University Of Oslo
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Understanding the Dynamics around Spatial Data Integration:

A case study from Mozambique

Márcia Névia Agnaldo Juvane

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A case study from Mozambique

Dissertation Prepared for the Degree of Master in Information Systems

By: **Márcia Névia Agnaldo Juvane**

Supervised by: **Zeferino B. Saugene, MSc.**

Jens Kaasbøll, Prof.

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Dedication

I believe she looks out for me; I dedicate this work to my eternal mother Orlanda. I also dedicate this thesis to my father Aguinaldo, to my brother Idálio, to my sisters Dirce and Malva for their support, prayers and love.

Abstract

Spatial data integration enables the use of reuse of spatial data coming from various different sources. Additionally spatial data integration facilitates sharing among different communities or organizations for several purposes. Data sharing promotes the reuse of existing information; it also promotes the collection of new data instead of spent time in collecting the same data.

However the use of different spatial data has been caused many inconsistencies because of the use of different nomenclatures, use of different technologies, use of different data formats among various organizations, and because each organization, has been collecting spatial data in their own way and so on. As a result, when there is an attempt to share or integrate spatial data many technical and non technical problems arise. I have studied spatial data integration in Mozambique using cases from public institutions such as CENACARTA, INE, DNA, MEC, DINAPOT and Maputo Council, all located in Maputo city, capital of Mozambique. The purpose of the research was to understand the challenges faced by workers from these institutions with regard of spatial data sharing from different sources.

The empirical fieldwork was conducted between June 2008 and December 2008. The study followed qualitative approach that included the following methods: interviews, observations, questionnaire, and document analysis in the public institutions. The empirical data was analyzed through the theoretical framework. Thus, my theoretical framework was based on a literature review that covers research from different fields, including basically literature on spatial data integration and sharing with particular attention in developing countries, and research on information infrastructure.

The findings revealed results that many authors have already come up to such as a lack of qualified staff to deal with GIS technologies, the fact that spatial data are collected differently by various institutions in terms of scale, coordinate system used, data formats used, etc, the spatial data is not being updated, lack of strategy on how spatial data should be available or used.

Keywords: Spatial Data, Spatial Data Integration, Spatial Data Sharing, Geographic Information Infrastructure, Mozambique.

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I would like to express my gratitude to the Juvane family for their love and support.

Lastly I would like to express my thanks to all people who kindly helped me in one way or another to make this research successful.

Márcia Névia Agnaldo Juvane,

May 2009.

Table of Contents

Table of Figures

Table of Tables

List of Acronyms and Abbreviation used

Acronyms/Abbreviation	Denomination
CENACARTA	National Remote Sensing and Cartography Centre
DA	Department of Anthropology
DANIDA	Danish International Development Agency
DAR	Department of Rural Water
DC	Department of Cadastre of Maputo Council
DCO	Department of Cartography and Operations
DINAPOT	National Directorate of Planning and Territorial Redevelopment
DISD	Development Information Services Division
DMPUA	Municipal Urban Planning and Environment Directorate
DNA	National Directorate of Water
DPEC	Provincial Directorate of Education and Culture
EB	Emin Bank
ESRI	Economic and Social Research Institute
GDP	Gross Domestic Product
GII	Geographic Information Infrastructure
GIS	Geographic Information System
ICT	Information and Communication Technologies
INE	National Institute of Statistic
MEC	Ministry of Education and Culture
MDG	Millennium Developments Goals
MICOA	Ministry of Coordination of Environmental Affairs
NCGICC	North Carolina Geographic Information Coordinating Council
PARPA	Action Plan for the Reduction of Absolute Poverty
PES	Plano Económico e Social
QDA	Qualitative Data Analysis
SDI	Spatial Data Infrastructure
SISE	National Services of Security State
USACE	United State Army Corps of Engineers
WB	World Bank

Chapter 1 - INTRODUCTION

It has been recognized that spatial data and non spatial is needed as a support for better decision making. Thus, it is vital to make sure that such data is available, accurate, and timely. Human and economic development cannot be divided by the location, because the location is an important predictor to measure and take decisions (WB 2009).

However, obstacles have made it difficult to use and share spatial data from different sources in most developing countries like Mozambique, where there are constrains due to the lack of resources like people, use of different nomenclatures, data formats, and scales used to collect spatial data.

For example, Mozambique, in order to reduce poverty and increase growth of the previous PARPA I (2001-2005) has defined six priority areas. The priority areas that needed more action were (PARPA 2001): education; health; basic infrastructure (roads, energy and water); agriculture and rural development; good governance; and macro-economic and financial management. However, the government has now recognized the need to incorporate Information and Communication Technology (ICT) in their program. The government now understands that this area cannot be analyzed separately, since the action plan has been viewed as integrated and constituted by many actors (PARPA 2006). Through the PARPA II it was defined that there is a need to improve the unified system that incorporates data from different sources ranging from land, grounds, and all environmental data. However this project did not end successfully due to various constraints, mainly because it encompasses many settings (organizations) that deal with different data.

The use of ICT has been recognized not to be a sector itself but something that all sectors (education, health, environment, and so on) should use as a solution in order to reduce and combat poverty.

Furthermore, one of the priorities of the government was to promote the use of information system to support natural resources management which includes land use, forest and wildlife. For that the PARPA II, states that there is a need to identify and map the occupation, use and exploitation of land and systematically update the national cartography. Additionally, the

government through the PARPA intended to improve the access to education and safe water by 2009.

Geographic Information Systems (GIS) are information systems that have the capability of storing, manipulating, processing, and disseminating spatial data. The exact location of any object is an essential part of the GIS process (even if it must be spatially degraded or detached from the exact location. (Steinberg and Steinberg 2006)

Examples of some useful researches related particularly to implementation of GIS technology in the health sector in Mozambique demonstrated the potential of this system in decision making. One of the studies has used GIS within the maternal mortality program to figure out the benefits in implementing GIS. From that the researchers pointed out that GIS can improve analysis and information presentation to facilitate data interpretation and use for decision making. (Ginger 2005; Saugene 2005)

The concept of spatial data sharing is fundamental to spatial information technology such as Geographic Information System. Spatial data sharing is defined as a process of giving out spatial data through exchange, interchange or transfer of spatial data between two or more users, organizations or computer technology, aiming at making different database systems interoperable (Yeung and Hall 2007). Many organizations in the world include spatial data sharing as an integral component of their corporate information technology strategy (Yeung and Hall 2007).

“The objective of data sharing is to make data available for the general public to use just like other physical infrastructures that are used on a daily basis.” (Yeng and Hall, 2007, p. 179) Roads, water supply, electricity and telecommunications services are examples of physical infrastructure. One of the benefits of spatial data sharing is that it promotes the minimization of efforts and time in collecting similar data among various organizations. As a result, organizations may spend much time in collecting new data or to improve the existing data.

In many developing countries like Mozambique, the use of geo-information technology is limited due to technical and institutional reasons such as: lack of financial resources, lack of spatial information, lack of skilled people, capacity of public institutions, security concerns, and lack of consensus on standards (Georgiadou, Bernard et al. 2006). Researchers from Mozambique and India have found the same thing (Ginger 2005; Lewis 2005; Saugene 2005) during studies carried out within the health sector.

These studies and similar ones revealed that poor availability of data, lack of expertise in Geographic Information System, and non existence of standards are some constraints that are crucial to highlight when talking about this technology. For instance, Geographic Information Systems require people that have specialized knowledge and skills. But because Geographic Information System technologies are still new, it requires important organizational changes and investments (Câmara, Fonseca et al. 2006).

Furthermore, it is also crucial to feed any GIS system with appropriate data both spatial and non spatial data, thus the managers will make decisions based on the data that reflect the reality. Some studies from Mozambique revealed that there was limited habit of sharing of data within the various departments at National Health Sector even among public institutions in Mozambique. One reason was that it was difficult to access spatial data; in some cases it was impossible to have necessary data from some institutions (Saugene 2005). Apart from that, the same author found that spatial data was provided in different formats making sharing of data more difficulty.

According to DISD (2001) the common standards, procedures facilitate the sharing of data across several organizations and users. For this end, they emphasized the need to empower communication among the people involved. Additionally, the sharing of data can reduce the costs involved without it.

Incompatibilities between datasets and the use of data in different formats make it difficult for many organizations to share their datasets. Then it is again important to have common standard data so that it can be easily shared among a wider community, and the best utilization of the data can be achieved (DISD 2001).

The fieldwork for this study has involved visiting of seven institutions that are: Ministry of Education and Culture, National Institute of Statistic, Cenacarta, National Directorate of Water, and Ministry for Coordination of Environmental Action, Maputo Council, and Ministry of Health during the period February 2008 to December 2008. Most of the institutions visited use GIS system and spatial data.

I selected these institutions not only because they have been managing spatial data, but also because most of them carry out activities in areas like education, water source, environment resources that are part of the Millennium Developments Goals (MDG). The MDGs aims to

ensure that by the end of 2015 all children should have access to primary education as well as that another goal is to ensure environmental sustainability.

Based on the MDGs, it is also intended that by 2015 the access to safe drinking water and basic sanitation must be available to more people. Within the environmental perspective it is MDGs' goal to integrate the basic principles of sustainability with policies and programs of the country in order to ensure that environmental resources are not lost. In order to achieve these objectives in rural areas, the National Directorate of Water stressed the need to have organized and updated the register of various infrastructures through the use of technology innovations. Another objective is to undertake hydro geological mapping on a useful scale to define the potential for construction of wells and boreholes (DNA 2007).

Based on this experience, different institutions in Mozambique recognized the need to have not only updated data of their jurisdiction but also recognized the need to integrate data from various areas such as water, land use, erosion, etc to help them to meet their goal areas. Detailed and updated information can enables who possess this information on hand to take certain actions at low level of error.

From the findings, I expected to outline some contributions in order to promote more use of spatial data among the institutions, and also to provide some considerations related to the obstacles that they may face when using spatial data for sharing. DISD states that the use of common standards tends to solve many of the incompatibility problems and then reduce the costs involved to acquire these data (DISD 2001).

1.1 Personal Motivation Study

Before my master's studies I did my bachelor thesis focusing on the use of GIS system at Health Learning Centres in order to help different actors in making decisions. At that time, the only spatial data that I had was related to the health facility, health learning centres, roads network and administrative boundaries.

From this study I had gained my first understanding of GIS and the constraints around it. Then I was interested in knowing how other public institutions were using their GIS system, and what constraints they faced when using these types of technologies. Furthermore, I wanted to

understand how different institutions have been integrating spatial data coming from different sources. This is because it is argued that many institutions face challenges during the process of data sharing for many reasons such as use of different data scales, different system, and so on. With this study I expected to further enrich the library of research in the area of GIS. I also expected to improve awareness of GIS in public institutions.

1.2 Research problem

Nowadays Geographic Information Systems technology is widely used in different areas. For example many countries use GIS technology to map land use, in health sector it is used to bring a holistic view, for example, to understand why certain diseases occur in determined places and to monitor environmental issues.

Different researchers have stressed the importance of spatial data in the process of decision making. Spatial data is an important resource for each infrastructure in any country and experiences from developed countries demonstrated that spatial information affects 80% of the human decision making (Ryttersgaard 2001).

In order to use GIS, spatial data is needed. However most of spatial data does not exist, or exists in unsuitable forms to be shared electronically. Yeung and Hall (2007) described reasons that inhibit the spatial data sharing among various stakeholders. Some of the barriers are related to lack of coordination between spatial data collectors. This leads to discrepancies about data needs; content for the same area; restrictions to make data available to public due the regulations; use of different scale, geographical reference, spatial resolution, data models and storage formats.

In most developing countries like Mozambique the problems described above are very common when implementing Geographic Information Systems. For instance, studies carried out in the health sector in 2005, show that to display health information using maps implies aggregation of different sorts of information that include, roads, rivers and lakes, which is not usually available to the health sector (Ginger, 2005, Saugene, 2005). Institutions use different data formats and scales, so there is a lack of data standard, therefore sharing of data among institutions is very limited.

Many spatial systems in Mozambique try to use environmental data to enrich their analyses. For instance, the Department of Cadastre of Maputo Council utilizes different spatial data ranging from datasets including cadastre, topography, satellite images, to base map. Many of these datasets are managed by different institutions. For example, base map, satellite images and topography are managed by CENACARTA.

Another example comes from DINAPOT that uses datasets from many sources like roads, ground, rivers, and administration division. Roads are managed by the National Administrations of Roads, grounds are requested from "*Instituto de Investigação Agrária de Moçambique*", and rivers are managed by CENACARTA.

Thus, each organization develops its own strategies in regards to capturing, processing, analyzing, and sharing of data. However, many challenges in attempting to integrate data from different sources come up due to technical and non technical inconsistencies within various datasets.

There are some inconsistencies because these institutions use different formats of data, different software that do not support some types of file formats, use of different scales of GPS to collect data. Moreover it was found that there are few people with appropriate skills to operate Geographic Information Systems. So there are people with different knowledge ranging from basic to high level, although the high level is not common.

The sharing of data does not only involve the need of having spatial data, but also implies the social effects. The sharing of geographic information necessarily presupposes the existence of relationships among individuals, and organizations (Onsrud 1995). Any Geographic Information System must produce useful information that can be shared among multiple users (ESRI 2003).

Having this holistic view I aim at understanding issues that different public organizations in Mozambique have regarding the use of spatial data within and outside the organization. From that, this thesis draws up considerations that should be used to improve the scenario regarding the use of spatial data and sharing between different stakeholders', which is what previous studies have stressed. The present study aims to address issues related to the use of spatial data in public institutions. Particularly I intend to analyze the current situation regarding the sharing of spatial data in those institutions.

1.3 Research Questions

This study uses methods to understand the sharing of spatial data, and to provide guidance on policies and practices for the establishment of spatial data sharing environment among public institutions in developing countries, based on the case of Mozambique. In order to accomplish this goal, I aim to answer the following questions:

- What are the major limitations of the use of Geographic Information Systems in public institutions in Mozambique?
- What are the major limitations for spatial data sharing (integration) among various public institutions?
- What strategies can be developed in order to allow easy spatial data sharing collected and managed by different institutions?

The formulation for these research questions were inspired on assertions made by Saugene (2005) and Ginger (2005), stressing that there is a lack of spatial data standardization and sharing among institutions in Mozambique. This research, therefore, provides an updated picture on what was already known in 2005 and was put forth by the above mentioned authors. Apart from that, this research assesses more than one sector of possible applications, to evaluate the use of Geographic information systems and spatial data. The research mentioned above only focused on the health sector, with the aim of promoting awareness towards the use and benefits of spatial data.

1.4 Research Objectives

The research focus is based on issues around the integration of spatial data to provide good decision making process among the managers within different public institutions in Mozambique. In detail, with this study, I intend to: (i) analyze the actual stage/level of spatial data use in public institution; (ii) find out if the institutions have been collaborating in data sharing among them; (iii) find out the constraints that these institutions face in using Geographic Information Systems to understand spatial related problems in Mozambique; (iv) provide guidelines to be followed when dealing with multi-sectorial spatial related problems.

1.5 Target Audience

This research is targeted to any reader that is interested or involved in Geographic Information Systems. Particularly this is more relevant to those in developing countries that focus on issues related to the use of GIS system as part of their daily work routine. In addition this study is also relevant for those attempting sharing spatial data captured in different sources. This work is also relevant for all public institutions from developing countries that have been using GIS systems or want to introduce these systems in their work environment.

1.6 Structure of the Thesis

This thesis is organized in seven chapters. The rest of this thesis is organized as follows. In chapter two I have exposed the profile of Mozambique and the current stage of ICT and GIS within the country. The aim of this chapter is to situate the reader on the place where the research has been carried out. The literature review is presented in chapter three. The literature review aims at introducing the background of GIS and spatial data and issues related to it, generally in developing countries. The chapter includes the presentation of relevant previous research in this area, and presents concepts that help me to analyze the findings of my research. The approach and methods used in this research to gather necessary data for my study is presented in chapter four. Chapter five presents the results of the findings of research settings of six institutions in which I conducted the research. Chapter six presents the analysis and discussion of the findings that are structured using the theory presented in literature review, this chapter is followed by the concluding chapter. In addition to that, recommendations are also presented in chapter seven.

Chapter 2 - RESEARCH SETTING

The aim of this chapter is to inform about the situation of Mozambique where the research study took place. Thus I wrote the geographical and demographical situation of the country. Furthermore economic situation of Mozambique is given.

2.1 Geographical and Demographic status of Mozambique Profile

Mozambique is located on the eastern coast of southern Africa. The country shares borders with six countries. On the Northern side it is bordered by Tanzania; at north-west it is surrounded by Malawi, and Zambia; on the west side it is bordered by Zimbabwe; to the south-west the country is bordered by Swaziland and South Africa; and in the east it is bordered by the Indian Ocean.

Maputo city is the capital of Mozambique with about inhabitant. The country has 11 provinces, 128 districts, 394 administrative posts, 1072 localities and 10025 villages.

The provinces are distributed in three regions: the Southern region comprising the provinces of Maputo province, Maputo city, Gaza, Inhambane; the Central region that includes Sofala, Manica, Tete, and Zambezia; and Northern region with Nampula, Niassa and Cabo Delgado.

According to the 2007 census (INE 2009) the country occupies an area of 799.380 km² and has a population of 20.530.714. The official language is Portuguese. However, there are many indigenous dialects around the country.

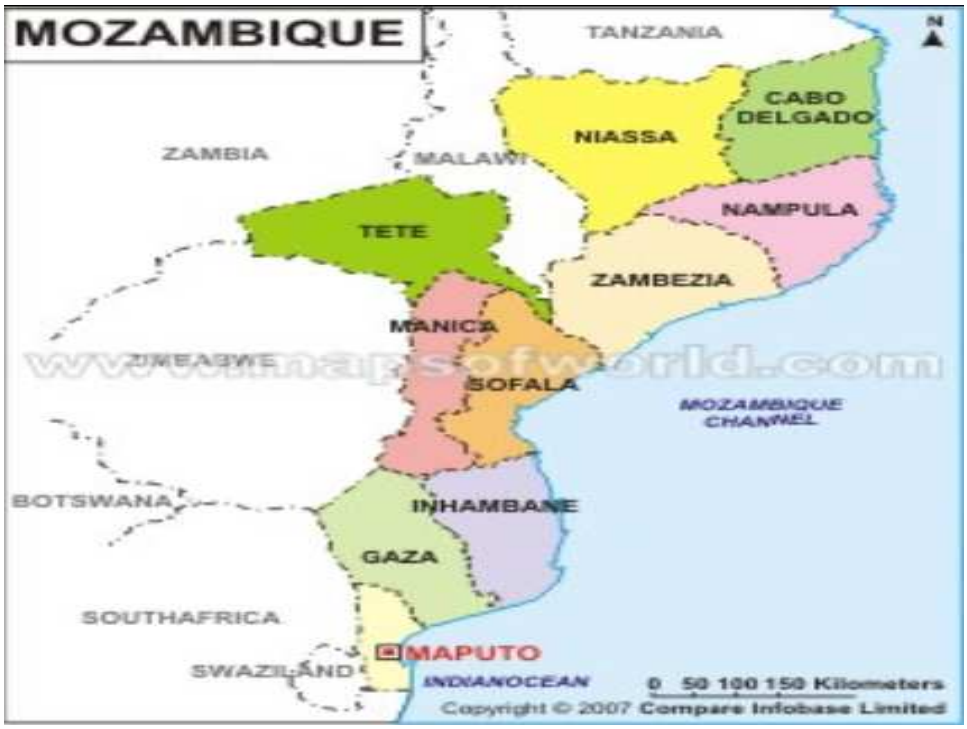


Figure 1 Mozambique map. Source: www.mapsofworld.com

2.2 Economic Situation

The country of Mozambique is still remains one of the poor countries of the world. On the Atlas of Global Development (2009) the country is ranked 195th out of 209. In 1992 the country signed the peace agreement in order to end the civil war that lasted sixteen years. The war devastated many families and infrastructures (roads, schools, hospitals) in the whole country. Thus, the country has undertaken economic reforms in all sectors in order to provide better services and improve time consuming in all processes.

Agriculture is the most important sector especially because more than 70% of the population lives in rural areas and depend highly on agriculture to survive. Although there have been considerable improvements the annual budget of country still depends on foreign donors.

One of the criteria used by United Nations to identify the least developing countries was based on the Gross domestic product (GDP) indicator. Although the average of growth of developing countries has accelerated since 2000, the GDP in 2007 of Mozambique was estimated to be of 7,752 millions of US dollars, which correspond to 2.2 percent (WB 2007).

In order to reduce the poverty, the government of Mozambique has set through an Action Plan for the Reduction of Absolute Poverty[1] (PARPA) program, fundamental areas that need much attention. These areas are: education, health, agriculture and rural development, basic infrastructure, good governance, and macro – economic, financial management. Apart from these areas they have included eight areas called "cross areas" that are: HIV/AIDS, environment, food secure and nutrition, ICT, rural development, disasters and clearance. The role of ICT is seen as a key component within this national agenda. According to PARPA (2006-2009) the purpose is that these areas cannot be analyzed separately, once the action plan is viewed as integrated and constituted by many actors (PARPA, 2006). This view is also shared by WB (2009), where they concluded that the growth of any country is depends on many factors such as education, health, and economic status. Moreover WB (2006) realized that the development of the country is also influenced by environmental factors like climate, human resources, landscape, communication and transport infrastructure, water use, etc. Table 1 shows some of key indicators of development applied for any country. In this case, the table mention about Mozambique context.

Table 1 Key Indicators of Mozambique. Source: WB (2009)

Key Indicators of Development	Mozambique
Total Population (2007)	21.37
Life Expectancy at birth years (2006)	42
Under Five mortality rate per 1,000 (2006)	138
Access to an improved water source (% of population, 2006)	42
Internet Users per 100 people (2007)[2]	0.9

For example the access to an improved water source in Mozambique (2006) was about 42 percent. According to WB (2009) water plays a key role to economic growth of a country. Appropriate water enables growth of the health of the community.

[1] Action Plan for the Reduction of Absolute Poverty (PARPA) is a framework stated by government of Mozambique that presents strategies to combat absolute poverty. PARPA aims to explain ways to combat the absolute poverty, the objectives, and the key action to be pursued that will guide the preparation of the States medium-term and annual budgets, programmes, and policies.

[2] Data source from the International Telecommunication Union's World Telecommunication Development Database

2.3 Empirical Settings

The aim of this section is to state the reader to the place where the fieldwork was carried out. In all, are six institutions were visited. The aim was to assess the use of Geographic Information System (GIS) and spatial data.

Thus, the following are the departments within the institutions where the fieldwork took place: National Remote Sensing and Cartography Centre (Cenacarta); department of Cartography and Operations from National Institute of Statistic (INE); department of ITC and department of Statistic both from Ministry of Education and Culture (MEC); National Directorate of Planning and Redevelopment Territorial (DINAPOT) from Ministry of Coordination of Environmental Affairs (MICOA); department of Rural Water from National Directorate of Water (DNA); department of Cadastre from Maputo Municipality.

2.3.1 National Remote Sensing and Cartography Centre

National Remote Sensing and Cartography Centre (CENACARTA) was created by the Council of Ministers on December 27th, 1990, as an Autonomous State Company under the Ministry of Agriculture, for the coordination of remote sensing activities in Mozambique, with the following main responsibilities: (CENACARTA 2006)

- To be a national archive of the imagery from the Earth Observing Satellites used in the country;
- To ensure dissemination of Remote Sensing and Geographic Information System techniques to the potential users;
- To organize training sessions in Remote Sensing and Geographic Information System;
- To perform the necessary geometric correction to the satellite images to be distributed to the users.

In 2004, new areas were added to Cenacarta which include geodesy, photogrammetric, cartography, aerial photography and political geography. Previously, these areas were under National Direction of Geography and Cadastre (DINAGECA) management. Because of these new areas, new responsibilities had been added to Cenacarta. Production, updating and

dissemination of geo-cartographical data related to Mozambique, and databases; coordination of activities among the different areas, technical and scientific research in order to improve methodologies and technologies used, production of various maps (thematic, topographical, aerial) in appropriate scales are some responsibilities belonging to Cenacarta.

Cenacarta in coordination with the National Services of Security State (SISE), and the Ministry of Defence together have been defining norms and policies of diffusion of data and cartographic products.

Figure 2 Front view of Cenacarta

In 2004 the area of geomatic was included in governmental plan, Action Plan for the Reduction of Absolute Poverty (PARPA II) for 2005-2009. The new PARPA (II) is different from previous one (PARPA I) because it emphasizes the need for integration of the national economy and increase productivity. It also emphasizes decentralization, and uses the district as base of development. They include the geomatic area because they realized the need of having an information system that allows ones to know information of natural resources existent like land, forest, and wildlife. For that end, inventory and mapping of land use and systematic maintenance of the national cartography must be undertaken.

2.3.1.1 The organizational Structure of the Cenacarta

According to Cenacarta (2006), the organizational structure of Cenacarta is organized through a top level Management where it is then categorized in Management Board and Technical Board. Down to this level, there is a Research Marketing Cabinet. This area is responsible for researching new geo-science technology development, quality, control and marketing of Cenacarta services and products. At the bottom level, three departments named Remote Sensing, Photogrammetry and Geodesy, Administration and Finance are organized. The operational activity has taken place in each of these departments and in a coordinated way. The organizational structure of the Cenacarta is presented in Figure 3.

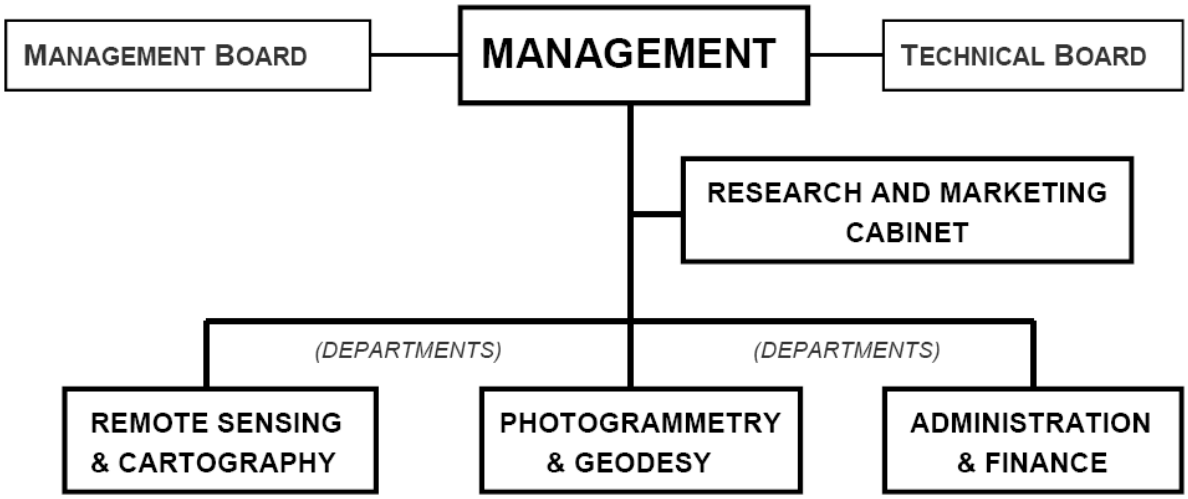


Figure 3 Organizational Structure of Cenacarta. Source: (CENACARTA 2006)

The departments that the research focused on were Remote Sensing and Cartography, and Photogrammetry and Geodesy because they have been working with spatial data. Therefore there is more attention being given to them, leading into my strong referral of them in this thesis.

The Remote Sensing and Cartography department is responsible for the production and maintenance of geographical data in general and thematic maps specifically. The department is also responsible for acquiring and processing satellite images; for collecting information to update the national toponomy and administrative limits of the country.

The Photogrammetry and Geodesy department are in charge of controlling the national network; the aerial photographic works, re-delimitation of boundaries of the country with neighbouring countries.

Cenacarta has been involved in different projects particularly sponsored by international agencies. For example, it has been involved in the development of a system of inventory of natural parks and game reserves for National Directorate for Forest and Wildlife (DNFFB) which aims at collecting information of existing ecological systems; National Cashew Tree population survey for Ministry of Agriculture which the aim was to assess the potential of population; land use and land cover mapping for Institute of Rural Development (INDER). The aim was to produce a land use base map on a 1:250.000 scale for the whole country and at 1:50.000 scale for selected areas to perform areas affected by floods in 2000; mapping the 2000 floods affected area for Ministry of Agriculture.

2.3.2 The National Directorate of Water

The National Directorate of Water (DNA) is a public institution under the responsible of Ministry of Public Works and Housing (MOPH). Within the organic structure there is the Department of Rural Water which is responsible of coordinating all activities and monitoring rural areas in the whole country. The main responsibilities are:

- To promote investments for execution of activities defined through PARPA, five-year Government Planning, and Social Economic Planning (PES);
- To draw of operational activities;
- To plan, and monitor activities that are found at provinces levels;
- To monitor, and to evaluate the compliance or execution of activities defined based on reports presented by provinces directions;
- To research projects of expansion of network of distribution of drinking water to rural areas through opening new water holes, and rehabilitation of sources in rural areas;
- Training and communication of technicians involved in activities.

The Department of Rural Water (DRW) is responsible for sailing the water supply in rural areas. In addition to that, it is the mission of this department to coordinate the activities of the sector such as the development of sector policies, action plans and regular coordination and supervision of projects at various scales.

Implementation of the projects at DNA works through funds of state apart from funds of some non-governmental organizations.

The DRW is using GIS technology to help them to identify areas where there is still no water that is needed, and also to identify areas with high percentage of failures of infrastructure for water supply. Thus, for better decision making, that means, better definition of operations strategies, DRW makes use of spatial data of sources of water although it is not yet complete with spatial data from all provinces of the country.

At this point, some provinces have been on the process of creation of spatial database. Other provinces such as Gaza are in the phase of data collection and validation of these data. From the time of my fieldwork, I found that, Gaza province is the one that has all its water sources referenced, although the data is constantly updated.

2.3.3 National Statistic Institute

National Statistic Institute (INE) of Mozambique is responsible for collecting, producing and then disseminating statistical information related to all areas within the country which includes education, health, agriculture, environment, and so on. The INE has also the responsibility of planning, implementing of national census, and national surveys.

The INE is organized as follows (INE 2004): at the top level is the president; at middle level there are 6 Central Social Directions; under central directions at the lower level are 13 departments. The department of Cartography and Operations is the area under my study within the INE. Figure 4 illustrates the organizational structure of whole INE.

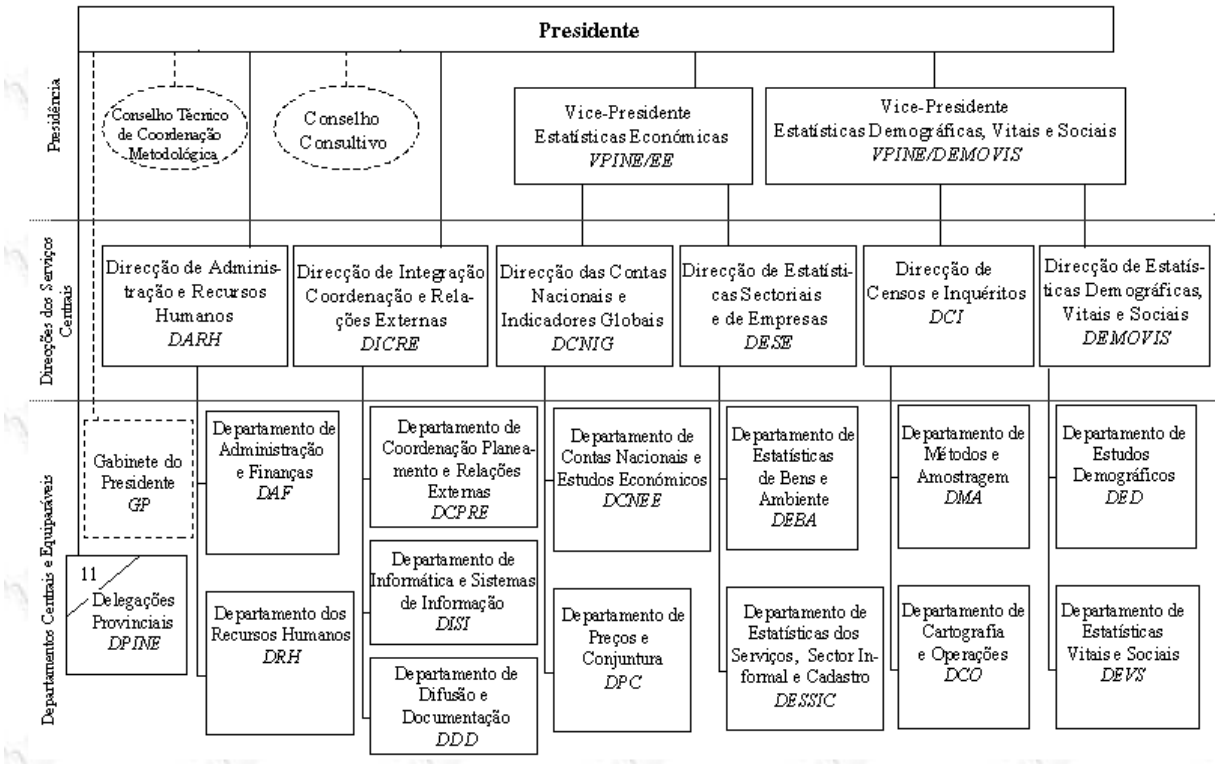


Figure 4 Organizational Structure of INE. Source: (INE 2004)

The Department of Cartography and Operations (DCO) has the responsibility of disseminating statistical, demographic and all data that they produce through maps. Thus, it works in coordination with different sectors like the Ministry of Culture and Education (MEC), Ministry of Health, and Cenacarta that provide statistics information and spatial data that they need. Thus each of these institutions is called ”Órgão Delegado” (translating it is Delegated Organ) that has the responsibility of providing necessary information to National Institute of Statistic.

GIS was introduced at the INE in 1998, with the purpose of diffusion of results of the demographic cense in map format, and production of socio demographic Atlas.

2.3.4 Ministry of Culture and Education

Education is fundamental for the development of any country. The Ministry has a Department of Information which is responsible for looking after the information systems and technology in the sector of Education and of Culture in the country. Apart from this department, the ministry has the Department of Statistics that has the task of producing, and disseminating statistical

information related to education in the country. Thus, both departments have worked in collaboration to provide statistics of education within the country.

The department of Information and Communication Technology has one system called "Carta Escolar" that maps almost education facilities of the country through the use of Geographic information systems tools. This system started in 2002.

The "Carta Escolar" system is installed in almost all the Provincial Directorate of Education and Culture (DPECs). However there are some DPECs that are in the process of lifting of data and others in the process of analysis.

2.3.5 Ministry of Coordination of Environmental Affairs

Ministry of Coordination of Environmental Affairs (MICOA) was created in 1994, after the first multiparty elections in Mozambique in order to coordinate the whole country all activities related to environment, natural resources and promoting strategies and policies that must be followed.

Thus, MICOA aims at working in areas such as: inter-sectorial coordination; research, planning and environment management; planning and land; environmental impact assessment; promotion, education and environmental disclosure; and inspection and monitoring (MICOA 2005).

According to MICOA (2005) the institution is organized in: (i) seven directions: National Directorate of Environmental Management; National Directorate of Planning and Territorial Redevelopment Land; National Directorate of Assessment of Environmental Impact; National Directorate of Environmental Promotion; Directorate of Planning and Studies; Directorate of Human Resource; and Directorate of Administration and Finance.(ii) Department of International Cooperation; (iii) Legal Office; (iv) Ministry Office;(v) and General Inspection.

It is the responsibility of the National Directorate of Planning and Territorial Redevelopment (DINAPOT) to perform tasks related to land use at national, provincial and local level. At local level the DINAPOT has the task of planning the land use in districts, municipalities, urban and detailed. At provincial level the directorate is responsible for performing provincial plans of territorial development, and then at national level the directorate aims to perform the strategic program of territorial development.

In order to produce these plans the directorate follows a predefined methodology. One of the step of the methodology is to analyze the inventory of actual situations from secondary sources (thematic and topography maps, satellite images, aerial photography, statistic data, infrastructure and sociality). The next step is to perform the survey of physical data and socio-economic missing. Aggregating all these data, the directorate displays results of finding through tables, charts, maps, reports. So that interested stakeholders must follow these plans.

Figure 5 Installation of MICOA where the DINAPOT is

As part of my research I had chosen the DINAPOT where they have been using GIS systems to present their findings and reporting. For instance, they have been using maps to show places where erosion occurs, and abstraction of groundwater. DINAPOT as well as the National Directorate of Environmental Management are both using Geographic Information Systems to manage and visualize their own data. GIS was introduced in 1996, with the aim of mapping the African coast.

2.3.6 The Cadastre Department of Maputo Council

Among various directorates, the Maputo Council has the Municipal Urban Planning and Environment Directorate (DMPUA). This directorate has the department of Cadastre in which one of their responsibilities is regarding the demarcation of lands which cover the Maputo municipal.

The department of cadastre uses Geographic Information Systems to map and manage pieces, sanitation, roads, the numbers of doors (building, social equipments, etc.). Furthermore, at the time of my fieldwork, the used Geographic Information Systems to help in the attribution of DUAT (Straight of Use and Use of Land), Identification of the Formal (built-up) and informal zones (when production of maps of addressing was not urbanized), production of guides of roads as a way to serve people like tourist banners, for enterprises (entrepreneurs), etc.

2.4 Information and Communication Technology Situation in Mozambique

As part of reducing poverty the government of Mozambique has included Information and Communication Technology (ICT) area in the PARPA (II) program. They highlighted the need to use ICT in all sectors, because ICT itself does not work isolated, must be integrated as a part of all public sectors.

The government of Mozambique has approved in 2002 a national framework consisting of policies and strategies which aim to draw up national vision of how and what ICT can contribute to the general development of the country, and then to use ICT in order to combat poverty in the country.
However, problems related to the use of ICT in the whole country still persist. According to Danida (2006), Mozambique has limited numbers of desktop computers, the ICT covers only the biggest cities while rural areas remain forgotten and lack of skilled people in the field are barriers that the country faces.

Constraints of high cost in international bandwidth and low capacity of access lines still remain in the country. The WB based on ITU statistic, have estimated about 0.9 of internet users per 100 people (WB 2009). Although the country has a modern telecommunication regulation and a

concrete implementation program for ICT policy, the positive impacts towards telephone and Internet penetrations remain to be seen (Danida, 2006).

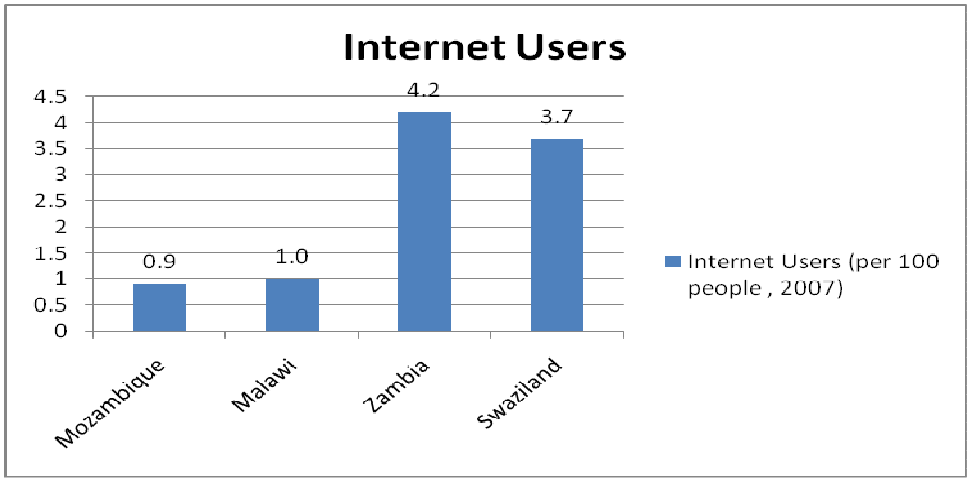


Figure 6 Internet Users in 2007 (per 100 people) Source: WB (2009)

Apart from internet access, the number of ICT in Mozambique is unknown but according to Danida (2006) it is estimated to be at 2.500 employments in that area. This number is not enough to accommodate the problems that the country faces regarding to lack of ICT expertise. Again, most of the people with skills in ICT are concentrated in the capital city, although the government has been emphasizing that the rural areas as polo of investments, and to reduce the poverty much work should be done in those areas where more than 70% of the population live.

Poor infrastructures in rural areas such as electricity, and roads are some reasons for the lack of ICT in rural areas rather than urban areas. The success of implementation of any ICT is highly dependent on electricity, in others words, without electricity it is difficult to argue the need of ICT in places which have lack of electricity.

Apart from infrastructure barriers, the country has been dealing with the lack of human resources with ICT knowledge. Because of low ICT skills the salaries are not satisfactory which leads to disparate differences in salaries. For example, Danida (2006) pointed out that, "Qualified and experienced IT professionals can command a salary of USD $7,000 and above for senior managers working within NGO, Donor or Donor funded community. In contrast, an entry level IT assistant with a 2-3 year diploma earns USD $300, which means that after investing in training of its IT staff, the public sector finds it difficult to retain staff" (Danida, 2006, p. 4).

2.5 Geographic Information Systems in Mozambique

There are considerable Geographic Information Systems (GIS) implementations in Mozambique and also research studies in the area. Examples of GIS use come from different areas such as health, water supply, land use, education, and statistics as mentioned in previous sections above.

Bearing in mind that Information and Communication Technology (ICT) are being used as a tool to improve decision making, considerable organizations have been adopting the use of geographic information systems. Illustrated examples from some organizations mentioned earlier on in this chapter are using GIS for various reasons, but in all they use it to help them on better planning and decision making.

Others cases that have been implementing GIS are illustrated here. For example, it was introduced as a pilot program in Maputo a new form to collect data related to the spraying of households and the distribution of medicines and rapid testes for malaria. Personal Digital Assistant, Global Positions Systems, and mobile phones were the technologies used to collect data. The geographical coordinates collected allow further the mapping of malaria. Macanze (2007) pointed that the use of ICT provides the Malaria Control Programme with evaluation and evidence based tools for decision making for a better planning and allocation of resources and to enable accurately to better define the interventions and the resources. Because most of the health problems occur in specific places, GIS then can be used as a tool to help them to have a real and simplified picture of the world where the disease occur.

The GIS is also used in educational institutions. The Catholic University of Mozambique introduced GIS in 1999 with focus on research at higher education. The university has Centre of Geographic Information that is in charge of GIS system. Challenges on choice of technology to adopt, which methodology follows, financing, choice of the language (Portuguese or English), and human resources were challenges that the university had faced (Kaup 2007).

In order to strengthen the human resources to be able to manage GIS in education a project supported by ESRI of Portugal was made in the Catholic University of Mozambique and University of Cape Verde. Specifically, the project was intended to contribute to the strength of human capital, by transferring technical, didactical, and scientific domains, based on quality criteria and adequate resource and technology use, necessary for the continuing sustainability of the GIS (Painho and Curvelo 2008).

GIS system stresses on the need of data from different sources, both spatial and non spatial. Data from different sources allow the decision makers to have a holistic understanding of problems under study. Ginger (2005) during her study on the challenges of implementation of GIS with focus in health sector found that data constraints in Mozambique inhibit the effective implementation of GIS. Ginger pointed out that sharing of data among institutions in the country even among departments of the same institution is a major barrier that makes it difficult to possess necessary data. Later she mentioned that the absence of standards for data exchange between organizations does not allow the sharing of data.

In sum although the country has many constraints that inhibit the growth of this new technology, awareness of GIS technology has reached some places. However it has been recognized the need to work more in order to have personnel work with essential knowledge to deal with technology. Cooperation and the need to define standards of data between different stakeholders should also grow, because it seems that each part has been working in isolation.

Chapter 3 – LITERATURE REVIEW

The aim of this chapter is to present relevant literature on Geographic Information Systems and theoretical concepts that later on guided me to explain and discuss key points that I find from my findings. Moreover the literature enables to inform the reader about what other authors have said about integration of spatial data and limitation that occur when dealing with GIS, particularly to developing countries like Mozambique that have been adopting Information and Communication Technology in general, and GIS specifically.

I start by addressing some concepts used within the arena of GIS. At first I provide the reader with information as what is Geographic Information System, what is spatial data. Furthermore, spatial data integration, levels of data sharing, user educations are presented. Then, issues of attempting to share spatial data and state of Geographic Information Systems in developing countries are presented.

From theoretical view the concepts of installed base, share and heterogeneity are described in order to discuss my findings later. The concepts and the theoretical views presented help to answer the research questions defined in this thesis.

3.1 Geographic Information System

Geographic Information System (GIS) is defined as a tool that has a capability to store, manage any kind of data based on spatial data. But this is not the goal of these kinds of systems. At the end GIS enable people to inform by displaying through maps detailed and complex analysis that otherwise might be difficult to understand. Based on the information displayed decision makings is made. For instance, the WB (2009) used maps to inform statistics of social and economy of people of many countries of world.

It was realized that the use of maps have helped improve the statistics at relatively low cost by combining information collected with spatial component (WB 2009). For instance, the WB (2009) states that by adding the location of public facilities helped the policy makers and program managers to identify vulnerable and underserved populations.

GIS offers a capability to display the real world, which is achieved by considering geo-referenced location. The spatial data also called geo-referenced means the extract of exact coordinates in terms of location of any object (for instance coordinates x, y) that can be joined with attribute data, also called non spatial data (e.g., the name of the hospital, its street address, patient capacity). The attribute data is placed in the same table with the spatial data but sometimes comes in a different table, but both are linked with spatial data through unique identifiers.

The big differences of GIS systems compared to other systems is the capability to store different kind of data ranging from non spatial data to spatial data. Although there is no single definition of GIS, professionals of this area agreed on basic principles (Steinberg and Steinberg 2006). These authors state out three principles as follow:

i. The first principle is related to technology where a GIS requires a combination of computer hardware and software tools;

ii. A GIS requires data, and these data must possess a spatial or location component;

iii. And at last, GIS requires knowledgeable individuals to develop the database and carry out the data processing.

Combining these principles allows the user to make the best use of the GIS system. However, these systems rely on many problems that do not allow achieving the best results. For example, Steinberg (2006) pointed out that GIS technologies require people that have a basic understanding of maps or map analysis.

According to ESRI (2003), GIS technology illustrates relationships, connections, and patterns that are not necessarily obvious in one data set, enabling organizations to make better decisions based on all relevant factors. Thus, organizations are able to share, coordinate, and communicate key concepts among them by using GIS as the central spatial data infrastructure. Therefore, GIS technology is also being used to share crucial information across organizational boundaries.

3.1.1 What is Spatial Data?

There are different definitions for the spatial data in the literature, but all converges on the same way. Thus spatial data is defined as data that identifies the geographic location of features on the

Earth. The spatial data can be recorded in different ways like: the use of Global Positioning System (GPS), remote sensing, aerial photography, etc.

Once the spatial data is collected, it is often accessed, manipulated, and analyzed through a system called Geographic Information System (GIS). Many organizations such as public institutions, private companies, educational institutions, and general public have been collecting and maintaining spatial data in their own formats and for their organizational needs. However, there are spatial data that they cannot afford but they need it, for various reasons such as: spatial data are not available; the data is beyond their control; there is lack of spatial data, etc. Because of those and other issues such as cost and time to access to spatial data arose the need for spatial data sharing by integrating data from different sources. Recent advances in the spatial data and the growth of spatial data sources available emphasized the importance of spatial data integration (Mostafavi 2006).

Spatial data or geographical data is collected in different scales, depending upon on the person or organization needs. Scale is defined as the ratio of distance on the map to distance on the Earth's surface (Loenen 2006). Thus, the geographical data collected at large scale offers details of a certain object, therefore the greater scale the greater detailed will be. However, Leonen (2006) argued that for large scale of the geographic information it is required high costs of collection, and maintenance.

Saugene (2005) argues that data sharing should be based on standards and other mechanisms that help to integrate data from different sources. With the availability of data integration tools and standards, spatial data will become common in the general digital environment.

Spatial data and information according to Ryttersgaard, J. (2001) is an indispensable part of the basic infrastructure in individual country, and experience from the rich countries shows that spatial information affects 80% of human decision making. The use of spatial data increases the efficiency where is needed, according to the user's needs. Management of spatial information and knowledge has to be recognized as a very important discipline in both developed and developing countries and in countries in transition (Ryttersgaard, J. 2001, p. 2).

According to SDI (2008), although the information is an expensive resource, geographic information is vital to make decisions at various levels as, local, national and global levels. There is a clear need, at all scales, to be able to access, integrate and use spatial data from disparate

sources in guiding decision making (NCGICC 2007). In order to achieve this level, the country should look deep insight on the implementation or integration of spatial data.

However there are several points that should be considered before the integration or sharing of spatial data that include verifying the spatial data sources, human resources skill to work with GIS.

3.1.2 Spatial data formats

Again the spatial data is collected, manipulated, and stored in GIS software in various different formats. Thus different organizations have been developing GIS software based on various data formats. For example, ESRI has various data formats which are directly readable by ArcGIS software.

In cases where one GIS technology needs spatial data from another one that has incompatible formats data conversion is generally necessary (Libraries 2009). *Data conversion* also called data converters transform the spatial data into a format that is compatible with the target GIS, because each GIS has its own unique format for organizing and storing spatial data (USACE 1995).

Note that not all formats are related to spatial data per se, but they are used within a GIS technology. Table 2 below shows some data format that different GIS software support.

Table 2 Data Standards Formats

Data Format	Description
Arc/Info	Export Format
ASCII file	Format for text attributes
Digital Line Graphs (DLG)	Standard Format
AutoCad	Drawing Exchange Format
Shapefile (.SHP)	ESRI standard geospatial data format
	Compatible to some extent with all released GIS software
Smart Data Compreension (SDC)	ESRI format readable by ArcGIS software but not ArvView 3.x
MDB Geodatabase	Native of ESRI ArcGIS
	It is collection of geographic datasets (spatial and tabular data)
MrSID	is a proprietary format of LizardTech's GeoExpress software
	Used for imagery compression, and used on orthoimages
	Used to create image mosaics
ECW	It is a proprietary format of ERMapper for imagery compression

Although there are various data converters used to meet specific GIS objectives, problems during the process of transformation occur. Problems occur due the use of different software and hardware, different data models, and data structure (USACE 1995).

For example, USACE (1995) stressed that different technologies, both hardware and software can alter the data format, and the way that is stored and organized. Therefore, data during this process lost the initial quality. Apart from technologies issues, and even knowing that data converters enables the exchange of data, there are problems of time consuming. The amount of time and computer programs needed to solve conversion problems can be time consuming (USACE 1995).

However, in order to overcome most of the problems during the process of spatial data transformation, development of standard formats has been developed by several companies. Standards allow spatial data interchange between incompatible technologies, preserving data contents, and data quality. Additionally, the development of standards reduces the number of computer routines needed for a successful data exchange (USACE 1995).

According to USACE (1995) “the existence of multiple data exchange standards helps to meet the specific needs” of the diversity spatial data community, because different GIS technologies require different standards, that somewhat may not be applied to other systems. However, agreements between the parts involved in the process of exchanging spatial data must come up.

Agreements enable a complete understanding about the geographic data being exchanged between both parts (USACE 1995).

3.1.3 Geo Information Agencies

Most of the problems related to the use of GPS are due the fact that there are many different coordinate systems over the world. As a result, the position measured by the GPS system does not always coincide with the ones supposed position. Depending on the map used when navigating with GPS receivers, care should be taken to ensure that the relevant reference system has been entered into the GPS. In addition to that, topographic maps are maps that give a general and simplified representation of a country that includes roads, rivers, lakes, administrative division, vegetation, etc.

Thus, I present below some software offered by some companies. Some of them develop and work with GIS technologies, satellite images and GPS machines.

QuickBird and Spot are examples of satellite images that capture images of high resolution. Images of high resolution are used to extract detailed information in various areas like, urban planning, large infrastructure, country defence, etc.

Erdas, Inc is a company that provides useful tools that enables to process imagery that can be used into GIS system. The softwares developed by this company support images of high resolution and low resolution.

Leica Photogrammetry Suite (LPS) is software used to process raw images that could be used into GIS systems.

Economic and Social Research Institute better known as ESRI, is a company that provide a range of tools used to process and analyze spatial data for GIS applications. For example, the technologies developed by ESRI include ArGIS, ArcView, ArcMap. ArcGIS Explorer is freely available.

Integrated Land and Water Information System (ILWIS) is an integrated system developed by ITC (Institute of Aerospace Survey and Earth Sciences), an international Dutch Government training institution. ILWIS is a free open source GIS software developed for planners, natural

resources managers, biologists, water managers. The software enables these group to edit, analyze, and display data, as well the production of maps.

3.2 Spatial Data Integration and Sharing

Data sharing means "the transfer of data between two or more organizations," (Cromley and Mclafferty, 2002, p.95) providing therefore, important benefits to the developers and users of geographic information. Spatial data sharing enables different stakeholders to use the same data for various purposes. However, the process of spatial data sharing in most of cases involves a change of the format of the geographical data.

There are different definitions of data integration in the literature. For instance Mostafavi (2006) defines data as a framework consisting of combinations of data originating of different sources in order to produce information with high quality. As a result, some of the benefits of integration are to eliminate redundant information, reduce the costs and improve efficiency (Jarulaitis 2007).

Although the advantages of data integrations are clearly defined, much consideration must be observed before the process of integration (sharing). In the case of integration of spatial data coming from different sources and produced based on some specifications complicates spatial data sharing (Mostafavi 2006). The importance of spatial data sharing has been highlighted in various publications.

The authors Yeung and Hall (2007) suggest that the benefits of spatial data sharing transcend the implementation but also encompass institutional culture, as well as hardware and software technologies that support its use. Figure 7 illustrates the perspectives of data sharing proposed by Yeung and Hall (2007).

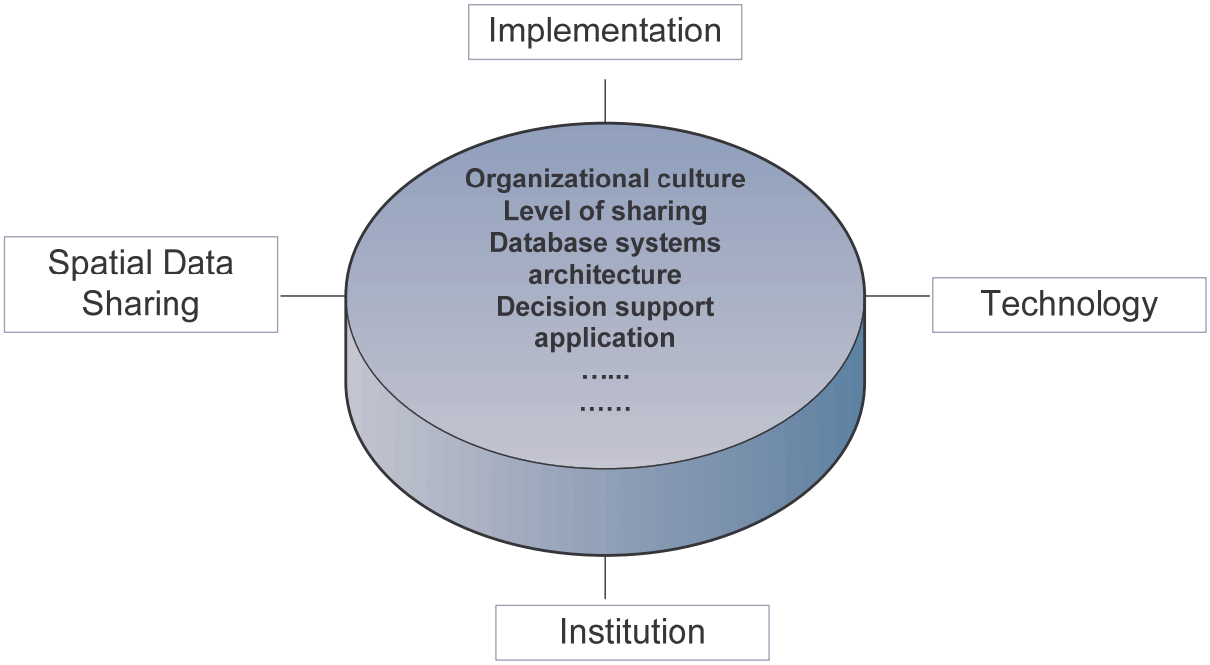


Figure 7 Spatial data sharing from different perspectives (Implementation, Technology and Institution)

Following this perspective (Yeung and Hall, 2007) the sharing of spatial data transcends technical issues, but also institutional arrangements like, policies rules are also important to considerer when there is a need of spatial data sharing. Within the institutional perspective, Ghaffar (2002) citing (Clarke 1995) argues that political support is needed for establishing cooperation. In addition to that, political support is needed for defining policy for pricing spatial information in order to ensure no monopoly of information among institutions (Ghaffar 2002).

In the same lines, Loenen (2009) defined a Geographic Information Infrastructure (GII) as a framework that aims to facilitating the efficient and effective generation, dissemination, and use of needed geographic information within a community or between communities (Loenen 2009). Based on this framework, he sets five interdependent components: datasets, policy which includes institutional framework and financial resources, technology, standards, and people.

3.3 Levels of Data Sharing

Spatial data sharing is divided into different levels (Yeung and Hall, 2007). These authors defined six levels of data sharing. According to the below table (Table 3) infrastructural spatial data sharing aims at providing global access to database and make data available to general public. Therefore, they imply the use of standards practices like protocols for data

documentation. Infrastructural level is based on the concept of Spatial Data Infrastructure (SDI) which is defined as "SDI is an initiative intended to create an environment in which all stakeholders can cooperate with each other and interact with technology, to better achieve their objectives at different political/administrative levels" (Rajabifard 2003). Whereas enterprise level aims at facilitating inter departmental information access within an organization. However according to Yeung and Hall (2007) both levels are based on open computing standards and a similar distributed architecture.

Table 3 Levels of spatial data sharing. Source: Yeung and Hall, 2007

Levels of Data Sharing	Data Sharing Characteristics		
	Systems Architecture	Procedure	Purpose
Infrastructure	Distributed network connected by the global telecommunications system	Global information access and application through database mediation	Seamless spatial database interoperability and integration using operational and legacy data
Enterprise	Federated databases and warehouses connected to an organization communications network	Inter departmental information access through database mediation	Simultaneous online transactions processing
Domain	Three-tiered client/server computing in a wide area network (WAN)	Shared database with sophisticated collaboration among different users or organizations	Sector based data management , multi-sourced spatial data analysis and modeling
Functional	Three-tiered client/server computing in a local area network (LAN)	Heterogeneous data exchange	Spatial data visualization and overlay analysis using data from multiple sources
Connected	Desktop computers with simple network connection	Homogeneous data exchange	Electronic exchange of text files and graphics files of the same format
Ad Hoc	Independent desk top computers	Manual data exchange with hard copy maps, diskettes, CD-ROM	Occasional exchange or sale of data from and Ad hoc requests

Domain level differs from functional level in that the first one seeks to provide data in support of the operational needs of a particular area or application domain such as public health, land parcel mapping or urban transportation management while functional data sharing aims at providing data for a particular application or project.

Data sharing by connected level is similar to ad hoc level spatial data sharing that the shared data are transmitted electronically across a simple data communications network. The use of Intranet in an organization falls into connected level.

At ad hoc levels data sharing aims at exchanging data between individual users or organizations. According to Yeung and Hall (2007) data sharing at this level used to be done in the past "manually using hardcopy documents and maps, magnetic tapes and diskettes"(Yeung and Hall, 2007, p.177), while nowadays it is often done by using optical data storage devices such as DVDs and electronic networks.

However the use of optical data storage at ad hoc levels is more appropriated and used in developed countries. In contrast to developing countries like Mozambique that still performs many tasks manually. So the use of hardcopy is still used in those countries where mainly the data is transferred basically in a form of file from one computer to another. This point of view is also applied to upper levels of spatial data sharing. The main reason is that development faces constraints of telecommunications networks, for example in Mozambique the use of internet is limited in rural areas, where also the electricity is not provided normally. It is argued that the development of any Geographic Information System has been influenced by the evolution of technology such as internet, telecommunications, software, and so on (Yufei Wang, Linlin Ge et al. 2005).

So the sharing of spatial data allows the reuse of data that in turn eliminate the need to duplicate the work.

3.4 Users Education

Much attention is focused on issues related to hardware and software. However human and non-technical factors sometimes play crucial role in the use of spatial technology (Yeung and Hall 2007).

Because spatial technologies rely on people with diversity of skills and background on spatial systems, it is important to provide education training to identified users. Yeung and Hall (2007) categorized the education users into four categories: project sponsors, systems staff, production and profession users, and occasional users. While Ghaffar (2002) categorized the education users into: managers, system administrators, and system operators, both at the infrastructure and organizational level. Furthermore, the users according to Yeung and Hall (2007) are divided in four levels or types of education: organizational level, occupational, individual, and popular (Yeung and Hall 2007). See Table 4 for more details about levels of education.

Table 4 Types of User Education. Source: Yeung and Hall (2007)

Types of use Education	Purpose	Target audience	Methods of delivery
Organizational	To ensure long term commitment and support for corporate executive and senior managers by keeping them up to date on the relevance of emerging technology to the mission and goals of the organization	Project sponsor	Regular briefing notes and presentations at management meetings
Occupational	To provide or enhance short and long term skill requirements to support the operations	Systems staff, production ,and professional end users	educational and technical training programs and courses product specific training, conferences, seminars and workshops, on-the-job training and mentoring
Individual	To provide or enhance immediate skill and Knowledge requirements of individual members of systems staff professional users	Systems staff, production, and professional end users	educational and technical training programs and courses product specific training, conferences, seminars and workshops, on-the-job training and mentoring
Popular	To keep the general public aware of the availability and potential use of existing spatial databases	The general public	Mass communications media including broadcasting, brochures, spatial data clearinghouses, Internet portal

The main objective of user education is "to ensure that all users are fully equipped, both technically and intellectually," (Yeung and Hall 2007 p. 223) to play their respective part in implementing and using spatial technologies effectively. However, user education is a complex task to achieve; therefore a user education program must be carefully researched and planned as part of the process.

The use of GIS requires specialized people and according to the Ghaffar (2002) the developing of geographic information infrastructure cannot take place with support of a strong knowledge and education infrastructure, therefore training is needed. The training should be addressed in a short and long term for managers, systems administrators, and systems operators (Ghaffar 2002).

Developing countries like Mozambique have lack of expertise in information and communication technology generally and in use of geo technologies in particular. For instance, one of very the common issues in developing countries is that there is lack of local expertise and capacity to operate and maintain large-scale GIS systems (Mohamed and Plante 2002). Thus, organizations are expected to provide training at all levels of local staff and training students in higher educational institutes in order to minimize the constraint of availability of people with required skills.

3.5 Barriers to Spatial Data Sharing and Integration

Although the spatial data sharing it is widely highlighted there are many constraints that inhibit the implementation of data sharing among organizations. Although the value that the GIS solution provides was recognized, it is also very important to take care of the availability of data collected and bear in mind that most of the data are not updated, specially for developing countries which have been dealing with many problems such low use of ICT, lack of resource, lack of expertise in ICT in general and GIS in particular.

Spatial data are collected at various levels, with different resolutions, different formats, and different scales depending on the purpose of the one that need such data. Thus, when there is need to share data from outside of the environment that was collected issues related to integration become one of challenge.

Apart from data formats mentioned above, the time data are collected constitute barriers that inhibit its. Spatial data can be pertaining to the time the data were collected or there can be issues about integrating data from different time periods (Thakuriah, Ortega et al. 2003).

Organizations have been relying on having spatial data from different sources that can be useful to their decision makings. These are some barriers that are associated to sharing of spatial data integration. The importance of these issues is to ensure that the data quality is not compromised to satisfy decision-makers needs (Mustafavi 2006).

If all sectors recognize the need of sharing data, any user from expertise until new in GIS area can integrate spatial data in their own system. Thus, the personal users or a whole organization will spend less time and cost to gather data for the applications. Having accurate and updated spatial data, will help to better plan, monitor, and provide better services and will increase the communication across organization as well.

Apart from the spatial itself, it is important to emphasize the role of the users that produce spatial data those who use such data. First, it is vital to create local sustainability in order to empower local expertise with skills and thus reduce the dependence on donors and external expertise. Secondly, it is important to get each person informed about how the information and consequently the use of Information and Communication Technology can be useful for their daily work.

Thakuriah, Ortega et al. (2003) stressed on difficulties of data integration because mainly the data comes from different sources. Despite that, these authors have organized the barriers issues of integration in four aspects: organizational issues, geographic issues, temporal, and technological issues.

Many organizations still do not want to share spatial data that they developed outside of organizational borders, even among departments in the organization. Thus it will be always difficult to integrate outside data, maybe because of this negative behaviour.

Geographical barriers arise because data are collected at different formats and resolution according to the purpose of such data. So when the time of sharing data outside of the organization comes up difficulties on challenges become a big problem. Despite that, temporal barriers are approached the same way as geographical issues, because most of data are collected in different periods of time, like different day, month, even year. Therefore the time data are collected can be issues about integrating data from different time periods (Thakuriah, Ortega et al. 2003).

Technological barriers are related to necessary skills to use the technology properly, and it also related to costs. According to Thakuriah, Ortega et al. (2003) it is necessary to ensure that appropriate training methods are made available, and monies are set-aside in order for individuals to cross the technological divide.

All these issues should be considered in order to provide appropriate data that the managers need on their decision making. The data from inappropriate time for example, gives a wrong perspective for those who need to take an action.

Despite that, spatial data integration issues were categorized into five perspectives (Mohammadi, Rajabifard et al. 2006): technical issues, institutional issues, policy issues, legal issues, and social issues. See Table 5.

Table 5 Data Integration issues. Adapted from Mohammadi, Rajabifard et al. (2006)

<table>
<tr><th>Technical Issues</th><th>Institutional Issues</th><th>Policy Issues</th><th>Legal Issues</th><th>Social Issues</th></tr>
<tr><td>Semantic</td><td rowspan="2">Collaboration models</td><td rowspan="2">Legislation issues</td><td rowspan="3">Data access and pricing</td><td rowspan="2">Cultural Issues</td></tr>
<tr><td>Reference System and Scale</td></tr>
<tr><td>Data Quality</td><td rowspan="2">Political Stability</td><td rowspan="2">Capacity building</td></tr>
<tr><td>Format</td><td rowspan="2">Linkage between data management</td><td rowspan="3">Privacy</td></tr>
<tr><td>Computational heterogeneity (Standards and Interoperability)</td><td>Awareness of Data

Existence</td><td>Equity</td></tr>
<tr><td></td><td>units</td><td></td><td></td><td></td></tr>
</table>

Combining the two models proposed by both (Thakuriah, Ortega et al. 2003; Mohammadi 2006) have common view regarding to spatial data integration issues. The technical issues (Mohammadi, Rajabifard et al. 2006) are within the technological issues (Thakuriah, Ortega et al. 2003), while institutional issues proposed by Thakuriah, et al. (2003) encompass institutional, policy, legal and social issues from Mohammadi Rajabifard et al. (2006) perspective.

3.6 Geographic Information System in Developing Countries

Problems such as availability of spatial data, lack of sharing data among organizations and duplication of data are all typical problems of developing countries.

The use of Geographic Information Systems (GIS) in developing countries is still far to be achieved, however many researchers have demonstrated how useful it is, mainly for the countries that are dealing with lack of resources, skills to use information and communication and technology in general and GIS in particular.

For example, Zeller (2002) described some problems that affect the use of GIS in developing countries such as, cost, infrastructures, education, and political stability. The use of GIS and hardware in developing countries are expensive since these products are developed and sold by developed countries. Zeller (2002) asserts that education constraints for developing countries are related to the problem of illiteracy and also because many people do not know how to use a computer. In Mozambique Saugene (2005), also pointed problems that the country is suffering and will suffer if it decided to use or adopt GIS technology in their daily routine work.

Furthermore, GIS was introduced in Tanzania, a developing country to support and monitor the eradication of Guinea worm (Thomson, Connor et al. 2000) ,the experience is being adopted by other countries that are implementing the same technologies.

As SDI (2008) points out, GIS users tend to develop their own data sets, even if there are existing spatial data sets available for them, because:

- They may not know available existing data sets that could be appropriately used for their applications; or access to these data sets is difficult;
- They are not used to sharing data sets with other sectors and/or organizations; and Existing spatial data sets stored in a certain GIS system may not be easily exported to another system. These problems arise from the fact that existing spatial data have been poorly documented in a standardized manner. Consequently, there have been duplicate efforts in spatial data development.

As a result, the new era of GIS is still characterized by: (SDI 2008)

- Many actors involved in data collection and distribution;
- A proliferation of GI applications, product types, and formats;
- Duplication as a consequence of the difficulties to access the existing data, and the highly specific quality of the data collected;
- Increasing difficulty in the exchange and use of data that came from different organizations.

Although there are many benefits that the users can allow, it is imperative to look over those problems in order to provide important data that will help to manage the system that deal with spatial data. The section bellow will provide some benefits that GIS tool offer.

For example, in Uganda like in many developing countries the spatial data is not fully developed. The case of Uganda according to Musinguzi, Bax et al. (2004) shows that there is a lot of duplication in data collection, a lot of spatial data is not documented; maps are at different scales; data are funded by foreign donors. The SDI aims to facilitate the use of spatial data among different stakeholders, however because of these and others problems several authors argue that developing world is not ready for SDI. Although this view is obvious the authors argue that these problems may be viewed as opportunities (Musinguzi, Bax et al. 2004).

According to EB (2004) one of the best capabilities of GIS systems is to bring together data from many sources creating a more complete picture of a situation that would otherwise be possible. As a result, organizations can make better decisions based on all relevant factors. The international community through the Millennium Development Goals recognizes that good data improve the capacity of developing countries by using innovations like GIS tools. Thus, there is a need to invest in data collection, dissemination, technical capacity, and to improve the use of existing datasets (WB 2009).

However, much work must be done in developing countries and Mozambique in particular, in order to deal with the data availability and quality, as well as cultural and organizational barriers among health sector. These are some barriers that make it difficult to integrate spatial data coming from different sources. Despite the above mentioned constrains, the trend is to increase information flow.

3.7 Theoretical Framework

3.7.1 Information Infrastructure

Information infrastructure (II) is defined as *shared by a larger community, enabling, open, heterogeneity, and installed base.* (Hanseth and Monteiro 1998; Hanseth and Lyytinen 2004) An object is considered II when it is used by large community, shared of all components within the infrastructure. It enables the addition of artifacts such as people, technology, laws, etc. For example, roads, electricity, telecommunication as considered information infrastructure because

under defined rules they are used for large community, they consist of different elements that are connected by standardized platforms.

Moreover an II it is conceptualized as a set of socio technical components that are independent and inter connected in some way (Nielsen and Aasted 2006). An II is not simple to develop, and it takes time to become stable because of these different components. Furthermore the problem that Hanseth and Monteiro (1998) found was that many people find it difficult to conceptualize the concept II, because it is not easy to identify an II, and the question arise when there is a need to compare II with another class of information systems.

In the next sections the concepts that defines II such as installed base, heterogeneity, openness, shared, enabling are described.

3.7.1.1 Installed Base

Installed base according to Hanseth and Monteiro (1998) means that infrastructures are considered as always already existing, they are never developed from scratch. The new version that must be linked to the infrastructure must be designed and linked with the existing ones, making them interoperable. However the new version it is highly influenced by the already existing one, from now called installed base.

Any II consists of many components that are interlinked in one or other way. But what is important to bear in mind is that ever there is a need to add a new component within the infrastructure, the new one must always be connected with the existing, so that there is no interruption of the infrastructure.

3.7.1.2 Heterogeneity

The concept heterogeneity goes beyond the technical artefacts, comprises non technical components like people, rules, etc. Heterogeneity means that the infrastructure consists of "technological components, humans, organizations, and institutions" (Hanseth and Monteiro 1998). It does no matter if is any information system, or really infrastructure, the most obvious is that any class of information system require people to manage it, because they do not work alone.

Furthermore, infrastructures are heterogeneous means that because within the infrastructure there are many independent components that are in some way interconnected. Bearing this in mind Hanseth and Monteiro (1998) argue that a specific component might be implemented in many different forms. The first form of heterogeneity takes place when one part of the infrastructure is being replaced over time by a new part. In this case the infrastructure will consist of two interlinked networks running different versions. Despite that, another form of heterogeneity occurs especially by larger infrastructure by interconnecting two existing different ones.

The third form of heterogeneity addressed by Hanseth and Monteiro is the one that occurs when larger infrastructures are developed based on existing one and independent. Once they are interconnected, when one component changes, the other components must be changed as well. For example, there are many formats for representing text, video, sound, image and graphical representations; however they are brought together and put into MIME format to enable transfer of multimedia information on the Internet (Hanseth and Monteiro 1998).

On the same line of thinking of installed base important considerations must be observed during the process of interconnect different components. These components might be compatible or not, either is the case the components must be aligned in order to not disturb the infrastructure.

3.7.1.3 Openness

Infrastructure are open in the sense that there is no limits for the number of the users, stakeholders, vendors involved, and other technological components, application areas or network operators (Hanseth and Monteiro 1998).

Because these many users, vendors, and technological components, and application areas within the infrastructure are developing several activities over time, are strengthen alliances, are changing requirements it implies that inside there is heterogeneity (Hanseth and Monteiro 1998).

However this does not means that everything has to be placed inside of the infrastructure as the infrastructure was a bag of garbage. For example, Hanseth and Monteiro provide an example between a hospital and any electronic commerce infrastructure, where it is impossible to exchange information because of the kind of information that both carry, particularly hospital carry confidential information that are not allowed to show up outside.

3.7.1.4 Shared

An Infrastructure is shared it means that the same single object is used by a larger community (Hanseth and Monteiro 1998). Because the object is a shared resource within the infrastructure, the same object is based on standardized interfaces (Hanseth and Lyytinen 2004).

It is important to built standard interfaces especially in this case where the infrastructure is used by a larger community, otherwise financial or humans resources would be spent.

3.7.1.5 Enabling

The concept enabling means that the infrastructure must support a wide range of activities, not only have to enable improvements of something existing (Hanseth and Monteiro 1998).

Thus the infrastructures are different from other class of information systems which these class systems are developed to execute specific tasks. In normal systems new versions are developed when the companies decide to add more components. While infrastructures are open for new components apart from the already existing, therefore the infrastructure becomes more interested and more users join to it.

3.7.2 Spatial Data Infrastructure as Information Infrastructure

The term spatial data infrastructure (SDI) is used to refer a set of rules, policies, institutional arrangements that all together aim to facilitate the use, availability and sharing of spatial data among several users ranging from organizations, public institutions, academia, to general public. In the geographic information infrastructure literature a wide of variety of terms, terminology, definitions are used. For example, the term national information infrastructure was used at first time by US vice president Al Gore. Despite that, many people, in and beyond the US, prefer the term ‘global information infrastructure’ (GII), in order to emphasize the interconnectedness of the network, of countries and of people (Loenen 2006).

Based on definition of II mentioned earlier on, spatial data can be an II because one of its purposes is to make spatial data accessible to everyone in low costs and easily, so it can be considered shared and involved. Spatial data infrastructure is compared to others infrastructures

like roads, telecommunications, electricity lines that are used by larger community. These infrastructures are supported mainly by government (Onsrud, Poore et al. 2004).

Furthermore, Loenen (2006) citing (Kelley 1993) defined a geographical information infrastructure as "a framework continuously facilitating the efficient and effective generation, dissemination, and use of needed geographic information within a community or between communities" (Loenen 2006 p.26).

IIs are *heterogeneous* means that the infrastructure consists of components of multiple sorts, including diverse technological components and non-technological elements (Hanseth and Lyytinen 2004). These components are connected in complex ways and change constantly. Bearing to mind that spatial data is an II, therefore it consists of various components both technical and non technical like people that are interested in spatial data, tools used to collect, process, and analyze spatial data. There are many users interested on such data, for example technicians users that develop programs or specific GIS systems; manager that are interested on having spatial component in their reports so that they could be able to plan, monitor and make decision based on reality facts.

In order to make sense of spatial data collected they are used in places where they are transforming and used for many tasks. Thus, it includes the use of technologies like computers, Global Positioning System, papers in forms of templates where spatial and non spatial data is recorded in organization where the data is used. So there are many components around it that should be considered, because in some cases these elements are out of control of the existing installed base, this means that they do not work isolated like islands, in other words one component of the infrastructure is connected with another infrastructure.

Although some spatial data is available freely, other data can be obtained by paying. However these data, paid or free, they are *shared* among different stakeholders. As Onsrud, Poore et al. (2004) stated that geographic data and related technologies are used for many applications by government agencies, private agencies, scientific community, and individual citizens in order to meet their real needs. Because the infrastructure is shared by different people, it is based on standards, so that, tools can interconnect in a standardized way.

For instance, the integration of spatial data set in one institution is influenced by different factors such as, spatial data format and scale, human skills, the relevance of data within the organization, software used, and so on.

Once spatial data is shared by larger communities as described, this means that along the time the number of people interest in such data might increase, thus the infrastructure becomes *open* for new users. Despite that, along the time new spatial data is collected, new features are developed and then integrated on existing GIS. Having that, spatial data, even GIS should be considered *enabling* by allowing the integration of new components. However by adding these components, there is need to observe that the existing infrastructure is ready to accept new components in order to avoid problems of integration.

Bearing in mind that the speech is in information infrastructure, *installed base* means that whatever is the infrastructure it will never be developed or designed from scratch. The installed base explains that since one part of the infrastructure is shaped, or new component is added the one has to fit in what is already exists (Hanseth and Lyytinen 2004). Therefore, the installed base will always influence how new components that need to be part of infrastructure have to be designed or developed. However, it is argued that because the infrastructure is build upon of an installed base, the infrastructure inherits both the strengths and limitations of that installed base (Loenen 2006).

Chapter 4 – RESEARCH METHODOLOGY

The aim of this chapter is to describe the data collection and analysis process regarding the approach used, the methods, and the techniques. For that, I present important principles that researchers from different fields have said related to the process of conducting research.

Thus, at first I present the research approach used in my study, followed by philosophical perspective branch. The research method that I used for this study is also presented in this chapter; furthermore the data collection techniques used to access data is also presented here. Finally, I describe how data was analyzed.

4.1 Qualitative Research

Qualitative research is more interested in understanding real problems by finding out why and how specific problem occur in a context through people behaviour. According to Oka and Shaw (2000) qualitative research attempts to understand meanings that people give to their needs or to social phenomena. While quantitative research involves the use of quantitative data (numbers) to understanding problems under study. According to Myers (1997) this process can be done by using quantitative methods such as survey methods, experiments, and all numerical methods.

Furthermore, quantitative research was developed in natural science to study natural phenomena, while qualitative research was developed to study social and cultural phenomena (Myers 1997).

Because the aim of this study was to find out how the selected organizations have been dealing with GIS and spatial data I opted for qualitative research. Moreover, I was interested in understanding the constraints faced related to spatial data sharing. The qualitative research was the most appropriate. Furthermore, qualitative research provides appropriate tools that enable me to analyze and answer rather than focusing on number.

4.2 Philosophical perspective

When conducting any research it is important to bear in mind which philosophical strategy to follow because without the knowledge of related philosophy, the researchers are apt to be

confused when analyzing qualitative data (Oka and Shaw 2000). Philosophy means views about how to recognize things that are to be researched.

Therefore philosophically qualitative research can be classified into positivist, interpretative and critical (Myers 1997). They differ according to the philosophical assumptions that each maintains. The positivist assumes that the "reality is objectively given and can be described by measurable properties which are independent of the observer (researcher) and his or her instruments" (Myers 1997). Despite that, interpretative assumes that in order to understand a specific problem in the world it is necessary to access the people's behaviour and feeling within the context of study. Finally, critical research assumes that "social reality is historically constituted and that it is produced and reproduced by people" (Myers 1997), therefore the critical research focus on changes.

In this study, I have adopted interpretative research because I aimed at getting deep understandings of the usage and sharing of spatial data in public institutions. In order to understand social phenomena, the interpretative paradigm is more suitable because it provides techniques that help to understand and interpret the phenomena and make meaning out of this process (Dash 2005).

4.3 Qualitative Research Methods

Myers states that "the choice of research method influences the way in which the researcher collects data." So he presented four research methods used in qualitative research: action research, case study research, ethnography and grounded theory.

Action research "aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework" (Myers 1997).

Case study research is widely used for research at information system arena. Myers defines case study research method as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (Myers 1997). According to Myers (1997), a case study can be positivist, interpretive, or critical, depending upon the underlying philosophical assumptions of the researcher.

Ethnography research is used in cases where in order to answer the research questions and gather research material, the researcher often live among the people he or she is studying, or at least spend a considerable amount of time with them (DA 2009).

While in the field DA (2009) argues that the researcher based on participant observation participates much as possible in local under study actively and observed everything in what they do when conduct ethnography research. Differently from action research, case study, and ethnography research the grounded theory "seeks to develop theory that is grounded in data systematically gathered and analyzed" (Myers 1997).

This study was based on case study research method because I aimed to put myself in the real worlds in which those public institutions dealing with spatial data are in order to get deep understanding of the use of GIS and spatial data. The case study is used to describe an organization and is much applied to study information system in organization (Myers 1997).

4.4 Data Collection Techniques

The case study provides many ways to collect data. Tellis (1997) citing (Yin 1994; Stake 1995) identified at least six sources when conducting case study which are: interviews, documents, archival documents, direct observation, participant observation, physical artefacts (Tellis 1997).

The fieldwork reported as part of this study was carried out between June to December 2008 in Maputo, capital of Mozambique in six (6) institutions visited which includes: Ministry of Culture and Education (MEC); National Institute of Statistic (INE) responsible of production and dissemination of demographic statistic, National Remote Sensing and Cartography Centre (Cenacarta) responsible for production, dissemination and diffusion of spatial data, Ministry for Coordination of Environmental Action (MICOA) responsible of management for environment, National Directorate of Water (DNA), and Maputo Council.

I explain below in detail how I have used these methods during my fieldwork.

4.4.1 Interviews

The most important data collection method used in qualitative research is the interview. Many researchers classify the interviews in three types (Oka and Shaw 2000): structured interviews, unstructured interviews, and semi-structured interviews.

In structured interviews, researchers ask a set of questions, in identified order, using the same words, to different interviewees while in unstructured interview there is no a predefined set of questions, the interview and the researcher talk freely. However, unstructured interview is more used by experienced researchers. Novice's researchers usually find them difficult because the researchers have to generate and develop questions according to what the interviewees say (Oka and Shaw 2000).

The semi structured interview is characterized by having a researcher with a prior set of predetermined questions as a guide. The guides according to Oka and Shaw (2000) "allow researchers to generate their own questions to develop interesting areas of inquiry during the interviews". This type of interview is widely used as the qualitative research interview (Oka and Shaw 2000).

The main method of data collection was through semi-structured interviews and questionnaires with the heads of the departments, and some staff of the departments within the organization. Table 6 shows the institutions that in which I conducted the interviews. The interviews were in Portuguese, because at first, it is the native language of the researcher and at the same time is the official language in Mozambique. However, the transcripts were made in English.

The main interviews were the first step contact. The appointments for the interview were requested through mobile phone and also by email. A total of eight formal interviews were conducted, their duration varying from 45 minutes to 1 hour. The interviews were all in the office, and face-to-face, where I was taking notes. The rooms were all silence, and the time of the duration of interview few people went there. After the interview the notes were transcribed in order to gain additional understanding and avoid loss of what the interview said.

Table 6 Institutions visited and numbers of interviews

Institution/Department	Number of Interviews	
	Formal	*Informal*
Ministry of Education and Culture: Department of Statistic and Plan Department of Information and Communication Technology	Two persons	-
National Institute of Statistic: Department of Cartography and Operations	One person	-
MICOA: National Directorate of Planning and Territorial Redevelopment	One person	-
CENACARTA	One person	Three persons
National Directorate of Water: Department of Rural Water	Two persons	-
Maputo Council: Department of Cadastre	One person	-

4.4.2 Questionnaire

In order not to take too much time from the interviewees, and because most of the interviewees were so busy, I used the questionnaire (See Annex A). Some of the questionnaires were given to them at the interview time. Others questionnaires were sent by email. I have used email because it was difficult to make appointment to people involved, they were busy and worked outside of the office, and particularly they constantly travelled to others provinces. However, the use of email fails in capability for immediate feedback and tends to be impersonal (Lee 1994).

The questionnaires provided were in Portuguese like the interviews, and the reasons for that were related to the language issues as mentioned earlier in the interview section. However, the transcripts were later translated to English.

4.4.3 Observation

Observation is very used when conducting cases studies. There are two forms of observation: direct observation and participant observation. Tellis (1997) states that direct observation occurs

when a field visit is conducted during the case study, and this technique is useful for providing additional information about the topic being studied while participant observation "makes the researcher into an active participant in the events being studied" (Tellis 1997).

Figure 8 Master Student observing a worker at Cenacarta

Participant observation is more used when conducting action research method where the research is involved and take action on the process.

During the fieldwork I carried out direct observation. From that I observed the way that staff workers work. The observation included also some GIS software, the equipments, and some maps that the organizations had drawn (see Figure 9). The observation of these artefacts was done during the time that I conducted the interview.

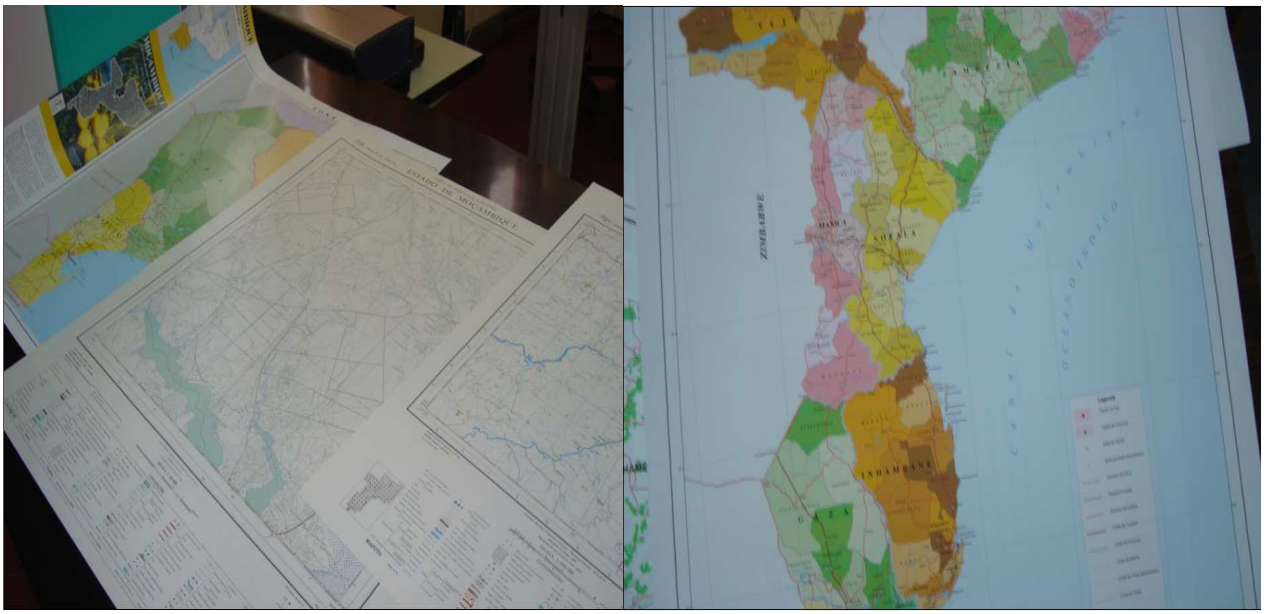


Figure 9 Printed maps from Cenacarta

4.4.4 Secondary source

Secondary sources such as documents provided by the interviews, online documents were explored. Because most of the institution have a website, before going for interviews, potential information was obtained from their website. This helped to clarify issues that are presented in their websites and also avoiding making redundant questions that are already on the pages. The interviewee also advised me to check their web site to download important reports that could help to understand the cases being studied.

4.5 Data Analysis

Qualitative researchers provide different ways to gather, analyze, and interpret data. Therefore data analysis is a dynamic process and iterative of collecting and analyzing the data during research. The process of analysis continues until the research study is interesting and is understood (QDA 2009).

Myers (1997) discusses three approaches to analyze data: Hermeneutics, Semiotics, and Narrative and Metaphor. Hermeneutics approach is an attempt to make clear and sense of the case under study in whole and then interpret it in parts. Myers (1997) pointed out that

hermeneutics approach is used in information systems study to try to make sense of the whole organization, and the relationship between people, the organization, and information technology because an organization is constituted by people with different and contradictory views.

Narrative and metaphor is widely used in information system literature. According to Byrne, Joliffe et al. (2006) metaphors can be seen as a symbol, a figure of speech, a simile, an image or an allegory that helps to make sense of situations, help in understanding new concepts or existing situations. For example, metaphor is mostly used to maintain or change the organizational culture is a common theme in organizational literature (Byrne, Joliffe et al. 2006).

The reason for selecting hermeneutics approach for this study was that each organization uses GIS for different reasons, and the people that use it have different background skills that are interesting to evaluate the use of GIS in that organization. According to previous studies lack of skills and lack of data standards are some examples that inhibit spatial data sharing among various organizations. The hermeneutics approach enabled me to comprehend what is going in spatial data integration issues, while semiotics approach is used to study media artefacts such as images.

There are various principles that we must bear in mind when analyzing empirical data. For example data analysis can occur before the data collection process has been completed (Oka and Shaw 2000). Furthermore, these authors advise that never collect data without substantial analysis going on simultaneously. Otherwise it will be a total disaster. Before the fieldwork I started to review works done in geographic information systems, particularly those related to developing countries like Mozambique through the literature review. Furthermore, I looked at some online documentation. The aim was to have the basic information on what the organization does, so that unnecessary questions were avoided during the fieldwork.

In order to make sense of the research findings I used triangulation method. Triangulation method is a process of verification to check the truth that increases validity by incorporating different viewpoints and methods (Stokrocki 2004). This process was done continuously until the moment that I felt more comfortable. For instance, after the interviews' notes were made and organized in themes. The themes made easier to categorize the data, so related data collected from the different settings visited were compared. Where gaps were found I had to consult again the personnel that I carried the data. Furthermore, I combined raw data from the transcripts of

interview with data from questionnaire with the purpose to make clear and find out if both methods provided data from same context.

When I found some inconsistencies I had to call or send emails in order to clarify and discuss issues about these inconsistencies. The Annex B and C illustrate some examples of email exchange during the process of thesis writing.

In addition to that, various drafts on the research findings were distributed to the main interviews in order to ensure and validate the contents of data.

4.6 Ethical Considerations

To assess the settings where the study was carried out, important considerations were followed.

- A preliminary authorization of the places visited by the institutions was necessary.
- A verbal consent and in some cases a formal letter was required to bear photos.
- The right to anonymity was maintained throughout the study, and was not exposed names of the persons interviewed during the study. However, in some cases, the person highlighted that it is his/she opinion not to organizations.
- Request for consultation of the documentation was done during the study. The documentation includes, application software, electronic files and paper files that the interviewees described during the interviews covered.
- During this study, request for validation of data was done consistently.

4.7 Limitations of this study

This study was restricted only to departments located at headquarters, which are in Maputo city, although it was observed that some provincial offices have used GIS technology and have done the data collection. Therefore, the analysis of data collected informs understandings of spatial data sharing at headquarter levels.

Another limitation of this study was lack of availability of key peoples. This was visible during the process of data validation, in which some did not give feedback. In addition to that, interviews in person contact with key people were held only one time because they were busy. But in return, contact by telephone and email in some cases helped to overcome this problem.

Although I had superficial access to some documents in some cases, I was unable to take photos of some of these because it was confidential information.

Chapter 5 - RESEARCH FINDINGS

The aim of this chapter is to present a summary of facts as a result of the fieldwork carried out from June to December of 2008, in different government institutions in Mozambique which includes: National Remote Sensing and Cartography Centre, Ministry of Coordination of Environmental Affairs, Ministry of Education and Culture, National Directorate of Water, National Institute of Statistic and Maputo Council. I have chosen these organizations because they have been using Geographic Information Systems for a long time and the accessibility was not much difficult compared to other government institutions. This chapter gives a description of the spatial information of flow of each institution that was visited, how spatial data is being managed, and the tools used for data in the management. At the end, it presents the limitation faced by them while dealing with spatial data sharing.

5.1 Spatial Data Management

In this section I intend to describe the management process mainly related to the management of spatial data which includes the flow of spatial data, the process of collection, processing, and analysis, data formats used by each department.

5.1.1 Spatial Data Information flow

The objective of this section is to explain how spatial data were managed by each institution that I carried out the study. Moreover, I try to explain the flow of spatial data, in terms of who are responsible for collecting spatial data (departments or sections) of the process of production of maps.

5.1.1.1 National Remote Sensing and Cartography Centre

National Remote Sensing and Cartography Centre (CENACARTA) is a centre created after the National Directorate of Geography and Cadastre (DINAGECA) and it was closed in 2004. The centre inherited the Geomantic Department of DINAGECA and consequently all the spatial data

was also inherited. The department included sections of Thematic Cartography, systematic cartographic, toponomic territorial division, geodesy, photogrammetry and a laboratory.

After the introduction of the centre and because of the new areas were incorporated, new forms of management of spatial data were also introduced. As a result the centre has collected various spatial data to aid map drawing. This process has been termed “Apoio de campo”, literally translating into English as “fieldwork”. The fieldwork consists of the collection of spatial data to fill information gaps in existing high resolution images, and to collect normal spatial data for various purposes.

Within the structure of CENACARTA (see Figure 10), all the activities related to fieldwork are done by the Geodetic department. These activities include collecting data for correction of images, or raw data necessary to carry out any task. It is also responsible to control the geodetic network within the country which is mainly related to the deployment of surveying landmarks across the country.

Once the data is collected it is entered in a computer through appropriate software and adjustments such as verifying the margin of errors are made. After that the data is sent to the Remote Sensing Department where the correction of images in turn is recorded in the software, the LPS Software. This software is also used to make the orthorectification of images like as aerial photos, satellite images. The process of orthorectification takes place because satellite images and aerial photos do not show features in their correct locations. So the spatial data collected it is used in the process of orthorectification.

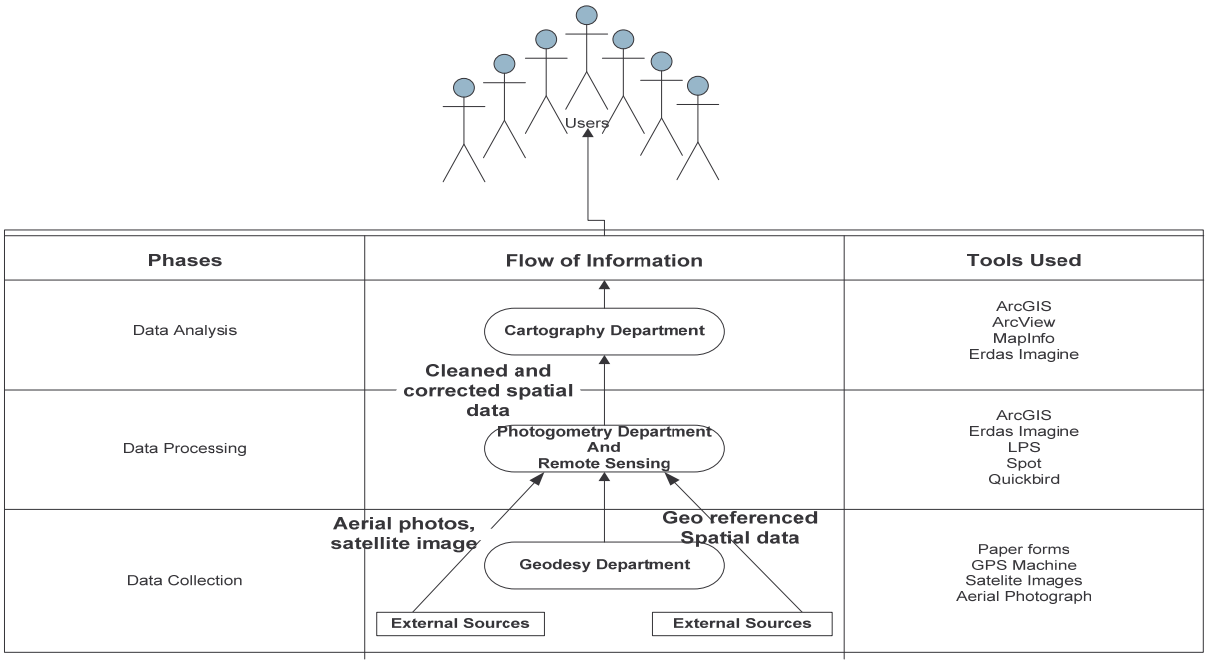


Figure 10 Flow of Information of CENACARTA

Eventually, after all the corrections are done successfully the Cartography Department is responsible for carrying out analysis which mostly or essentially involves development of maps based on spatial data that was previously collected.

Regarding the thematic maps requested by external stakeholders, two cases can occur depending on availability of such data as they need to create the required maps. For example, sometimes when it is necessary to collect data in the field, the process follows the basic flow starting from Geodesy to the Cartography Department; however, the first and second steps (which include data collection and data processing) can be skipped when there is spatial data to perform the analysis and create the thematic maps required and first step can be skipped when the customer has already the required data.

In cases where there no need to collect spatial data from scratch, before the use of data from external sources (stakeholders), the data is checked to ascertain its provenience (which datum was used, which coordinate system was used, and so on), to determine the margin of error. Only after these observations are made the external data can be used successfully.

5.1.1.2 Department of Cartographic and Operations of National Institute of Statistic

The Department of Cartography and Operations (DCO) collects spatial data for many uses. Therefore there is not a unique way (or standard way) to collect data. For example, in order to transform the digital cartography to analogical cartography in 2004 the department had organized in two phases.

The first phase was necessary to update spatial data in the field. For that, based on templates defined by the department, the data was collected in district levels. Then the data collected was introduced in a computer in a provincial level.

Then the data was sent to head office of DCO in Maputo in two formats: analogical form and digital format. The second phase that consisted of transforming the data collected in digital format carried out at head office. Here they used the manual of creation of digital base. Based on this manual, the process of data modelling was made. The Figure 11 illustrates a simplified flow of spatial data.

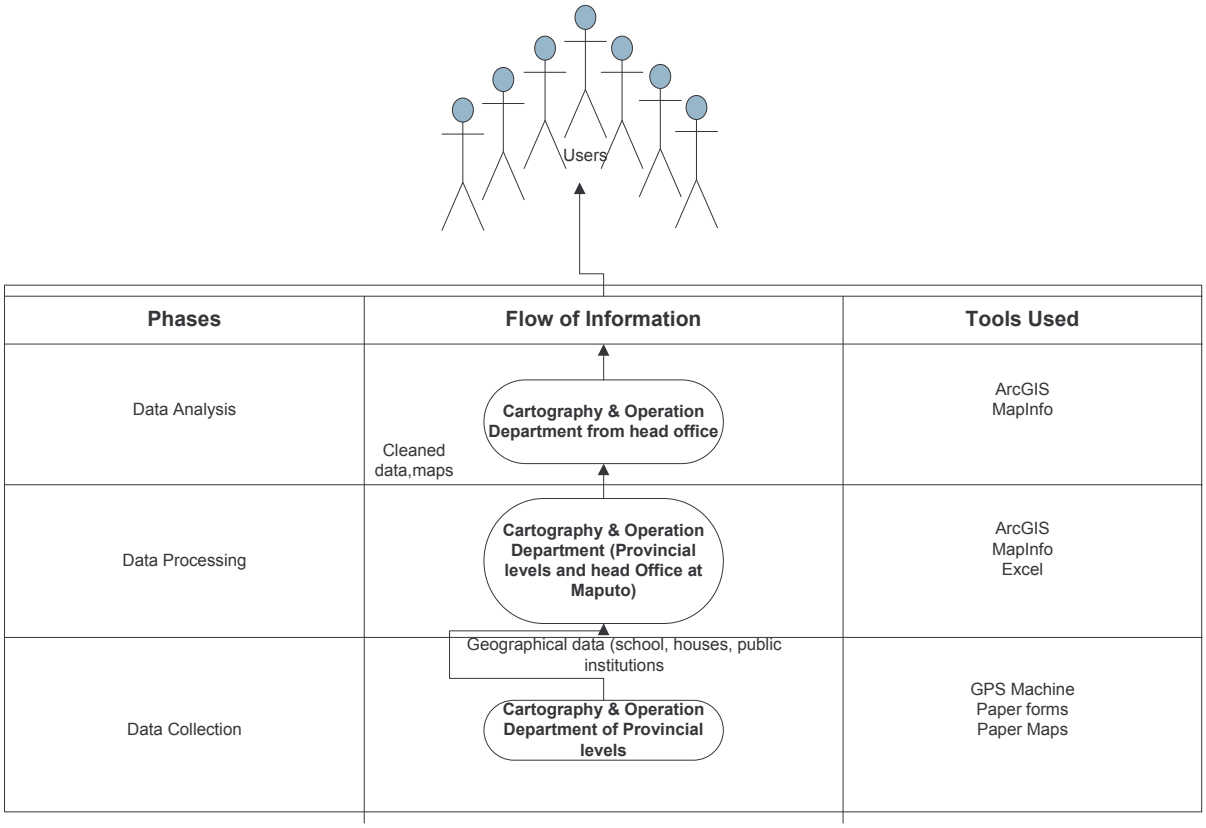


Figure 11 Flow of Information of Department of Cartography and Operations

Usually the department uses data from other institutions. According to the interviewee, in order to produce their own spatial data, before starting to collect spatial data from the root, the department finds out if other institutions have spatial data that they need. The data collected in those institutions when available is used as a start point to draw for example maps of their interests.

5.1.1.3 Ministry of Education and Culture

The Ministry of Education and Culture (MEC) among the various information systems it is also using a Geographic Information Systems (GIS) called *Carta Escolar*. This system provides location of infrastructure such as schools, water boreholes, access roads, etc., and also assists managers in decision making.

Regarding the spatial data production information flow, the data is collected at the provincial directorate of each province, introduced in computer (in MS Access database). Later the spatial data collected is sent in mdb format to the national level.

At national level the data is introduced into the system (EducStatistic) by the department of statistics. Then, in order to carry out spatial analysis the information in this database is linked to *Carta Escolar*.

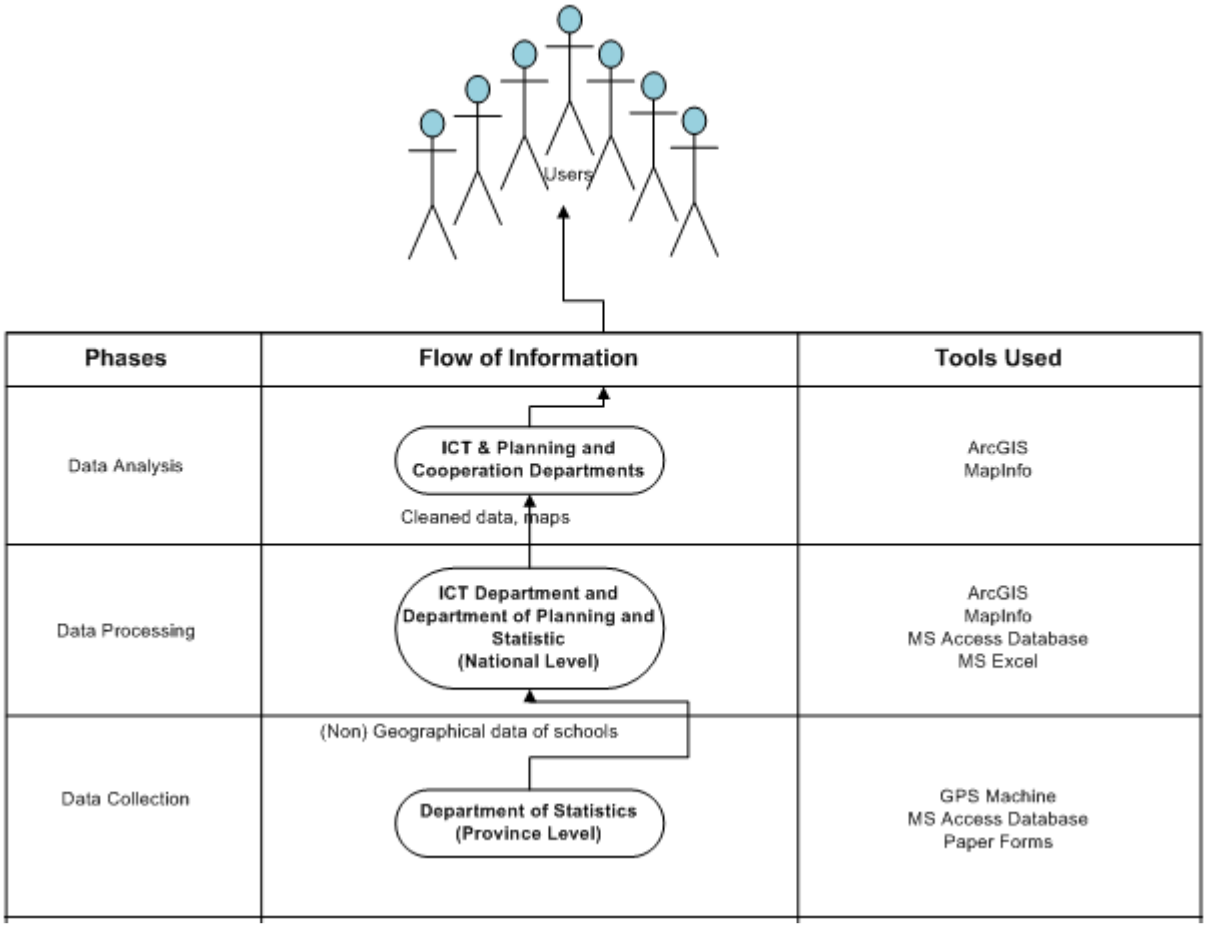


Figure 12 Flow of Information of Department of Statistic and ICT department of MEC

5.1.1.4 National Directorate of Planning and Territorial Redevelopment of MICOA

National Directorate of Planning and Territorial Redevelopment (DINAPOT) has collected spatial data usually from the field and then introduces in computer software. After this process the spatial data is used for different purpose according to the required analysis that the department has in hand. When asked about what the department does with the spatial data they collect, the interviewee said:

"The data are gathered, used, stored and forgotten."

With this answer the interviewee meant that spatial data is only discovered when there is a needed analysis to be performed otherwise it is stored without any use.

The Figure 13 below shows the flow of spatial data management within this department. Although the figure illustrates that the spatial data is processed and analyzed at national levels,

from the findings, the interviewee pointed out that spatial data is also collected, processed, and analyzed at provincial levels to make local decision makings.

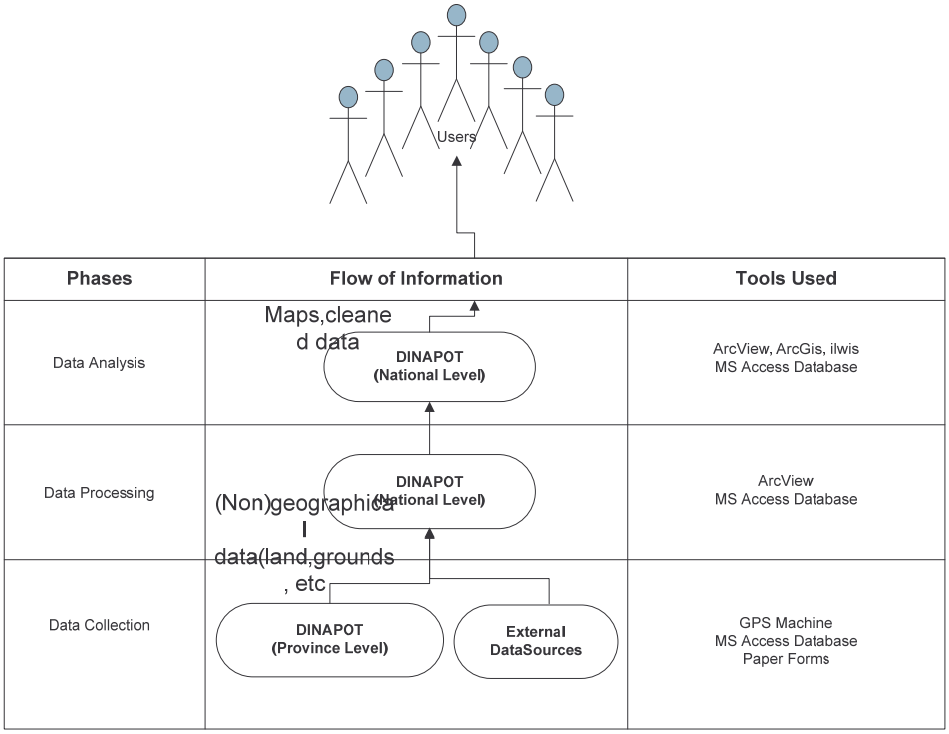


Figure 13 Flow of Information of DINAPOT

5.1.1.5 Rural Water Department of National Directorate of Water

The spatial data process starts by the collection at district levels. This data is registered in paper forms created as templates provided to technicians by Department Rural Water (DRW) in Maputo. The data is then sent to provincial levels where it is then introduced in database, in others words, from the paper the data was introduced to a computer. The data is organized in the same way as the template used in fieldwork. Therefore, spatial data and non spatial data were introduced.

The information is then sent to Central level (DNA) particularly to Department of Rural Water in digital format, where the central database is also updated. The central database contains information of all sources of water existent in all provinces.

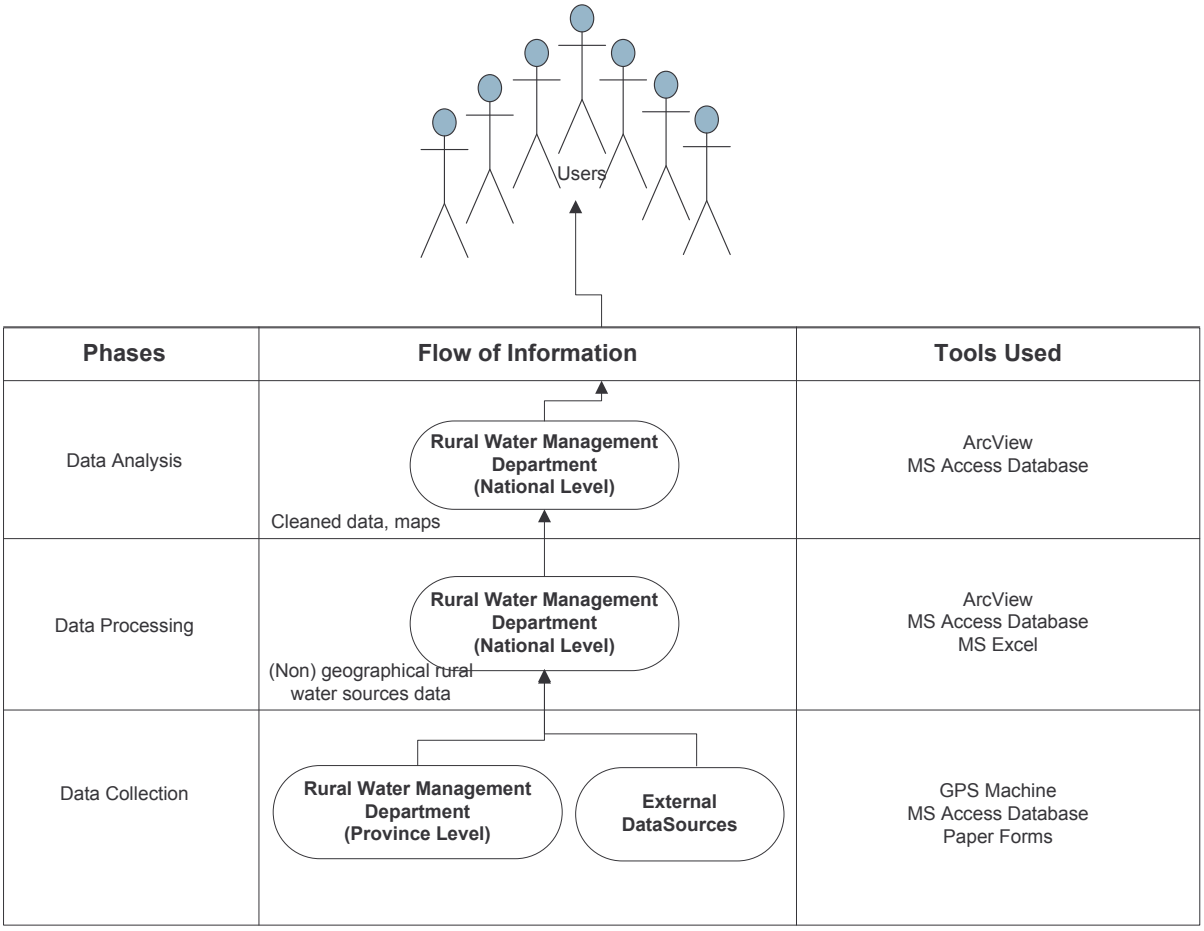


Figure 14 Flow of spatial data at Department of Rural Water

5.1.1.6 Department of Cadastre of Maputo Council

The department of Cadastre is under tutelage of Direcção Municipal de Planeamento Urbano e Ambiente (DMPUA). The flow of spatial data regarding to this department cover only the municipality of Maputo.

Thus, spatial data such as parcels, all buildings (private, public) plots, lands were collected by this department. However in order to draw up thematic maps they used base maps from Cenacarta.

Within the department of cadastre there are two sections denominated section of addressing that is responsible for collecting and processing spatial from all buildings of Maputo city. Until the time of fieldwork all buildings of Maputo were geo referenced. On the other hand, there is a section called cadastre that is responsible for managing spatial data related to land that is around

Maputo. However, both sections work together for instance, to transfer spatial data that one needs from another one.

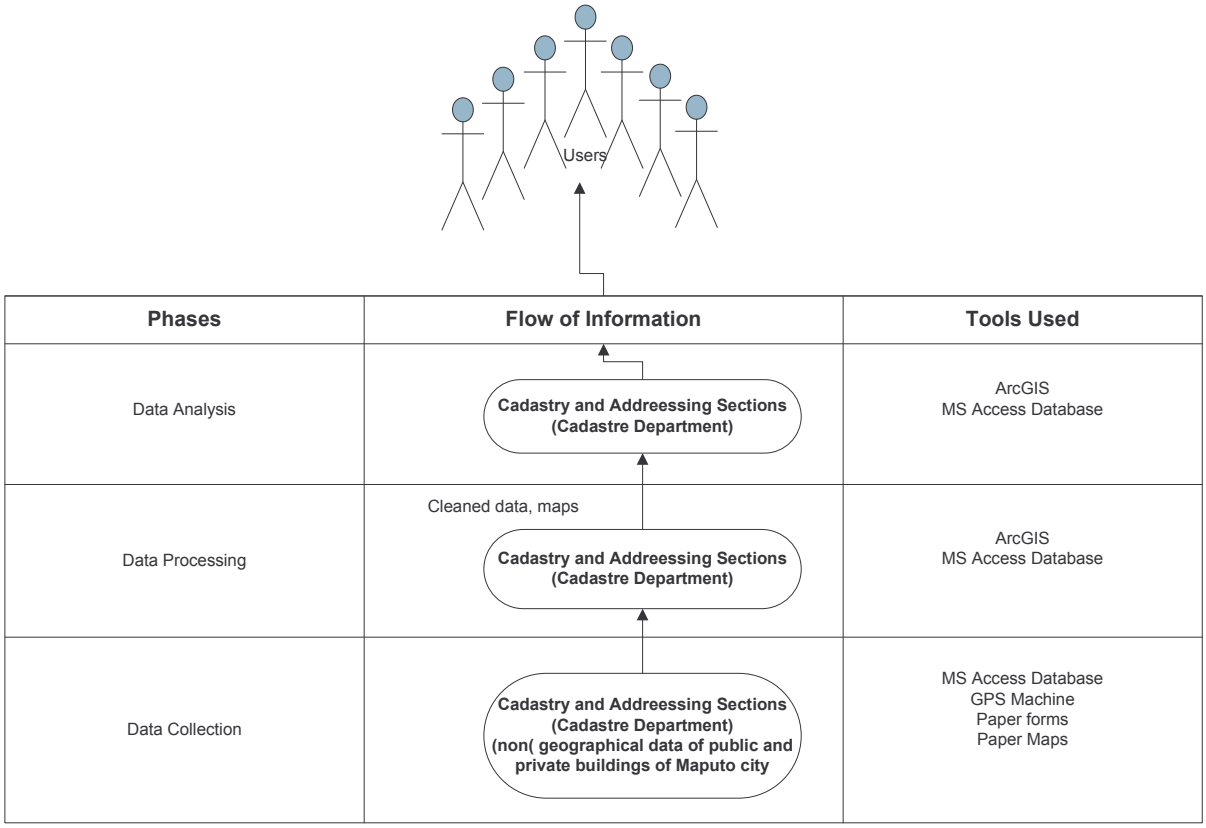


Figure 15 Flow of spatial data at Department of Cadastre

5.1.2 Data Formats

The file format refers to logical structure to store spatial data. However, some softwares' use specific file formats. So if one is interested in data coming from different sources it is important to evaluate if ones' system supports it, otherwise they must find another way to convert it in a more suited way. Many organizations have developed products based on some specifications such as formats, scale, coordinate systems, precision in datasets. The Table 7 illustrates some files formats that vendors have been using.

Company	Data Format	Filename Extension
ESRI	Vector	.shp, .shx, dbf
MapInfo	Vector	.map
AutoDesk	CAD	.dxf

Table 7 Examples of data formats available

Eventually all the visited institutions use spatial data in shapefile format with. CENACARTA being the only institution that works with many different file formats. Their spatial databases stores spatial data also in the following formats: JPG (IMG), Tiff, and GeoTiff for images.

The department of ITC within the Ministry of Education and Culture, and DINAPOT apart from shapefiles both manipulates files in .map format. Apart from shapefiles and map formats the department of Cadastre as well as DINAPOT are using CAD file format.

Spatial data produced by the CENACARTA are at different scales depending on the needs. For example, a base map on the scale 1:25.000 is more detailed than a map with data on a scale of 1:50.000, this is because of the amount of information or objects that can be represented on the map.

5.1.3 Tools Uses

In this section, I present my research findings on data collection processes, with a particular focus on the tools used and formats used to save spatial data. To begin with, I will write about the tools used for data collection, then the tools used for data processing, and I will finish off with a section on the tools used for data presentation.

5.1.3.1 For data Collection

Data collection is a process of collecting data that must be used for various purposes. Data collection is defined as a process of preparing and collecting data where the main purpose is to obtain data to keep on record, to make important decisions, and to provide information to others.

It was noted that, before starting the process of capturing of spatial data, important aspects have been defined, for example, it is defined the scale that the GPS will use; it is also defined which coordinated system will be used.

- **Paper forms**

Paper form serves as an interface to register data that is collected during the fieldwork. In each of the visited institutions I found out that it uses a standardized paper form as a template for data collection. People who decide to collect data use this paper form to store the data. These paper forms contain basically sections related to spatial data and others to non spatial data. For

example, CENACARTA was used in two templates for the fieldwork. The figures below show two templates used for the above mentioned fieldwork.

The template A (see Figure 16), the one with a larger image, is used to pinpoint the location where a Global Position System recording is to be made. The template B (see Figure 17) is also used to locate the position where the work must be done. However the difference between those templates is that template B already comes with geographical coordinates of the place, so it is easier to locate the place where the work will be done.

Figure 16 Template A

Figure 17 Template B

The Figure 18 is another template used at CENACARTA to register spatial data, and information such as who took the measurements for the location in question. It should be noted that this template initially shows the target location's coordinates. This information serves also to find the place where the work has to be done, and to correct the coordinates in cases where the technicians find that the given coordinates are wrong.

CENACARTA – GPS – GCP SKETCH

CORRECÇÃO DE IMAGEM: XAI-XAI		**GCP No. :01**
ZONA:		**DATA:06.08.2007**
X aprox: 564,143.01	**Y aprox: 7,230,477.34**	**Z aprox:**

X final:	**Y final:**	**Z final:**

Comentários: *Escala 1: 1000*_____

_____

_____

_____

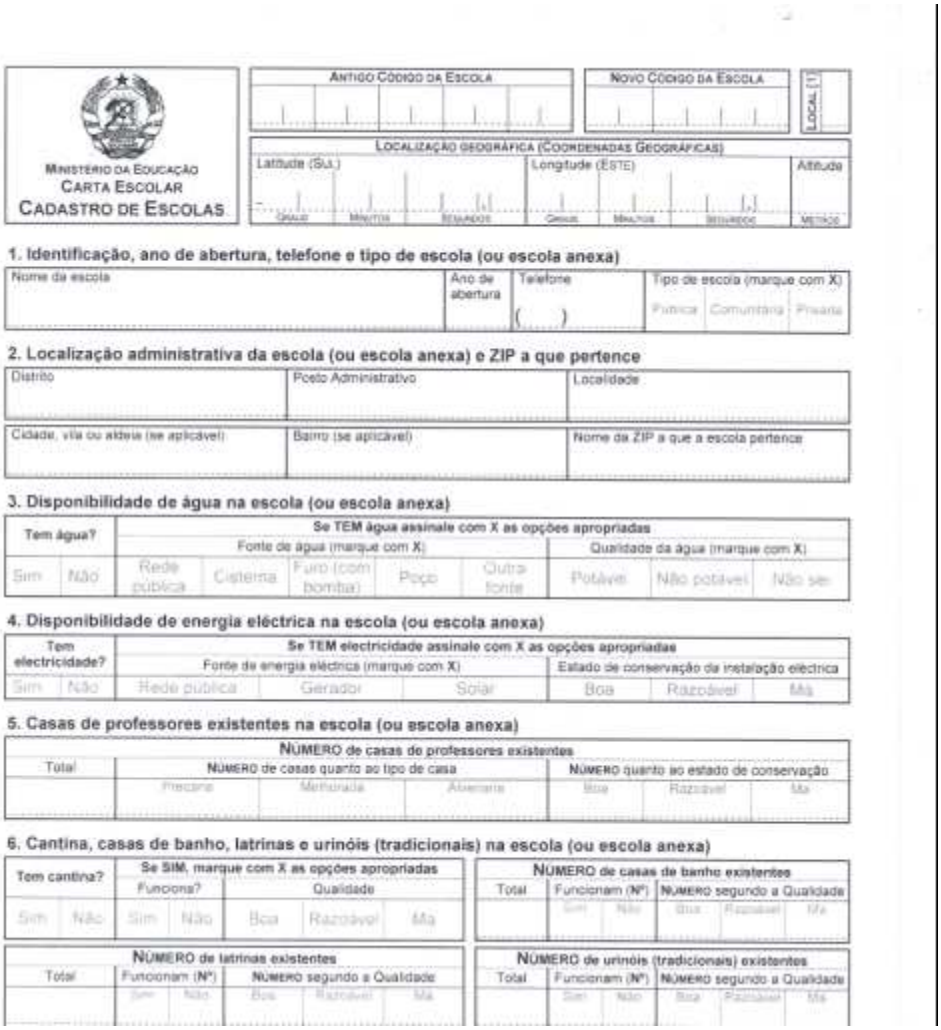
_____

_____

ALTURA DA ANTENA:	**SKETCH_01_DE_16**
MEDIU:	**VERIFICOU:**

Figure 18 Template called Sketch Maior

The following templates below (see Figure 19, Figure 20 and Figure 21) were used during the process of collecting spatial and non spatial data of schools, water supplies, and delimited area respectively within the country.



MINISTÉRIO DA EDUCAÇÃO
CARTA ESCOLAR
CADASTRO DE ESCOLAS

ANTIGO CÓDIGO DA ESCOLA | NOVO CÓDIGO DA ESCOLA | LOCAL [1]

LOCALIZAÇÃO GEOGRÁFICA (COORDENADAS GEOGRÁFICAS)
Latitude (SUL) | Longitude (ESTE) | Altitude

1. Identificação, ano de abertura, telefone e tipo de escola (ou escola anexa)

Nome da escola	Ano de abertura	Telefone	Tipo de escola (marque com X)
		( )	Pública / Comunitária / Privada

2. Localização administrativa da escola (ou escola anexa) e ZIP a que pertence

Distrito	Posto Administrativo	Localidade

Cidade, vila ou aldeia (se aplicável)	Bairro (se aplicável)	Nome da ZIP a que a escola pertence

3. Disponibilidade de água na escola (ou escola anexa)

Tem água?		Se TEM água assinale com X as opções apropriadas							
		Fonte de água (marque com X)					Qualidade da água (marque com X)		
Sim	Não	Rede pública	Cisterna	Furo (com bomba)	Poço	Outra fonte	Potável	Não potável	Não sei

4. Disponibilidade de energia eléctrica na escola (ou escola anexa)

Tem electricidade?		Se TEM electricidade assinale com X as opções apropriadas					
		Fonte de energia eléctrica (marque com X)			Estado de conservação da instalação eléctrica		
Sim	Não	Rede pública	Gerador	Solar	Boa	Razoável	Má

5. Casas de professores existentes na escola (ou escola anexa)

NÚMERO de casas de professores existentes						
Total	NÚMERO de casas quanto ao tipo de casa			NÚMERO quanto ao estado de conservação		
	Precária	Melhorada	Alvenaria	Boa	Razoável	Má

6. Cantina, casas de banho, latrinas e urinóis (tradicionais) na escola (ou escola anexa)

Tem cantina?		Se SIM, marque com X as opções apropriadas						NÚMERO de casas de banho existentes				
		Funciona?		Qualidade				Total	Funcionam (Nº)		NÚMERO segundo a Qualidade	
Sim	Não	Sim	Não	Boa	Razoável	Má			Sim	Não	Boa	Razoável	Má

NÚMERO de latrinas existentes						NÚMERO de urinóis (tradicionais) existentes					
Total	Funcionam (Nº)		NÚMERO segundo a Qualidade			Total	Funcionam (Nº)		NÚMERO segundo a Qualidade		
	Sim	Não	Boa	Razoável	Má		Sim	Não	Boa	Razoável	Má

Figure 19 Template used at MEC

MINISTÉRIO DAS OBRAS PÚBLICAS E HABITAÇÃO
Direcção Nacional das Águas
Departamento de Água Rural

Ficha de levantamento de uma fonte de água **Identificação da fonte**

Código anterior: _____ Código actual: _____

Nome da fonte: _____

Localização geográfica

Folha Nº: _____ Longitude: _____ Latitude: _____ Cota: _____

Província:_____ Distrito:_____ Posto Adm.:_____

Vila:_____ Localidade:_____ Bairro/Aldeia: _____

Data da entrega	
Financiador:	
Empreiteiro:	
Fiscal	
Custo total da obra:	

Figure 20 Template to collect spatial and non spatial data at National Directorate of Water

Anexo nº7

INSTITUTO NACIONAL DE ESTATÍSTICA
III RECENSEAMENTO GERAL DE POPULAÇÃO E HABITAÇÃO, 2007
MOLELO PARA A ÁREA DE ENUMERAÇÃO (AE)

Provincia	Distrito		Posto Administativo de	
Localidade de		N1	N2	N3
Nome do Cartografo				
Data inicio da delimitação da AE. / /200			Data da Conclusão da delimitação da AE. / / 200	
Total de Agregado Familiar da AE			Número da AE	

Limites da Área de Enumeração

Ordem do GPS	Coordenadas		Nome da referência	Observação
	Easting	*Northing*		

Referência Interna da Área Enumeração

Ordem do GPS	Coordenadas		Nome da referência	Observação
	Easting	*Northing*		

Figure 21 Template used Census in 2007 by INE

From these cases where the paper forms are used to register data, after data collection, the fields on the paper form were matched to the fields in their respective database. The goal of that was at all to automate by transferring from the paper to the computer.

- **Software**

  For the data collection, all institutions make use of Global Position System[3] (GPS) software to capture spatial data. As referred in literature review chapter GPS is a tool that enables the capturing of spatial data of any object in the Earth.

  For example, MICOA uses GPS machine developed by Garmin Company. The Garmin GPS has also a software application that enables the data to be transferred from GPS Machine to the computer.

  On the other hand, because CENACARTA, apart from GPS machine data also uses satellite image and aerial photographic in order to capture images of space, additional software is used to store this information. Most of this software comes with the tools used to capture those images.

  It also noted that after the fieldwork the data collected was entered into a computer. Thus most of them were registered in MS Excel application. For example, the department of rural water was using application Microsoft Excel to register data. The same application was also used at Department of Cartography and Operations of INE.

5.1.3.2 For Data Processing

At this stage, tools used to process the spatial data are presented. Basically data processing is defined as a set of programs or computing functions that enables to organize and manipulate data, either numeric or non numeric data.

[3] Global Position System (GPS) was developed in 1979 by Department of Defense of USA which shows the location of any entity on earth anywhere, any time in any weather. Retrieved at < http://www.aero.org/education/primers/gps/whatisgps.html > at 24.02.09

Based on the scope of this thesis, I found that there are a vast range of software's programs being used by the institutions to process spatial data. The ArcGIS software is a completed integrated system developed by Environmental Systems Research Institute[4] (ESRI) that enables users to deploy Geographic Information Systems functionality wherever it is needed. This is an advanced version of the ArcView. This software application has different features that enable to carry out a vast range of spatial analysis. As presented earlier this software (ArcGIS and ArcView) is being used by all institutions that were visited during the study.

Erdas Imagine designed to enables users to prepare, store, display digital images, satellite images to be used in any GIS software or CAD. This is particularly used at Cenacarta for different purposes once they have been working with satellite images and aerial photography.

On the other hand, to create maps MEC, the National Directorate of Planning and Land at the MICOA apart from ArcView, it is using MapInfo, and ILWIS software. MapInfo is software developed that enables to design geographic information systems applications based on specific tools. The ILWIS was acquired because is freely available, while another ones the DINAPOT had to buy. Despite that, the interviewee from DINAPOT said that it was in progress the development of a system built on the basis of the MS Access and ArcExplorer tools. The purpose of the system is to provide information to the general public using the Internet.

Table 8 Software used for data processing and analysis

Company	Organization					
	Cenacarta	INE	MEC	MICOA	DNA	DC
ESRI products	ArcGis ArcView ArcMap	ArcGis	ArcView ArcExplorer	ArcView 3.2 ArcGIS ArcExplores	ArcView 3.3	ArcGis 9.2
MapInfo	MapInfo		MapInfo	MapInfo		
Erdas Imagine	Erdas Imagine					
DesktopCAD				CAD		CAD
ILWIS				ILWIS		

[4] ESRI was founded in 1969 with a mission focus on the principles of organizing and analyzing geographic information. The company's focus remains on producing excellent software and delivering exceptional service to users. Retrieved at < http://www.esri.com/company/about/history.html >

Apart of ArcView that they used to manipulate spatial data the department of rural water used a database called *Rural Water Data Base for Provincial Directorate of POPH* (Direccao Provincial de Obras Publicas e Habitacao) based on MS Access application.

5.1.3.3 For Data Analysis

For data analysis the six organizations have used the same software's used for data processing. For example, Department of Cartography and Operations of INE, CENACARTA, as well as Department of Cadastre of Maputo Council are using ArcGis software to analyse data through the maps.

5.2 Data Sharing Issues

During the fieldwork it was found that the departments have been asking from data produced by external organizations outside of their own organization, even within inter departmental in same environment. As example the Ministry of Education and Culture provides the spatial information and detailed information of education situation that produces to National Institute of Statistics. The Ministry of Education and Culture not only provides information to other institutions as well as receive information from the Ministry of Health that is related to the location of health facilities; Ministry for Coordination of Women and Social Action related to the location of nurseries, kindergartens, or in education pre-school; Ministry of Industry and Trade related to the location of shops, markets, malls, etc.; DINAGECA/CENACARTA where they request clean maps; and again from INE that is related to the total number of population in a given region, projected development of each region, information of the social infrastructure of the country in general, whose information is then cross between the two institutions.

It found that, for instance the Statistic and IT departments within the Ministry of Education and Culture provide their spatial data and detailed information of education situation to institutions like Cadastre and Operation department within the National Institute of Statistics.

Table 9 Externally spatial datasets that Ministry of Education and Culture makes use

Spatial Dataset	Owner
Health facilities	Ministry of Health
Population number, social infrastructure of the country	National Institute of Statistic
location of nurseries, kindergartens, or in education pre-school	Ministry for Coordination of Women and Social Action
location of shops, markets, malls, etc.	Ministry of Industry and Trade
Base map	Cenacarta

In the same way DINAPOT makes uses of spatial data produced by others institutions like CENACARTA, National Administration of Roads, and Ministry of State Administration. The Table 10 illustrates the datasets that these institutions provide to DINAPOT.

Table 10 Externally spatial datasets that DINAPOT makes use

Spatial Dataset	Owner
Grounds	Instituto de Investigação Agrária de Moçambique (IIAM)
Roads	National Administration of Roads
Administration division	Ministry of State Administration
Rivers	Cenacarta

Based on the findings, the majority of the department's have been requesting spatial data via ad hoc levels. For example, CENACARTA sells geo referenced information through CD-Rom device. Whereas, CENACARTA is the one that make geo referenced information like roads, rivers, administrative division of the country, available to general public through their website. In this case, data is available through an infrastructural level of sharing, because everyone can have access to data that the website displays and uses it for various purposes.

5.2.1 Data formats problems faced while attempting to share data

For instance, when I analyzed the data of two provinces from INE datasets I found that the same data was organized in different ways. One province created a filed called *Position* and stored the coordinates (Latitude and Longitude) while the other province created two columns (Latitude and Longitude) and filled the date separately. The fields latitude and longitude that compose the geographical coordinates normally are registered in different columns. However, it is clear that for sharing purposes data of Manica province where both fields were found in one column it is hard to be shared with other institutions. The Figure 22 below illustrates these cases. On the first case (Case A)**Error! Reference source not found.** the column painted with a red colour shows that the geographical coordinates were registered in a unique column. Despite that, from the second case (Case B), the geographical coordinates painted with red colour were registered in different columns.

Case A: Manica Province

A	B
Infra-estrutura	Position
CS Eduardo Mondlane	-19.11049 33.47641
CS de Gondola	-19.07698 33.64152
CSM de Chiuala	-18.40715 33.24046
CSM de Espungabera	-20.45276 32.77214
CSM de Inhazonia	-17.94810 33.19436
CSM da Missão	-19.95943 33.36048
CSM de Chitobe	-20.82441 33.36979
CSM de Macossa	-17.89980 33.93918
CSM de Mungári	-17.16432 33.55202
CSM de Nhacafula	-16.87035 34.07635
CSM de Guro	-17.41974 33.34912
CSM de Sussundenga	-19.40957 33.29404
CSM de Chissui	-19.14317 33.44788
CSM de Nhamaonha	-19.12426 33.49926
CSM de 1º de Maio	-19.11447 33.45803
CSM de Vanduzi	-18.95355 33.26479
EP1 de Zimpinga	-19.11410 33.82934
EP1 de Socel (anexa)	-19.10190 33.77188
EP1 de Socel	-19.10105 33.77155
EP1 de Zimpinga (anexa)	-19.10120 33.85025
EP1 de Nbia-Bongue	-19.09442 33.89448
EP1 de Bamba (anexa)	-16.87716 33.57985
EP1 de Bamba	-16.92820 33.58119
EP1 de Bamba (anexa)	-16.97204 33.53902
EP1 de Chigombe	-16.88292 33.76402

Case B Zambezia Province

A	B	C
INFRA-ESTRUTURA	LAT	LON
Centro de Alfbetização	-17.1985335	+35.8412057
Centro de Alfbetização	-17.2372002	+35.8342051
Centro de Alfbetização	-17.0396609	+36.2091887
C.de Alf.de Adultos	-16.3173849	+35.7582557
C.de Alf.de Jovens	-16.2955410	+35.7961231
C.de Alf.de Adultos	-16.2358672	+35.7684803
C.de Alf.de Adultos	-16.2524862	+35.7998781
C.de Alf.de Adultos	-16.4686991	+36.1847055
C.de Alf.de Adultos	-16.5276808	+36.1261099
CS de Tetete	-15.3865243	+36.5263974
CS de Lioma	-15.1719476	+36.8049770
CS de Rigone	-15.7492662	+36.7890769
CS de Namarroi	-15.9538759	+36.8659812
CS Tipo 2 de Muliquela	-15.9542460	+37.1208769
CS de Mugema	-15.3981220	+37.5547780
CS de UP- 4	-15.4565840	+36.9553520
CS de Tacuane	-16.3668931	+36.5152448
CS de Lugela	-16.4255638	+36.7432433
CS de Nante	-17.4383230	+37.2857201
CS 4 de Dezembro	-17.8802169	+36.8916660
CS de 24 de Julho	-17.8753836	+36.8810767
CSM de Sabe	-17.6160247	+35.5253005
CSM de Macuarro	-15.7713354	+37.0844739
CSM de Serra 2	-15.3150649	+36.6588288
CSM de Uede	-16.0883779	+36.9593972

Figure 22 Forms used to organized fields

The above cases have other aspects that are also related to the used terminology. Different names were given to the columns that refer to the same geo referenced data (latitude and longitude). For example, dataset from Manica province used the name *Position* while the dataset from Zambezia used Lat to refer Latitude and Long to Longitude. In addition to that, it was visible that in the same template two languages, Portuguese and English were used. (See Figure 21 and Figure 22)

Data sharing between organizations is limited to data converters, transfer standards, and later open file formats. Furthermore although most of spatial data exist in digital form, a great amount of data still exists in paper form and is outdated. For example, at department cadastre the interviewee said that most of spatial data are outdated even though they had to convert from map paper to computer by scanning.

Despite the interviewees had not provide examples of type converters that they use, since they use data collected by external institutions that in turn are not compatible with them, from the GIS technologies that they use, they noticed that data converters are used. For instance, DCO of National Institute of Statistic works with ArcGIS software while Ministry of Education and Culture use MapInfo software. Each one supports different file formats. In this case, data converters are used in order to adjust the data in the format used by the institution.

5.2.2 Technical Issues hampering data sharing

Most of the times and according to one interviewee from CENACARTA the spatial data and maps are converted from one format to another, depending on the needs, and in this process some data lose their quality because they become unobtrusive and mangled, that because of the initial format, scale and pattern used.
When asked about the problems related to data quality, the interviewee of INE replied: "*The data in most case is not accurate. For example, the Ministry of Education and Culture has geographic data of some schools. To make sure that this data is accurate it is important to know how the Ministry of Education and Culture has collected that data; the data is not saved automatically, in others words, first copied the data from Global Position System to paper, and then the data from the paper is introduced in a computer.*"

This is a specific example of problem of data quality. Another example that the interviewee had described comes from the use of system of spatial data. If the Datum[5] used is not the same used at geodetic coordinates can also reduce the quality of data.

[5] Geodetic datum or datum defines the size and shape of the earth and the origin and orientation of the coordinate systems used to map the earth. Hundreds of datum is in use around the world. Source: < http://www.colorado.edu/geography/gcraft/notes/datum/datum_f.html > 27.02.09

One of the interviewee from the ministry mentioned that "much data could be used but actually there is lack of knowledge of existence of data such as health facilities, water, etc. they don't use it."

When asked about problems that CENACARTA has been facing, the interviewee replied that the lack of hardware equipment affects the normal way to perform the activities on time. This is because most of the equipment that they have it was installed in the decade 60. Therefore, according to the interviewee *"a base map in the 1.50.000 scale under normal conditions should take 3 days to update, at the present, it takes approximately 90 days because the work is largely done manual."*

5.2.3 Organizational Issues hampering data sharing

One of the basic aspects that the literature has been is concerned to the organizational aspects. For example the implementation of any GIS requires a strong knowledge and education infrastructure within the organization acquired by providing training programs to all users that will direct or indirectly work with GIS. (Ghaffar 2002)

The most common problem that the interviewees described within their organizations is related to the lack of expertise and the reduced number of people to deal with spatial data and Geographic information system. From the Figure 23 it is obvious that there is lack of people that work with GIS, except Cenacarta and National Institute of Statistic that have considerable number. From the Figure 23 is not represented the number of people using GIS technology in DINAPOT. Despite this, the interviewee indicated that the number of users is very low.

The lack of expertise was observed for different reasons. For example at Cenacarta, the interviewee said that they have lack of specialized people in various areas such as cartographers, geographers. For example, the interviewee stresses that the country of Mozambique does not form cartographers.

The interviewee also pointed out that most of technicians, though in a considerable number, are those that were formed in 1982 at Eduardo Mondlane University in Geography course, and then after many years there is a need to bring new people. However, some of them are aboard having education training in GIS area.

The university introduced a new course called Science of Geographic Information, which means they will be formed around 2012 according to the interviewee. Until then, the Cenacarta still works with the personnel staff that they have. The interviewee of Cenacarta believes that these future graduated students will contribute to overcome the lack of specialized works in geographic information systems.

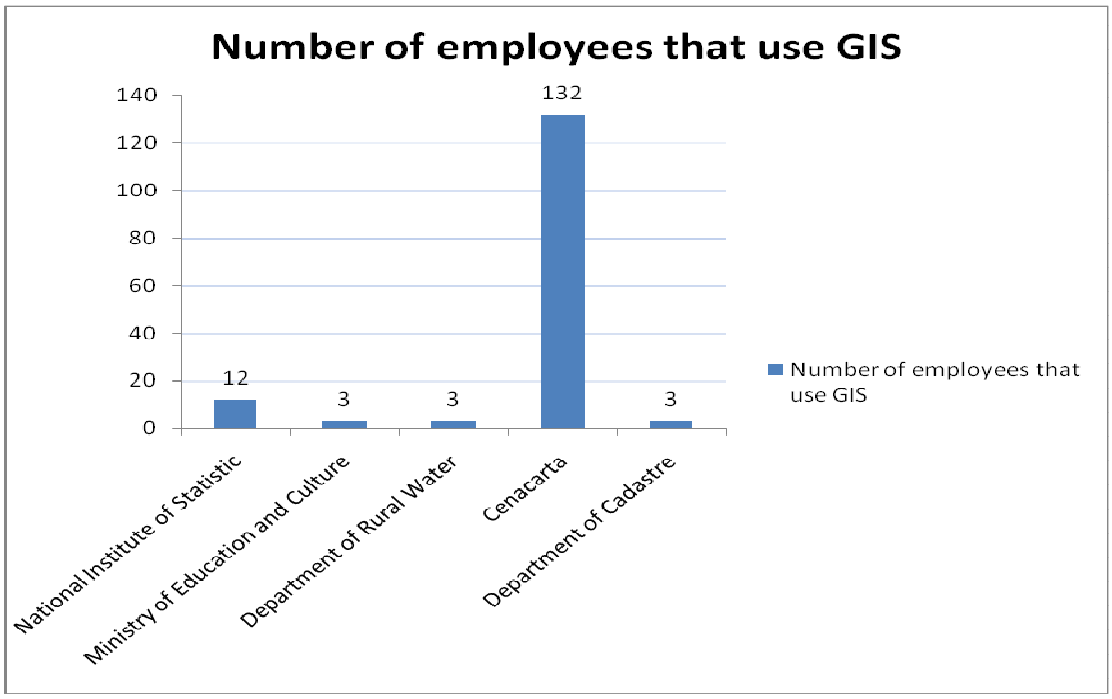


Figure 23 Number of people that work with GIS

Moreover, the interviewee of Department of Cartography and Operations of INE explained that one reason that inhibits the growth of the organization is related to the constant change of people to another place. As a result in most cases the workers that were got used to do things in the way that their managers had defined, when a new manager comes, the workers must follow the tasks according to the way the new manager defines. Despite that, the use of GIS at Ministry of Education and Culture is still "restricted" to a small group of staff, because this technology has recently been introduced within the institution.

In the Department of Rural Water when the GIS were introduced they had provided education training to their technicians with sponsorship of Japan government. In the same way with other

organizations the department lack on people with appropriate skills where only three people work with spatial data within a total number of 35 technicians that the department has.

Nevertheless, the organizations had provided training on GIS. In most cases, training was provided before and during the introduction of GIS. For example, before the acquisition of introducing of Geographic Information Systems at the department of cadastre some technicians were sent to Portugal for training in that area.

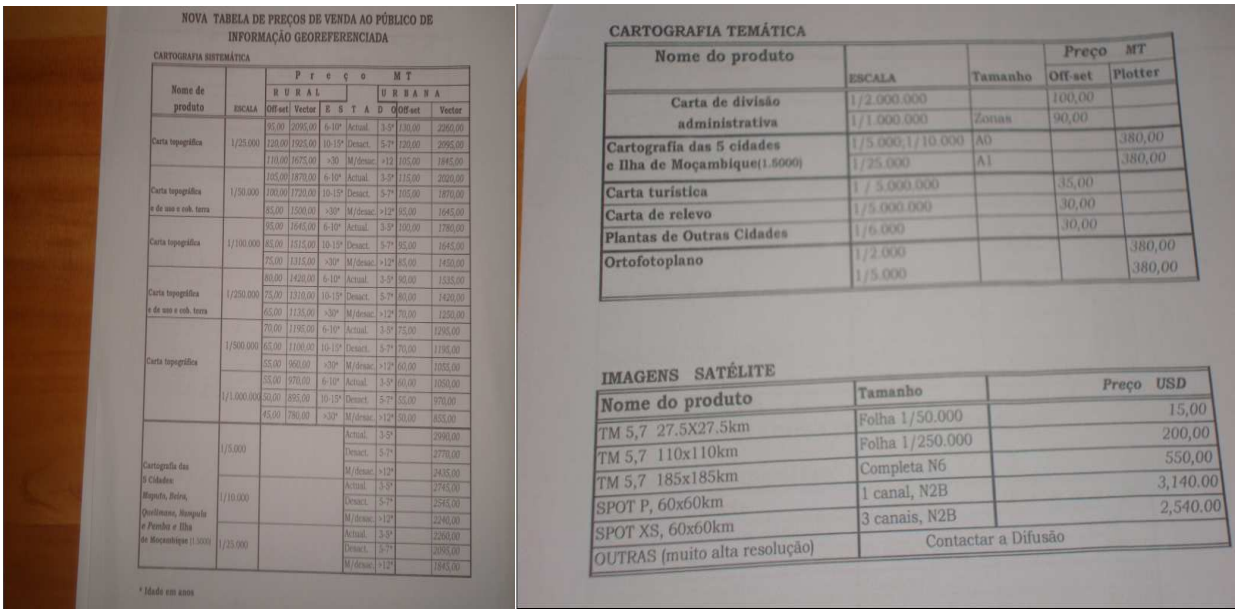
At the beginning of the mapping of the data, the department received students from the Faculty of Geography from Eduardo Mondlane University, and it was decided that they might help in the activity if they worked separately. Thus one computer was provided to each student working with a specific layer. At the end of the day the layers were merged.

However, two months later it was discovered that in every time the layer were merged the objects of the layer were putting on top, in each line there were more than 40 decorative overlays. After so many turns they managed to solve the problem with support of resource to some scripts founded in Internet for overlap. This case shows that the users, system staff the ones that were doing the work, as well as profession users the ones that were controlling the work from Department of Cadastre were not well equipped to avoid this mistake.

When the GIS were introduced within the Department of Rural Water, the institution provided training to his technicians with the sponsorship of Japan government. The objective was to mapping all infrastructure of rural water supply, as a way to improve planning, monitoring and decision making.

Access to spatial data is another issue faced by general public or particular companies. CENACARTA the institution that has the responsibility to disseminate spatial data, sells most of data, however some is distributed freely. The pricing is defined by Mozambican state, and according to the interviewee the price in most cases that the state defines does not compensate the production of such data. Although CENACARTA is an autonomy company the policies like prices of products that their produce is regulated by state.

The Figure 24 illustrates the table of prices of geographical information from CENACARTA for general public of products such as systematic cartography, thematic cartography and satellite images. From the table, it was noted that the prices are defined according to the age of data, scale, and the form that the customer need the data (paper format or electronic format).



NOVA TABELA DE PREÇOS DE VENDA AO PÚBLICO DE INFORMAÇÃO GEOREFERENCIADA

CARTOGRAFIA SISTEMÁTICA

Nome de produto	ESCALA	Preço MT						
		RURAL				URBANA		
		Off-set	Vector	ESTADO		Off-set	Vector
Carta topográfica	1/25.000	95,00	2095,00	6-10*	Actual.	3-5*	130,00	2260,00
		120,00	1925,00	10-15*	Desact.	5-7*	120,00	2095,00
		110,00	1675,00	>30	M/desac.	>12	105,00	1845,00
Carta topográfica e de uso e cob. terra	1/50.000	105,00	1870,00	6-10*	Actual.	3-5*	115,00	2020,00
		100,00	1720,00	10-15*	Desact.	5-7*	105,00	1870,00
		85,00	1500,00	>30*	M/desac.	>12*	85,00	1645,00
Carta topográfica	1/100.000	95,00	1645,00	6-10*	Actual.	3-5*	100,00	1780,00
		85,00	1515,00	10-15*	Desact.	5-7*	95,00	1645,00
		75,00	1315,00	>30*	M/desac.	>12*	85,00	1450,00
Carta topográfica e de uso e cob. terra	1/250.000	80,00	1420,00	6-10*	Actual.	3-5*	90,00	1535,00
		75,00	1310,00	10-15*	Desact.	5-7*	80,00	1420,00
		65,00	1135,00	>30*	M/desac.	>12*	70,00	1250,00
Carta topográfica	1/500.000	70,00	1195,00	6-10*	Actual.	3-5*	75,00	1295,00
		65,00	1100,00	10-15*	Desact.	5-7*	70,00	1195,00
		55,00	960,00	>30*	M/desac.	>12*	60,00	1055,00
	1/1.000.000	55,00	970,00	6-10*	Actual.	3-5*	60,00	1050,00
		50,00	895,00	10-15*	Desact.	5-7*	55,00	970,00
		45,00	780,00	>30*	M/desac.	>12*	50,00	855,00
Cartografia das 5 Cidades: Maputo, Beira, Quelimane, Nampula e Pemba e Ilha de Moçambique (1:5000)	1/5.000				Actual.	3-5*		2990,00
					Desact.	5-7*		2770,00
					M/desac.	>12*		2435,00
	1/10.000				Actual.	3-5*		2745,00
					Desact.	5-7*		2545,00
					M/desac.	>12*		2240,00
	1/25.000				Actual.	3-5*		2260,00
					Desact.	5-7*		2095,00
					M/desac.	>12*		1845,00

* Idade em anos

CARTOGRAFIA TEMÁTICA

Nome do produto	ESCALA	Tamanho	Preço MT	
			Off-set	Plotter
Carta de divisão administrativa	1/2.000.000		100,00	
	1/1.000.000	Zonas	90,00	
Cartografia das 5 cidades e Ilha de Moçambique(1.5000)	1/5.000;1/10.000	A0		380,00
	1/25.000	A1		380,00
Carta turística	1 / 5.000.000		35,00	
Carta de relevo	1/5.000.000		30,00	
Plantas de Outras Cidades	1/6.000		30,00	
Ortofotoplano	1/2.000			380,00
	1/5.000			380,00

IMAGENS SATÉLITE

Nome do produto	Tamanho	Preço USD
TM 5,7 27.5X27.5km	Folha 1/50.000	15,00
TM 5,7 110x110km	Folha 1/250.000	200,00
TM 5,7 185x185km	Completa N6	550,00
SPOT P, 60x60km	1 canal, N2B	3,140.00
SPOT XS, 60x60km	3 canais, N2B	2,540.00
OUTRAS (muito alta resolução)	Contactar a Difusão	

Figure 24 Table of retail selling price of georeferenced information by CENACARTA

5.2.4 Geographical and Temporal Issues

Temporal issues are the ones related to the time that spatial data is collected and when the same data is used. The findings show that most of base maps have more than thirty years ago. For example CENACARTA, the one that produces and sells base maps have spatial data not updated. For example, base maps at 1.25.000 scale, 1.100.000, 1.500.000, 1.1.000.000 have more than 30 years old. The Table 11 below illustrates some base maps gathered from CENACARTA.

A similar point it was found in Department of Cadastre of Maputo Council. From there, the interviewee said that most of the spatial data were in a paper format and it was not updated, so the analysis data they have been making are based on those non updated base maps.

Table 11 Base maps from CENACARTA. Source: Table of Pricings of geo referenced data

Type of map	Scale	Years old	State
Base map	1.25.000	More than 30	Not updated
	1.25.000	Between 5 to 7 years	Not updated
	1.100.000	More than 30	Not updated
	1.100.000	Between 10 to 15 years	Not updated
Base map and land use	1.50.000	More than 30	Not updated
Base maps of 5 cities: Maputo, Beira, Quelimane, Nampula, Pemba and Mozambique Island	1.5000	More than 12	Not updated
		Between 5 to 7 years	Not updated

The geographical issues have the same treatment as temporal issues; however the geographical issues are related to data formats and resolution used during the process of spatial data collection. For example, the interviewee from Department of Cartography and Operations of National Institute of Statistic pointed out that:

"Problems of data quality arise because different organizations have been using different scales and resolution when collecting data. For example, GIS requires that the scale used must be defined before the data collection, so when times of having data from external sources, problems of integration arise."

From the Table 11 it is visible that maps bases produced in CENACARTA are in different scales. So it is responsibility of the customer to choose the scale that can fit with their interests. As example, the Department of Cadastre used the base maps from CENACARTA for building upon the thematic maps for their purposes.

At CENACARTA it was found that spatial data are updated according to the kind of data. For example my interviewee said that topographic base maps are updated every 10 years; thematic data like land use are updated every 5 years; and finally satellite images are updated daily.

However, Cenacarta has outdated maps from more than 40 years ago that need updating. Administrative division map of the country is another one that is not updated. Cenacarta produces base maps at 1.50.000 scale which is available to the general public with restrictions. This information is not only for local use, it is provided to institutions such as National Institute of Statistic, Ministry of Education and Culture, National Directorate of Water, other institutions, and also to the public in general. This geographic information should be accessed through payment or freely at Cenacarta. There is an official document that defines rules to request permission for aerial surveys over the country. Free information that includes spatial data is also available through internet on the Cenacarta website (http://www.cenacarta.com).

5.3 Reflections

The aim of this section is to describe important notes in the form of summary of what I was presenting previously in this chapter. I organized the summary in two following parties: lessons learned and best practices. In the lessons learned I present aspects that are important to consider, either positive or negative aspects that I have learned regarding on how organizations use spatial data. Apart from that, in best practices I present the main aspects that organizations can use in their environment.

5.4 Lessons Learned

The very little or no prior knowledge of GIS inhibits growth of changes. If the users have appropriate knowledge to manage GIS, then it will be a considerable advance on the implementation of any GIS. The cases show that there are few people working with GIS and from that they it was found that the lack of skills inhibit much improvements in regards to GIS.

The use of different nomenclatures or attributes makes it difficult to integrate and share data from different sources. A great deal of spatial data is organized based on some specifications like the use of nomenclatures to define each object, the relationship between different datasets. Despite that, the findings show that the different rules and the terminologies used for geographic data complicate spatial data sharing, reuse, and spatial data integration and fusion.

Another important aspect that the findings show is that GIS can be used for multiple purposes. This can be seen for the institutions that I used for the field where they used GIS as a tool to enable them to take actions. For that, they require base map that serves as a starting point to draw maps. Apart from that it requires external data that enables them to make decisions based on real situation.

5.5 Best Practices

I found that the more interesting aspect followed by all departments are related to the use of templates used for fieldwork. The templates not only help the technicians to record data, but also enable them to have registered data for many years that could be used in the future.

Apart from templates for data collection, I observed from the databases that I have accessed that they have been using the same terminologies of names, although I found some mistakes on them, it is noted that terminologies allow them to use same standards so that data could be easily used by many systems. For example, the Ministry of Health had defined nomenclatures make refers for the health facilities such as *Centro de Saúde* abbreviating is CS. This nomenclature is then used by as a way to have a standard form to denominate it. From department of Cartography and Operations of INE I found the same nomenclature used (see Figure 25). The nomenclature is accompanied by respective code.

INFRA-ESTRUTURA	ABREV	CODICO
CS de Tetete	CS	12
CS de Lioma	CS	12
CS de Rigone	CS	12
CS de Namarroi	CS	12
CS Tipo 2 de Muliquela	CS	12
CS de Mugema	CS	12
CS de UP- 4	CS	12
CS de Tacuane	CS	12
CS de Lugela	CS	12
CS de Nante	CS	12
CS 4 de Dezembro	CS	12
CS de 24 de Julho	CS	12
CSM de Sabe	CSM	4
CSM de Macuarro	CSM	4
CSM de Serra 2	CSM	4
CSM de Uede	CSM	4

Figure 25 Nomenclature defined by Health Ministry and then used by INE

Chapter 6 - ANALYSIS AND DISCUSSION

In this chapter I analyze my research findings based towards the research questions addressed in this thesis. The aim of this chapter is to answer the following research questions:

- *What are the major limitations of the use of Geographic Information Systems in public institutions in Mozambique?*
- *What are the major limitations for spatial data sharing (integration) between various public institutions?*
- *What strategies can be developed in order to allow easy spatial data sharing collected and managed by different institutions?*

In order to answer the research questions proposed, I set four research objectives: (i) analyze the actual stage/level of spatial data use in public institution; (ii) find out if the institutions have been collaborating in data sharing among them; (iii) find out the constraints that these institutions face in using Geographic Information Systems to understand spatial related problems in Mozambique; and (iv) to provide guidelines to be followed when dealing with multi-sectorial spatial related problems.

6.1 Data Sharing Issues

Based on my research questions, one of the issues I wanted to understand is the level of data sharing within the institutions that I have visited. Additionally I intended through the research to find the constraints that inhibit spatial data sharing among public institutions.

This section will discuss the questions: *What are the major limitations of the use of Geographic Information Systems in public institutions in Mozambique? and What are the major limitations for spatial data sharing (integration) between various public institutions question?*

In general, most of the institutions have required data produced and managed by external sources. The external sources in this context can be external institutions or other departments within the same institution.

The findings indicated that, the exchange of data in different organizations is mainly done in ad hoc way. Data sharing at ad hoc levels suggests that the transfer of data in based on requesting from one actor to another one and according to the Yeung and Hall (2007) this process of data exchange is done manually through diskettes, CD-Rom, etc. In the case of Mozambique, and from the findings, the exchange of data is done using the above devices; one reason at first glance is that the use of network like Internet is not yet stable especially in rural areas that have lack of electricity. But this is not a real challenge because the involved visited institutions that manage spatial data are all located in Maputo, capital of Mozambique, where problems of internet is not at all high. The impact of ad hoc way of exchange data in the GIS integration is viewed as dependent on the physical transfer of data between computer systems. As a result the data sharing between the institutions in Mozambique will still characterized by the typical request and response relationship (Yeung and Hall 2007).

In contrast, Yeung and Hall (2007) argued that spatial data sharing should be implemented as a proactive information technology strategy for an organization rather than a reactive strategy. Thus they suggested that the spatial data sharing should be based on virtual sharing where an application is able to use data simultaneously on multiple servers over a network.

It was expected that within a particular organization the exchange of data was done using a local network, for example intranet. However, I found a different scenario. In an institution where one department needed data from another department, they had to go personally and receive it in ad hoc form. Under this circumstance Yeung and Hall (2007) propose that, the use of computer connected through a simple network within the organization is suitable when homogeneous data must be transferred.

Despite those problems, the good thing that I found is the use of Internet to access to spatial information. For example, as I noted in my findings chapter, the CENACARTA is the one that make some data available through the Internet by downloading it. The reason for that according to the interview was that the center received many requests for various sorts of spatial data from

students, general public, as well (non) public institutions. The use of web access enables all users to access data and reduce the number of inquiries and data requests to staff in each individual organization (NCGICC 2007).

Thus, in this section I analyze the limitations that I have found from my findings that are associated to spatial data sharing. These problems are discussed under four topic areas: lack of specialized people within GIS and related technologies, data format inconsistencies, lack of clear strategy from the government on spatial data.

6.1.1 Lack of Specialized people

The research revealed that there are considerable efforts involved in the use of Geographic Information Systems. However these efforts were limited due the lack of specialized people in the GIS area. Therefore more attention is still needed in order to a GIS become more effective in the management of various areas.

From the findings I found a mix of people with different background, but most of them with no appropriate skills to deal with GIS technologies. Under this circumstance I found that the lack of expertise in GIS it is not only in quantity, but also in quality. For example, in the department of Cadastre of Maputo Council problems arouse because the students from Eduardo Mondlane University were not professional in that area and for them the work was considered a sort of exercise from what they learnt at school. Therefore, they took long time to solve the problem; mainly maybe it was their first time doing such work. Academic educations are encouraged to provide training through the students from geo information course.

The findings also revealed that the change of people from one position to another, contributes to the organization do not develop. About that, an interviewee said:

"*When a new person has a place of leadership, many times the subject will perform the tasks on the basis of the philosophy of this new manager.*"

This situation happens because the new manager comes with new working methods. As a result conflicts between both parties occur. To overcome this, formal discussions are necessary; first the

manager must give notice of how the company was working. Secondly the manager must be able to explain why and how the new methods introduced gains the company.

Although most of the departments where the fieldwork was carried out, provided training to their staff before starting the implementation of GIS, it was found that most of training was sponsored by foreign companies that had some interest on the implementation of GIS. For example, the Department of Cadastre of Maputo Council had a financing in which some technicians were sent to Portugal in order to enrich the knowledge in GIS area. In the case of CENACARTA, some technicians are abroad to training in those areas.

Thus, I think that total dependence on foreign countries inhibit the growth once the training finished; because there is no continuity to equip the staff in GIS. Furthermore, I found that the training took place only at the beginning of the project.

At the end it is expected that training will bring changes in people. Thus in each six of the above situations suggested by Yeung and Hall (2007) at the end people should do different and new things, or perform the same tasks, but in different ways. However, the contrary situation was found. People that work with GIS technology has been improving their knowledge based on personal delivery. For example, an interviewee explained:

"*I will not call them specialists in GIS because they did not have training in that area. However, they have knowledge in that area because of their personal learning."*

The head of departments have in mind why they are using GIS technology. In general, they said that GIS helps to better plan and take decisions in the areas that they manage. However, I felt that for some of them, their technical knowledge is very limited. For example, in one case an interviewee said "*I do not know…we only choose that one*" when asked why the department uses a particular technology.

6.1.2 Data Format Inconsistencies and GIS Technologies

6.1.2.1 Data Format Inconsistencies

One of the major benefits on integration of data is that once the data is collected it can be used for different tasks, organization or general public (Nedovic-Budic and Pinto 2000). Therefore writers argued that the use of same data formats, software from all parts involved enables the sharing of data efficiently.

The interviewees of this study have cited that one of the problems presented in data collected from another institution is related to the lack of data quality. This issue was explained in many ways. One is that during the process of data collection the technician has to set the coordinate system (datum system) that the GPS will follow. However, different institutions have been using different coordinate systems during the process of spatial data collection coordinate system, and because of that problem in data quality arise and time is wasted during the process of making necessary conversions in order to fit with the one used by another organization.

Apart from coordinate system issues, another reason that hampers the use of spatial data is related to the differences in data scales (or resolution) when capturing spatial data.

The differences between them delay the process of transforming in terms of time and costs consuming. However, it is important to consider that during the process of conversion of scales, files formats from the original ones, integration issues arise. In order to avoid future problem in data sharing Loenen (2006) suggests the use of standards that can be used among different stakeholders.

Furthermore, the cases from the findings shown that the technicians have used a similar way to enter data collected from fieldwork to computer; however discrepancies were found. For instance, the case presented in the findings where I mentioned the situation related to differences in handling spatial data where the fields (latitude and longitude) in one province were registered in different columns while in another province was entered in a unique column separated by space. This brings the idea that if one institution (even within the same institution) decided to request data, problems of integration will occur because the system will understand it as one value, they must be separated fields. As result, time is wasted to solve this problem.

Apart from internal formats and according to literature the use of same formats also involved the use of same software to enable the integration more efficiently. However, I argue that the use of different software technologies can be minimized as I described in literature review there are many tools used to convert a file format from one to another one that could be read and used within specific technologies. However, the problem that I see is not only related to the lack of knowledge of existence of data converters tools, but also encompass the lack of skills to deal with them. Thus, there is a need to pay attention to such conversions because it is argued that, during this process of conversion data quality is lost.

6.1.2.2 Heterogeneity in Geographic Information Systems

Geographic Information System is characterized by many actors involved not only in data collection and dissemination of spatial data but also involved in defining prices. In the case of Mozambique, it was found that there are different actors involved on this process of collection and dissemination of spatial data. The CENACARTA within the GIS framework are responsible actors for producing base maps, and topographic maps in different scales. These maps are later on used by different public institutions, education academics, and general public. These actors (DNA, MEC, DC, DINAPOT, INE, etc.) also apart from using the base maps, have also been collecting specific spatial data regarding their organizations. However, the way that those spatial data is collected and stored differs from each other. So when a time of integrating spatial data comes, time consumed becomes a challenge.

Furthermore, the heterogeneity is shown when analyzing the tools used to manipulate spatial data. A mix batch of tools is used within this framework which includes paper forms, computer data, paper maps, GIS technologies, etc.

CENACARTA is the one that have worked satellite images, aerial photographic. However, the findings suggest that much of their equipment is obsolete, and expensive to replace the existing ones. The costs to acquire GIS technologies such as remote sensing camera, aircraft are very expensive. Because of that, there is a need to define a geographic information infrastructure to harmonize the access of spatial data once it is also expensive to collect and maintain it (Loenen 2006; Yeung and Hall 2007).

From the findings it was visible that the institutions have been using updated version of technology, so they are not far from what the market offers in term of products. For example, one organization that I have visited started to use ArcGIS version 8.1, then they convert to version 9.1. Actually they are using ArcGis 9.2.

Despite that, the findings illustrate that the choice of particular software was independent from the ones used in other organizations. Although most of visited institutions have been using common software like ArcGis, ArcView, all products from ESRI, (see Table 8) they did not bear in mind that the choice might enable integration of spatial data with different stakeholders future. For example, one institution had a choice of particular software mainly because of costs. Another one did not find special reasons for buying the software. This point shows that although the use of same software technologies facilitates the process of spatial data integration, it will be difficult to convince all parties to use the same standard. Bearing this idea in mind, Mohammadi, H, et al. (2007) when addressing the advantages in data integration argued that mechanism of converting and guidelines are needed for transforming data from one categorization system to others (Mohammadi, Rajabifard et al. 2007).

However, most of the time, the issue of heterogeneity is influenced by external factors out of the institution. Basically most of the applications used are result of partnerships made between the institutions (within the country or outside the country). Each public institution resorts to international vendors to acquire products such as Global Positioning System (GPS), software like, Erdas, ArcGIS. However, the way that the choice of software was made varies from organization to organization. For example, into the department of Cartographic and Operations of INE, the financing influenced the choice of ArcGis even knowing that the technicians preferred the MapInfo software. Bearing this in mind the interviewee pointed that:

"*There are few people in Mozambique using MapInfo, the ArcGIS technology is most used. In our case we use ESRI Company for the acquisition of ESRI technologies that is represented in Mozambique, so things became easier.*"

Therefore all the factors enable me to say that they did not realize that the option of a particular format either software, scale or data format are all important when talking about integration of

data. Although all of them recognized the need of sharing spatial data by having a common repository, they are not fulfilling the importance on spatial data.

6.1.3 Lack of update spatial data

The CENACARTA is responsible for creating cartographic maps, so that various users coming from vast areas can use it. The findings (see Table 11) revealed that most of the topographic bases are outdated. Updated data allows those who will make use of it to take actions that reflect the reality.

One of the main factors making it difficult to most of institutions to update data is related to lack of money. Basically, projects to update spatial data have been dependent on funding from non-governmental organizations. Most of institutions depend highly on state budget to perform many activities. For example, the findings showed that process of spatial data collection takes place in the rainy season. However, what happens in real world is that the budget arrives near to that season. An issue expressed by one interviewee is that: "*There is much bureaucracy in relation to money provided by state….when the money comes; most often is not provided in time*"

So the availability of money on time should be considered in order to perform necessary tasks. For that the government should rethink the best way to allocate budget. When the budget is allocated to an institution, this in turn makes the distribution according to the priority areas. Since the area of geospatial information is not considered a priority, so in most cases money does not remain for this area. To overcome this situation, the interviewee from CENACARTA states that:

"*Many of our projects go forward because of high support of foreign countries…For example, I have this project in hand to be delivered today, so that if approved it will start next year."*

Within the GII perspective, the use of updated spatial data is central to meet the needs of all users which include public institutions, and general public.

6.1.4 Collaboration between various stakeholders

Additionally, the collection of spatial data is always based on what spatial data already exists. The cases shared the same point of view, by addressing that once certain spatial data is needed, before they start to collect it, they find out if there is any organization that already has the data that they are looking for.

As I described in literature review chapter, different users tend to develop their own datasets, even knowing that there are existing spatial datasets available for them (SDI 2008). The existing data sets are not in appropriate form, or it is difficult to access the spatial data; the existing spatial datasets are not used for sharing with other organizations; and the existing geospatial data sets cannot be easily exported from one system to another one, these are some reasons that some users prefer to develop their own spatial data set (SDI 2008). In my research case I found an organization that did not provide spatial data requested by another one. However, another reason that hampers the use of digitally installed base is the absence of data sharing policy at least between government institutions. This view point was provided by an interviewed user who quoted the following:

"*One time ago the department needed spatial data collected and managed by another institution that another organization had on hand. We request our partner (government institution) to provide such data. However, most of the times the request was simply refused… I do not know why they refused, until now we still do not have the data."*

There is little collaboration among organizations in data sharing despite the need of having spatial data (Chunithipaisan, James et al. 2002). From the findings one of the interviewees gave an example in which they wanted to get data from another institution, but they were not given it, without any exact reason. More than that, the organizations only contact another organization when they really need data. Collaborations must be a dynamic process, and the people involved should apply all forces to make it work. Extracts from the interviews that I conducted show that collaboration in some cases is still weak in Mozambique. One interviewee mentioned that "*much data could be used but we do not use…actually there is lack of knowledge of existence of data such as health facilities, water, etc. they don't use it.*"

Some of responders during the fieldwork have quoted that the unified system that the government decided to develop and implement in 2003, the cadastre land system will allow storing information from various source in a unique system. About that, one of respondents said that:

"*I think the cadastre land project is stopped. This solution could be ideal if the internet was accessible to everyone….some years before there were some districts that did not have electricity, and until now problem of electricity still exist. So these projects take time to reach, but it is also good because we already started with a simple idea."*

Another respondent from other institution said:

"*There is a system that aggregate information and it is under Cenacarta control. But I think that there is a great data, but it is still very weak. I'm not sure about the actual stage of it, I do not want to tell to you something without certainty"*

These examples illustrate that there is lack of feedback and communication between the various parts and no one has exact stage of the process. Despite that, the findings show that, people have perceptions of how data from different sources can be combined and can be used in their day to day. For example, the interviewee from Department of Rural Water pointed that: *"With GIS and data from different source, the department could monitor the impact of number of diseases that exist before and after the existence of water in an area determined."*

In the same line, the interviewee from Department of Cadastre said: "*One of the biggest concerns is the creation of a management tool in which all users with or without knowledge of the GIS can easily visualize geographic information in order to provide a subsidy in its activity in different organic units of the Maputo Council*."

These extracts show that GIS technologies could be applied to many more human activities. For example Loenen (2006) argues that there is always a need to have access to answers to questions like where I am, where are you, and what is where? Furthermore, Loenen (2006) pointed that these kinds of questions can be linked to property issues, situations of war, criminality, economic development, health, geographic planning, disaster management, and many more (Loenen 2006).

The findings revealed that the prices are not satisfactory to accommodate the price of production which can be summarized in the time consume in the collection of spatial data, analysis and data processing. Thus, looking a GIS as public resource, where various institutions collect and maintain spatial data on their own way, I feel that there is need to let the producers of spatial data involved in setting the price, because they are the ones who know better than anyone the value of the product. To be able to adapt prices challenges in the individual country it is recommendable to have special focus on legal aspects, access to data and pricing (Ryttersgaard 2001; Ghaffar 2002).

6.2 Strategies Requirement for Effective Spatial Data Sharing

In this study, problems that inhibit the sharing of spatial data between public institutions have been identified in five parts. First, different institutions have been collected spatial data in different formats which includes scales, resolutions, files formats. Second there is a lack of clear strategy regarding to the use and sharing of spatial data between institutions. Thirdly, there is lack of specialized people into the GIS arena. Then, most of spatial data are not updated. Organizational barriers also inhibit to have an effective spatial data sharing environment. In this context Loenen (2006) argues that geographical data needs to be collected to become part of the infrastructure, it needs technology for its transfer, and it needs technology for its presentation and interpretation.

Based on these issues presented through the findings and discussion, I proposed here the necessary strategies that could be followed not only for the case of Mozambique presented in this thesis but also could be applied to other developing countries with similar issues.

6.2.1 User Education Issues

One issue that hampers the effective use of GIS is related to technical skills needed to manipulate spatial data. The study has shown that the issue of skilled personnel influences the process of spatial data use. For example, the findings presented in the previous chapter showed that, lack of people with appropriate skills is still one of the greatest constraints regarding the use of

Geographic Information Systems and spatial data. The education training for all users (project sponsors, system staff, production, profession users, even to occasional user) provides a powerful way to improve the actual gap.

User education is a continuous capacity building that aims to ensure that all users are fully equipped, both technically and intellectually. Having these picture from my findings, Yeung and Hall (2007) suggest that training might take place in the following cases: when new people are hired by the organizations; when existing members of staff are given new job assignment; when new working methods, including new technologies are introduced; and new applications are implemented; there is a major upgrade of a software version, lack of productivity is detected; and higher standards of job performance are required.

In order to overcome one of the main problems, that is lack of appropriate capacity building, necessary training is needed, and it was a consensus from the findings that training is very important. Technologies are constantly updated, new products and tools are launched in the market. Limited skills together with lack of training inhibit the use of these technologies. Mohammadi (2006) recommends that in order to assist the implementation of integration of spatial data people involved on that, like users, data providers need instructions on how to integrate spatial data from different sources. I feel that the training should not be limited only to the ones that develop the system, but should be extended specially to the ones that collect spatial data. This view is because there are procedures that the technicians should follow when collecting spatial data, such as the coordinated system to use, the appropriate and standardized scale that should be used by all who are to reap the same object.

Again and again, education training should be addressed not only to those that work directly with GIS technologies, named system users but also sponsors projects (executive and senior managers. section heads), production users should be included. This point was also addressed by Macueve (2008) in their discussion of how Mozambique has to overcome the lack of human resources, the strategy proposed was to enhance training people for technological part, the public servants, and all citizens in order to be aware of the new model of governance, which was e-government (Macueve 2008). The main reason was that, the choice of any technology from an organization in some extent is not determined by the users systems. Basically, if the sponsors are not the ones

that choose the technologies, the section heads of the departments are the ones that do that. The project sponsors include executives, senior managers, and section heads who, because of their positions in an organization, "make strategic decisions regarding the direction of spatial information technology use and the allocation the resources required" (Yeung and Hall, 2007, p. 220) for GIS projects. Additionally, based on my findings these users use reports generated by GIS technologies to make decisions regarding on their area.

Thus, it is crucial to capacity not only the user systems, but also the managers with required knowledge, in order to decide for example which technology is appropriated to the organization, if does it ArcGis well suited to perform the results that the organization is looking for rather than MapInfo. In order to answer these scoping questions, the managers have to bear in mind appropriated knowledge to do it. Loenen (2006) highlighted that in the same way with many other types of information and information systems, the collection, maintenance, and dissemination of geographic information requires qualified human expertise and equipment to process, manage it.

As the training is very demanding in the use of ICTs in general and for GIS in particular, the training should be extended not for training the existing staff and to a greater degree of new one, but, to overcome the barriers of the country by training and mobilizing people to the GIS technology as a whole.

In this study I also concur with and recommend the strategy proposed by Saugene (2005) that argues the need for organizations dealing with spatial-related problems to collaborate and share resources such as technologies, and human resource. Such sharing of resources facilitates the transfer of knowledge and other relevant resources between the collaborating parties. According to empirical findings of this study, most training in Mozambique is funded by NGOs. Enabling the sharing of knowledge and other resources would see NGOs fund training for public institutions, whilst benefiting from the knowledge on GIS. Based on the results of this study, most training has funding of NGOs. Because the hub involves GIS professionals from public institutions, this would also help the institutions to qualify even after their professional projects and the donors have gone, because the advantage institutions would learn from each other in this hub.

Just as the government of Mozambique and many others developing countries have recognized the role that ICT plays in the development of the country, the same government should pay special attention to the importance of spatial data GIS technology. By developing geographic information infrastructure that can guide and enhance the use of spatial data within all public institutions and so on, this infrastructure will improve the awareness of spatial data. Mohammadi (2006) states that the weak collaboration among stakeholders, together with data management approaches are key institutional issues which act as barriers against data integration (Mohammadi 2006; Mohammadi, Rajabifard et al. 2006; Mohammadi, Rajabifard et al. 2007). Furthermore, geographic information infrastructure is a way to formalize and clarify the processes, tools, information tools, as well as facilitate communication between different spatial data systems and data sets.

6.2.2 Collaboration and the rule of the government

The building of an infrastructure takes times, once the time passes new requirements appears to the infrastructure (Hanseth and Monteiro 1998). The findings show that in order to establish a cadastral system, different considerations should be taken in account. For instance, one interviewee state that:

"*The cadastral land systems that were under development stopped for long time and it started around 2003. However, when analyzing this, I think that there are many shortcomings such as: if all rural areas had access to internet it would be the ideal solution…then there are those that a years ago had not electricity, even until today…however much has been done, at least we had an idea which was to develop a cadastral land system, so the implementation of that system will also take its time."*

The case above shows that though the government had defined the development of the system as part of their policy; there are many challenges that need to be overcome, in order to finish it successfully. The above described system aimed at having a system that store all data related to land use. However, for that the system had to incorporate data on mines, land, geology, etc. So, the system had to integrate data from different areas in a unique system, in order to allow everyone who needs to build different thematic maps.

Furthermore, I believe that lack of feedback, access and restriction to data among various parts involved were as the most outstanding barriers. In order to overcome these in future projects regular meetings among them are necessary to inform the stage of project. Additionally, once the new spatial and non spatial data is collected over time, each intervenient should inform and make those data so that discrepancies among the systems will not be very high.

Previous studies (see Ginger 2005, Saugene 2005) suggested that collaboration between various stakeholders should take place in order to reduce costs and build an integrated environment. From my finding I feel that, communication among institutions exist because to some extent they share spatial information; however there is a need to enhance more collaboration.

The success of implementation of the system is highly dependent on what each of the areas involved already has and what has been developed. Thus, new arrangements should be considered in order to improve what presently exists and therefore should be connected with the installed base. For example, one of the objectives of GII in Australia was to ensure the use of spatial data that meet individual requirements, even though that the data is collected and maintained by different agencies, in order to maximize the government investment in collecting and maintained spatial data (Loenen 2006).

The benefits of spatial data sharing cannot be stressed enough if institutional issues are marginalized. Based on the framework proposed by Yeung and Hall (2007) (see Figure 3) and also discussed by (Ghaffar 2002) institutional issues described in literature review chapter goes beyond to data access, spatial data legislation, and organization habits rather on focus only to technical issues. In respect to that, the case of Mozambique requires not only people with appropriate knowledge to deal with geo technologies, but also a strategy that encompasses access, legislation that can enable local spatial data sharing among different stakeholders.

For example, the interviewee from Department of Rural Water pointed out that the GIS technologies are not included within the strategy of using ICT in the institution. Basically, the department uses GIS but it is not deal within the strategies of the institution. This is also contradictory with the DNA outlined in MGD goal; by adopting innovative technologies the water infrastructures will be better monitored.

Although implementation of many GIS projects in Mozambique counts on the help of donor agencies, there is a need to make these projects locally sustainable in order to reduce financial, technological and human dependency. Since the government is struggling to reduce poverty by defining priority areas such education, health, agriculture, through the PARPA (II) program and did not set geo ICT area as priority, there is a need to make the geo information area a public resource and become self sustained with the aiming at facilitating the spatial data sharing among public institutions, and later on among citizens. However, it seems that the government is aware of the need to update the national cartography.

Therefore, there is a need to set the action plan, in order to update the base maps that are used by various (institutions and general public) as the root to deploy several maps. And, on the side of general public there is a need for the state to make public institutions and general public to be aware of GIS and related technologies. This can be done through academic schools, divulgation through brochures and/or websites.

In order to access geographic data, Loenen (2009) categorized two forms of pricing: the first one, the open-access approach assumes that government information is available for a price not exceeding the cost of reproduction and distribution, with as few restrictions to use as possible (Loenen 2009). Furthermore, he states that the second approach assumes that, the price of government information covers at least the cost of creation and dissemination, and may include a return on investment (Loenen 2009).

The CENACARTA is the institution responsible to disseminate spatial data. One of interview stressed that the prices of the products that the institution produced, are not satisfactory. One of reasons for that is that the government is the one that set the prices. Another reason is that some kind of spatial data is available freely for public institutions; however for general public it is available with restriction. Based on Loenen (2009) approach the prices in Mozambique are defined on open-access way, as a result the CENACARTA will not grow mainly because lack of funds resulting from products sold.

Without interoperable collaboration, consistent pricing, policies, together with appropriate capacity building spatial datasets cannot ensure effective data integration and use to their maximum potential (Ryttersgaard 2001). In terms of Mozambique it was found that spatial data is

largely provided to general public based on formal letter request where the user state what purpose is intended. Only in one case, it was found that access of data was based on money exchange.

Moreover previous studies (see Ginger 2005, Saugene 2005) suggested the use of standards to avoid discrepancies among data and then sharing of data could easily take places. I have explained in this study that different institutions have been using standards templates for register spatial and non spatial data collected in the field, although I have noticed some mistakes in filling it. So the use of standards which includes templates used to collect (non) spatial data is stabilized now when I compare with Saugene and Ginger (see Saugene 2005, Ginger 2005) suggested in 2004. However, I think that what has to be done is that people need to understand that the use of these standards should be satisfactory in respect to the rules of computer game. In addition to that, this study suggested that problems in scales, data formats are still pertains. In the same lines, Saugene and Ginger argued that the use of different scales, data formats inhibit integration of data.

These authors found that there is a few of spatial data sharing between the institutions in Mozambique. As I referred in my research findings chapter and argued through my discussion chapter, different institutions have been using data from other ones. So, nowadays public institutions have been sharing more spatial data among them compared to five years ago.

Despite that, I think that the process of spatial data sharing is not based on formal framework that is visible and understood by everyone, in this case the government should develop a geographic information infrastructure which includes policies, rules of spatial data where one of the aims is on how the organizations should share spatial data, which data should be freely available for general public. There is a general need to create strategic alliances among public agencies as well as a the public and the private sector in order to share resources, knowledge and experiences and to create synergism (Ryttersgaard 2001).

As addressed in the previous section, there is a need to capacitate users with appropriate training on dealing with GIS technologies and spatial data. However, providing such training depends on each organization's resource capacity to provide a good environment that allows for the improvement of knowledge and technical capacity for people who work direct on indirectly with

GIS technology. Thus, the government should create environment for that. In his paper on human resource capacity in developing countries, Kimaro stresses the need to create effective use of knowledge to ensure the use of ICT in developing countries (Kimaro 2006). Empirical evidence from this study suggests the same. My empirical findings show that the number of users for GIS solutions in Mozambique is low, mainly due to the lack of requisite technical skills on the same.

Chapter 7 - CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusions of this study in attempting to meet the research objectives defined in chapter 1. Research contributions and further research are also presented in this chapter in sections 7.2 and 7.3 respectively. Based on the analysis and discussion of the empirical findings in the previous chapter recommendations are also presented in section 7.4. To begin with, I present the research conclusions.

7.1 Research Conclusion

This study aimed at understanding the use of GIS in developing countries like Mozambique, and it focused on the issues that inhibit the sharing and integration of spatial data coming from different sources. Based on that, I addressed three research questions that are:

- *What are the major limitations of the use of Geographic Information Systems in public institutions in Mozambique?*
- *What are the major limitations for spatial data sharing (integration) among various public institutions?*
- *What strategies can be developed in order to allow easy spatial data sharing collected and managed by different institutions?*

7.1.1 Limitations of Use of Geographic Information Systems

The findings revealed that, lack of trained people to manipulate GIS technologies and spatial data, use of different scales during the data collection phase are problematic issues for data sharing and GIS users. In addition to that, the findings revealed that the lack of strategy and institutional support regarding the use of spatial data has lead to problems. The main reason is that these GIS projects are developed under external donor agencies sponsors, in terms of training provided to the staff, and also in terms of support to make the projects happens. In

addition to the problem of lack of funds, there is also lack of updated base maps that are used and shared as installed base to develop thematic maps.

In order to overcome most of these problems I have discussed during this thesis the need to provide educational training at all levels. In addition to that there is a need to update the available base maps in order to reflect the reality of the country. Furthermore, I stressed on the need to develop a geographic information infrastructure (GII) with focus on the use and sharing of spatial data. This would enhance collaboration and communication between the parties that would use such a GII. Such sharing of resources would also facilitate the transfer of knowledge and other relevant resources between the collaborating parties.

7.1.2 Limitations for Spatial Data Sharing

This study has revealed that the use of different GPS coordinate systems and scales, within GPS tools, inhibits data sharing among institutions. Because of that, the institutions waste time to convert the coordinated system from one form to another. Apart from that, the fact that people do not follow the standards of nomenclature makes the process of integration of data more difficult.

To overcome the incompatibility problems mentioned above this study suggest the use of common standards within a GII perspective.

This study has also revealed that the lack of qualified staff on GIS has a negative effect on the manipulation of data. Having people with appropriate skills in GIS solutions is critical towards facilitating the effective manipulation of spatial data.

Although the organizations under study do share data in some cases, the findings from this study have revealed that most data is not updated. For example, the base maps produced by Cenacarta and shared by all institutions that need them, are not updated. For this, the study suggests that there is a need to update data.

This study has also found that the cost of purchasing spatial data in Mozambique is quite high for the general public and acts as a deterrent to acquiring spatial data. In addition, there is only one organization that sales such data in Mozambique.

7.1.3 What Strategies can be developed in order to allow easy spatial data sharing

The development of a GII platform that facilitates the access to data and sharing of resources like tools among different institutions can enhance the capability of government, and general public. The build of GII is a way that can enable easy sharing of spatial data, tools, IS. As it currently is, the collection of new spatial data by individual organization is expensive.

One of the aims for building such GII is to minimise the cost of acquiring new spatial data for individual organizations, through promoting data standardization and sharing across organizations. Empirical evidence from this study has shown that the organisations under study are unable to update their data due to lack of both financial and necessary human capacity. For example, most of these organisations rely on donor funding to implement and maintain GIS solutions. This is what necessitates the building of the GII to enable organisations share scarce financial and human resources.

In this study I also concur with and recommend the strategy proposed by Saugene (2005) that argues the need for organizations dealing with spatial-related problems to collaborate and share resources such as technologies, and human resource. Such sharing of resources facilitates the transfer of knowledge and other relevant resources between the collaborating parties. According to empirical findings of this study, most training in Mozambique is funded by NGOs. Enabling the sharing of knowledge and other resources would see NGOs fund training for public institutions, whilst benefiting from the knowledge on GIS.Based on the results of this study, most training has funding of NGOs. Because the hub involves GIS professionals from public institutions, this would also help the institutions to qualify even after their professional projects and the donors have gone, because the advantage institutions would learn from each other in this hub.

This study also recommends that organisations should dealing with GIS should have clear policies and strategies for aligning the use of GIS to organisational goals. Empirical evidence gathered during this study shows that some of the organisations visited do not have GIS incorporated in organisation ICT strategies. This makes it hard for these organisations on plan and set aside resources to further their current GIS solutions.

7.2 Research Contribution

This study contributes to the existing knowledge both theoretical and practical perspective.

7.2.1 Theoretical Contribution

Based on the discussion of my findings, this thesis contributes to the use of GIS technologies and spatial data sharing issues in developing countries. Through my discussion I presented key problems associated to data sharing in public institutions in Mozambique. The spatial data sharing problems include: (i) lack of people with appropriate skills in GIS technologies; (ii) data format inconsistencies ranging from scale used, resolution, coordinated system, different nomenclatures among institutions; (iii) lack of updated spatial data (particularly base maps) that is shared among stakeholders; (iv) the role of government to allow easier communication and define a strategy regarding to the use of spatial data. These issues were also addressed by various authors in developing countries. For instance, Ginger (2005) and Saugene (2005) reported the problem of lack of human resources in GIS in Mozambique.

The same authors reported problem of lack of updated data, and data format inconsistencies, and furthermore the lack of spatial in Mozambique. However, my study found a different scenario regarding to the lack of spatial data in Mozambique. From that, based on my findings, there is a great amount of spatial data although I found problems associated to data collection procedures, data formats used to store spatial data.

Studies have proposed the importance of spatial data sharing mostly spatial data is seen as public resource. Ryttersgaard (2001) argued the need to have a national homogeneous and updated datasets. Therefore, the government has to recognise spatial information as a public resource that needs to be efficiently coordinated, maintained, updated and managed in the interest of the nation (Ryttersgaard 2001). Furthermore, it has been highlighted that necessary policies for pricing spatial data are needed to avoid monopoly of those data (Ghaffar 2002). Yeung and Hall (2007) addressed the need of users education not only in the initial phases of implementation of GIS, but the education should be addressed to as new staff is contracted, new technologies appear, etc. The same idea was also pointed by Macueve (2008). Furthermore, Yeung and Hall (2007) stated that the training should be extended to managers of the project, or departments, and also to individual user.

The reasons why spatial data is developed for many users while there are existing spatial data available for them was addressed by SDI (2008). They found that the existing data is not used because is not in appropriate form, or because is not used for sharing, or because is not easy to import data from one system to another one. Based on my study, I found cases where spatial data was not shared to an organization. Apart from that, spatial data is shared among institutions even knowing that the data is not in concordance with formats used in own institution.

From Information Infrastructure perspective, the concepts from II helped me to analyse the spatial data process as an II. For instance, the concept of installed base enabled me to see that before developing new spatial data there is a need to verify if these data does not exist already.

Additionally, assumed that public institutions in Mozambique have exchange spatial data among them based on different data formats, scales, GIS software, Hanseth and Monteiro (1998) described that within II perspective the new component must be designed and connected to an old one. Therefore, in the process of data exchange, the scales used should be converted to the already existing one. From that, there is a need to find the appropriate software to accommodate this issue.

The literature stressed that an infrastructure will never be develop from scratch (Hanseth and Monteiro 1998; Hanseth and Lyytinen 2004). For instance, Saugene (2005) described that the process of making (non) spatial database was strongly influenced with the existing data. In this case data from external source was used to build the database.

Most literature discussing information infrastructure (see Hanseth and Monteiro 1998; Hanseth and Lyytinen 2004) argues that the infrastructure is shared by large community such as roads, electricity, Internet. Bearing in mind those base maps, topographic maps are used as base to develop maps from different institutions as well as from individual users, so these maps are shared by larger community. In this case, the majority of these maps are developed and distributed by CENACARTA. Additionally, spatial data developed by individual organization such as INE, CENACARTA, MICOA, DNA, etc is also shared among them.

However, in order to an II be shared by larger community standardization processes in terms of procedures, rules should be considered (Hanseth and Monteiro 1998; Saugene 2005). In the case of this study, the findings revealed that the institutions have used standard forms during the fieldwork, however this process of standardization should not just be limited to the use of templates as mentioned in the previous section, but expand to how the data should be collected,

which scale and format the data should be used. Standardization should also include how spatial data should be accessed and used among public institutions, and also made available for citizens.

7.2.2 Practical contributions

Apart from the above mentioned theoretical contributions, this study has helped me highlight currently existing problems that restrict GIS data sharing amongst the organisations where I did my research work. I have been able to share insights with these organisations on how they can improve spatial data use both within their organisations and with other organisations, involved in similar work. For example, I was able to discuss the need for the development of a common platform for spatial data sharing with some of my respondents.

Further to this, I have also managed to advise the organisations on how they can improve the quality of their spatial and non-spatial data, by improving on data collection tools (e.g forms) and following laid down guideline for data collection. Empirical evidence from this study has shown that the organisations under study did, in some cases, use data collection forms that are standardized and data collectors did not always follow set procedures for this task.
This study also documents best practices on using GIS solutions from the organisations where I did my research. This, then, highlights practices that need to be replicated to enhance the effective use of GIS solutions in Mozambique.

In addition, in the section on recommendation, I outline specific guidelines that need to be followed when introducing new GIS solutions or making changes to existing ones.

7.3 Further research

Based on this study, I could be interesting to study how to create a public spatial data infrastructure. This research revealed gaps in role of government in providing necessary support in terms of human and non human resources and also in terms of lack of Geographic Information Infrastructure (GII). Therefore future research is needed on how the government could institutionalize the GII.

7.4 Recommendations

There are some recommendations from this study that can be applied by public institutions in Mozambique, and developing countries in general to improve the use of GIS solutions as well as to improve spatial data sharing among institutions.

1. When implementing GIS solutions it is necessary to follow set standards on data collection, processing storage and sharing.

2. When implementing GIS solutions it necessary to provide training to target user to ensure that they have requisite skills to meaningfully interact the implemented solutions.

3. Available (non) spatial data should be regularly updated to reflect the current reality as pertains to the same. In the case of Mozambique, it is necessary that CENACARTA regularly updates its data than is currently the case.

4. Besides the updating of data CENACARTA as well as others institutions need to update its equipment. Currently the organisation uses very old equipment. It is necessary for the Mozambican government to also prioritize CENACARTA's work and raise funds for the replacement of its aged equipment.

5. It is important to build a culture of data sharing across organizations. This would help reduce data withholding by organisations. In some cases organisations fail to share data not because of lack of standardization, but because they lack the will to do so.

6. In cases where organisations are already using GIS solutions, new solutions should be developed by extending on currently existing ones and knowledge on GIS use. This would ensure compatibility between already existing solutions and new ones. Furthermore, building on already existing solutions and knowledge would reduce the risk of failure as the new solutions would most likely not suffer from similar challenges as currently existing ones.

The above recommendations is not limited to Mozambique and others developing countries only, but can be applied by public institutions in developed countries to improve the spatial data sharing and use of GIS technology. Thus, the recommendations are independent of the organization structure.

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ANNEXES

Annex A: Questionnaire used during for data collection

GUIÃO DE ENTREVISTA

Márcia Névia Agnaldo Juvane, estudante de mestrado em Sistemas de Informação pela Universidade de Oslo em colaboração com a Universidade Eduardo Mondlane, no âmbito do trabalho de pesquisa para a sua tese que tem como tópico " Desafios de integração de dados espaciais. Caso de estudo de Moçambique" (Understanding the Dynamics around Spatial Data Integration: The case study from Mozambique.), pretende realizar entrevista à V. Excias. Agradece desde já pelo precioso tempo disponibilizado.

O presente questionário está relacionado com o uso de tecnologia GIS (concretamente, mapeamento, serviços que esta tecnologia providencia no formato de mapas, partilha de dados, tipo de dados) dentro de alguns sectores públicos em Moçambique.

O objectivo deste guião de entrevista é obter da organização percepções de uso de GIS dentro da organização. Mais que isto é entender como estas instituições interagem entre elas na troca e partilha de dados espaciais. Assim sendo, a autora pretende com este trabalho avaliar como as instituições podem integrar dados espaciais de uma forma padrão de modo a reduzir custos resultantes da implementação de GIS.

Pretendo que este questionário seja de fácil percepção e rapidamente concluído. Se não for possível obter facilmente as informações para qualquer pergunta, por favor, responda "Não sei".

Por favor, devolve este questionário preenchido para Márcia Juvane e / ou igualmente via email para o endereço: racyjuvane @gmail.com

	Questão	Resposta	Exemplos / Explicação
	Qual o nome da organização		
1.1	Departamento		
1.2	Qual é a função do departamento?		
	A organização suporta o uso de GIS/ mapas pelos funcionários? **Caso sim**, Houve algum treinamento ou algum tipo de procedimento existente na organização que ajudasse a manipular essa tecnologia? Quando foi introduzido e qual foi o proposito do mesmo?		

<table>
<tr><th></th><th>Questão</th><th>Resposta</th><th>Exemplos / Explicação</th></tr>
<tr><td></td><td>Caso não, Quem acha dentro da organização deveria ser convencido sobre a introdução do GIS por forma a torná-lo mais acessível a si?</td><td></td><td></td></tr>
<tr><td>2.1</td><td>Para que fins operacionais usa (ou poderia usar) a tecnologia GIS</td><td>Nós actualmente …

Nós poderíamos …</td><td>Para os serviços do dia a dia, por exemplo, analisar dados de saúde, dados da população, etc.</td></tr>
<tr><td>2.2</td><td>Para que fins estratégicos usa (ou poderia usar) a tecnologia GIS</td><td>Nós actualmente…

Nós poderíamos…</td><td>Para suporte a tomada de decisão e formulação de estratégias, por exemplo…
Previsão de futuros serviços por exemplo mudanças demográficas.</td></tr>
<tr><td>2.3</td><td>Qual destes componentes da tecnologia GIS que almeja deveria suportar?</td><td>
<table>
<tr><th>x</th><th>GIS Componente</th><th>Nome do Produto</th></tr>
<tr><td></td><td>Funcionalidade completa de um sistema GIS</td><td></td></tr>
<tr><td></td><td>Visualização GIS</td><td></td></tr>
<tr><td></td><td>Integração de dados</td><td></td></tr>
<tr><td></td><td>Troca de dados espaciais</td><td></td></tr>
</table>
</td><td>A funcionalidade completa do sistema GIS irá visualizar, editar e gerenciar dados geoespaciais.

Uma visualização GIS permite "ver apenas' de mapas e dados geoespaciais associados.</td></tr>
</table>

	Questão	Resposta	Exemplos / Explicação
		☐ através de uma interface padrão ☐ ☐ Fotografia aérea ☐ ☐ Especialista em Hardware ☐	
2.4	Quantos funcionários capacitados na utilizacao de dados espaciais ou GIS	Número de especialistas GIS Aproximação em % de funcionários que podem ver informação espacial Aproximação em % de funcionários que podem actualizar dados espaciais	Por favor inclui Os existentes na organização, os contratados e os que pertencem a uma organização parceira mas que tem dado suporte.
2.5	Que tecnologias (softwares) usam para manipular dados espaciais?		
2.6	Quais sao os criterios que estiveram na origem da escolha de um software em detrimento de outro?		
2.7	Que dificuldades tem a instituição enfrentado no uso de dados espaciais?		Por exemplo a falta de pessoal qualificado na área, pode ser um constragimento, falta de treinamento, ou falta de fundos. Ou outras dificuldades

<table>
<tr><th></th><th>Questão</th><th>Resposta</th><th>Exemplos / Explicação</th></tr>
<tr><td>2.8</td><td>Como é feito o tratamento de dados espaciais (fluxo de informação), quando é a instituição a recolher no campo até ao momento em é usado pelo utilizador final? Quais os passos seguidos? E caso obtém de uma outra entidade existem algum tratamento especial?</td><td></td><td></td></tr>
<tr><td></td><td>Que benefícios a sua organização ganha com o uso do actual GIS?</td><td>
<table>
<tr><th>x</th><th>Beneficio</th></tr>
<tr><td></td><td>Poupança</td></tr>
<tr><td></td><td>Eficiência em lucros</td></tr>
<tr><td></td><td>Precisão melhorada</td></tr>
<tr><td></td><td>Melhoramento na satisfação do cliente</td></tr>
<tr><td></td><td>Melhor tomada de decisão</td></tr>
<tr><td></td><td>Redução de riscos</td></tr>
<tr><td></td><td>Outros (por favor especifique)</td></tr>
</table>
</td><td></td></tr>
</table>

	Questão	Resposta	Exemplos / Explicação
3.1	Pode dar um exemplo concreto de como tem usado o GIS?		
3.2	Quais são as diferentes formas que a organização usa para visualizar dados processados?		**Exemplos: podem ser, mapas, tabelas, graficos, etc**
3.3	Quais são as maiores limitações enfrentadas no seu local de trabalho no acesso ou processamento de mapas e informação georefenciada que podem ser facilmente reduzidas ou eliminados com a aplicação adequada de um sistema de informação		

<table>
<tr><th></th><th>Questão</th><th>Resposta</th><th>Exemplos / Explicação</th></tr>
<tr><td></td><td>geográfica integração?</td><td></td><td></td></tr>
<tr><td>3.3</td><td>Que benefícios poderia a sua organização ter de uma nova adopção ou de um sistema GIS integrado?</td><td>
<table>
<tr><th>x</th><th>Benefícios</th></tr>
<tr><td></td><td>Poupança</td></tr>
<tr><td></td><td>Eficiência em lucros</td></tr>
<tr><td></td><td>Precisão melhorada</td></tr>
<tr><td></td><td>Melhoramento na satisfação do cliente</td></tr>
<tr><td></td><td>Melhor tomada de decisão</td></tr>
<tr><td></td><td>Redução de riscos</td></tr>
<tr><td></td><td>Outros (por favor especifique)</td></tr>
<tr><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td></td><td>Tecnicamente como acha que a implementação do GIS poderia ser efectuada de modo que tivesse os resultados esperados (quais as suas observações em</td><td></td><td></td></tr>
</table>

<table>
<tr><th></th><th>Questão</th><th>Resposta</th><th>Exemplos / Explicação</th></tr>
<tr><td></td><td>relação a esse assunto)?</td><td></td><td></td></tr>
<tr><td>4.1</td><td>Por favor, descreva pelo menos um desafio técnico relacionado com adopção de GIS sua instituição enfrentou e como conseguiu superá-lo.</td><td></td><td></td></tr>
<tr><td>4.2</td><td>Quais são as suas realizações em GIS até agora?</td><td></td><td>Pode ser mapas, programação, desenvolvimento de dados, apresentação de dados, etc.</td></tr>
<tr><td>4.3</td><td>Qual é a cobertura das analises que efectua ou que gostaria de fazer?</td><td>
<table>
<tr><th>x</th><th>Área</th><th>Especifique</th><th>Escala</th></tr>
<tr><td></td><td>Distrito</td><td></td><td></td></tr>
<tr><td></td><td>Localidade</td><td></td><td></td></tr>
<tr><td></td><td>Região</td><td></td><td></td></tr>
<tr><td></td><td>Província</td><td></td><td></td></tr>
<tr><td></td><td>Outros</td><td></td><td></td></tr>
</table>
</td><td>Por favor, especifique a actual área contra cada entrada para onde colocou “X”.
Se apropriado, especifique a escala onde a cobertura e obrigatória.</td></tr>
</table>

<table>
<tr><th></th><th>Questão</th><th>Resposta</th><th>Exemplos / Explicação</th></tr>
<tr><td>4.5</td><td>Que conjunto de dados espaciais a instituição cria ou tem criado ou já criou?</td><td>
<table>
<tr><th>Dados</th><th>E partilhado (E) externalmente</th><th>Pode ser partilhado (P)</th><th>Modelo de Licença</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>
</td><td>Digite "E" sempre que um dado já está a ser compartilhada, e um "P" se um dado pode ser partilhada.

Sempre que um conjunto de dados é partilhada, explicar como se encontra licenciada, e / ou se um pagamento. Ex.. "Nenhuma acusação".</td></tr>
<tr><td>4.6</td><td>Que tipo de dados dados geoespaciais faz uso, que não foram criados pela instituição?</td><td>
<table>
<tr><th>Dados</th><th>Próprio e o modelo de licença</th></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>
</td><td>Quando dados externos é utilizado, por favor, explique onde ele vem, e do tipo de arranjo de licenciamento.</td></tr>
<tr><td>4.7</td><td>Como a instituição solicita os dados? Por telefone, em pessoa, baixa de um site ou outro?</td><td></td><td></td></tr>
<tr><td>4.8</td><td>Quais são as ideias que tem acerca de existência de técnicos nesta área e coordenação multi-departamental,</td><td></td><td></td></tr>
</table>

<table>
<tr><th></th><th>Questão</th><th>Resposta</th><th>Exemplos / Explicação</th></tr>
<tr><td></td><td>multi-institucional na utilização de GIS?</td><td></td><td></td></tr>
<tr><td>4.9</td><td>Quais são os padrões (standards) que tem usado na criação de dados espacias?
Para as instituições que nao criam dados quais são os data standards dos dados que tem obtido de parceiros
)</td><td></td><td>Quais são os formatos dos dados espacias que cada uma das instituições tem manipulado....
por exemplo: uns podem manipular com shape files, outros com CAD, outros com imagens de satelite (formato outros com dados no postGIS, outro com EpiInfo)</td></tr>
<tr><td>4.10</td><td>Que conjunto de dados espaciais precisa, mas que não consegue ter acesso?</td><td><table><tr><th>Dados</th><th>Razão de não estar acessível</th><th>Porque precisa dele?</th></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table></td><td></td></tr>
</table>

	Questão	Resposta	Exemplos / Explicação
4.11	Tem alguma experiência em GIS baseados na Web?		
4.11.1	Como é que o GIS está inserido dentro da estratégia de utilização de TIC na instituição?		Por exemplo, uma solução independente vertical, um objecto modelo que está incorporada em aplicações, uma arquitectura orientada a serviços, etc. Por favor, deixe em branco caso não tenha implementado um GIS.
	Existe alguma solução GIS que poderia fornecer exemplos de boas práticas ou de oportunidades para reutilização em outras organizações do sector público? Por favor, faça uma breve descrição.		Isto pode variar de: • Relatório de Lições Aprendidas a partir de um projecto. • Padrão dentro de sua solução que poderia ser re-utilizadas, tais como o desenho, arquitectura ou Método de Aquisições. • Uma solução que é proprietário e que poderia ser replicado noutros locais. • Um serviço gerenciado que pode ser oferecido a outras partes do Sector Público.

	Questão	Resposta	Exemplos / Explicação
5.1	Tem solicitado ajuda de outras instituições do sector público com experiências na utilização de serviços providenciados por GIS? Por favor, uma breve descrição.		A autora esta interessada em compreender as necessidades do sector público para o GIS, e, no mínimo, fornecendo exemplos de boas práticas a partir de dentro do Sector Público.
5.2	Que instituições não-governamentais acha que deveriam ter a oportunidade de completar este questionário ou ser entrevistado?		A missão é a de avaliar as necessidades de todo o sector público.
5.3	Gostava de fazer parte de um grupo com objectivos de desenvolver estratégias que podem ser utilizadas para		

	Questão	Resposta	Exemplos / Explicação
	uma efectiva integração da partilha de dados ou de dados? Quais seriam as ideias chaves que levarias para discussão neste grupo?		

Preenchido por	
Posição	
Data	
Endereço electrónico	
Telefone	

Qualquer informação adicional poderá faze-lo no fim do documento.
Muito obrigado pela vossa ajuda.

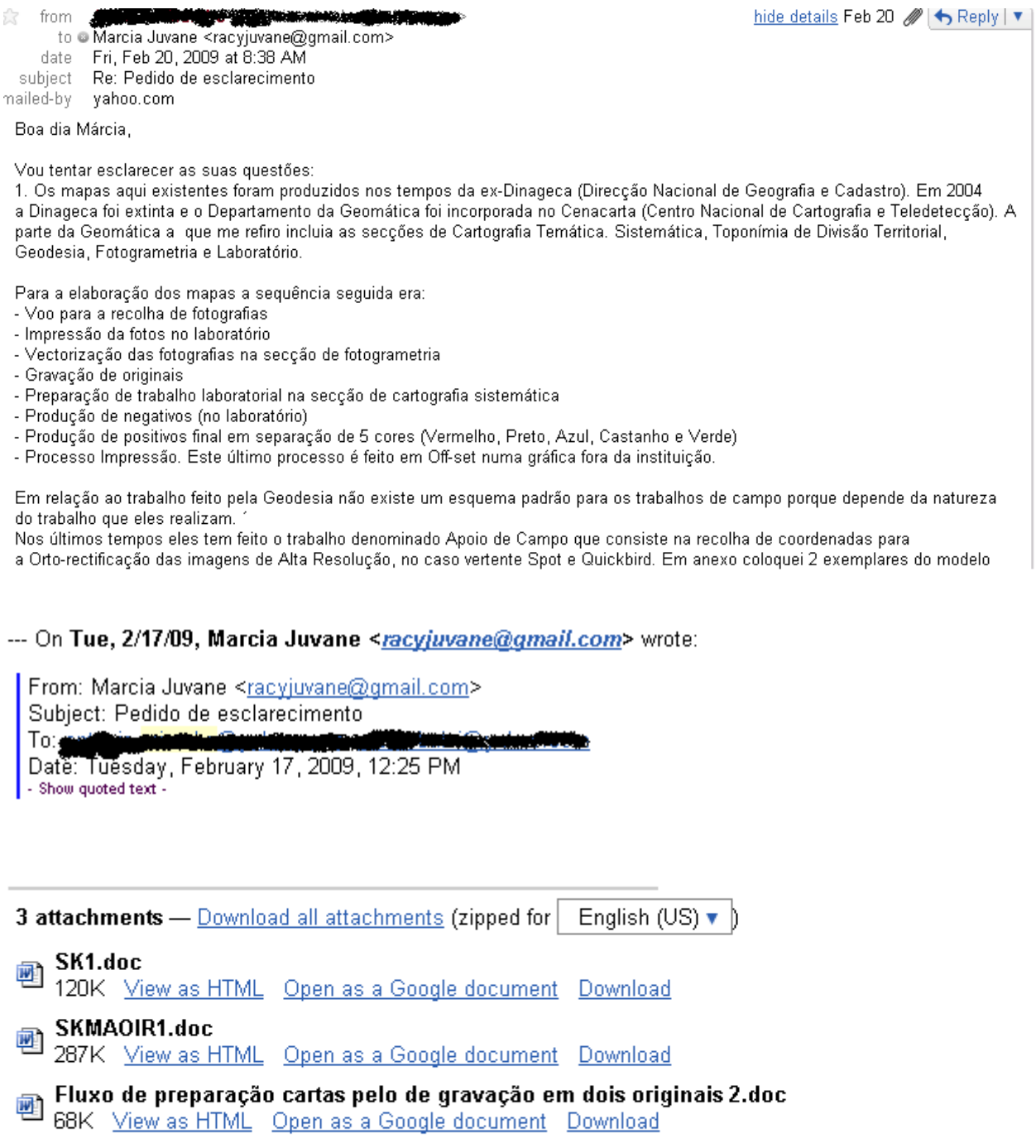
Notas de Explicação:
GIS (do inglês Geographic Information System) é um sistema de informação capaz de criar, editar, armazenar, exibição, análise e partilha de informações geoespaciais.

Informação geo espacial é informação que é referenciada geograficamente, quer como um único ponto, uma linha, ou de uma área.

Exemplos no sector público incluem:

Ponto	Unidade sanitária, Paragens
Linha	Ruas, esgotos, rotas
Área	Localidades, fronteiras, conservação área, parques nacionais

Annex B: Email used to clarify some inconsistencies



from [redacted]
to Marcia Juvane <racyjuvane@gmail.com>
date Fri, Feb 20, 2009 at 8:38 AM
subject Re: Pedido de esclarecimento
mailed-by yahoo.com

hide details Feb 20 Reply

Boa dia Márcia,

Vou tentar esclarecer as suas questões:
1. Os mapas aqui existentes foram produzidos nos tempos da ex-Dinageca (Direcção Nacional de Geografia e Cadastro). Em 2004 a Dinageca foi extinta e o Departamento da Geomática foi incorporada no Cenacarta (Centro Nacional de Cartografia e Teledetecção). A parte da Geomática a que me refiro incluia as secções de Cartografia Temática. Sistemática, Toponímia de Divisão Territorial, Geodesia, Fotogrametria e Laboratório.

Para a elaboração dos mapas a sequência seguida era:
- Voo para a recolha de fotografias
- Impressão da fotos no laboratório
- Vectorização das fotografias na secção de fotogrametria
- Gravação de originais
- Preparação de trabalho laboratorial na secção de cartografia sistemática
- Produção de negativos (no laboratório)
- Produção de positivos final em separação de 5 cores (Vermelho, Preto, Azul, Castanho e Verde)
- Processo Impressão. Este último processo é feito em Off-set numa gráfica fora da instituição.

Em relação ao trabalho feito pela Geodesia não existe um esquema padrão para os trabalhos de campo porque depende da natureza do trabalho que eles realizam.
Nos últimos tempos eles tem feito o trabalho denominado Apoio de Campo que consiste na recolha de coordenadas para a Orto-rectificação das imagens de Alta Resolução, no caso vertente Spot e Quickbird. Em anexo coloquei 2 exemplares do modelo

--- On **Tue, 2/17/09, Marcia Juvane <racyjuvane@gmail.com>** wrote:

From: Marcia Juvane <racyjuvane@gmail.com>
Subject: Pedido de esclarecimento
To: [redacted]
Date: Tuesday, February 17, 2009, 12:25 PM
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Annex C: Email used to clarify some inconsistencies

Date: Thu, 5 Feb 2009 22:58:28 +0200
Subject: Pedido de informacao
From: racyjuvane@gmail.com
To: [redacted]

Boa noite, [redacted]

> Me apresentar como a Marcia Juvane, que estive em contacto consigo para uma uma entrevista no ambito do meu trabalho de mestrado nos finais do ano pasado.
>
> O questionario preenchido esta sendo valioso, mas durante o processo, fui notando a necessidade de ter mais alguns detalhes da sua parte.
> So que de momento me encontro em Dar Es Salaam no ambito do meu mestrado, nao poderei vir fisicamente. Agradecia que facultasse mesmo por email.
>
> As questoes que tenho sao:
> 1- Como 'e feito o tratamento dos dados espacias, desde a sua colecta no campo ate ao momento que o utlizador fianl usa, em termos de fluxo de informacao?
> dados sao recolhidos, armazenados, trabalhados e esquecidos.
>
> 2 - Quando 'e que foi introduzido o GIS na sua instituicao e para que fins?
> 1996 se nao me engano no ambito do projecto de EAF14 de mapeamento da costa africana
>
> 3 - Que ferramentas usa para produzir mapas? que razoes estiveram por detras da escolha desse software?
> esri arcview 3.2, arcgis, illwis - foram pura e simplismente comprados e ultimo porque e free
>
> 4- O novo sistema que falou durante a entrevista que seria acessivel via internet foi desenvolvido usando que ferramentas? Qual o objectivo do mesmo?
> ainda veremos como sera acessivel na internet. foi desenvolvido na base de acess e arcexplorer. objectivo - organizar dados e disponibilizar ao publico
>
> 5 - Quando se faz a colecta de dados espacias no campo tem levado alem do GPS algum modelo em formato de papel, para registrar alem dessas coordenadas outros atributos?
> usamos garmin e fazemos registo no papel