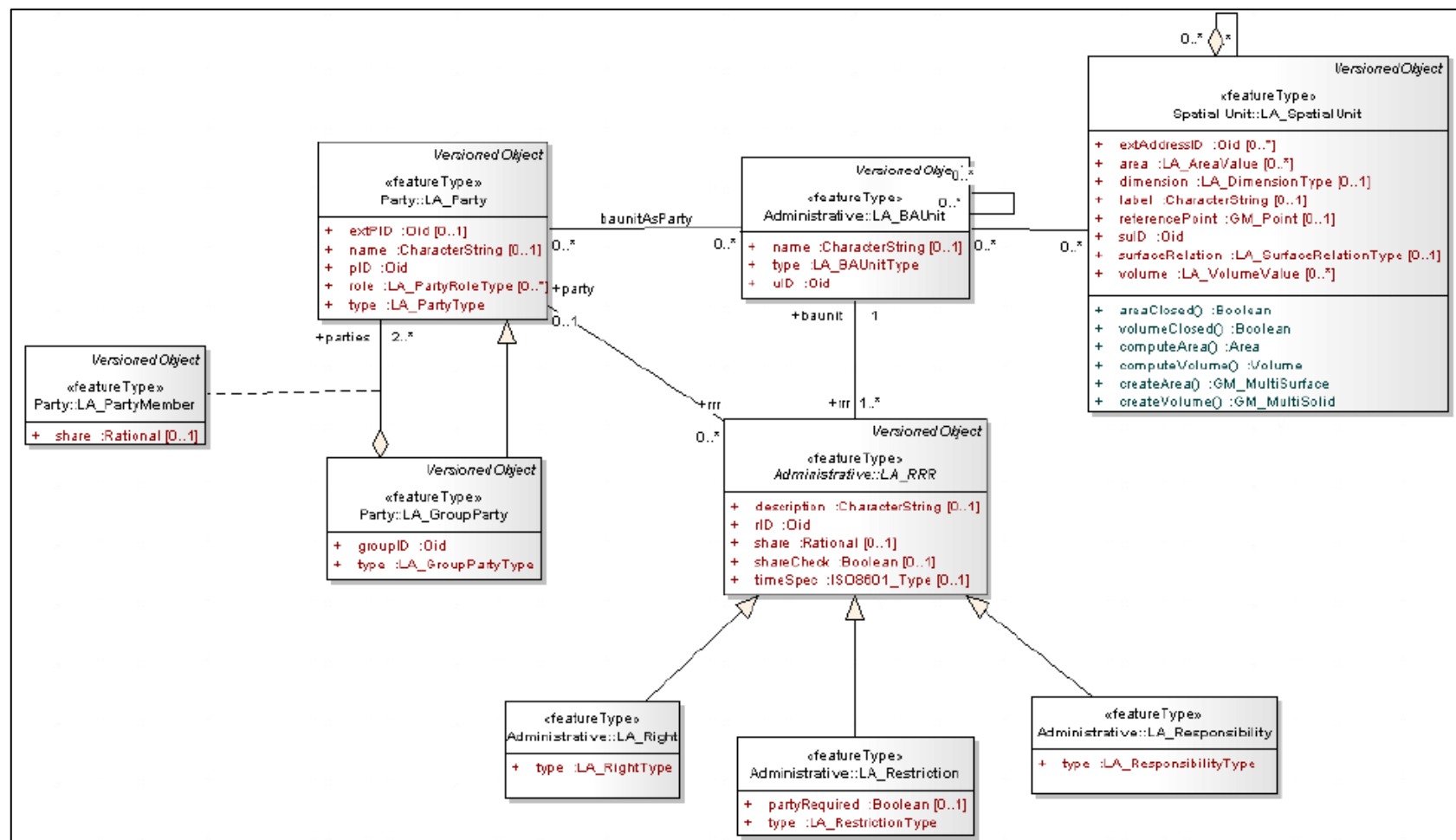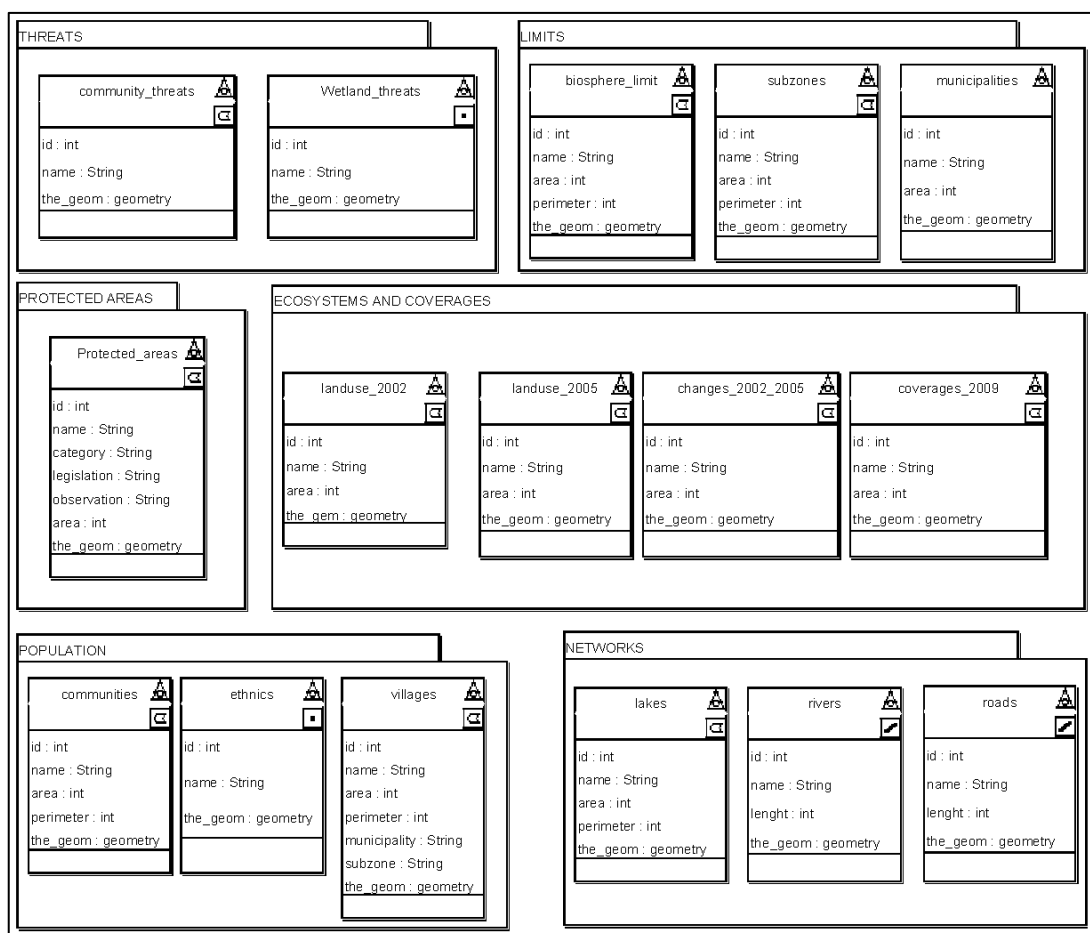
Figure 2. Socio-environmental database
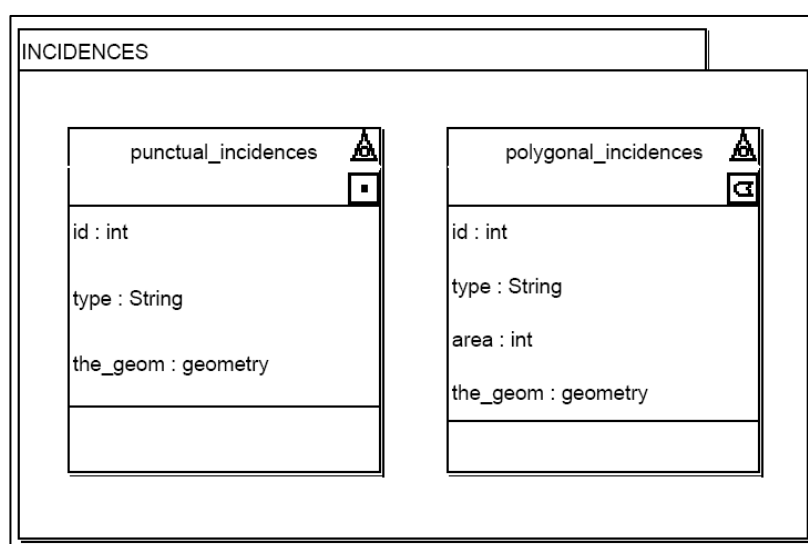
Figure 3. Structure of the SIMONI incidences Database

98

Annex 3. Involved agents

Acronym	Name	URL
National Level		
ICF	National Institute of Forest Conservation and	http://www.icf.gob.hn/
IP	Property Institute	http://www.ip.gob.hn/
SEPLAN	Ministry of Planning and External Cooperation	http://www.seplan.gob.hn
SERNA	Ministry of Natural Resources and Environment	http://www.serna.gob.hn/
CIPF	Forest Heritage Information System	
Regional Level		
PROTEP	Land Use Planning and Environmental Protection Project	http://www.icf.gob.hn/secciones/protep/index.swf
RIO PLATANO REGIONAL		
ICF Regional offices		
ICF	Olancho/Jutiapa	http://www.icf.gob.hn/
ICF	Rio Platano	http://www.icf.gob.hn/
ICF	Gualaco	http://www.icf.gob.hn/
ICF Local offices		
ICF	La Unión	http://www.icf.gob.hn/
ICF	Palacios	http://www.icf.gob.hn/
ICF	Marañones	http://www.icf.gob.hn/
ICF	Sico Paulaya	http://www.icf.gob.hn/
ICF	Olancho	http://www.icf.gob.hn/

	Municipalities	
	Iriona	
	Brus Laguna	http://www.alcaldiabruslaguna.com/
	Juan Francisco Bulnes	
	Ahuás	
	Wampursirpe	
	Dulce Nombre de Culmí	
	Other Agencies	
PRORENA	Native Species Reforestation Forest	http://prorena.research.yale.edu/home.htm
ICADE	Institute for the cooperation and development	http://www.icadehonduras.org/
PANTHERA		http://www.panthera.org/
MOPAWI	MOSKITA PAWISA APISKA	http://www.mopawi.org/
UNAG	University of Agriculture	http://www.unag.edu.hn/index.php/en/
	Indigenous Associations	
- Check Point 5.1.2 "Indigenous communities organizations" of this Thesis.		

Table 1. Involved agencies in the Rio Platano Region SDI

Annex 4. Geoportal - Map server captures

Figure 1. Rio Platano Region Geoportal
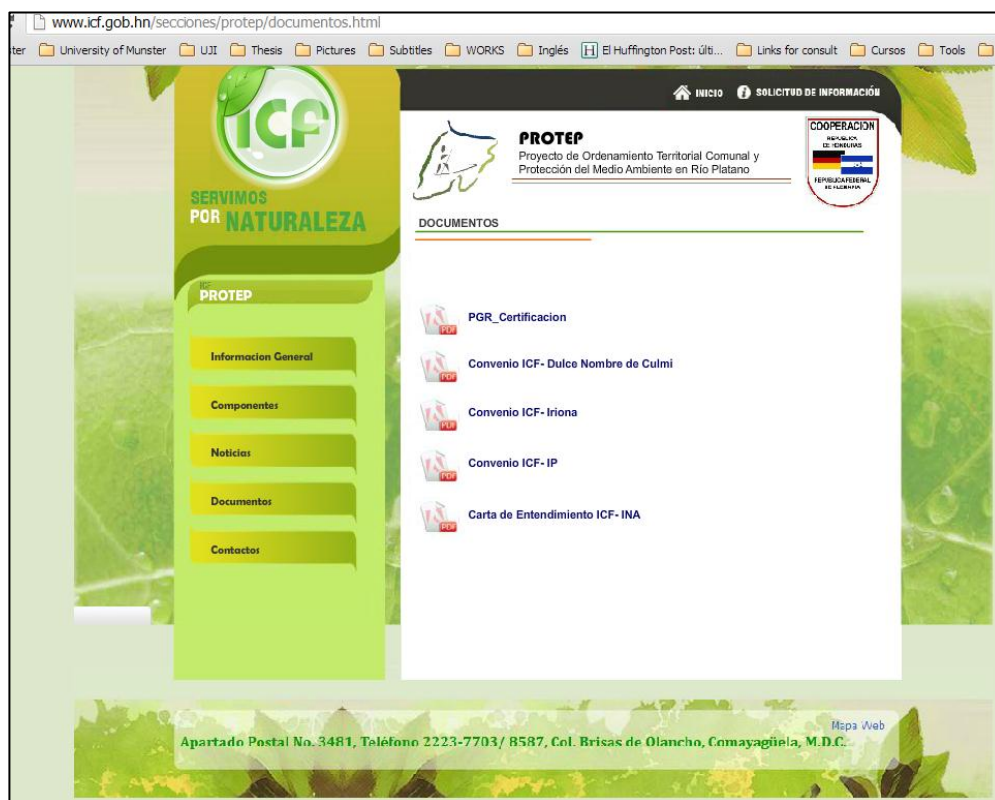
Figure 2. Agreements among agencies
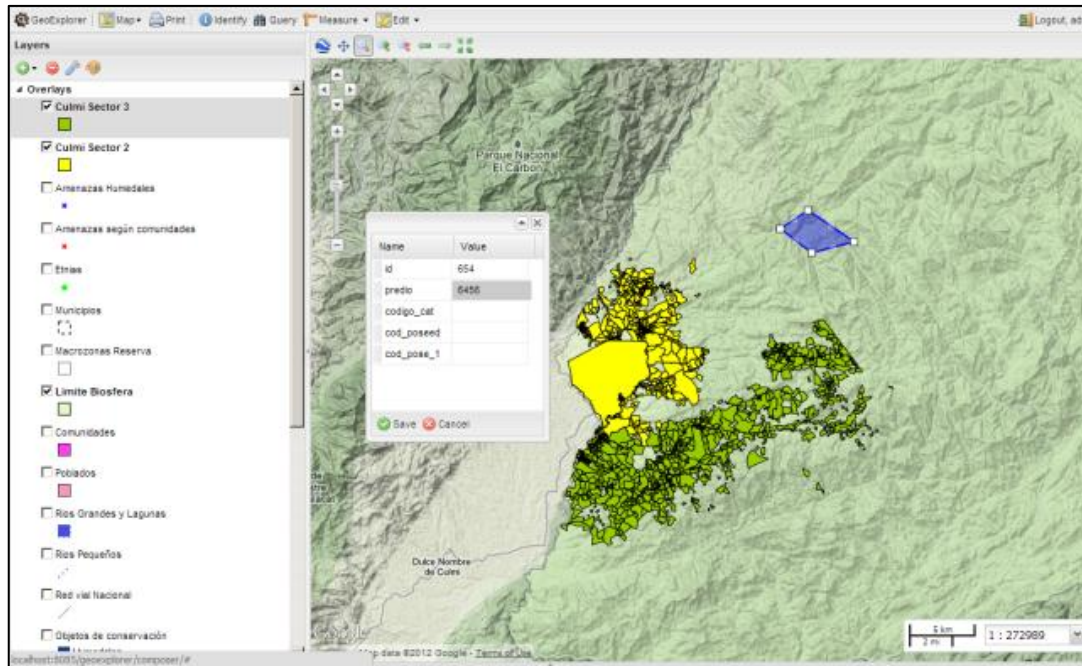
Figure 3. User with edit permission
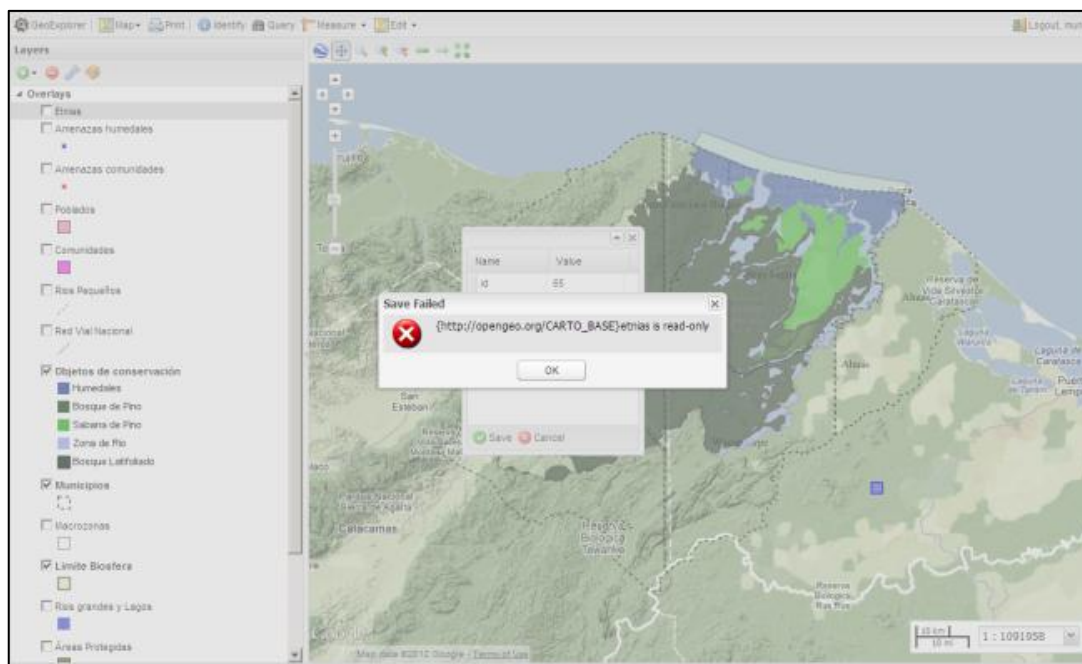
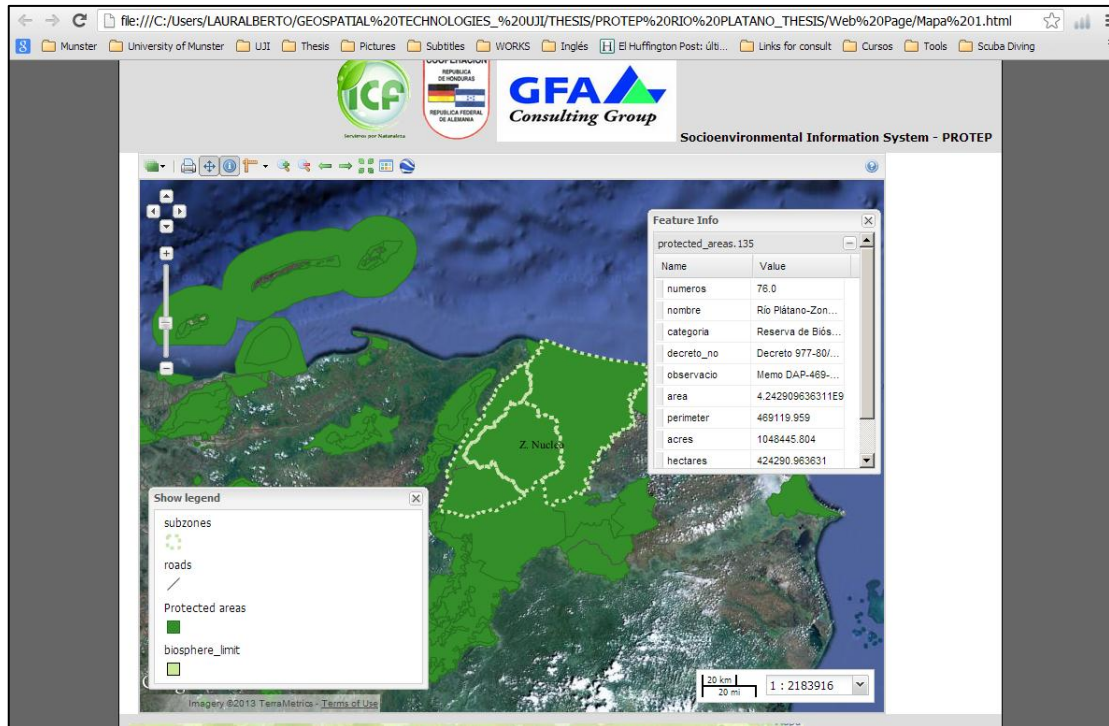**Figure 4. User without edit permission**

Figure 5. Rio Platano Region Map server Webpage
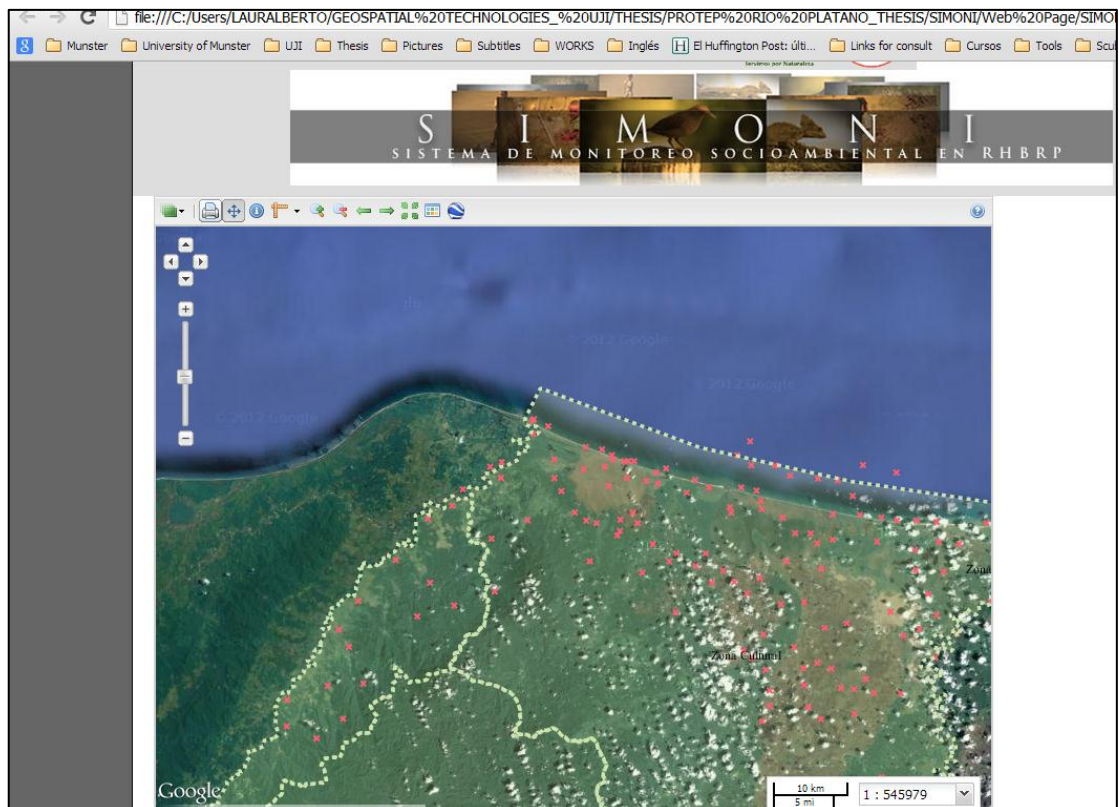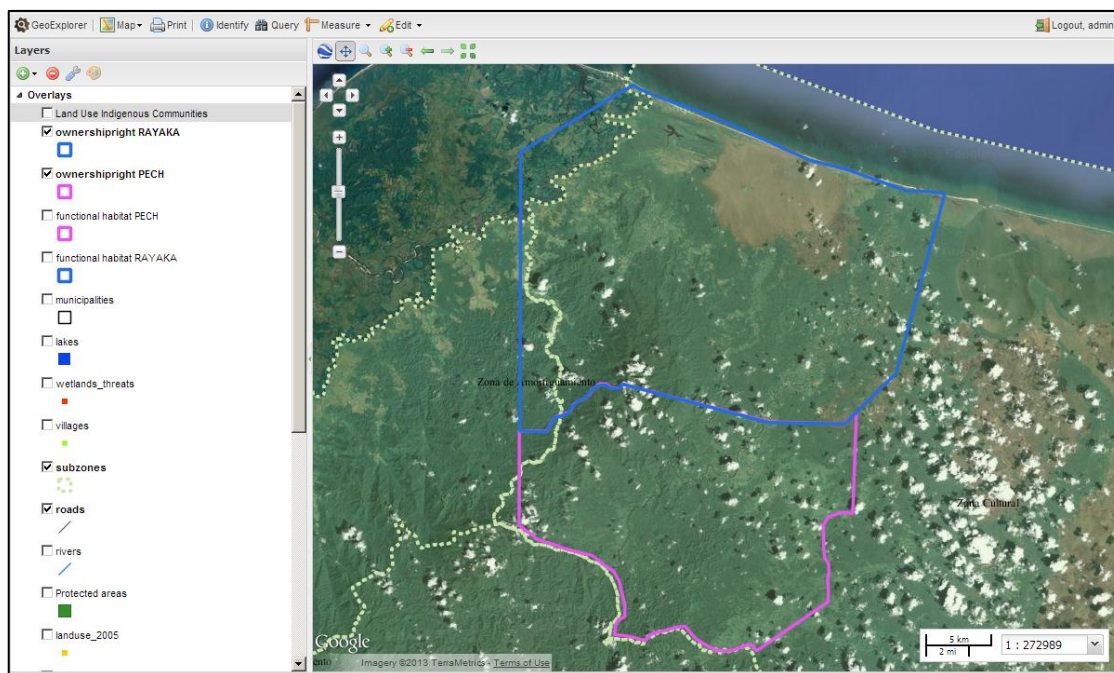

Figure 6. SIMONI Map server Webpage

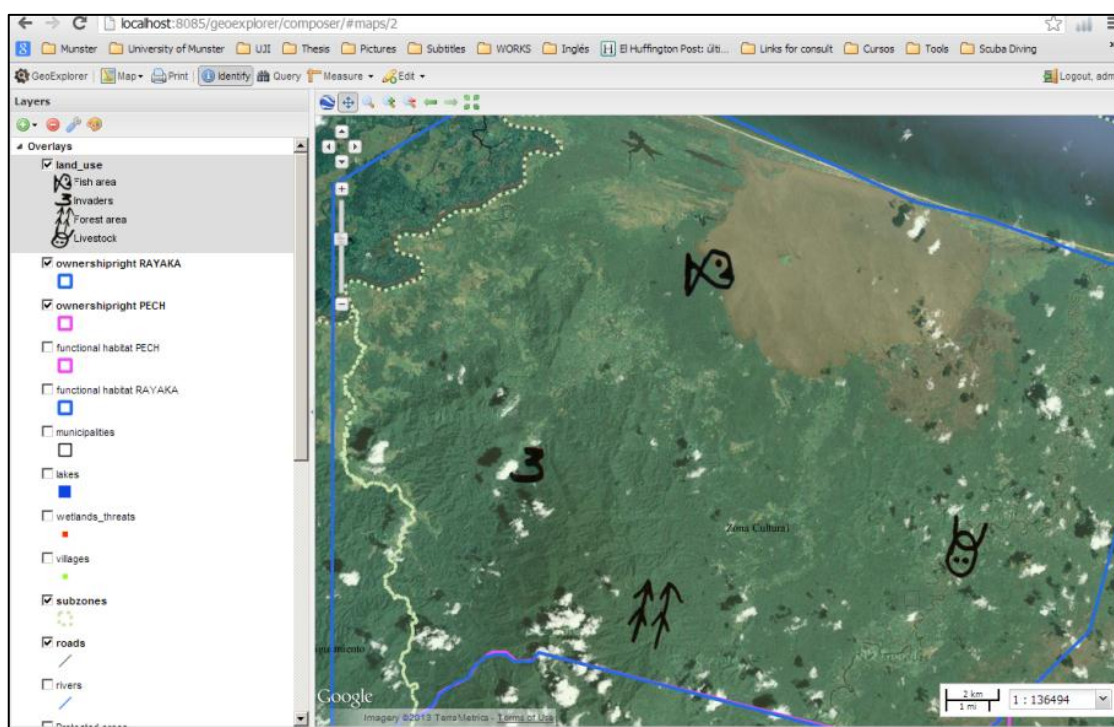**Figure 7. Land Rights indigenous community represented in Map server**

Figure 8. Adding Participatory Pictograms in Map server

Annex 5. SLD file

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    xmlns:ogc="http://www.opengis.net/ogc"
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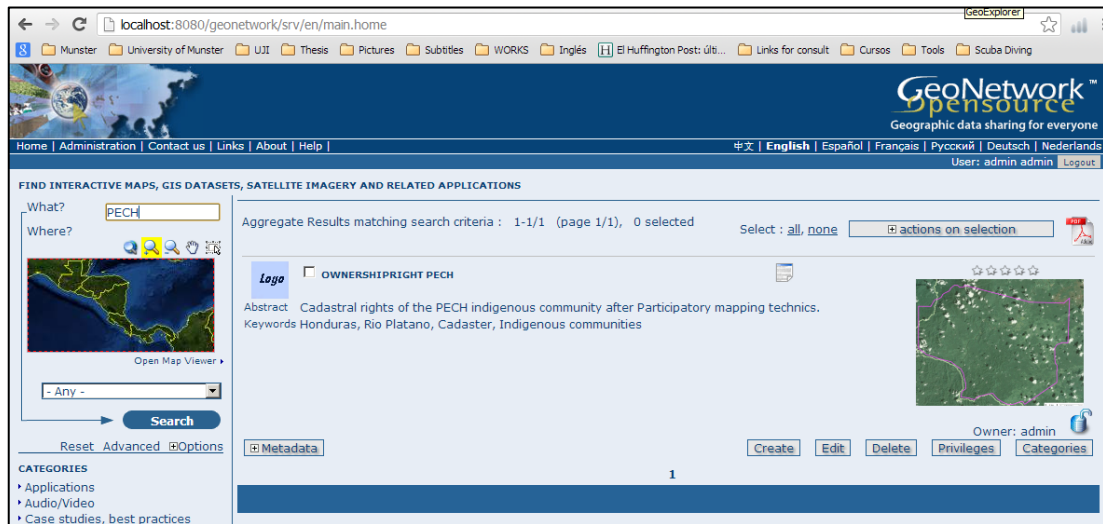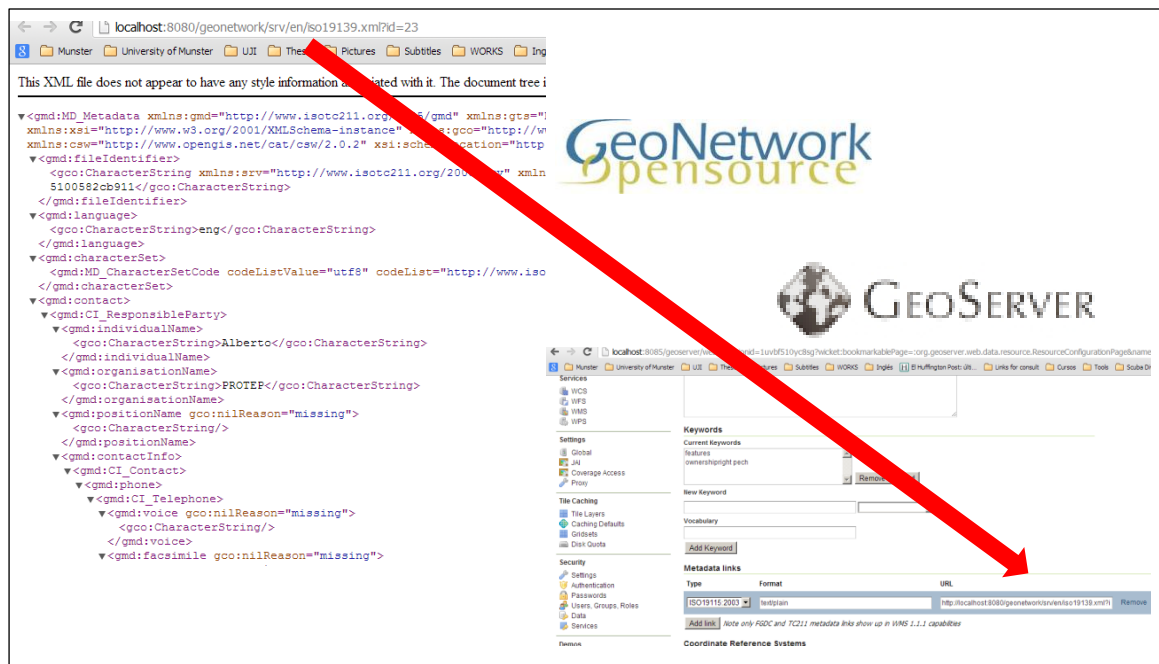
SLD code

Annex 6. GeoNetwork captures

Figure 1. Search Tool in GeoNetwork

Figure 2. Add metadata file in Geoserver

Masters
Program
in **Geospatial**
Technologies