UNIVERSITY OF OSLO
Department of Informatics

Challenges, Opportunities and Strategies for Using Geographic Information Systems for Public Health Management

An Action Research Study from Mozambique

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Master Thesis

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DEDICATED TO

The memory of my Sister "**Amelita Benjamim Saugene**" and **the Saugene** family for their love, support, encouragement and strength.

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LIST OF SOME ABBREVIATIONS AND ACRONYMS USED

ANT - Actor-Network Theory

DCH - Department of Community Health

DCH_GIS - Department of Community Health Geographic Information System

DHIS - District Health Information Software

DHS - Demographic Health Survey

EmOC - Emergency Obstetric Care

GIS - Geographic Information System

GPS - Global Positioning System

HIS - Health Information System

HISP - Health Information System Programme

ICT - Information Communication Technology

II - Information Infrastructure

INE - National Institute of Statistics

INPE - National Institute of Spatial Research

IS - Information System

IT - Information Technology

MINEC - Ministry of Education and Culture

MoH - Ministry of Health

NHIS - National Health Information System

NSDI - National Spatial Data Infrastructure

TBA - Traditional Birth Atendants

WHO - World Health Organization

ABSTRACT

Public health systems rely on many different components: the institutions of Ministry of Health; the health staff and the information and communication systems used by these organizations to collect, analyze and disseminate relevant data, and use these to help to improve health care delivery. This thesis focuses on understanding the challenges proposed by the current health information system on decision-making process. Specifically, the thesis analyses the drawbacks of the information system for decision-makers.

Studies were performed in three provinces aiming at understanding the questions that guide this study, namely: (i) what are the major limitations of the information systems for decision-makers?; (ii) what challenges are there when using spatial information to address challenges of public health decision-makers with focus on maternal mortality?; (iii) what approaches can be used to address these challenges?; and (iv) what strategies can be developed to implement Geographical Information System (GIS) technology for health management in Mozambique?

Studies carried out show that for several reasons (such as the data needed for decisions are incomplete, not reliable or timely enough), health planners rarely use health-related data for their decision-making. Many problems within the health sector are related to the question "where". For example, where do we find the highest BCG or measles coverage, where is malaria most prevalent, or where are TB medicines required, or where should a new health facility be located? The questions around "where" are location-based and can be effectively represented using maps.

As part of the study, a practical framework was developed aiming at bridging the gap between the location of various problems and their management through the use of GIS. This framework comprised building a GIS prototype in order to promote health community awareness about the availability, use and benefits of spatial data within the health sector. For that, data were migrated from Excel and paper-based databases to the DHIS, and then related to spatial databases and results showed in maps.

By allowing the linkage between routine health data being collected, various kinds of data that are associated with locations (on maps) as 'spatial data', GIS can potentially serve as a useful tool for understanding health-related problems, including other spatial factors such as

catchment population + incidence of illnesses, socio-economic, environmental, topographic (related to vulnerabilities to malaria, cholera) location of facilities, infrastructural elements and infrastructure availability (e.g. health facilities providing Emergency Obstetric Care).

However, the adoption of GIS involves a heterogeneous network comprised by, for example, representation of diseases (e.g. health indicators, etc.), people (e.g. decision-makers, planners, donors, health workers, etc.), socio-political structures and artifacts (e.g. forms, software systems, etc.), which are socially constructed involving the use of information system. Alignment of this heterogeneous network required the development of a social-technical framework. Theories such as (i) Actor-Network Theory and (ii) Information Infrastructure were the basis of this framework.

This thesis makes contributions to both theoretical and practical domains. In terms of the knowledge and new insights that this research generates to the field of health information system and perhaps also to the software development field, one of the most important contributions concerns the entire purpose of this study, *"to promote awareness of the availability, use and benefits of spatial data from the health community perspective"*. A cultivation approach is proposed to highlight the need for the formation and operation of knowledge sharing culture in public sector information technology innovations.

The research sought to identify the dimensions and dynamics of inter-organizational networks as the frameworks of knowledge exchange in information system development and implementation. In this thesis it is argued that innovations depend on the sharing of knowledge, culture, experience, etc, in order to create information systems that span organization boundaries. Thus, specific recommendations are presented to strengthen the information systems.

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CHAPTER I   INTRODUCTION

1.1. Introduction

The mission of public health is to fulfil the "society's interest in assuring conditions in which persons can be healthy". To carry out this mission, the public health system relies on three components: the public health workforce; the employers of this workforce, including governmental and private organizations; and the information and communication systems used by these organizations in collecting and disseminating accurate data(Melnick, 2003).

The availability of reliable data is a prerequisite for suitable planning and decision-making to help address these problems. Accessing and using relevant, correct and legible data from different sources at all levels of the health care system is a general challenge for health planners.

However, health care systems in most developing countries face increasingly diverse and complex problems as well as severe resource constraints. For example, maternal mortality and morbidity ranks as the largest cause of loss of healthy life among women of reproductive age in the developing world. At the 1987 Safe Motherhood Conference in Nairobi, Kenya, attention was drawn to the fact that maternal mortality ratios in developing countries were often 100 times greater than those commonly found in developed countries(Hill, Stanton, & Gupta, 2001).

Efforts to reform Health Information Systems (HIS) are being made, especially in the developing world, in order to address health related problems. For example, "over the past decade a number of international forums have declared a reduction in maternal mortality as one of their goals, including the 1990 World Summit for Children, the 1994 International Conference on Population and Development, the 1995 World Conference for Women, and the 2000 Millennium Summit"(Hill et al., 2001).

However, health decision-makers continue to experience problems in their daily work. This is because the available routinely collected data are often presented in the form of tables or isolated figures, the reading of which is arduous and time-consuming. Thus, decision-making is not easy. The format and the quality of the data collected is not good and the data is also not frequently sent in a standard from and in timely fashion.

Traditionally, the focus of these systems has been on non-spatial information. But, according to White (2003), "it is estimated that over 90% of health data special public health data has a spatial geographical component. At its simplest, this is because the vast majority of health data explicitly relate to human activity and humans exist within a spatial framework, moving around and interacting with each other and the environment"(White, 2003).

While it is possible to analyze such data without taking into account this geographical component using spreadsheets or databases, for example, this is effectively throwing away potentially important and valuable information. At basic level we can use such information by displaying results of an analysis on a map, for instance mapping health diseases and their location, and at more sophisticated levels for conducting epidemiological modelling analysis.

In many cases, it is likely that spatial distribution is an important factor in understanding the mechanisms of public health issues, such as the spread of a disease or the utilization of a service. As a result, increasing attention is also being given to spatial information in recent years. There are many ways in which the geography or spatial distribution of public health data can be important. After all, is it possible to understand the mechanisms behind variations in service utilization without taking into account travel distances?

Some of these questions can be better supported by using modern techniques of data acquisition of mapping, such as through remote sensing. The use of these mapping techniques and the integration of other sources of information in digital format require a Geographic Information System (GIS)(Teeffelen, Leo, & Otto, 1993).

GIS are a computer and allied technology that allows for the analysis of public health data with a geographic dimension. GIS in the health sector provides a digital lens that focuses on the dynamic connections among people, health and well-being, and the changing physical and social environments. It also helps to clarify and emphasize spatial patterns in community health, quickly retrieve relevant data about a geographical area, display many layers and types of community information in the same space, and model the behaviour of disease and environmental events.

Although using GIS may not be easy, its application can potentially support decision-making by enabling health decision-makers to more easily monitor and determine the geographic structures of health data, mapping communities at risk, and identifying risk factors more readily.

This chapter is divided into four main sections where I will discuss issues related to: the role of information for health management; research issues addressed in this thesis; additional exposure to the field and, finally, the HISP project.

1.2. Public Health Management in Developing Countries: The Role of Information

Many problems have been reported on the performance of HIS in developing countries in general and in Mozambique in particular. Many of those countries are restructuring their HIS, primarily by decentralizing the systems in order to empower the lower levels, particularly the district levels.

To address these problems, the HIS requires the integration of comprehensive information on the environmental, economic and social dimensions of society. Ideally, the information should provide a perspective of these dimensions of developing countries, although the effective implementation of HIS within countries requires that information is also collected at local and provincial levels. The role of information is being accepted as more and more: initiatives such as the Global Knowledge Partnership (GKP) and the African Information Society Initiative (AISI) have recognized the importance of information and knowledge as a tool for sustainable development. Insights into the importance of information for decision-making within the HIS are not new. For example, the founding policy documents, Agenda 21[1] and NEPAD[2], identify information as a critical component in being able to understand the integration of the environment and development. Information is also needed to

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[1] AGENDA 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment. The preamble to this agenda clearly states that it is the responsibility of national governments to formulate their own strategies, plans, policies and processes to implement sustainable development.

[2] NEPAD, a policy framework on sustainable development is the New Partnership for African Development. Similarly to Agenda 21, embraces the need for sustainable development and has formulated actions that have to be taken on the African continent.

implement and monitor sustainable development. Recommendations that consistently come up in Agenda 21 on the use of information for sustainable development include:

o providing decision makers, planners and the general public open and direct access to precise and reliable information through the use of appropriate electronic and non-electronic formats;

o improving the integration and use of social, economic and environmental information for sustainable development;

o ensuring that the interactions and synergies between the social, economic and environmental dimensions are understood through the development, analysis and modeling of appropriate indicators;

o developing an understanding of international theory and best practices in the development of indicators and the setting up of information systems for sustainable development;

o developing the capacity of developing countries to collect, store, integrate, analyse and disseminate information at different spatial levels; and,

o developing the institutional capacity and ability of decision makers to use the information.

Agenda 21 goes further in making recommendations about the use of information for effective decision-making. Two areas that the policy identifies as being of importance are bridging the gap and improving the availability of information. Bridging the gap refers to the difference between the developed and developing world in terms of availability, quality, coherence, standardization and accessibility of data. This agenda also, covers a wide range of social themes including combating poverty; demographic dynamics and sustainability; promoting education, public awareness and training; protecting and promoting human health and promoting sustainable human settlement development(Schwabe, 2002).

1.2.1. Public Health and Non-Spatial Information

Health management requires the monitoring of the health status of the population, the provision of services as coverage and utility, drugs stocks and consumption patterns, equipment status and availability, finances, and personnel on a regular basis. This requires timely and accurate information from various sources. Accurate, relevant and up-to-date

information is essential to health service managers if they are to recognise weaknesses in health service provision and take actions towards service delivery improvement.

Historically, the HIS in Mozambique has collected and tabulated data on community health and other health issues. Policy makers and practitioners need to consider and use epidemiological, economic, management, demographic, and other types of information to make and implement informed decisions for public health. This information derived from health and management information systems, public health surveillance systems, registries, surveys, and studies can provide a basis for setting health priorities, formulating health policies, obtaining and allocating resources, and planning, implementing, monitoring, and evaluating public health prevention and disease-control interventions and programs.

Much of the data needed for decision-making are already collected by one or more information systems or studies. However, several barriers contribute to the underutilization of available data. These barriers include:

o Decision-making in public health, as in other areas, is driven by crises, hot issues, and the concerns of organized interest groups;
o Decision makers may be uncertain about how best to utilize available data;
o Data gatherers may not know how best to analyze, interpret, and present the data to decision-makers;
o The data may be unretrievable because of collection, storage, or processing issues; and,
o The volume of data may be so great that extracting the appropriate information is difficult, or the information system may not collect appropriate data.

For several reasons, health consumers and health planners have rarely used health-related data(Melnick, 2003):

o Data is not timely.
o Data arrives in hard-copy form, containing limited analysis at the provincial and at the national levels. Such hard-copy data are not amenable to further analysis. So local planners must ask the responsible district or province to make specific data runs, requiring additional time and staff support.

o Many different levels collect and maintain health-related data in different formats in different locations, making the data less accessible for consumers, health planners, and local health departments.

o Data analyzed and reported at the provincial level and above are not useful for assessing the health of diverse communities.

The approaches that are being used by Community Health decision-makers in order to address these problems do not bring "profitable goods". Every year the information that is provided to health stakeholders (Community, government, NGOs, WHO, etc.) present the same problems.

1.2.2. Public Health and Spatial Information

Many of the problems facing the daily work of Community Health planners and decision-makers are related to geography and the question "where". People and the factors that cause diseases are dispersed, often unevenly, across communities and regions. The processes that bring people into contact with disease agents also vary across geographical areas. For instance, for many years Mozambique has been one of the countries with the highest maternal mortality rates in the world. The cause of these values may be hard to understand without taking into account the following:

o the catchment area of the institutional deliverers;
o where women with "first natal visit completed" live?
o where the highest cases of birth under 2500 grams (<2500 grams) have taken place? And,
o where to intervene in order to improve the follow-up of antenatal visits or, to improve health services delivery?

The reasons for understanding these factors are because most of the information needed to populate HIS indicators is linked to a geographic or spatial context. One of the main reasons why information on sustainable development should be in a spatial format is that it allows the social, economic and environmental status of areas to be graphically displayed. In addition, the extent of the problem can be shown using classification techniques and other form of spatial analysis.

Having an understanding that the geographic location provides a perspective to the social, economic and environmental circumstances that prevail in that area, by mapping information on a regular basis, trends in relation to certain sustainable development issues can be determined (eg. changes in geographic condition of a most predominant malaria region). Another powerful function of spatial information is that it allows different types of information to be collected from diverse sources (eg. satellite images, aerial photographs, maps, field surveys, social surveys, etc) and integrated. For instance, taking the malaria example, information on geographic condition collected from satellite imagery can be integrated with population statistics from census data to gain a better understanding of what socio-demographic factors cause malaria prevalence.

In this sense, geography can also be used as a proxy, for example measuring the distribution of diseases against socio-economic conditions; identifying where condoms can be issued to eliminate risks such as premature pregnancies, or to protect women against HIV; identifying what the difference in percentages is for oral contraceptives issued between geographic regions; and identifying how to fight against the spread of HIV/AIDS and other infectious diseases.

GIS technology, as referred before, also allows information to be integrated from different scales and aggregated to a common spatial unit of analysis. This is probably the most powerful function of GIS. This ability allows further statistical analysis to be done to determine the relationship between different factors. For example, it has been shown that high maternal mortality within the rural areas is mainly a result of the economic vulnerability of the population. This could only be accurately determined with the use of spatial information.

However, much organized spatial information in the health sector in Mozambique is traditionally compiled in the form of paper maps. These maps may take many years to create and keeping them up-to-date requires major efforts in data collection, recompilation and reprinting. Consequently, many maps represent outdated sources of information.

Thus, it is apparent that it is necessary in many instances to consider the geography behind health data. Although this is not an easy exercise, the application of GIS may aid in decision-making enabling health decision-makers to more easily monitor and determine the

geographic structures of health data; mapping of communities at risk, identifying the risk factors, and planning for intervention.

1.3. Research Issues Addressed in this Thesis
1.3.1. Research Domain

The health sector can be considered as an important and relevant sector within which countries or societies can benefit from information systems, where experiences relevant to local settings can be drawn upon. The health sector is important and relevant in this respect because it extends to the most peripheral areas of the society and effective use of information is crucial to primary health care delivery and health management. One central characteristic of developing countries is that health problems are experienced by the majority of the population.

There is generally low level of use and management of local information within the HIS in developing countries, and very little research and development is aimed at the health sector in the world's poorer countries. Being Mozambique a developing country, it has to restructure the existing HIS to reflect and support the use and management of information for decision-making purposes. At local levels, most of the health care services are being delivered, and it is this level which is the origin of the health care data and for the statistics being generated in health systems.

1.3.2. Research Study

The main goal of this study thesis has been to promote health community awareness of the availability, use and benefits of spatial data. This involves suggesting strategies on how to strengthen health information systems by focusing on spatial analysis and presentation of health data.

The health information system in Mozambique is called SIS, which is an acronym for the Portuguese meaning of Health Information System (HIS) -"Sistema de Informação de Saúde (SIS)." The current HIS in Mozambique dates back to 1982 and covers the primary and the secondary levels of health care. The HIS was revised in 1989 due to constraints related to lack of defined objectives, complexity of the forms (too many, lack of data definition), and data duplication. The revision of HIS led to a reduction of the number of forms used for data

collection, from 60 to 12, and some basic indicators were included in the forms for use at district and health facility levels. The forms have fields for calculation of indicators or coverage rates. The idea beyond calculation of basic indicators was to promote local use of information, but the intention has not materialized practically at district and health facility levels. Later, in 1992, a computer-based system at provincial level was introduced in the provincial capitals in Mozambique(Brown, Sitói, & Irias, 1997), representing the first national computer-based information system.

According to Braa et al. (2001), this information system was designed in order to report on the activities of the various vertical health programmes (e.g. immunization, family planning, drug distribution) from the districts, via the provinces to the national level. This design was based on upward reporting to support the national level and the various vertical health programmes needs for information, and the needs of provincial and district health management were not focused upon(Braa et al., 2001).

Taking into consideration these issues, this study suggests the use of GIS systems in public care settings as an efficient tool for supporting decision-making process. For that, the following objectives and questions have been identified.

1.3.3. Research Questions

The objectives of this study are: (1) to assess the health information system in Mozambique; (2) to analyse approaches to the development and institutionalization of GIS system in developing countries; (3) to develop a prototype of a GIS-based information system for a particular application domain of community health; (4) to suggest strategies and ideas on how to strengthen health information systems at local, district, province, and national levels, more generally to improve decision-making procedures through the use of GIS systems in Mozambique; (5) to assess the progress of the GIS systems in Brazil in order to identify learning gathered that could guide the adoption of this technology in Mozambique and to other developing countries; and (6) to formulate recommendations to be followed by health decision-makers in developing countries when dealing with spatial related problems.

Based on the objectives of this study, the following research questions are addressed:

(1) What are the current major limitations of the information systems for decision-makers?

(2) What challenges are there when using spatial information to address challenges of public health decision-makers with focus on maternal mortality?

(3) What are the approaches to address these challenges? And,

(4) What strategies can be developed to implement GIS technology for health management in Mozambique?

1.4. Additional Exposure to the Field

Before starting the fieldwork for this thesis project, I was fortunate to come across opportunities that provided me with exposure to some of the issues I would subsequently encounter. I briefly describe below my prior exposures to GIS in a developed country, Norway, and the health care system in Mozambique.

During the first semester of my Masters studies in Information Systems, August to December 2003, I carried out a project as part of the GIS course, as a way of practicing the use of GIS for public health. Non-spatial and spatial data from Mozambique were required for that. From this study I started understanding the first constraints of using GIS, particularly in developing countries. I also used the Norwegian experience to be a base of comparison of what I encountered later in Mozambique, in order to learn about posterior approaches.

Another prior exposure was from February to March 2004, while taking a course on qualitative research methods in Mozambique during the second semester, whereby I conducted observation at Manhiça health facility and health district. Here, few health workers were interviewed, including the head of the health district.

A further exposure occurred around the period March to June 2004. From these studies, I learned about two general issues which were useful for my thesis project. I was first introduced to issues related to research design and methodology. Secondly, I was introduced to levels of the health care system and information flows within a national health care system.

1.5. The HISP Research Project

The HISP Research project started in 1994 by researchers from Norway and the University of Western Cape and Cape Town. The main goal of this research project is to design, implement, and sustain a HIS to support primary health care delivery at grass root levels for developing countries.

HISP has developed open source software called District Health Information System (DHIS) based on Microsoft Office 97/2000. DHIS was designed to capture routine (generated in the health facilities) and semi-permanent (for administrative and monitoring purposes like staff in health facilities, total population, etc) health data.

Currently, HISP is ongoing in a number of developing countries, including South Africa, Mozambique, India, Tanzania, Ethiopia, Malawi, Mongolia, Cuba, Nigeria, and China. The HISP project was introduced in Mozambique through Eduardo Mondlane University in collaboration with the Ministry of Health. Given the introduction of the PhD program in the country, it was envisioned that doctoral students would drive the process – the informatics students leading the technical informatics component, and the doctors providing the health inputs.

HISP seeks to create a network for sharing knowledge, experiences, technology, etc. within all the countries where it is implemented, and embraces institutions, people, researchers, data elements, indicators, and so on. PhD and Masters Students, including myself, are undergoing training within a HISP-Mozambique framework. This research is set within the HISP research project.

1.6. Organization of the thesis

The thesis is organized in seven chapters. In this introduction chapter, I have presented the research topic, problem domain, research questions, expected contributions and the structure of the thesis. A background of the socio-economic and demographic context and ICT situation of Mozambique and Brazil are provided in chapter two. I then present in chapter three the theoretical framework to help analyze the interrelationship between communication practices, GIS technology and information systems introduction. In chapter four, I summarize the research approach adopted for the collection and analysis of empirical

data. In chapter five, I provide a brief overview of the research findings from the two research settings included in this thesis. Then, in chapter six I analyze the findings relating it to the literature. In chapter seven, I present the discussion part of this thesis, the contributions, both theoretical and practical followed by brief concluding remarks. The appendices contain copies of reviewed documents, tools for data collection, and necessary permissions for the study.

CHAPTER II   RESEARCH SETTINGS

The purpose of this chapter is to provide an introduction to the settings comprising the present research, which includes a description of the countries in which this study was carried out. This chapter also broadly outlines the procedures followed in order to gain access to the research settings. The study presented in this thesis is based in empirical research performed in two countries, Mozambique and Brazil during the period of May 2004 to March 2005. In Mozambique, the study was carried out within the Department of Community Health (DCH) in the MoH and three provinces, namely Gaza, Inhambane and Zambézia. On the other hand, in Brazil the study was carried out in the cities of two States, namely the the city of Belo Horizonte, in the state of Minas Gerais and the city of São José dos Campos, in the state of São Paulo.

The chapter is organized in two broad sections. The first section provides an overall understanding of the background of Mozambique. This is, therefore, divided into three subsections where the demographic, social and economic, context is described, including the ICT and health sector contextual backgrounds. The second section presents the background of Brazil. This section is divided into two subsections within which I outline the demographic, social and economic context, including the ICT situation.

2.1. Empirical Setting: The Mozambican Context

Mozambique is located in the south-eastern cost of Africa (Figure 2.1). Like many others developing countries, Mozambique too is experiencing multiple problems ranging from poor living conditions, inefficient provision of health care services, and the prevalence of absolute poverty. Social development processes are largely inequitable, especially in the health sector, and the relatively positive changes being experienced in the cities are not yet being felt by a majority of the population, particularly those living in rural areas.

2.1.1. Demographic, Social and Economic Context of Mozambique

Mozambique has a population of 17,242,240 inhabitants, according to the projections of a census carried out in 1997. Almost 73% of the population lives in rural areas and 70% lives below the poverty line; 23% are women of reproductive age and 46% are under 15 years of age. The crude birth rate is 45.2 per 1000 population, the death rate 18.6 per 1000, life

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expectancy is 46 (44.5 for men and 47.5 for women), and the population growth rate is 2.7% (data referring to the period 1996-2000).

Figure 2.1: Map of Mozambique

According to the 1997 Demographic and Health Survey (DHS), neonatal mortality is estimated to be 54 per 1000 live births, infant mortality 135/1000 and child mortality (<5 years) in 201/1000. The total fertility rate is 5.6 births and maternal mortality is estimated between 500 and 1500 per 100,000 live births. Additional findings reported that: 40% of girls aged 15 to 19 had already experienced motherhood, only 5% of adolescents were using contraceptives and, although 50% of females and 76% of males knew of the existence of condoms, only 2% of females and 10% of males reported having used a condom during the last intercourse. These findings, among many others, show clearly the seriousness of unwanted and unplanned pregnancy, as well as sexually transmitted infections such as HIV/AIDS, to which adolescents are exposed.

With regard to the utilization of health services, the access to health services for the general population is approximately 40%, and 44% of births take place in health institutions, ranging from 81% in urban areas to 33% in rural areas. The Caesarean section rate is 2.7%, with a range of 7.3% in urban areas to 1.4% in rural areas. Contraceptive prevalence

(modern methods) is quite low (5%) and varies widely from 28% in the southern capital of Maputo to 0.7% in the northern Province of Cabo Delgado. In urban areas, 17% of women use modern contraceptive methods as opposed to 2% of rural women.

AIDS is an increasingly serious problem, which mainly affects the economically active population; 63% of the estimated 700 daily new infections occur among people below 30 years of age. The current prevalence of HIV infection among people aged 15 to 49 is 16% for the entire country, ranging from 12 to 20% among different sub-populations, and is higher among women than men within the same age population group. Data collected in 1998 in four surveillance posts for ante-natal care in Beira, Chimoio, Maputo and Tete, reported an HIV prevalence rate among pregnant women of 9.9%, 18.3%, 17% and 17% respectively in the four cities. In response to the increasing epidemic of HIV/AIDS in the country, a national strategic plan was developed and a multisectoral national council for AIDS has been created. At the same time, activities are being intensified to reverse the situation.

2.1.2. The Health Information System in Mozambique

The Ministry of Health is divided into four directorates: the National Health Directorate, the Human Resources Directorate, the Administrative and Management Directorate and the Planning and Cooperation Directorate. Within the Planning and Cooperation Directorate there are three departments: Cooperation, Planning, and Health Information. The Health Information Department is in charge of the health information systems, which were instituted in 1982 by the Ministry of Health with technical support from the WHO.

The health management information system in Mozambique consists of a range of health facilities, institutional centres, and their staff such as health facilities, health district offices, province health offices, the national health office, and a health information infrastructure. These health facilities and institutional centres are inter-connected in order to provide services such as health care and the reporting of health data. In this section, I will discuss issues related to the Department of Community Health activities.

2.1.2.1. Department of Community Health

Children make up one-half of the population and usually more than one-half of the patients needing medical care(Mirsky, 2001). Because many of their diseases are preventable, most countries in the world have special programs to help children stay healthy.

The Department of Community Health (DCH) is a department under the National Health Directorate within the MoH responsible for activities related to mother and child health. In each Health Province Directorate there is one DCH representative.

Although the aim of this department is to keep children healthy, we know a child's health is very much influenced by his/her mother and her healthy practices, both before and after the child's birth. For this reason, this department has also become concerned with the mother's health, as well as how she takes care of her children. This department activities includes vaccinations for the children, nutrition advice to the mothers, antenatal care of pregnant mothers, child-spacing services, simple treatments, health education about sanitation, water, home environment, etc., and any other local mother or child health problems that may need attention.

In Mozambique, immunization campaigns are carried out in all health facilities as part of their routine function. Because not enough newborns are brought to the health facilities at the present time, however, immunization campaigns are carried out, particularly in areas where there are no health facilities. One of the most challenging tasks within the DCH is the maternal and child mortality reduction.

Mother and Child Mortality

More than 525,000 women die every year from complications of pregnancy and childbirth, exacerbated by existing poor health and inadequate care. For each woman who dies, many more suffer damage to their health. In addition to maternal deaths, each year over 15 million women experience severe pregnancy-related complications which lead to long-term illness or disability. These statistics are one of the most stark indicators of the widening gap between rich and poor – both within and between countries. For each woman who dies of maternal causes in the developed world, 99 will die in the developing world(Mirsky, 2001). A woman in Mozambique has a 1 in 9 risk of death during her reproductive years (see Figure 2.2).

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Afghanistan	1 in 7 women
Sierra Leone	1 in 7 women
Somalia	1 in 7 women
Angola	1 in 8 women
Yemen	1 in 8 women
Ethiopia	1 in 9 women
Mozambique	1 in 9 women
Mali	1 in 10 women
Nepal	1 in 10 women
Uganda	1 in 10 women
The Gambia	1 in 13 women
Zambia	1 in 14 women
Tanzania	1 in 18 women
Kenya	1 in 20 women
Bangladesh	1 in 21 women
India	1 in 37 women
Pakistan	1 in 38 women
Philippines	1 in 75 women

Figure 2.2: A woman's lifetime risk of maternal death by country (Mirsky, 2001).

The tragedy is that almost every one of these deaths is avoidable. They are caused by social injustices such as early marriage and violence, by poverty which leads to malnourishment and anaemia, by undesired fertility and by lack of access to safe, legal abortion and adequate maternity services. When a woman dies in this way, her surviving children are also at risk – each year, maternal health complications contribute to the deaths of at least 1.5 million infants in the first week of life, and 1.4 million stillborn babies.

Much of the work of health facilities will therefore be concerned with infants and children. As a result, the high maternal mortality[3] is one of the main reproductive health problems identified, and the Ministry of Health (MoH) has therefore conducted an analysis of 90 maternal deaths, which occurred in hospitals in seven provinces during the period 1 January 1997 to 30 June 1998, in order to determine the main factors associated with maternal deaths in Mozambique.

Among the 90 maternal deaths studied, 75 were attributed to direct obstetric causes of death, due to puerperal sepsis, haemorrhage, uterine rupture, and eclampsia. The remaining 15

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[3] A maternal death is defined by WHO as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental of incidental causes".

women died from indirect causes, such as malaria, anaemia, AIDS, pneumonia and intoxication from traditional medications. The analysis of the main contributing factors to these 90 maternal deaths were based on the model of the "Three Delays"(Libombo, 2002; MISAU & FNUAP, 2000).

During the same period, safe motherhood needs assessment took place in the provinces. This exercise analyzed the main components of safe motherhood, such as family planning, pre-natal care, and emergency essential obstetric care for the main obstetric complications. Adolescent reproductive health care was also analyzed. Interviews, focus group discussions, observations and studying the clinical files were the main methods utilized to obtain the necessary information. Both studies yielded very important conclusions for the strategic direction to be given to the national reproductive health programme, and the results were disseminated at a workshop on national safe motherhood in April 1998.

2.1.2.2. Flow of Information

Similar to the health care provision, the health information system in Mozambique is organized into four levels (health facility, district, province and national) (see Figure 2.3), and is designed to report activities of the various health programs such as immunization, family planning, drug distribution and other planning and management activities at all levels. Data are first collected at health facilities and aggregated at the district health offices, where they are transmitted to the provincial, directorate and then to the national levels.

At every facility level, there is at least one health facility that provides health care services. Apart from providing primary health care services, the health facilities are responsible for the collection of health data in various forms and its transmission to the next level of the district. At the health facilities, data related to a patient is first entered in books and tick registers. On a monthly and weekly basis, these figures are summarized and sent to district health offices, indicating the number of patients seen in a particular clinic classified by specific diseases.

Within each district, there is a team of two or three people comprising the Nucleus of Statistics and Planning (NEP), who are responsible for the health information systems. This team is responsible for collection, collation, aggregation, analysis and transmission of health data received from all health facilities including data regarding the services, to the province.

Health staff in charge of the health information system is mainly nurses with elementary, basic or mid-level medical training.
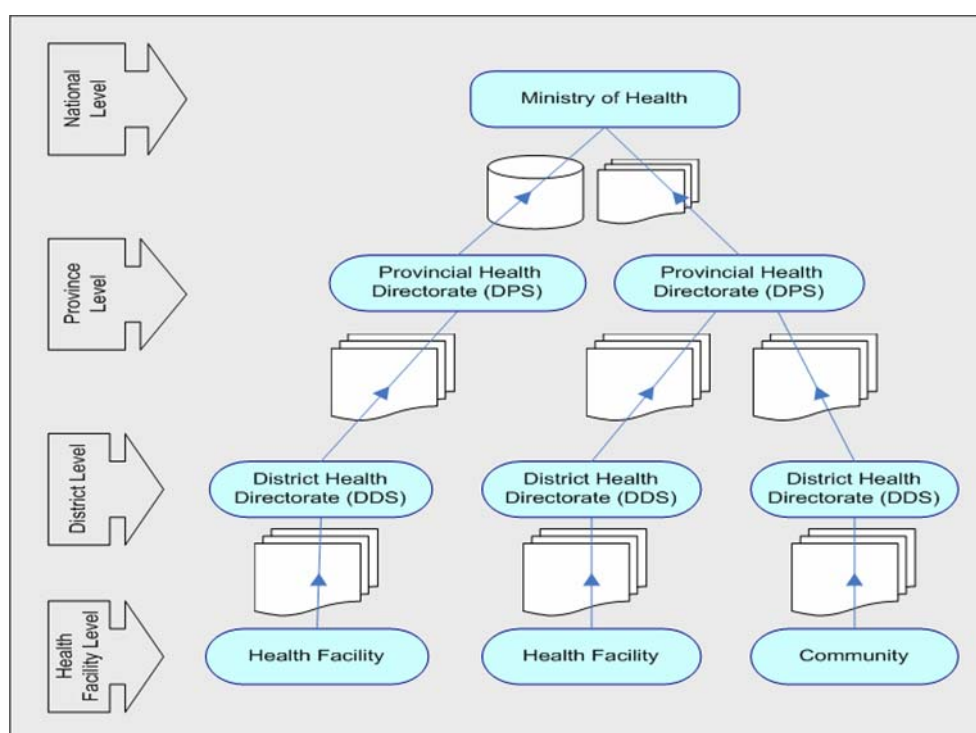
Figure 2.3: Flow of Information within HIS in Mozambique

On a monthly (and weekly for epidemiological information) basis, the district office receives reports from health facilities with statistics of each health program which they then aggregate into consolidated reports and send to the province. While the health information system in the health facilities and the district is paper-based, at the province it is computerized, i.e., the data received from the districts is entered into their respective provincial computer-based systems relating to infectious diseases (called BES – Boletim Epidemiológico Semanal), routine health (called SIS – Sistema de Informação para a Saúde), and monitoring and planning (SIMP – Sistema Integrado de Monitorização e Planificação). These systems require data to be copied onto floppy or zip disks to be sent to the national level. On average, each province has more than three computers, while most of districts have not yet seen their first computer (Braa et al., 2001)

Since 1982, each health program had their separate reporting information systems, especially at the province and national levels. In order to simplify and integrate the various programs, the HIS was revised in 1989. The desire to create integrated and decentralized National health information systems has not yet been accomplished and data still flows mechanically from the district and province levels to the national level with limited

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feedback and without adequate integration with various programs of action. Most health programs continue to have their stand-alone system, including data sets and reports(Braa et al., 2001). For example, routine data from tuberculosis, malaria and HIV/AIDS are not coordinated and their reporting structures are outside the Health Information Department(Chilundo & Aanestad, 2003).

Furthermore, data is not kept in a systematic way by the individual health facilities, due to lack of skills, people being overworked, limited supervision, limited training and little support(Macueve, 2003). Health workers (nurses and doctors) run some of the health facilities, even though a great number of them do not have an adequate educational background. The process of collating, analyzing, transmitting, and presenting the health data is so tedious that by the time a report is prepared, the data are obsolete and decisions are often made without relying on any information input. Within the existing context of reforms, a number of initiatives are currently ongoing to strengthen the health information system and address the challenges of fragmentation and lack of analysis. The HISP is one of these ongoing initiatives.

2.1.2.3. Distribution of Human Resources

The biggest and most important component of any health system is its human resources (HR). Without a foundation of skilled HR, health care systems cannot function adequately or effectively. The effective, equitable and appropriate production, training and deployment of health workers have been associated with periods of high gain in southern Africa. Health workers have played an important role in organizing social and community action for health, particularly within primary health care systems.

The health system in Mozambique is comprised of a total of about 1,200 health facilities which employ about 16,248 people - 10,141 health technicians (all levels) of which about 435 are physicians (Jamisse, Songane, Libombo, Bique, & Faundes, 2004) (being most located in Maputo) and about 6,200 administrative staff (non-medical personnel)(MPF & MISAU, 2004). While the National Health System employs a higher proportion of elementary and basic trained personnel, the percentage of university trained personnel is very low, especially in the district and general hospitals. At district level, there is a lack of personnel trained in management and administration. In general, the National Health System has been struggling today to fill the gaps caused by the departure of qualified

technicians, a problem magnified by the relatively fast growth of health facilities, especially in the rural areas. However, questions still remain whether the health facilities are in fact properly staffed, and if the health services that people are actually accessing are of the expected quality. Under current reform efforts and conditions of relatively increased stability and economic growth, the government is seeking to further strengthen and expand the provision and management of health services.

In summary, the socio-historical and political context of Mozambique has had significant influences on the health sector. These influences are important to understand the challenges in introducing computer-based health information systems. For example, the colonial rule neglected the rural areas with respect to health care, and this neglect was further reinforced by the civil war which led to the destruction of health facilities. While the government was simultaneously building new facilities, they had to deal with this stark legacy of inadequate infrastructure.

The same happens with the status of human resources in the health care sector. The exodus at the end of the colonial rule left very few physicians and trained staff. This shortage was particularly magnified in the rural areas. These shortages significantly influence the current computerization efforts. The high foreign investment in the health sector makes Mozambique very aid-dependent, and consequently subject to donor influences. These influences have contributed to a multiplicity of donor supported information systems, which have implications on the introduction of new initiatives like HISP.

2.1.2.4. Health Information System Problems

The management of the health system is hierarchical and centralized at the Ministry of Health. The higher levels have limited authority and control over the execution of programs and plans designed at central levels(Macueve, 2003). The general problem in the health sector in Mozambique is that primary health care services are not accessible to everyone. Reasons for these problems include lack of funds, and lack of human resources and infrastructures for technical and communication services, which makes communication and access to remote areas difficult for both patients and the health staff.

The ICT infrastructure and human capacity is currently mainly centralized at province levels. In reporting health data from the health facilities, the distance between the district

health office and the health facilities matter. This is because health facilities are supposed to send the data to the district by their own means, regardless of the fact that most of them have no transport facilities. The roads are poor and communication has to take place mainly by a person riding a bicycle. During the rainy seasons, most of the health facilities get blocked and thus cannot manage to send data to the district. In some cases, they send data when they can, and as a result there are significant delays in the health reports sent to the district.

Because of poor visibility of actions it is difficult for health decision-makers from upper levels to get, for example, the health facilities profile, to easily see if the health facilities are prepared to run specific programs such as maternal and child care, HIV/AIDS, and TB, or to decide where to locate new health facilities in order to address problems related to the lack of infrastructure.

Other problems are related to the health data that is reported through paper forms. So, what is filled in the form is sometimes what the worker thinks was done during the day. This is also influenced by the lack of culture on filling correct data and in making analysis. Many of the health workers do not know why they fill in these forms, or the only reason they argue is that they have to send data to the upper level. Forms are filled in mechanically, without knowing the meaning of the data, or at least what will be the end of it. Non-use of collected data to make decisions and poor feedback is also a factor which influences health workers not to worry about the correctness of data. Another issue is that there is no trust on the information (data), because of the educational level of the people who are running the health facilities. Below, I summarize the problems related to HIS.

Correctness of data: Health workers at health facilities are doing much work but reporting less, because they do much work during the day and in the afternoons they try to remember what they have been doing during the whole day for reporting purposes.

Timeliness: For each level of information flows there is a deadline to send reports to the upper levels, which are rarely ever met. It happens that the reports are sent with missing data, making it largely useless for basing actions upon. Reports are thus a mere formality.

Feedback: Data are collected daily, weekly and monthly and sent to the upper levels. But the reverse flow is scarce. No one praises to a well-done job, they just complain of what was

done wrong or missing. This does not stimulate/encourage people to collecting data. There are mistakes in the collected data that are not cross-checked, for instance why in a certain month the immunizations coverage is more than the target population, or why it is more than 100%.

Poor analysis of data: The data that seems to be correct are the data collected by the NEP people, from which some graphs are prepared. When the person in charge at the district level discovers that some data is missing, or that calculations were not done correctly, he/she discuss it with the person who brought the data. However, if the person is a servant the problem is not discussed, and consequently the data is not trusted. There is no analysis of data concretely, and the report merely serves the bureaucratic needs.

Lack of resources: Information use is not coordinated. Some districts are more organized in aggregating data and sending to the next province because they have infrastructures and receive more resources. The health system at all levels is dealing with lack of personnel and material resources. There are some health units that are run by one person, if he/she is not able to do the diagnosis, the patient has to be transferred to other health units, which is inconvenient for patients who have to walk long distances while being ill. Also for the servant too, he has to care about data, and for him it is more important to fill in the forms and send them because it is a sign that he/she is working. The lack of resources strains the health system. One of the interviewees said, "we do not have folders, that is why my room looks so untidy, and I am shifting these last year records to place them somewhere else and use this folder for the records of this year". Although the situation of resources is not good, the people never stop working and try to do the best they can to not stop the routine health activities.

Legacy system at DPS: SISPROG is an old system running at the provincial level and which is difficult to change. SISPROG receives data from the manual forms collected from the districts. If these forms are changed, it becomes impossible to change SISPROG so as to cope with the introduced changes. The format of the paper form (Mod. SIS-B06) being used within the NHIS is different from the Mod SIS - B06 in the SISPROG system. In order to populate the database it is required for the health workers to sum up columns before entering them.

2.1.3. ICT Situation in Mozambique

Although ICTs are regarded as new in most developing countries, experiences of computing devices used in Mozambique can be traced back to the colonial period (since the 1940s) when some leading companies used adding and accounting machines, as well as mechanical tabulators for statistical purposes related to transact trade. The first computer was installed in a tobacco company in 1964-65(Kluzer, 1993).

Mozambique has a small and reasonably advanced ICT community in the capital Maputo, but a weak coverage in the provinces and rural areas. This is of course a reflection of economic and structural factors. A goal to provide nationwide online services to citizens may be many years away. However, experiences in the implementation of ICTs are also found in telecenters located in the districts of Manhiça and Namaacha, in Maputo province(Macome, 2003). In 1999, the Informatics Center of the Eduardo Mondlane University (CIUEM) set up two telecenters with support from the International Development Research Centre (IDRC) in Canada, and they plan to further expand to other rural areas. These telecenters provide a variety of services such as Internet access, e-mail, word processing, photocopying, scanning, fax, telephone, television and video viewing, libraries and training. The objectives of these telecenters are to enable a wider access and use of information technology in rural areas, to help reduce the existing regional imbalances in terms of access and to develop the capacity to use ICTs effectively.

Many studies done in Mozambique, such as the study carried out by The Swedish Agency for Public Management in collaboration with CIUEM – Center of Informatics of Eduardo Mondlane University, from December 2001 to January 2002, shows that if the perspective is widened to include information resources in general, a range of assets for the future Information Society can potentially be developed(Mosse, 2005).

In Mozambique, computers are not widely available. They are too expensive for most people. Most computers are used in the public sector, and nowadays schools, NGOs and the private sectors are incorporating a wide range of computer users. In the health sector, computers are primarily available in the province level.

The Country ICT Survey of Mozambique shows that in terms of the Harvard Guide, Maputo has a small but distinct community with access to PCs and reasonable Internet services.

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However, the rest of the country, and in particular the rural areas, still has a very limited or even minimal access(Statskontoret & CIUEM, 2002).

The number of PCs in the country were estimated to be around 40 000 in 2003. Internet accounts are between 6000-7000. Fixed telephone lines are about 90 000 in the country, and the fast growing mobile networks counted over 150 000 subscriptions in early 2002. A rapid expansion is projected both in the fixed and mobile networks, extending them further into the provinces and rural areas. However, price levels are regarded problematic to growth and to a wider usage of online services.

In the next few subsections of this section I will briefly discuss the status of spatial and non-spatial ICT infrastructure with a focus on the health sector, which is the topic of this research.

2.1.3.1. Spatial ICT Infrastructure

Mozambique has a number of quite sophisticated large-scale GIS databases that are part of an information platform for further development(Statskontoret & CIUEM, 2002). The basis for much of this development is cartographic information from the National Directorate for Geographic and Cadastre information (Dinageca) and the Centre for cartography (Cenacarta), both under the Ministry for Agriculture. There appears to be a certain amount of overlap between them, maybe due to the past development history, with Dinageca as the national institution for the production of traditional maps, and Cenacarta as the institution for the provision of satellite images and products derived from them.

In the production lines of Dinageca, there are two main streams, topographic maps and maps with cadastral (land administration) information. Basic map-data exists in a couple of databases. Roads, rivers, administrative boundaries etc are digitized from topographical maps (1:250.000). Land-cover and land-use information has been digitized from satellite images, and field surveys. In addition, there are scanned images of topographical maps for the whole country, scanned from printed maps 1:250 000 and for most of the country at the scale of 1:50 000. Larger scales are only available for five major cities, Maputo, Beira, Quelimane, Nampula and Pemba. These vector databases are based on aerial photos and adapted for printing of maps 1:10 000 and 1:5000(Statskontoret & CIUEM, 2002).

There are two sets of databases covering cadastre information: real property registers in textual form and graphical databases containing maps showing the spatial aspects of properties and plots. The Real Property Records are held at the province level, with a copy at Dinageca. Graphical databases for four provinces (Maputo, Gaza, Manica and Zambézia), and for two of them (Maputo and Gaza) copies are available at Dinageca. For these two provinces, there are also links established between the two sets of databases, to facilitate production of different types of thematic maps.

Geographical information in digital form is also held at a number of other institutions, both governmental and private. Normally, the activity-specific information is overlayed on top of basic cartographic information from Dinageca/Cenacarta. However, due to unrealistic prising and insufficient communication between institutions, there are a number of cases where the institutions themselves have digitized the bases from paper maps, usually in collaboration with donor institutions.

2.1.3.2. ICT in Health Sector

Within the ICT policy of Mozambique, the health sector is defined as one of the priority areas for ICT applications. ICTs are seen to play a central role in the processes of strengthening the informational basis of decisions related to health care delivery and disease control(Ministério da Saúde, 2001).

The Health Structure in Mozambique, ranging from the Ministry of Health to the province directorates, is populated by Microsoft Windows Operating System and Applications. From the community of health workers that I interviewed, few people from the Ministry of Health have used a GIS System. At the province directorate, some health workers have are aware but none have used a GIS System before. At the ministry level, there is some software that can be used to deal with spatial information. However, it is not being used. Numerous initiatives are ongoing to equip the health departments with more computers.

The ICT Policy of Mozambique specifically addresses the role of ICTs in improving the efficiency of health systems through the processing and analysis of routine health data and its reporting to higher levels of the health administration hierarchy. Prior to 1992, the health information system was paper-based, covering all levels (district, province and national) and included multiple health programs such as Mother and Child Health, family planning,

immunization, Malaria and Tuberculosis. However, some of these vertical programs (such as Tuberculosis and Malaria) were autonomous and collected data based on their individual needs rather than that of the overall health services(Braa et al., 2001). After 1992, the Ministry of Health revised the health information systems with the aim to integrate most of the existing health programs and since then computer-based initiatives have been ongoing in the health sector in Mozambique. These computerization initiatives led to a reduction in data collecting forms (from 60 to 12) and the installation of a computer-based database (SISPROG) in all provincial health offices and at the national level in 1992(Braa et al., 2001).

Contrary to the objectives for integration, however, SISPROG did not support all existing health programs. This situation led to the generation of several computerized systems from other health programs in different platforms, which were supported by different international donors, especially at the provincial and national levels. As a result of this, the current data flows, within and across levels, are still not integrated in the SISPROG. For example, data from the Malaria program is reported through three different computer applications - SISPROG, Malaria vertical program, and BES - this creates a challenge for the integration of the various existing health information systems(Chilundo & Aanestad, 2003).

2.1.3.3. Computer Expertise

Much of the technical skills and ICT industry is based in Maputo. A few organizations, academic, public and private, have high competence in ICT, but the demand for skills and services outstrip supply. In some provinces there is only a handful of qualified and experienced technicians and maintenance service organizations. The ICT infrastructure of Mozambique provides a technical basis for back office rationalization build up of national resources and functions, as well as for developing certain strategic services. However, it is obviously much too weak for providing online delivery of services to broad groups of users on a national basis.

In the health sector, computer courses are routinely taught at national and province levels in order to promote expertise in using computer programs to analyze health related information. Then, it can be easily understood that the health workers employed at the national level have more expertise than those working at the province directorates and much

less for those at the district level. The reason for this is the small number of computers within the health structure. It was also possible to see from the survey done during this study, that much of the health workers use computers to write reports and letters, few do Excel calculations, though not much on analyzing data. For example, the HISP team in the last two years introduced training for the health workers in Inhambane and Gaza provinces. The aim of this training course is to teach them how to use computers, because most statistics officers at district health directorates did not use computers routinely, or did not have know-how to use it. The courses also focused on showing staff how the health system works and the importance of health data. They were also introduced to concepts on District Health Information System (DHIS), computer database system, how it operates, and what can be done using this software.

At the national level, the health workers that filled in the questionnaires have been involved in courses related to data analysis and been trained in specific data analysis computer programs. I participated on an EPI Info course given for the health workers at the community health department over 10 days in December 2004. At the province level, this happens about one to two times a year. Those health workers that have been trained in using computer programs for data analysis seldom use their knowledge to the purposes they have been trained in their every day work.

2.2. Empirical Setting: The Brazilian Context

Brazil, located in Latin America (see Figure 2.4), and became independent from Portugal in 1822. As a kingdom became a federal republic in 1889. Authoritarian military rule between 1964 and 1985 left a legacy of social inequality, bureaucratic inefficiency, and state ownership of large parts of the economy. During the 1990s, there was a strong economy and a stable government. In 2001, a new civil code guaranteed legal equality for women.

Brazil, the fifth largest nation in the world, is a large country in South America. Mostly tropical or semitropical, it occupies a surface of 3,265,100 square meters, that is, one half of the land surface and the population of South America.

2.2.1. Demographic, Social and Economic Context of Brazil

Brazil has a population of 176,029,560 inhabitants, having recorded an economic growth rate of nearly 10% annually from the late 1960s to the early 1970s, referred to as the

"economic miracle of Brazil". Since then, however, Brazil has suffered from long-pending economic stagnation. After that, Brazil had its morale lifted again by bringing down inflation from an annual 1,246% rate in 1993 to 1,8% in 1995, thanks to the "Real" Stabilization Plan in mid 1993.

Figure 2.4: Map of Brazil

Health and educational indicators, also display a delay of development in that region. The infant mortality rate is almost three times higher than other regions-60 per 1,000 against 26 in Southeast. The specific fertility ratio is around 2 in the Southeast, while 3.1 in the Northeast, showing a considerable reduction of 60% from 1970 to 1996 (ref. 1998 Brazilian Magazine of Population Studies), but, still true versus that of the Southeast one, reported in the 1980's. Concerning education/literacy rate, the Northeast is left wanting, it is the lowest of the five regions. Literacy rate in rural areas is 68.0%, 66.5% male and 70.5% female. Slavery composed of African people during the colonial period and an acceptance of other immigrants has helped create an extremely diversified society(Planning, 1999). A great majority of the population has adopted Roman Catholicism and speaking Portuguese and the features and cultures brought by said immigrants have spread and intermingled within Brazilian society, thus forming a cultural homogeneity.

2.2.2. Spatial ICT Situation of Brazil

During the 80s, aiming at the protection of the local information technology industry, the Brazilian Government adopted a "market reserve" policy. For eight years, through Law 7232/84, there was a heavy economic incentive provided by the government to produce local information technology (IT) hardware goods. Then, the government requested INPE to devise a strategy for local development of such technology. Therefore, in 1984, National Institute of Spatial Research(INPE) established its Image Processing Division (DPI) aiming for: (a) local development and dissemination of image processing and GIS systems in Brazil; (b) establishment of a research program in Image Processing and GIS, and (c) pursuit of co-operative programs with universities, government organizations and private companies.

> INPE (National Institute for Space Research) is the primary Brazilian institution for research and development in space-related fields. INPE is responsible for different activities involving spatial data, including: (a) operation of a remote sensing ground station receiving LANDSAT data since 1974 and SPOT data since 1986, including management of one of the largest archives of remotely sensed data in the world, (b) creation of a Remote Sensing Division in 1972, which has been conducting research and application projects and that conducts a graduate program in Remote Sensing and GIS that has granted more than 150 Masters degrees since 1974 (a Ph.D. program was started in 1998); (c) operation of a numerical weather prediction and climate centre (CPTEC) which issues forecasts and climate analysis, with many products available online, and (d) development of remote sensing satellites, including the CBERS series of satellites (a LANDSAT-class satellite) built in co-operation with China(Camara, Fonseca, Onsrud, & Monteiro, 2004).

In 1986, INPE brought out Brazil's first GIS+IP system (SITIM) which worked on MS-DOS PC-286, with a home-grown add-on graphics card that had a resolution of 1024x1024x24 bits. SITIM had been designed to a very tight level of integration between IP and GIS and SITIM was used extensively by 150 universities and research labs, up to 1996. Given the recent advances in hardware and software and the changes in information technology policy in Brazil, DPI/INPE started the development of SPRING software; the first Internet version was made available in late 1996. SPRING provides a comprehensive set of functions for processing of spatial information, including tools for Satellite Image.

The response from GIS users in Brazil has been extremely positive, not only from GIS students and government officials but also from small private start-up companies specializing in GIS and small surveying firms that have wanted to enhance their capabilities.

Actual rates of adoption of SPRING technology can be estimated, based on the evolution of the number of users that have downloaded it, since the software was first put on the Internet, in December 1996. During 1997, there were 500 accesses by different individuals and organizations. In 1998, after a Windows version was available, the count jumped to 2000. At the end of year 2000, it had gone to 8000, and around 20000 users are expected to have obtained SPRING by the end of 2001(Camara et al., 2004). In addition to its development of software, INPE has coordinated an effort to develop a comprehensive reference on GIS. Written in Portuguese and available on-line, SPRING is arguably the most complete resource of its kind on internet today(Camara et al., 2004).

Motivated by the database paradigm shift and backed by its previous experience in SITIM and SPRING, the INPE group is currently developing TerraLib, an open-source GIS component library. TerraLib enables quick development of custom-built applications using spatial databases. Currently, such capabilities are only available by means of proprietary solutions such as COM components available in products such as MapObjects, GeoMedia and ARC/INFO-8. These components are based on transitional technologies that either duplicate in memory the data available in the DBMS or use additional access mechanisms such as ArcSDE. TerraLib aims to improve on such capabilities by providing direct access to a spatial database without unnecessary middleware.

As a research tool, TerraLib aims to enable the development of GIS prototypes that include new concepts such as spatio-temporal data models, geographical ontologies and advanced spatial analysis techniques (Heuvelink 1998). TerraLib's partners include TECGRAF/PUC-RIO (Computer Graphics Group at the Catholic University in Rio de Janeiro)(Camara et al., 2004).

INPE considers that the geographical information community would benefit from the availability of a general, open source GIS library. This resource would make a positive impact by allowing researchers and solution developer's access to a wider range of tools than what is currently offered by commercial companies. In a similar approach to the Linux and subsequent open source software efforts, they recognize that such development does not

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happen by spontaneous growth, but a core set of technologies need to be created from which further developments may freely extend.

The proposal for the development of the TerraLib spatial library aims precisely at offering the GIS community a basis for further development. The current intent, although open to debate and further consideration, is that the TerraLib spatial library will be licensed using the GNU Library License (or Lesser General Public License - LGPL), thereby allowing spatial information applications be developed by both the commercial and open source communities to be built from the library. While INPE's intent is to not force commercial companies utilizing the library to make their applications open source, they themselves intend to develop several core open source spatial information appliances using the GNU General Public License (GPL) and encourage others to develop similar open source spatial applications.

Through this approach, they believe those from developing countries will be better able to actively participate in developing application software meeting the needs of their own nations and the needs of similarly situated individuals and organizations throughout the world.

Epidemiologic Surveillance Support System

Epidemiologic Surveillance Support System (in Portuguese, Sistema de Apoio Unificado para a Detecção e Acompanhamento em Vigilância Epidemiológica - SAUDAVEL) was a project run by a team comprised by staff from Image Processing Division, Federal University of Minas Gerais, Spatial Statistics Laboratory, PRODABEL - Information Technology Company for the City of Belo Horizonte, Federal University of Paraná, National School for Public Health, Aggeu Magalhães Research Center, and Scientific and Technological Information Center.

The main aim of this project was to produce critical technological tools to make possible anticipate and amplify preventive interventions, optimizing activities and resources in health promotion. In Rio de Janeiro, for instance, the mean incidence rate of dengue varies from 27/100.000 inhabitants in non epidemic years to 470 cases/100.000 hab during epidemics: 17 times greater. Besides, the so called (re)emerging diseases and its fast spread are placing new challenges for the health systems, particularly in relation to epidemiological

surveillance techniques. The Nile Fever is a good example, with its 3500 human cases and 180 deaths in 2002, in 42 American states. This fever, transmitted by mosquitoes, has wild birds for reservoir, including species with seasonal migratory habits to Brazil.

On the other hand, there is a synergism between social processes and the ecosystems where they happen, related to a state of widespread increase in the social vulnerability and persistence of inadequate conditions of life. As a result, endemic diseases in urban areas, with high population density, where before they were rare, proliferate and disseminate. Leptospirosis is a paradigmatic example to illustrate this problem. The disease has two different incidence profiles: in endemic situation, the population groups with more cases are the most deprived ones, because the transmission follows the contact with rat urine, in extremely precarious environment conditions. Following floods caused by storms, the risk profile changes and the epidemics strikes better-off people.

The complexities of Brazilian urban reality point new targets to the control of transmissible diseases such as dengue fever, filariasis, visceral leishmaniasis, all occurring in large Brazilian cities, usually in the same population groups, transmitted by vectors, with important animal reservoirs, each with its own different characteristics. Added to this scene is the newest epidemic of the modernity: the violence that can be characterized as an urban endemic disease, with important interaction with all others, impacting on the same deprived population. To deal with these problems this project was carried out aiming to timely detect changes in counts of cases characterizing epidemic outbreaks, and to model and identify risk and protection factors in endemic and epidemic moments.

In order to increase the competence of the health sector in the control of transmissible diseases it was necessary to develop new tools for epidemiological surveillance, integrating environmental aspects, risk factor detection, and automatic and semiautomatic methods, allowing outbreak detection and follow-up in space and time.

2.3. Summary

This chapter has been devoted to providing a description of the settings that was developed for this research, including details of the socio-economic, demographic context and the ICT situation. The Mozambican setting present's discussion on the main health information system problems and the Brazil settings discusses issues related to spatial ICT

infrastructure. In summary, the given background helps to situate the study in terms of its context, history, and current status of the health sector and ICT. In the next chapter, I describe the theoretical framework developed to aid such an analysis

CHAPTER III   LITERATURE REVIEW

This chapter provides a review of relevant literature and presents the theoretical background relevant to this thesis. The research topics and theories which I will review here will be reflected in my empirical study and furthermore in the discussions and analysis, and interpretation of the findings of this study. For that, the following sections are presented: section 3.1 comprises three subsections where I present relevant literatures on ICT and GIS in developing countries. I then present in section 3.2 relevant issues on implementation of GIS in developing countries. Section 3.3 presents the challenges in introducing GIS systems in developing countries. I then present in section 3.4 the social perspective of information systems. Section 3.5 presents the web and actor-network perspective of information systems. Then in section 3.6 the participatory design approach for health information system development is presented. Finally, in section 3.7 I present my theoretical perspective.

3.1. ICT and GIS in Developing Countries

Information and Communication Technology (ICT) may be defined as the convergence of electronics, computing, and telecommunications. This convergence has helped to unleash a tidal wave of technological innovation in the collection, storage, processing, transmission, and presentation of information. This convergence helps to provide more rapid and efficient mechanisms for responding to shifts in demand patterns and changes in international settings through more efficient production processes and new and improved products and services.

3.1.1. ICT in Organizations

The survival and growth of organizations in increasingly turbulent contemporary environments depends upon effective utilization of ICT for aligning the organizational structure with environmental changes. How ICTs can help organizations in responding to the challenges of effectively harnessing ICTs, to achieve flexible organizational structures are key ongoing challenges for developing countries(Sahay & Avgerou, 2002).

ICT can play a substantial role in the following major areas:

o improving access to services;

o strengthening the basis for decision-making;

o promoting information exchange among users; and,

o Enhancing the effectiveness of institutions.

For example, quality in health care delivery is largely dependent on the availability of and access to information (Figure 3.1), which directly contributes to the capacity building of the service providers and increases the awareness and thereby the health seeking behavior of the community. Thus, the use of ICT can help reduce disparities between the services available in urban and rural areas and reduce the costs involved in transporting patients to urban facilities.

ICT and Health: a symbiotic relationship

Health needs drive developments in ICT

Health promotion
Disease prevention
Diagnosis
Treatment
Rehabilitation
HS performance

ICT

HEALTH

Bioinformatics
Improved access
Wider coverage

Developments in ICT help shape health systems and service delivery
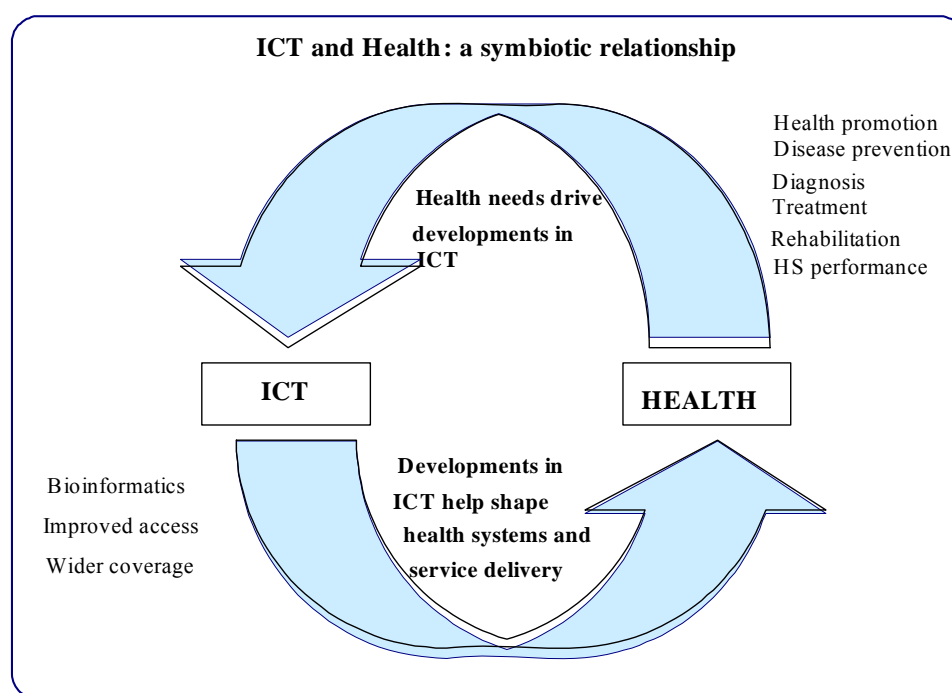
Figure 3.1: Relationship between ICT and Health.

Because an effective information dissemination system enhances the participation among the stakeholders more than an application, ICT is fundamental to enhancing knowledge, and communicating for better health. ICT itself does not do anything useful; in order to realize any gains, it must become part of an information system. As Heecks has argued, it is important to emphasize that these technologies only provide new mechanisms for handling

an already existing resource: information. Therefore, to understand ICTs, one must first understand information practices and needs.

The increasing global interdependencies and the accelerating pace of change demand more flexible and adaptive organizations(Malone & Crowston, 1991). Kenaroglu, (2000) has defined organizational flexibility in terms of "vulnerability" and "adaptability". Then, effective implementation of ICT can potentially decrease vulnerability by reducing the cost of expected failures and enhance adaptability by reducing the cost of adjustment.

Piore and Sabel (1984) cited in Kenaroglu (2000), argue that ICT-based systems offer organizations the opportunity of functional integration, multi-skilled staff, rapid and flexible decision-making structures. This implies a greater delegation of responsibilities and greater autonomy to operating units, and a more flexible and "organic" approach enabling a quick adjustment to changing environmental conditions(Kenaroglu, 2000).

Information management skills rely on the ability to make choices about the optimal arrangements for particular situations. Unlike earlier generations of technology, ICT offers not a single "best" way of organizing, but rather represents a set of more or less appropriate alternative organizing, staffing, and managing options that may be adopted in different organizational contexts.

Thus, following Heeks, ICTs cannot be understood without analyzing information. Developing an enterprise system requires information about several different things. For example, this means information relating to *supply*, such as the availability and sources of finance, labour, technology, raw materials, and other enterprise inputs. Information is also required about *demand*, including market opportunities and its characteristics such as issues related to location, price, size, and quality. Information is also needed about *other environmental factors*, like competitors, laws, etc(Heeks, 1999).

3.1.2. ICT in Developing Countries

Many researchers see ICT as a powerful new opportunity for at least some developing countries to improve their competitive position in certain fields and to foster their development precisely because of their relative lack of established infrastructure. However,

often, the focus is placed entirely on the technology, and not enough on the information and the practices surrounding it that are required to make their ICTs deliver effective outputs.

For instance, in Mozambique, banks, public and private institutions and the government are currently engaged in introducing ICT in order to improve their services. Examples have been shown by Mosse and Sahay (2003), related to ICT in health where they argue that "Mozambique has been attempting to introduce ICTs in various sectors to promote socio-economic development"(Mosse & Sahay, 2003). This is also supported by Macome, when she talks about ICT projects in rural communities, the "Telecentre Project", which is the first experience of its kind in Mozambique(Macome, 2003).

Although the socio-economic structure of many developing countries are not flexible on handling organizational or institutional changes, the complex interrelations between these changes and information technology have significant implications for the way ICT does and will affect the societies and economies of these countries.

The main issue facing developing countries is thus not so much the access to a particular technology, but dealing with the challenges relating to the processes of technological change and the human and social factors that need to be adapted to these processes. Also, the introduction of ICTs requires certain new skills of design, maintenance, and management, as well as complementary infrastructural facilities such as reliable telephone systems, power supplies, and physical infrastructure like roads and transport. Deficiencies in these factors prevent the widespread adoption of information technology in developing countries. Quality of data, too, requires an adequate level of skill, infrastructure, and managerial know-how that is generally lacking in developing countries.

These constraints on ICT development in developing countries have been well documented by researchers. For example, Mosse and Sahay, in relation to the introduction of ICT in the health sector, argue that these ICT initiatives take place in a context that is historically and culturally shaped; the socio-cultural structures are reflected in patterns of how work is currently done(Mosse & Sahay, 2003). NORAD recognizes the challenges posed by ICT in development contexts and acknowledges the increasing digital gap between the rich and the poor parts of the world. In May 2000 a working group submitted a report entitled "Bridging the digital divide – challenges and opportunities for NORAD and its development partners".

In the light of the report NORAD decided to integrate ICT into development cooperation in order to combat poverty more effectively (NORAD, 2002).

3.1.3. GIS in Developing Countries

The term GIS describes computerized information storage, processing and retrieval systems that are specifically designed to cope with geographically-referenced spatial data and the corresponding attribute information. These systems have the potentially to support activities of organizations in managing spatially distributed resources by examining trends, identifying factors that cause them, revealing alternative paths to solve a problem, and indicating the implication of decisions.

Al-Romaithi (1997) describes GIS technology as a product of the developed world, which has unique complexities and problems when applied to developing countries because of their very different socio-economic realities and priorities(Al-Romaithi, 1997). Cultural differences in concepts of time, scale, detail, distance, values, topology and relationships mean that GIS implementation is context sensitive. Beyond these cultural differences, GIS implementation is also affected by institutional contexts and organizational interrelationships(Martin, 1998).

Thus, the implementation of GIS in non-western settings requires a flexible and context sensitive approach(Martin, 1998), involving a variety of modifications to suit local needs. Successful investigations of GIS installations in non-western contexts require an approach that analyses the interactions between the technology and the specific social or institutional setting.

Despite these multiple difficulties in effectively applying GIS, its value in developing countries is becoming increasingly significant, given the current worldwide concern about the state of our environment and the pressure to sustainably manage natural resources.

For example, in recent years GIS technology has been used in health care setting of developing countries to:

o **Organize and analyze information:** There is a growing understanding and appreciation regarding the power of health and health-related information in planning and implementing health programs. Health information is also becoming more and more

readily available. Given these points and the fact that most health information is tied in some way to geography, it is becoming increasingly important that health professionals, organizations, and communities create systems that empower them to really take advantage of the many different types of information that is available and that can be brought to bear on health issues and program management.

o **Assist in planning and implementing, but it is also a powerful tool to present ideas and motivate people to take action:** GIS and maps in general can be a powerful tool when presenting ideas as many people learn best with visual aids. Remember, one picture can be worth a thousand words. Presenting ideas using maps and GIS can help people see patterns and to better understand service gaps or barriers to access. For example, many regions in the world have very rugged terrain or limited transportation routes. Without systems that allow you to present information on service sites and information about geographic barriers simultaneously, it is possible that you could mis-interpret the information available.

o **Design more carefully target health programs to specific population needs:** It is crucial that health programs are tailored to the specific needs and unique characteristics of a community. GIS allows you to characterize and organize information about a community and link those characteristics to the services that are provided. What languages are spoken in a community? What is the distribution of those living in the community by age, and gender? What communities have the highest number of women of childbearing age? Where are mosquitoes most prevalent? Is there clean drinking water? What percentage of the population is in poverty? Systems that allow you to organize and analyze this data geographically can be very powerful when designing health programs and assessing health needs.

o **Track and monitor the incidence of disease and/or inventorying available health resources:** Understanding and monitoring the incidence of disease or conducting inventories of existing resources is a simple and powerful use of GIS. Where is a disease most prevalent? What population has the greatest disease burden? Where existing health resources are located and where are gaps in services? These are classic uses of GIS and can be easily implemented.

3.2. Implementing ICT and GIS for Public Health in Developing Countries

> It is now accepted that the use of computers in the health systems of developing countries "is a need, not a fashion"(Sepulveda, Lopez-Cervantes M., & Frenk, 1992). Studies have shown that microcomputers not only lead to an improvement in the quality of decision-making and to more efficient and rational management of resources, but that they also bring about a significant reduction in the costs of data-processing(Sandiford, Annett, & Ciburslkis, 1992).

Nowadays there is an evolution regarding the diffusion of ICT, and consequently GIS, within many developing countries. Most of this disseminations aims at speeding up research and development processes through regulatory reforms, thus accelerating community access to new promising products; providing tools for better decision-making support; evaluations and benchmarking; addressing inequities, and enhancing monitoring capability for governments. The field of health care continues to experience change and many new technologies, such as Telehealth Networks and Electronic Health Record (EHR) Systems are attempting to be integrated.

The information revolution, of which GIS is an integral part, is taking place in society, and embedded in a broader context of socio-economic change. The socio-economic realities and priorities of the "Third World" are quite different and, if GIS is to be used for the challenges facing developing countries, then it must respond to those realities and priorities.

However, we must carefully evaluate why and how a technology should be adopted before "jumping onto the technology bandwagon." How technology is applied in a health care environment may have serious legal consequences for those involved. Factors such as privacy of information, consent, liability, jurisdiction, and other, are issues that come to mind while introducing ICT and GIS technologies within health care in developing countries.

One important ongoing area of application of ICTs in developing countries concerns the public health domain. In the next section, I discuss some of the opportunities and challenges related to the effective applications of ICTs in this sector.

3.2.1. How can ICTs support Health Information System in developing countries?

Wilson *et al*., define HIS as a set of tools and procedures that a health programme uses to collect, process, transmit, and use data for monitoring, evaluating and controlling the health system(Wilson, Rohde, Puchert, & Hedberg, 2001).

Health management is a pre-requisite for effective health services, and can potentially be improved by better HIS. However, HIS in developing countries face diverse problems such as resource (human and infrastructure) constraints, poor information, multiplicity of programs, and donor dependence. Lippeveld and Sapirie (2000) argue that, most developing countries have routine (paper-based) HISs in place to collect and report data; these are seen largely inadequate and ineffective to support health care(Lippeveld & Sapirie, 2000).

Braa *et al*., argues that, HIS in developing countries tend to be data-led where data is seen an end in itself, rather than being action-led, with a focus on how collected information will inform decision and action(Braa, Monteiro, & Sahay, 2004).

ICT has the potential to change the delivery of health care services and patient care, and the management of the health care system around the world. Technologies and applications are changing at ever increasing speeds and so are the dynamics of the process surrounding the implementation of e-health technologies and applications. Some important areas of applications concern accelerating patient access to new and promising technology. As a result, most developing countries are attempting to strengthen and computerize their HISs but most of them have to date yielded unsatisfactory results. This is because the implementation of HIS in developing countries is a complex and very challenging task, as the process demands not only a technology transfer, but also the introduction of a different kind of culture that accompanies the system. In addition, public health setting in developing countries is a complex environment, characterized by the existence of different donors, different levels of organization, and use of top-down approaches for decision-making.

Basically, there are two things to help make HIS work effectively in challenging developing countries contexts. The first one concerns sustainability, which refers to how the HIS can work in practice, over time and in a local setting. This involves shaping and adapting the systems to a given context, cultivating local learning processes and institutionalizing routines of use that persist over time. The other challenge refers to scalability which

concerns the problem of how to make one working solution spread to other sites, and be successfully adapted there(Braa et al., 2004). To support the sustainability and scalability of health information systems; it is of vital importance to generate local, self-sufficient learning processes together with working mechanisms for the distribution of appropriately formatted experiences across sites. It is also emphasized that interventions must be aligned with the surrounding configurations of existing institutions, competing projects and efforts, as well as with every day practices. In relation to the introduction of ICT in health sector in Mozambique, Mosse and Sahay (2003) advocate that historical and cultural practices and socio-cultural structures are reflected in patterns of how work is currently done.

However, the adoption of ICT in the health sector in developing countries will continue to face challenges from weak infrastructure and resources and resistance unless issues such as lack of awareness are successfully addressed. The barriers with regard to technology, regulatory frameworks, financial requirements and socio-cultural issues need to be addressed. These challenges require a concerted national framework that pools knowledge together, community, district and/or province networks of centres of excellence and a national coordination mechanism.

As a way to bring these opportunities to the health environment, there are complexities that must be taken into account. This includes dealing with socio-economic, cultural and political issues.

Another important ongoing area of application of ICTs in developing countries concerns the GIS domain. In the next section, I discuss the opportunities and challenges related to the effective applications of ICTs in this sector.

3.2.2. How can GIS Support the Health Information System Decision-makers in Developing Countries?

The use of maps in epidemiological investigation is far from new(Gilbert, 1958), with examples dating back to the seventeenth and eighteenth centuries(Lawson & Williams, 2001). The increase occurred in the nineteenth century with the advent of methods in modern epidemiology and the systematic recording and collection of mortality and morbidity data. One of the most important and best-known examples of using maps for epidemiological investigation is the work of John Snow and his now famous study on the

distribution of Cholera around the Broad Street water-pump in the Golden Square area of Soho, central London.

A GIS can be a useful tool for health researchers and planners because, as expressed by Scholten and Lepper (1991),

> Health and ill-health are affected by a variety of life-style and environmental factors, including where people live. Characteristics of these locations (including socio-demographic and environmental exposure) offer a valuable source for epidemiological research studies on health and the environment. Health and ill-health always have a spatial dimension therefore. More than a century ago, epidemiologists and other medical scientists began to explore the potential of maps for understanding the spatial dynamics of disease(Scholten & de Lepper, 1991).

Maps produced by a GIS can also be used by health officials as a monitoring and evaluation tool, showing the spatial distribution and differential evolution of diseases. The kind of problems that GIS can help decision-makers solve though their spatial analysis tools include questions like, "Where should health care centres be situated and what services should they offer to answer efficiently the needs of populations varying in numbers, densities, and health problems?"

GIS can make a significant contribution to resource allocation and planning decisions, and spatial epidemiology by integrating health infrastructure (location of health facilities), demographic data (age, sex, social class and level of deprivation), geographic boundaries (wards, health units, community nursing areas, etc), health status (mortality rates, morbidity rates), and health influences (environmental behavior) altogether (see Figure 3.2).

44
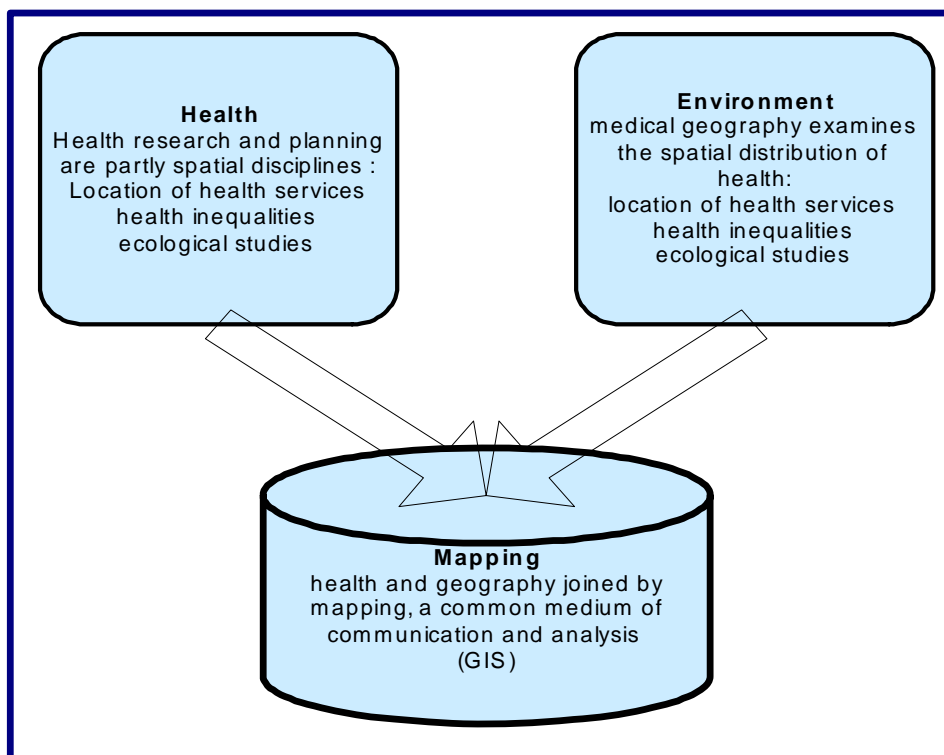
Figure 3.2: GIS in health (White, 2003)

When such data is integrated within a GIS, it can help in the monitoring and evaluation of health programs, by showing the spatial distribution of diseases in space and time, facilitate the monitoring and appraisal of the effectiveness of health programs. Specifically, they can be used in the health field to answer questions expressed in Table 3.1. By answering the questions in Table 3.1 a couple of decision-making problems will be forwarded.

However, GIS projects in developing countries are facilitated by international agencies and follow mainly a top down approach with very little consideration of the local situation(S Sahay & G Walsham, 1997). A number of technological and organizational problems are reported by researchers such as those related to highly centralized decision-making, which discourages the participation of end users in the change process (design and implementation).

Table 3.1: Usage of GIS in health care (Hozumi & McKinney, 2004)

Category	Questions to be answered
Track the number and location, and of children who have been immunized for various diseases in a particular community.	• Who has been immunized? • What have they been immunized for? • Where do they live? • Where do they go to school? • Where is their nearest health center or health provider? • How far to they live from known risk factors?
Inventory and assess the array of health and social service programs available to a particular community or population.	• What services exist? • What is the service capacity? • Where are the services located? • What is the distance between service sites or between service sites and the communities that they serve? • Are there any gaps in services? • Are there gaps in service capacity? • Are there physical or geographic barriers that hinder access to existing services?
Educate and inform people regarding the location of specific health services.	• Where are specific services located? • Where are the providers located that speak my language? • Where are the public transportation routes? • Where can I go to get health education or health related information?
Estimate the number of trained midwives within a certain distance of a community center.	• How many midwives are there within a 15 mile radius of the community center? • How many women of childbearing age live within a 15 mile radius of the community center? • How many children have been born within a 15 mile radius of the community center? • How many of these midwives have received appropriate training?
Identify communities located within unsafe distances of health hazards.	• Where are the known health hazards? • Where do people live relatively to these known health hazards? • What populations are particularly at risk? • What is the prevalence and incidence of the diseases that are related to these known health hazards? • Where are the health services located within the region?

3.2.3. What are the Challenges in Introducing GIS Systems?

It has been underscored by different authors in relation to the power of ICT and GIS technology for health care decision-making support. But their introduction within the health structure, as in others fields, is not necessarily the "silver bullet" that solves the problems of the health delivery services. There are a lot of weaknesses that should be taken into account.

The challenges for introducing GIS are magnified as compared to only IS or only HIS because of technical and institutional reasons. Also, the fact that GIS is composed of

different elements imposes additional challenges. This becomes more visible, given the fact that people issues are more problematic than technology, things (technology and user expectations) change increasingly rapidly, uncertainty is always present, interdependence is inescapable, and that there are considerable differences in national or even regional cultures(Longley, Goodchild, Maguire, & Rhind, 2001).

Even though the introduction of GIS is very similar to other ICTs, it would appear that GIS is particularly difficult to handle from an organizational viewpoint. Budic (1994), addresses this by arguing that "Introducing computerized technology, such as GIS into local government operations is risky business(Budic & David, 1994)." She supports the arguments by underling that "Implementation obstacles are reported even by successful users of GIS technology." However, a couple of factors have to be taken into account while developing a GIS System.

Al-Romaithi (1997) adds that for GIS to be of use to addressing the current challengers facing developing countries, planners would need to actively respond to these realities and priorities, including such problems as: inadequate financial and human resources; infrastructure bottlenecks; difficulties in initiating change in government organizations; the existing work-culture; and issues related to the transfer of appropriate technology. Sahay and Walsham (1997) points that one of the main reasons for failure in GIS implementations is that very little attention is given to adapting the technology to the needs and capabilities of the countries and organizations in which it is going to be adapted(S. Sahay & G. Walsham, 1997).

Many different factors have been described to contribute to project failure, which we have synthesized under four broad categories(S. Sahay & G. Walsham, 1997): technology transfer; institutional factors; data management; and manpower. These are discussed below in some detail.

Technology Transfer

As discussed earlier, GIS technology is a product of the developed world, and is generally introduced into the context of developing countries through the process of "technology transfer." In majority of cases, the transfer of GIS technology to developing countries is facilitated by international aid agencies. As a result, the process of technology transfer is

influenced significantly by the agenda and management styles of these specific agencies involved.

Differences of opinion between the aid-agencies sponsoring GIS projects and officials of the recipient country are often responsible for the breakdown of the transfer process. Aid projects normally come with stipulations about the kind of software and methodologies that should be used, and consultants from developed countries are called in to oversee project management.

Problems associated with technology transfer are related to the contents of what is transferred, the structure of the transfer process, and the absence of mechanisms to sustain the system once the aid project is completed. For a truly sustainable transference of GIS technology, it is important to ensure that within the domain of the receivers of technology, which are often state institutions, conditions are established wherein project can be continued and reinforced(S. Sahay & G. Walsham, 1997). This process of technology transfer is again fraught with a number of significant problems related to institutions, manpower, data, and project management.

Institutional Factors

Like any new technology or tool, GIS can be intoxicating. Difficulties with this can be technological but many times may be organizational. Various authors have highlighted a number of institutional factors, especially within government organizations, that significally influence the effective use of GIS in developing countries. Sahay and Walsham (1997), for example, points to the problems that arise because of the existing culture within government agencies. If users are not actively involved in the process of change, the project can be a disaster. Often people are determined to implement complicated GIS software and present fancy maps but do not realize how time and resource intensive they can be to create and maintain overtime. Choosing the right software and learning how to use it, ensuring that you have the appropriate hardware to run the software, finding and entering good data, ensuring that all your data is compatible and in the right format are issues that can individually or collectively complicate and stall GIS projects even for those who are very experienced.

To make decisions using GIS, there has to be good cooperation between the computer specialist who is developing the system, and the subject-expert who has to interpret the

output. However, the developer and the user are typically responsible to different ministries and departments, and the functional manner in which these organizations operate makes the sharing of data and other technical and organizational resources extremely problematic(S. Sahay & G. Walsham, 1997).

Sometimes it is easier and more efficient just to use a map with a set of pins or to place dots on a simple computer generated map. Sometimes the benefits of creating a GIS do not outweigh the costs. Like with all projects, it is important to clearly understand what you hope to accomplish and have a good sense of the questions that you want to answer before you jump in. Once you know this, you can accumulate the data and decide what tools you need to power your system. However, sometimes it can be problematic for an organization to handle the long data establishment period; this often leads to frustration because of the long period between the investment and the realization of the promised value.

Initiating GIS changes the way in which organizations operate. Consequently, the problems addressed affect virtually all levels of the organization hierarchy and operational paradigms. The idea of building databases of a country's resources and of using that information to help plan and direct the future development of the country concerned is only possible within a context of collective commitment and political stability as well as a belief that the future can be determined and approached with knowledge from the past(Teeffelen et al., 1993). Building a GIS system in countries like Mozambique may require additional effort and collective commitment and should be seen as an investment that will benefit all decision-makers, rather than a system that belongs to only one department.

Several examples of the introduction of GIS in developing countries illustrate situations where social interactions have an effect on configuring the technology. The reverse is also true in that technology has the potential to configure the social interactions. To understand the challenges, constraints and build strategies while adopting a GIS system in Mozambique, it is necessary to study how the elements that make the GIS Systems be integrated, in order to produce knowledge useful for solving practical problems.

For this purpose, theories like those which address ways of understanding how infrastructures (made by human and non-human actors) can fit together are studied. This study includes also those that help on building GIS system (with participation of the users) through interaction and participation of the stockholders.

Data Management Factors

Like all data systems, GIS is only as good as the data that powers the system or the expertise or experience of the person implementing the system. One picture can be worth a thousand words but it does not mean that you are painting the correct picture. For example, if you create a set of maps that shows that all of a regions health facilities are clustered in one area you could be convinced that the area has ample resources. However, if you do not know the population of that area, the expertise of the providers in the clinics, and/or the actual burden of disease in the area then you cannot draw any clear conclusions regarding the appropriateness of the resource distribution. As a result, the effectiveness of GIS depends on the degree of relevant data as inputs. One of the most challenging problems with GIS is finding timely data in the appropriate format. An effective implementation of GIS is severely vulnerable due to the limited availability of useful geographical data. Two aspects lead to this problem, namely: the existence of data and the accessibility of existing data.

The first problem is concerned with maps which are scarce because making maps as well as updating them is a costly and time consuming activity and in many developing countries is difficult due to financial constraints. In addition to information from maps, information about physical and socioeconomic features also tends to be scarce, because obtaining these types of data need field surveys which are time consuming and expensive.

An issue that also contributes to the non-availability of appropriate spatial data arises from cultural and technical limitations. This is also influenced by the dependence of many GIS applications in developing countries on data generated using remote-sensing technology.

The aspect regarding the lack of accessibility of data is derived from the fact that different existing data sets tend to be hard to combine. In some cases creating a combination of data sets even proves to be impossible(Longley et al., 2001; Teeffelen et al., 1993). One reason for this is that often the newly established GIS projects function as isolated islands of innovation. Many software packages have built in mechanisms that allow you to link databases in other formats or import data from other programs. Sometimes this is easy but often it is difficult. You can always enter your own data into the system but this can be extremely time-consuming, particularly when you are mapping multiple layers of demographic information about a regions or community.

Technical data problems also arise because of data being collected in non-standardized formats, whose conversion is not supported by standard GIS software. Absence of policies to define data standards for access and exchange magnifies the problem of developing GIS systems, and many GIS projects are initiated without any coherent data management strategies.

Manpower Factors

With the introduction of GIS, many users will normally be supplied with data from a variety of sources. There is a shortage of persons with GIS expertise in the industrialized world and consequently there is an even greater shortage in developing countries(Teeffelen et al., 1993). This makes it necessary to develop new and complex organizational relations to obtain a good flow of data. Because GIS are expensive computer tools which require well organized data, a high level of skill is required in order to be used effectively.

An acute shortage of trained manpower provides critical constraints in the implementation of GIS projects. In general, when compared to the rapidly increasing demand of GIS personnel in developing countries, the supply remains grossly inadequate. For example students interested in taking up GIS as a career often have no alternatives, but to go abroad for studies, and frequently prefer to stay and work in organizations outside their home countries. GIS does not provide an established and visible career structure in developing countries, thus discouraging students to take up GIS jobs on a long-term basis. The inadequate prevailing government salary structures also make it very difficult top attract and retain qualified personnel and prevent them from joining the more lucrative private sector.

In Mozambique, for instance, centres of spatial research have, over the years, been carrying out high quality research in GIS, but these efforts are not primarily oriented towards producing GIS professionals for the market. According to Sahay and Walsham (1997), universities represent large and complex bureaucratic structures, wherein policies on the existing curriculum are "written in stone." Convincing such organizations to make radical changes, such as introducing new degree courses, is an extremely complex and time-consuming task – a project in itself.

The issues that I have highlighted in the above discussion by themselves cannot provide an understanding of all issues that surround the developing process of building GIS systems in

developing countries. Then, as a way of understanding better those issues it is important while developing the GIS system to view the process using social science approaches.

3.2.4. What are the Strategies for GIS Implementation?

GIS implementation in developing countries is usually considered as the entire technology transfer process, from when an organization becomes aware of GIS technology through to when it adopts it. "Adoption" is used here to mean that an organization has incorporated a GIS into its operations and regularly uses it where appropriate in its day-to-day activities. This implementation can be seen as a six-phase process:

i) *Awareness:* People within the MoH became aware of GIS technology and the potential benefits to their organization. Potential uses and users of the GIS become widespread.

ii) *Development of System Requirements:* The idea that a GIS could benefit the organization was formally acknowledged and a more systematic and formal process was instituted to collect information about the technology and to identify potential users and their needs.

iii) *System Evaluation:* Alternative systems were proposed and evaluated. The evaluation process takes into account the needs analysis of the previous phase. At the end of this phase, a formal decision was made whether or not to proceed with development of a GIS.

iv) *Development of an Implementation Plan:* Having made the decision to proceed with acquisition of a system, a plan needs to be developed to acquire the necessary equipment and staff, make organizational changes, and fund the process. The plan requires a formally accepted document.

v) *System Development Start-Up:* The creation of the database and system, along with operating procedures need to be established. Considerable attention is needed to establish appropriate data quality controls to ensure that the data entered meets the required standards and that suitable updating procedures are implemented to maintain the currency and integrity of the data.

vi) *Operational Phase:* By this stage, the initial automation of the system is complete and operating procedures are developed to maintain the database and provide the information services that the organization requires. In this phase, procedures need to be developed to maintain the GIS facility and upgrade services, so that the GIS

continues to support the changing information needs of the organization. Operational issues concerning the responsibilities of the GIS facility to provide needed services and to guarantee performance standards become more prominent.

According to Budic, (1994) acquisition is a necessary but insufficient condition for GIS adoption by an organization, its units, subunits, and/or members. Three distinct measures of user satisfaction, system usage and system performance; are employed on evaluating the implementation success of various information systems. All these indicators can be experienced by fulfilling the requirements related to successful "initiation" of GIS technology.

Eason (1988) quoted in Budic, (1994) presents five strategies for implementing GIS in organizations, namely, Big Bang, Parallel Running, Phased Introduction, Trials and Dissemination, and Incremental implementation/Evolution (see Figure 3.3).

There is an inverse relationship between the speed of change and the opportunities users have to learn and adjust, which is particularly significant to the acceptability of change.
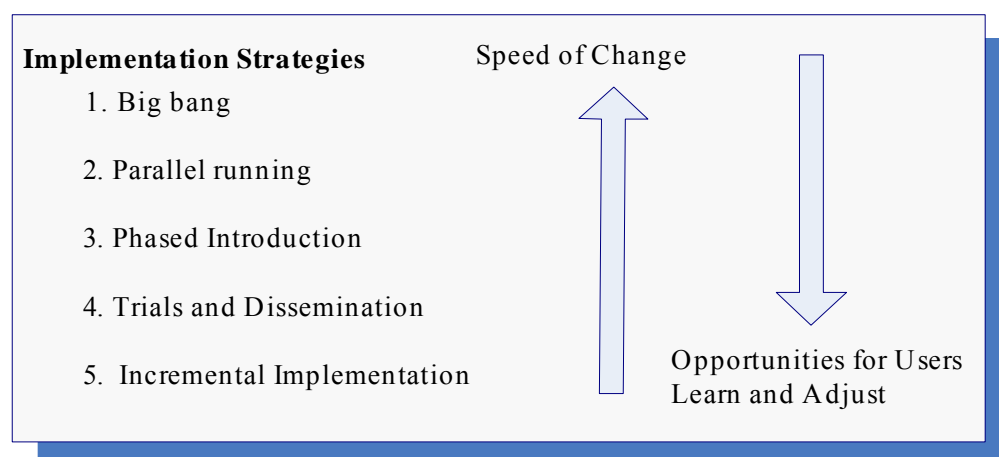
Figure 3.3: The five implementation Strategies. Adapted from (Budic & David, 1994)

The five implementation strategies are discussed below.

(i) *Big Bang:* One of the most difficult kinds of implementation is when an existing system is being discontinued in its entirety at the end of one day, and a new system replaces it on the following day.

(ii) *Parallel Running:* One popular way of minimizing the risks to the on-going work is to introduce the new system alongside the old one, and to run them in parallel until everyone is confident that the new system will be effective. If parallel running is used as

a strategy, it needs an agreed programme of tests, so that everybody can see the progress that is being made towards the switch to the new system and can participate in decision-making.

(iii) *Phased Introduction:* The problems of making massive changes can be eased by phasing in the changes over a period of time. There are two ways in which large-scale changes can be subdivided to facilitate phased introduction. First, the functionality of the technical system can be introduced in phases, so that the basic task processes can be supported in the early phases and subsequent facilities can be added, which supports e.g. decision-making tasks. Second, it may be possible to introduce the system in different parts of the organization at different times. A combination of these two approaches can also be used. A good planning rule is that phasing should ensure that each group of users receives a service they value early in implementation to ensure that they have a positive early experience of the system.

(iv) *Trials and Dissemination:* This strategy explicitly recognizes that there will be "teething troubles" when a new system is introduced, by holding a major trial or pilot project before embarking upon full-scale implementation.

(v) *Incremental Implementation:* The logical alternative to a revolutionary change is gradual evolution. The advantage of such an approach is that users are never confronted by major change but have only to cope with small incremental steps. The growing sophistication and flexibility of technology is making the incremental implementation of systems is an increasingly practical proposition. The more evolutionary the approach, the more time the users have to adjust but the more likely the momentum of the project is to be lost.

Analyzing the constraints of implementing GIS technology in Mozambique and relating to the five implementation strategies presented above, an incremental implementation can fit well as a strategy to be used to address them. Also, on addressing these constraints, Bernhardesen (1999), suggests following the "Simplified GIS strategy". This strategy is described by an elementary "four S". The initial system should be *small* to minimize financial risk and to speed familiarization with new technology. The organization should be *sure* about the requirements. The decision-markers to *see* soon, both to justify investment and to encourage the staff involved. After meeting these three requirements, a measure of *success* will be at hand, relatively quickly and for a minimum investment(Bernhardsen, 1999).

Following this strategy on implementing GIS for health management in Mozambique will be important to identify a part (province, district and health facility) within the HIS infrastructure and a dataset (TB, Malaria or HIV) according to the user requirements as a pilot study for the first phase.

Another important issue in implementing GIS technology in an organizations, according to Budic, (1996) is user training, involvement in system design and implementation, "participation approach", and support and commitment at the administrative level(Budic & David, 1996).

3.3. Information Systems as Social Systems

Information systems (IS) are understood as a network composed of actors, responsibilities, dependencies, social structures, organizational entities, objectives, tasks and resources as well as a collection of (software) modules, hardware, data structures and interfaces. Thus, information systems are much more than just computer and telecommunications equipment, as they also involve people and their actions in the organizational settings in which they work. Similarly, HIS can be discussed as complex systems that tend to be deeply embedded in everyday social practices, such as around data and information within the health sector, include filling in forms and records, collecting data into aggregated forms, compiling statistics and reports, and reporting these to higher levels(Braa, Heywood, & Hedberg, 1999).

Since most Information Systems incorporate the use of information technology (IT), and because ISs are understood by different individuals, and is given meaning by the shared understanding of such phenomena which arises out of social interaction, and not from the essential characteristics of technology, there is a need to address these IS as social systems so that the actions of the people involved are acknowledged.

When an information system is designed, it follows a standardized alignment in order to produce the desired results. This includes answering the basic question which aim to explain how a diverse group of actors reach agreement, and how a social order establishes a certain degree of stability or exhibits structural properties. The lack of alignment and coordination between the various actors and artefacts in the HIS has been described by researchers to be the main factor contributing to the poor quality of HIS, and the subsequent frequent failure of systems development projects(Heeks, 2002).

Walsham (2002) adds by explaining that "the implementation problems associated with Information Systems are well-known and invariably they concern the interaction of human, organizational, and technical factors, which cannot be easily separated. This complex interlinking can best be addressed by conceptualizing computer-based IS as social systems in which technology is only one of the elements"(Walsham, 2002).

This broader perspective of IS offers opportunities for a deeper understanding of the implementation and use of these ISs and their development within the context of the workplace in which they are applied.

The concept of web models can be used to study ISs in a social context. Walsham explains this concept:

"Web models draw broad boundaries around the focal computer system and examine how its use depends upon a social context of complex social actions. The models define this social context by taking into account the social relations between the set of participants concerned with the IS, the infrastructure available for its support, and the previous history within the organization of commitments made in developing and operating related computer-based technologies(Walsham, 1993)."

These social systems are part of a larger infrastructure of heterogeneous components. To understand the behaviour of these components it is important to analyse the infrastructure upon which they are built. An infrastructure perspective helps to understand the linkage between different systems including the ICTs.

3.4. Actor-Network Theory and Information Infrastructure

Actor-Network Theory (ANT) was first proposed by Latour and Callon in France, and comprises a set of terminologies used for describing the interactions between human and non-human participants within an information infrastructure. It is a set of terms derived from science and technology studies and social construction of technology. It is also an analytical tool used to describe technologies influence on human behavior. According to Monteiro in Ciborra (2000) this approach "… *provides a language to describe how, where, and to what extent technology influences human behavior. This is valuable when identifying the influence of seemingly grey and anonymous components such as standards or system*

modules that are already installed. In particular, it allows ANT to zoom in and out of a situation as required"(Ciborra & Associates, 2000).

ANT systematically avoids the dualism between technology and society, focusing on the processes through which social and technical networks are created by linking together both technical and non-technical elements. As Law (1997) puts it, "…entities take their form and acquire their attributes as a result of their relations with other entities"(Law, 1992). In the same way, Law (1992) argues that society, organizations, agents and technological artefacts are all effects generated in patterned networks of diverse materials(Law, 1992).

Monteiro (1999) has argued that, the development and use of ICT involves non-technical issues such as political, organizational development, group and communication dynamics, ethical and cooperation and/or conflicts of interests(Monteiro, 1999). From the HIS design perspective, the pressing question is: how to address simultaneously technical as well as non-technical issues? ANT will help focus our attention on the analysis of how the human and non-human actors within the HIS are networked together, the process through which they are sustained and scaled over time. These actors that make part of the network influence each other trough inscriptions and translations. Inscriptions are written into artifacts (this can be a technology, a paper-clip, a user manual, a hammer etc.) that are part of an actor-network.

Three concepts from ANT are of particular relevance which I will be using throughout the analysis. These concepts are: *alignment* - how actors in a network share the same interests and goals; *inscription* **-** how an artifact embodies patterns of use; and *translation* **-** is a continuous process of actors negotiating their relationships and adjusting their relationships to other actors through inscription.

In ANT, translations mean reinterpretation, representation or appropriation of others interests to ones own. Through translation, the same interest may be represented in different ways thereby mobilizing broader support(Aanestad & Hanseth, 2000). Inscriptions is the process of making networks your own through reaching an agreement and succeeding in the implementation of a standard, and are (a) the result of translating ones interest into material form(Callon, 1991), (b) the way technical artifacts express patterns of use(Monteiro, 2000). Inscriptions can be of a technical character or non-technical (social) like the social collaboration in setting up data elements into a database. In general, any component of the

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heterogeneous network of skills, practices, artifacts, institutional arrangements, texts and contracts establishing a social order may be the material for inscriptions. When an information system is designed, it follows standardized alignment which has to be followed in order to produce the desired results. However, it needs to be revised from time to time to address the interest of the users. This alignment is achieved through the translation of interests and the enrolment of actors into the network (Callon, 1991).

ANT draws on the strengths of qualitative research to provide a powerful, but somewhat different framework for understanding IS innovation. However, as ANT's primary objective is to describe technological systems and non-technical structures as socio-technical networks, it should be well suited for describing interrelations between network organizations and network technologies.

The actors that make part of a health information system include the health staff; the data standards, the communication channels (forms), etc. According to Monteiro (2000) the constitutive elements of an information infrastructure are the collection of standards and protocols, user expectations and experience, bureaucratic procedures for passing standards and inscribing patterns of use(Monteiro, 2000). For example, the various forms of information exchanged are overlapping and interconnected. The same piece of information may be exchanged as part of different transactions, for instance, by transmission of a SIS form from a health facility to the health district and then to the province. Also, many public health professionals are familiar with, and apply standards for vital statistics data (e.g., birth and death information), standards for reporting specific public health data (e.g., infant mortality rates) and standards for classifying diseases (e.g., International Statistical Classification of Diseases and Health Related Problems). Thus, the constitutive elements of this information infrastructure should be the health professionals, the collection of standards and protocols related to the forms, user expectations and experience, bureaucratic procedures for passing standards or reporting health data.

Hanseth (2002) defines information infrastructure (II) with the following keywords: shareable, common, enabling, physical embodiment of an architecture, enduring, scale and economically sustainable.

Recent research in IS has argued for the re-conceptualization of IS as II. The motivation of such a re-conceptualization comes from the increased and distributed nature of

contemporary systems, and also how system needs to be shared and open to allow for flexibility in growth and to accommodate new needs or applications over time. For example, Hanseth and Monteiro (1997) use II to denote the fact that ISs are something bigger than the traditional system. II, like the *web models,* is a notion that encompasses a whole network of human, social and technical components(Hanseth & Monteiro, 1997). Hanseth and Monteiro describe II as evolving, open and heterogeneous, and puts forward the term *Installed Base* to explain how the social system can change: "*The fact that infrastructure are open and evolve over a long time has important implications for how this evolutions unfolds, and what kind of strategies may be adopted in order to manage or control it. When an infrastructure is changed or improved, each new feature added to it, or each new version of a component replacing an existing infrastructure, the installed base, heavily limits and influences how the new can be designed, and in fact, how it can evolve(Hanseth, 2002).*"

Many factors influence the change process when dealing with social systems, which explains the observed difficulties relating to the ability to change IS within the health sector or to build it from scratch. Regarding HIS as an II implies that it develops and grows over a long period of time with layers built upon one another. New features tend to get added as extensions or changes of something already there, the *installed base*. Building a large infrastructure takes time, and as time goes by, the infrastructure has to adapt to the new requirements that occur. Since the whole infrastructure cannot be changed simultaneously, the new infrastructure must be designed in a way that it can be linked to the old one. In other words, infrastructures are never developed from scratch, but rather developed by interconnecting and interrelating existing components. Consequently, the present installed base, that is to be built, carries the heritage from (and is affected by) the former installed base. Depending on the size, the degree of heterogeneity and the degree of flexibility, the installed base can affect an infrastructure to move towards an inertial state. When *designing* a *new* infrastructure, it will always be integrated into and thereby extending others or it will replace one part of another infrastructure.

However, as the installed base grows, it becomes more important and increasingly difficult to build new systems from scratch or to implement substantial changes(Hanseth, 1996). Thus, the installed base influences how the new elements can be designed. Then IS can be seen as part of a larger infrastructure, which is comprised of heterogeneous components that

are integrated through standard interfaces to provide shared open resources to a community of users(Hanseth, 2002).

Another important concept from II is *cultivation*. The cultivation approach tells us not to change, and thereby upset, an organization more than what is necessary to accomplish the task at hand. This differs from a construction approach which assumes that a new and well functioning organization can be designed and implemented from scratch with little need for knowledge of what exists. Business Process Reengineering is a typical example of the construction approach. The cultivation approach states that only such areas that function poorly or do not match the envisioned organization should be changed. This will enable well functioning parts to continue to develop on their own, while unsatisfactory parts are addressed. In fact, it mostly resembles the way a gardener trims a tree to make it grow on its own but in a desired direction.

Based on the assumptions that standards are playing crucial roles in relation to infrastructures one issue identified as of significance importance is of *standardization*. It is obvious that new infrastructures always require lots of standards. Equally is obvious that existing standardization practices and approaches are not at all sufficient to deliver the standards needed. Standardization refers to a process of simplification and abstraction with the aim to define and communicate significant aspects of the processes, artifacts and structures across time and space. The aim is to enable some form of universalisation and mass production(Sahay, 2003). Standards represent agreed upon rules for the production of (textual or material) objects required because they span multiple, spatially distributed communities of practice(Bowker & Star, 1999). Although standards help to provide a sense of stability, as their temporal and spatial scope increases, they take on an increasingly inertial nature, making it difficult and expensive to change.

Establishing a working II is a highly complex socio-technical task which at least includes: designing a large collection of communication standards, testing and adapting these to a wide range of different use situations, and ensuring that the standards are developed according to the procedures of international standardization bodies. Thus, ANT can help in creating an understanding of the process of establishment of an II.

During the field studies it became clear that the major part of the work carried out functioned satisfactorily. Only a few issues needed to be changed in order to make the work

as a whole function better. Cultivation was, therefore, chosen as the guiding principle for design work as it emphasizes the need for change yet argues for a conservative attitude. This corresponds well to the researcher's perspective on change. *Cultivation* and *Installed base* from II has been adopted as the guiding principles for how the researcher relates to change. However, there are complex interactions in this process, which must be well understood which areas should be addressed and in what order. This makes it natural to focus on distinguishing between different activities and examine the interface between them. This process can be well understood with a participation perspective in mind.

3.5. Participatory Design in Health Information System Development

Information systems tend to be one-offs, but the cost of building systems has been difficult in the past, because building a prototype was often almost as expensive and took nearly as long as developing the final system, and therefore was rarely undertaken.

There are many approaches to system design and implementation. Some of these involve complex methodologies that have been developed for large commercial systems development projects. Other approaches are based on constructing working models or "prototypes" of the system to be worked with and evaluated by the end-user. Still others involve combinations of these approaches with varying degrees of emphasis on study, documentation and prototypes. However, selecting the best approach depends on many factors including: level of support, previous experience with automated information systems; existing information technology policy and practices; potential costs of implementation; and so on. Approaches to implementation can vary. They can be large and comprehensive or begin with relatively simple and inexpensive applications -- initial emphasis is placed on learning -- and become more complex and operations oriented as time progresses. This section will highlight approaches that focus on the role of users in the development process.

3.5.1. System Prototyping

The prototype method was formally introduced to the information system community in the early 1980s to combat the weakness of the traditional waterfall model. The early prototyping process was for developers to design and build a scaled-down functional model of the desired system and then the developers demonstrate the working model to the user.

This results in comments and feedback on its suitability and effectiveness. The developer then continues to develop the prototype until the developers and the users agree that the prototype is satisfactory.

Prototyping is an important part of Rapid Application Development (RAD) and is used to help establish the user requirements and in some cases the prototype evolves to become the system itself. Prototyping helps to speed up the process of eliciting requirements, and speed is obviously important in RAD, but it also fits the RAD view of evolving requirements and users not knowing exactly what they want until they see or experience the system(Avison & Fitzgerald, 2003).

Prototyping addresses some of the problems of traditional systems analysis; in particular, the complaint that users only see their information system at implementation time, when it is too late to make changes. With prototyping, user acceptance of a system is regarded as far more likely. By implementing a prototype first, the analyst can show the users something tangible – inputs, intermediary stages, and outputs – before finally committing to the new design.

A prototype is frequently built using special tools such as screen painters and report generators, which facilitate the quick design of screens and reports. The user may be able to quickly see what outputs will look like.

Prototyping is also regarded as a way of encouraging user participation. The hands-on use of prototyping by users provides experience, understanding, and the opportunity for evaluation. Once users and managers realize that things could be changed and that they could exert influence, it can lead to improved participation and commitment to the project.

3.5.2. User Participation

In the traditional systems analysis methodology, the importance of user involvement was frequently stressed. However, the computer professional was the person who was making the real decisions and driving the development process. Systems analysts were trained in, and knowledgeable of, the technological and economic aspects of computer applications but far more rarely on the human (or behavioural) aspects which are at least as important. The end-user (the persons who is going to use the system) frequently felt resentment, and top

management did little more than pay lip service to computing. The systems analyst may be happy with the system when it is implemented. It may conform to what the system analysts understand are the requirements, and does so efficiently. However, this is of little significance if the users, who are the customers, are not satisfied with it.

Participatory approach is aimed at changing user's perspectives about the information system. They would see the information system as a tool for the skilled worker, and the worker should be in control of the tool.

Problems within the health information system are heavily laden with cultural, political, and economical values. Greenbaum and Kyng (1991) argue that "when information systems are introduced within an organization they change the organization. The design of these changes needs to start with an understanding of the use situation"(Greenbaum & M. Kyng, 1991). But, the HIS network is not easily describable; we cannot expect the information system analyst, who sees the workplace from outside, to capture the same vision about the organization as someone involved in the day-to-day activities.

The social perspective on IS has been popular among many Scandinavian IS researchers, and several Scandinavian IS projects have contributed to this research area. User participation in system development is the main component of the approach. This refers to the involvement of users in different activities in the system development process.

Following RHINO (2001), "The restructuring of routine health information systems should involve all key stakeholders in the design process." Experience suggests that systems that are designed by a team of "information experts" without adequate involvement of key stakeholders usually fails to reflect the needs and practical reality of service providers and managers, and does not encourage ownership of the system(RHINO, 2001).

Many actors have pointed reasons for user participation such as:

- ✓ To improve the knowledge upon which systems are built;
- ✓ To enable people to develop realistic expectations and reduce resistance to change; and,
- ✓ To increase workplace democracies by giving the members of an organization the rights to participate in decisions those are likely to affect their work.

The first two reasons are targeted at using knowledge of the workers to tailor the new system to the actual work it is meant to support. The third reason however is more related to cultural and political aspects of systems development, aiming at improved workplace democracy.

This participatory approach will change the user perspective about the information systems. They would see the information systems as a tool for the skilled worker, and the worker should be in control of the tool. Involving users as competent practitioners in the HIS change process will help avoid wide range of visions about the new technology.

The starting point of the Scandinavian design (Participatory) approach is that every human should have the right to participate equally in decisions concerning his or her life. This is about the importance of inclusion of skilled users in the process of design and use of computer-based information systems (Bjørn-Andersen & Hedberg, 1997; Ehn, 1993). This approach is politically significant, interdisciplinary, and action-oriented. It raises questions on democracy, power, and control at the workplace and assumes that the participation of skilled users in the design process can contribute importantly to successful design and high quality product(Ehn, 1993).

Many projects were developed with the aim of finding strategies for increasing work life democracy through user participation in the system development effort, i.e. involving users in work activities during systems development by giving them the rights to participate in decision making in areas that are likely to affect their work.

In order to bring the same view of the workplace and to ensure sustainability of health information systems, Greenbaum and Kyng (1991) argues that "involving the users on design process can help on selection and better understanding of the problem and this will lead to mutual learning between this and the IS analyst about their respective fields by providing same perspectives of work (workplace, computer system)(Greenbaum & M. Kyng, 1991)." This will also help in creating a common vision about the new technology among users and between the users and the developers.

However, the restructuring of routine health information systems should involve all key stakeholders in the design process. Experience suggests that systems that are designed by a team of "information experts" without adequate involvement of key stakeholders usually

fail to reflect the needs and practical reality of service providers and managers, and does not encourage ownership of the system. Assessment and design of routine health information approaches should involve a broad range of stakeholders, including representatives of all management levels of the health system(RHINO, 2001).

3.6. Theoretical Perspective: GIS Introduction as an Information Infrastructure

This study project aimed at developing strategic guidelines to be used in developing GIS System for professionals in the public sector. General guidelines, due to the complexity of the research matters, can be difficult to define and make applicable. On the other hand, guidelines could also be on a higher level, providing designers with a framework to understand the nature as well as the possibilities provided by an infrastructure.

3.6.1. Understanding ICT Innovation

Rogers (1995), describes an innovation as an idea that is perceived to be new to a particular person or group of people(Rogers, 1995). Implementation of an Information System thus inevitably involves innovation as the system will almost always be seen as new by at least some of its users.

McMaster et al. (1997) add that innovations do not wait passively to be invented or discovered, but are instead created "... from chains of weaker to stronger associations of human and non-human alliances. ... Each actant *translates* and contributes its own resources to the shape and ultimate form of the emerging black box(McMaster, Vidgen, & Wastell, 1997)."

By far the dominant paradigm in an innovation research is that of innovation diffusion (Rogers, 1995), in which the four main elements are: characteristics of the innovation itself, the nature of the communication channels, the passage of time, and the social system. On other hand, Law (1992) uses ANT to look on innovation and the core of this approach is translation (Law, 1992) that can be defined as: "... the means by which one entity gives a role to others".

The model of translation as proposed in actor-network theory proceeds from a quite different set of assumptions to those used in innovation diffusion. Latour (1987) maintains that in an innovation translation model the movement of an innovation through time and

space is in the hands of people each of whom may react to it in different ways. Callon et al. (1983) propose that translation involves all the strategies through which an actor identifies other actors and arranges them in relation to each other(Callon, Courtial, & Turner, 1983).

In this way, the adoption of an innovation comes as a consequence of the actions of everyone in the chain of actors who has anything to do with it. Furthermore, each of these actors shapes the innovation to their own ends, but if no one takes up the innovation then its movement simply stops; inertia cannot account for its spread.

3.6.2. Theoretical Framework

I am interested in analyzing the relationship between data, information and knowledge in the GIS system development context. For this purpose, I analyze the networks of people, artifacts, organization, and systems, which come together to support the generation and collection of data, their processing and utilization. Each step of the process is socially negotiated and requires various mechanisms of translations of interests of different actors. To understand these processes, I draw upon selected concepts from ANT, such as inscriptions, translations, alignment and enrolment.

However, the attributes of a good/ideal GIS system (in Figure 3.4) related to issues as Open data policy - GIS data and information should be accessible by any user, freely or at inexpensive costs and without restriction; Standardization- standards for data format and structure should be developed to enable transfer and exchange of geospatial data; Data/Information sharing- data should be shared in order to save cost and time for digitization and information should be shared among users in order to foster operational use of geospatial data; Networking-distributed computer systems as well as databases should be linked to each other to a network for better access, as well as better service, Multi-disciplinary approach - because GIS is a multi-disciplinary science, scientists, engineers, technicians and administrators of different fields of study should cooperate with each other to achieve the common goals, Interoperable procedure - GIS should be interwoven with other procedures such as CAD, computer graphics, image processing, etc; are the same as an Information infrastructure, then we can see GIS as a information Infrastructure.

Using the innovation approach as an explanation of the successful adoption or not of a GIS innovation it is important to concentrate on things like details of the new system itself, how

the change agents enable its adoption, why users accepted the implementation, and over what time period this all occurred.
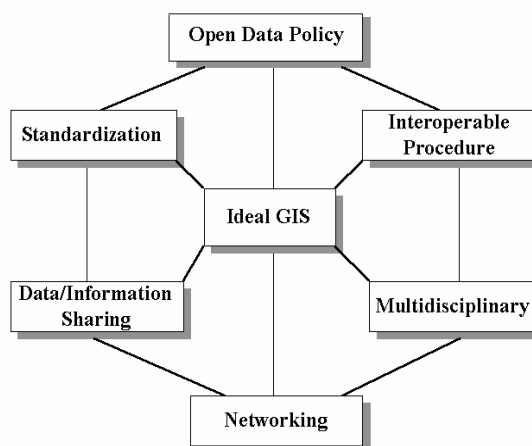

Figure 3.4: Ideal GIS.

Considering a GIS as an innovation that occurs within institutions, a translation process will require focus on understanding the actors that makes part of the different networks (Computer Systems, Information Systems, Information Infrastructures, etc.) within the Ministry of Health, how the Health Information Infrastructures, are created, strengthened and weakened, rather than on causes and effects.

Then, the key to innovation will be summarized as creation of powerful enough consortiums of actors to carry it through. However, getting this innovation accepted will call for strategies aimed at the enrolment of others, in order to ensure the creation of the black box. Latour (1987) suggests that this is done by 'interesting' others and then getting them to follow our interests, so becoming indispensable to them(Latour, 1987). This can be understood through user focused approaches forwarded by theories that address issues like the study of different behaviours of human or non-human actors (infrastructures) that make a network (see Figure 3.5) that produces information.

Figure 3.5: GIS Information Infrastructure
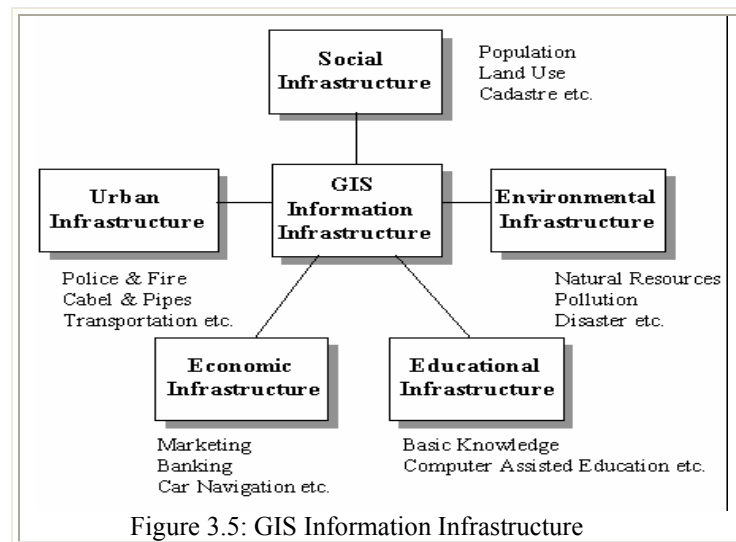
By framing these perspectives in the theory of information infrastructures one can see a fruitful, painting of a rich socio-technical picture of design. At the same time, professional designers and others promoting a design are left with little power to take decisive actions, as design is strongly decided upon as being made up by collective consumer behavior. The use of theories like ANT and Information Infrastructure will help to understand issues that cannot be understood with a traditional innovation view.

3.7. Summary

To summarize, this chapter presents a general vision of GIS technology, its basic concepts, GIS implementations opportunities, constraints and challenges. It is highlighted in here that the process of design, uses and impact of ICTs depends on user's attitudes and expectations, as well as on the capacity of institutional organization and management. These processes should be analyzed using generalized and expanded treatments of both qualitative and quantitative techniques, rather than simply quantitative tools. Adoption of ICTs involves a substantial learning curve and a high level of investment from users, whether they are individuals or organizations.

Approaches to assessing GIS implementation are limited by their focus on technology and information products, unable to address the formative interactions between GIS technology and social context. Actor Network Theory and Information Infrastructure are alternative perspective on science, technology and society that offers several concepts and strategies useful in assessing these formative interactions of the infrastructures.

Tracing the implementation and supporting actor-networks and information infrastructure behind a GIS has been demonstrated as one way to identify these important interactions. That can help on understanding the complexity of information systems and their relations to the broader context.

Methodologies that aim to understand the context are highly suitable for developing countries. Common to all this literature is the view of IS as something more than just technical artefacts, seeing IS as a complex system which also includes contextual issues.

Finally, participation is another approach discussed in here and which can also help understand the context. However, the approach need to be understood more critically and without the assumption that it will always bring benefits.

CHAPTER IV   RESEARCH METHODS

This chapter presents the research approach and relevant qualitative research methods used for data collection and analysis, along with a discussion of their limitations. My empirical focus was on the HIS in Mozambique, particularly the GIS for the community health department. This chapter is arranged as follows: section 4.1 introduces the general considerations in relation to the empirical approach used in the study; in section 4.2, the research approach is presented; section 4.3 discusses the research methods used to collect data; and finally in section 4.4 the data analysis techniques is presented.

4.1. Introduction

This study is part of an ongoing action research project called HISP to introduce HIS in various developing countries including Mozambique. My study formed part of a project which specifically aimed to develop a GIS system for the Community Health Department (DCH) in the Ministry of Health in Mozambique. The very nature of adapting and implementing such a system needs lots of action around design, development or implementation of the system. Events including participation in the developments of datasets, local discussion and implementation, and training were part of my action intervention. As part of the HISP team, I tried to encourage and promote participation among all people involved in the process, for example, after delivering the first stable prototype I visited the province and showed the application to the staff there. In the province, I faced different technical and organizational problems which I discuss later in this chapter. This analysis also helped me to identify problems related to the current information system which informed the prototyping process of the GIS system for the DCH. The study thus falls under the framework of an action research paradigm, based on a participatory research methodology.

4.2. Research Approach

In this section, I outline the five phases of the Action Research approach framework, in order to build theory, knowledge, and practical action by engaging with the HIS in practice.

4.2.1. Action Research

Action Research is defined by Greenwood and Levin (1998) as *"… social research carried out by a team encompassing a professional action researcher and members of an organization or community seeking to improve their situation. Action research promotes broad participation in research process and supports action leading to a more just or satisfying situation for stakeholders(Greenwood & Levin, 1998)."*

Action research is a well-established methodology, widely applied in social and medical science research. The action research method approach/views information systems research as social enquiry rather than social science. This method is grouped with practical action and is aimed at solving immediate problems while carefully informing theory (Baskerville, 1999). However, action research has been typified as a way to build theory, knowledge, and practical action by engaging with the user's context. The fundamental contention of the action researcher is that complex social processes can be studied best by introducing changes and observing and monitoring the effects of these changes. Action research is characterized by intervention experiments that operate on problems or questions collaboratively perceived by practitioners and researchers within a particular context.

According to Baskerville and Wood-Harper (2002), action research consists of five phases (see Figure 3.1) in a cyclical process. This can be described as an "ideal" exemplar of the original formulation of action research(Baskerville & Wood-harper, 2002) to study important organizational and social problems together with the people who experience them. The five phases are now described.

Diagnosing: This corresponds to the identification of the primary problems that are the underlying causes of the organization's desire for change. In my study this phase was characterized by assessment of the NHIS, and the practical problem experienced by the users. As the main goal of this research was to analyse the technical and the organizational issues in the HIS in Mozambique, at the national and province levels all historical health data was identified and their respective source. Within the Community Health Department, spreadsheet data was extracted from a spreadsheet application called SIMP. In order to understand the needs of the DCH decision-makers it was also necessary to investigate the spread of computer facilities over the MoH and the province directorates (DPS). This was done by administrating a questionnaire in the DCH, at the level of Ministry and Provinces.

Three provinces (Gaza, Inhambane and Zambézia) were selected for this analysis. The survey was successfully finished in two provinces where it was found that the DCH was well-equipped with computer facilities to support GIS.
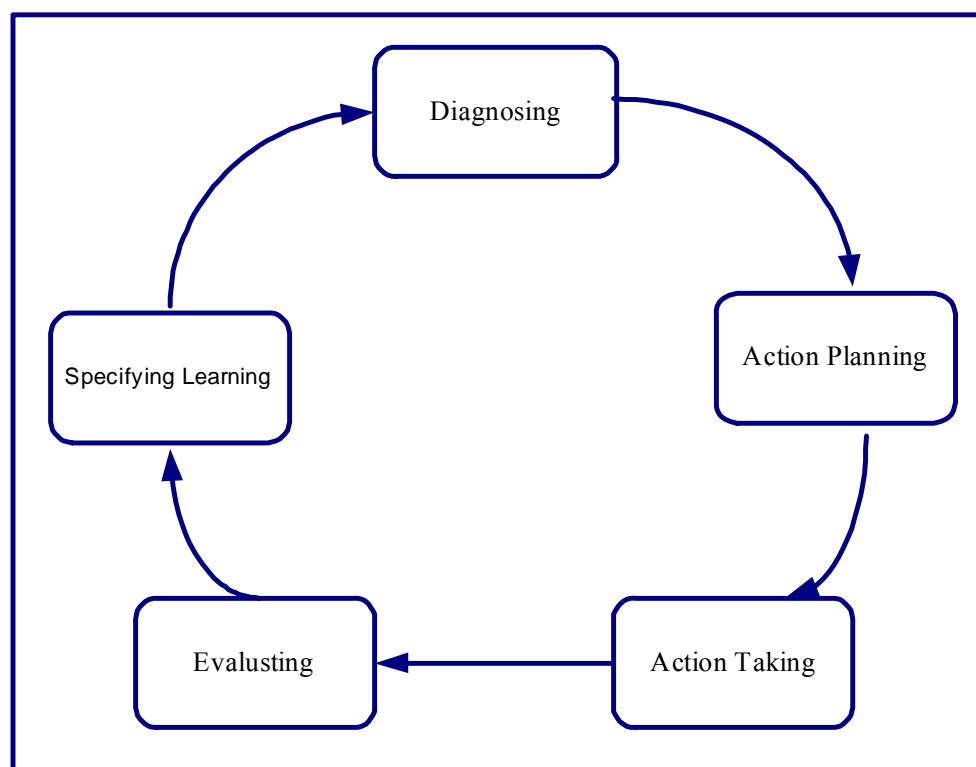

Figure 4.1: The Action Research Cycle (Baskerville, 1999)

Action planning: In this phase, we worked in collaboration with the practitioners, including the health staff. Actions including the identification of non-spatial and spatial data were carried out. This established the target for change and the approach to realize it. The action plan also included the prototyping process to inform the database design. This included a formal group and individual level interview process, pre-specification standards for prototype components and a sequential application prototyping cycle. Various stakeholders were contacted during the GIS development process. Mainly this activity specified organizational actions that should relieve or improve these primary problems related to health data.

After a discussion with the users it was decided to use data that is coming from the Planning Department via the SIMP application. There was a need to collect spreadsheet data in order to develop and populate the non-spatial database. Because the study is being developed under the sunshade of the HISP project, it was decided to use the DHIS as a non-spatial

database and populate the spreadsheet data on it. Spatial information was also required, for which it was necessary to identify and approach various institutions dealing with maps.

Action taking: This activity involved implementing the planned actions through a collaborative process involving researchers and practitioners. This included assessing the different IS within the MoH, assessing the spatial data and also the development of the GIS system. The team acquired hardware and software, conducted rapid and brief interviews with the users, and started an initial rapid prototyping cycle of the database design.

In this phase, health related data was extracted from SIMP to DHIS. Five people were hired to populate data into the DHIS database. Simultaneously, different sources of spatial information were identified, including the INE, MISAU, and DINAGECA. This was important because the maps obtained were not prepared to be shown and linked to non-spatial information related to particular location. It was necessary to work on those maps in order to be related with the attribute databases.

Evaluating: Following completion of the above actions, the collaborating researchers and practitioners evaluated the outcomes, including determining the extent to which the theorized effects of the action were carried out. This was based on demonstration of the different outputs including the non-spatial database and also the GIS system, to the potential users and obtaining their comments or feedback.

To make the GIS implementation more effective, both the technical and the organizational components and their interactions were considered. This included verifying accuracy of the data entered into the non-spatial database, and also, comparing it to the data showed in the GIS application. This process was done for three provinces: Gaza, Inhambane and Zambézia. Discrepancies between the extracted data from SIMP and the non-spatial database represented errors in entering data into the non-spatial database.

Specifying learning: The knowledge gained in the action research can be directed to three audiences. First, reflects the new knowledge in the DCH around the GIS, second, where the change was unsuccessful, its diagnosis helps prepare for further actions research interventions. Finally, the success or failure of the theoretical framework provides important knowledge for the scientific community to deal with similar issues future research settings. The different GIS prototypes delivered at each stage of the development process can be

discussed as a "success" because they revealed the design feasibility, and created user enthusiasm, and provided incentives to the management to further the project. However, some aspects of the prototypes can be called "unsuccessful" because all the non-fulfillment of specifications due to limited amount of data, and data of poor quality. For instance, due the inexistence of data we could not provide good example from the prototype that can help the decision-makers to understand maternal and child mortality issues. The unavailability of community level data for example, did not allow specific to perform specific spatial analysis required for understanding some spatial related problems. I now describe the key elements of participation that constructed the action research effort.

4.2.2. Participation in Action Research

Participation is fundamental to action research: it is an approach which demands that participants perceive the need to change and are willing to play an active part in the research and the change process. All research requires willing subjects, but the level of commitment required in an action research study goes beyond simply agreeing to answer questions or be observed. The clear cut demarcation between "researcher" and "researched" that is found in other types of research is not so apparent in action research. Here, the responsibility for theorizing is shared with client participants, members of the organization who are actively engaged in the quest for information and ideas to guide their future actions(Baskerville, 1999). In this study, the participation was primarily around the design and development of the prototype.

The MoH in Mozambique is composed of various stakeholders with different range of interests.

The use of this approach prevented the potential of conflict between the researchers and practitioners, and to obtain trust. In this study the participants were treated in equals. As a researcher I worked as a facilitator of change, consulting with participants not only on the action process but also on how it will be evaluated. This had benefits by making the research process and outcomes more meaningful to practitioners, by rooting them in the reality of day to day practice. Throughout the study, findings were feedback to participants for validation and to inform decisions about the next stage of the study.

Many times as a research I had to work across traditional boundaries (for example, between health and social care professionals or between hospital and community care settings) and juggle different, sometimes competing, agendas, an action research approach helped me in this process.

4.3. Research methods

The collection of data and other information is essential to action research as it is the prime output of observation, and the prime input to reflection, as well as for planning future meetings. Given that the system was to be designed around an existing set of work processes that involved structured interactions between numerous personnel - both within and between organizations, ethnographic methods were used. Ethnographic methods include observation, interviews, document analysis, surveys or questionnaires, and participation in meetings (Ellis, Quiroga, & Shin, 2002). These methods, each contributed to the formation of a rich, comprehensive picture of the social structure, and revealed both opportunities and constraints on system design.

To initiate this study, an organizational chart was analyzed to help devise a strategy for gathering necessary information. This wide range of information helped me to triangulate my findings, so that an observation measured by one means can often be confirmed or qualified by another observation elsewhere. The use of multiple research methods helped me to triangulate on identifying the health decision-makers problems. However, it has not always been easy to gather the information that I needed. For example, the list of indicators which we received from the Department of Community Health included new indicators which source of data collection tools has not yet been discussed at national level and much of those indicators were undergoing a review process. I present below the summary of each method used in this research.

4.3.1. Interviews

An interpretative methodology (Walsham, 1995) was used in the collection of empirical data for this study, consisting of unstructured interviews conducted across the provinces, MoH and other offices in Mozambique.

Interviews were used to collect, organize and clarify perceptions. They were also used to clarify information not clearly understood through observation. Interviews offer researchers the chance to explore topics in depth and to gain appreciation of the context within which the interview was conducted (Cornford & Smithson, 1996). This was the main method used in this study to obtain data and information. For that, interviewees were selected to reflect as wide a range as possible of the components of the Mozambican healthcare system, at both national and province levels of care.

Interviews lasted between half-hour and two hours each, and involved a representative cross-section of decision-makers, including two Mother and Child programme WHO representative in Mozambique, designers, and the health staff. A semi-structured style of interviewing was used at the first interview, but it became quickly obvious that this was inappropriate to the very informal, unstructured manner in which interviewees liked to interact. Extensive longhand notes were taken throughout the interviews and the use of tape-recording equipment was avoided as the respondent seemed reluctant. Unstructured interviews, in which people were invited to talk about their job and also to clarify some issues, were supported by the collection of additional written material, particularly related to the "Maternal and Child Health" program. The interviewees list was composed mainly by decision-makers within the DCH, database administrators, and statistic officers at national and province levels. However, in Inhambane province attention was given to the district level statistic officers needs.

Problems experienced include getting to see the right people; time to prepare, travel and write-up; and keeping interviews on the topic. For example, I intended to interview several people, mainly directors and administrators. But this proved difficult to achieve, because of their unavailability. As a result, interviewees were selected based on the availability of people. Where possible, I asked the interviewees to recommend further potential interviewees. In all cases the interview commenced with an explanation of the rationale and expected value of the interview.

During the follow-up visits to the provinces, I made interviews with the system administrators in order to get some insights on how the HIS was operating and on technical issues related to the HIS database. While few formal interviews were conducted, I had long and constructive discussions with many people at all levels of the NHIS in an informal and semi-structured manner.

In all cases the interviewees were given the assurance that their responses would be treated as confidential, and none of their responses could be traced back to them..

4.3.2. Survey Questionnaire Administration

A survey questionnaire (see Annex B) was med to help identify important similarities and differences in permitting approaches between the departments within the MoH and the DPSs. A small sample of three provinces and their DCH departments was then chosen for more detailed study. A common set of questions was used in the generic part of the questionnaire to allow horizontal comparisons between the provinces and the MoH. For example, one questions in the questionnaire aimed to know the ICT situation and the expertise in each province.

However, within the generic section the interviewees in the health sector were prompted to identify their roles in terms of information flows. In some instances the interviewer assisted the interviewees with the completion and to clarify the questions. There were a total of 34 questions, with space for additional comments at the end. Respondents were also asked to give some narrative comments regarding the major flows of data to and from their departments/section how effective were these flows, what additional data was required, and the role that played in facility these flows.

Ten questionnaires were provided to each Health Province Directorate and twenty questionnaires to the Department of Community Health in the Ministry of Health (see Figure 3.2).
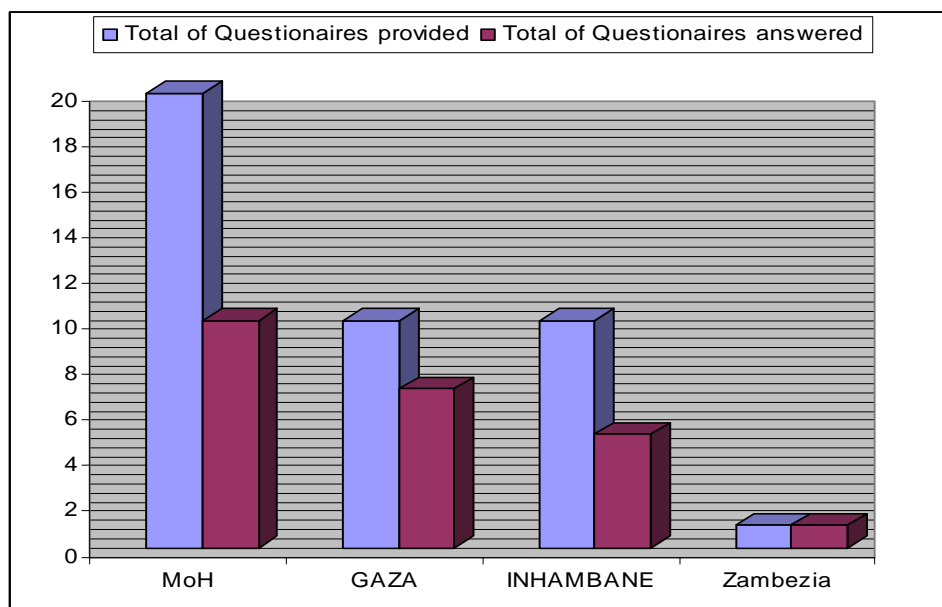
Figure 4.2: Relation between the questionnaire provided and answered by the health staff

4.3.3. Observations

In this study, observations revealed details about application processing tasks, interactions between staff, and the types of documents and forms being made. As with the survey, the processing tasks were found to be loosely structured and were somewhat similar across the different provinces and the ministry.

Much knowledge was derived by observing health decision-makers, and statistical workers in action, prior to the interviews. Another important aspect of observation was to note the infrastructure and the reporting formats.

I carried out participant observation in all the three provinces including the MoH which helped me to conduct a detailed notation of the behaviours, events, and contexts surrounding the HIS. I participated several times in the training of DHIS software especially on demonstrating how the tool can be used to enter and analyze health data. I also participated with the Community Health Department Staff at the national level in an EPI Info course. From those interactions I understood how data collection, analysis, and reporting took place at the national level, and also the situation of ICT usage.

4.3.4. Document Analysis

Documents analysis helps to understood practical how work is done and also policy statements. I examined the standard forms used to collect and report maternal and child

data, drawings, maps, annual reports from the provinces, and the MoH, strategic plans, and other documents. Furthermore, examination of documents revealed inconsistencies in the data. For example, knowing what data is set from the province or what is recorded at the national level?

My analysis focused on existing application, reports (monthly, quarterly and annual) used at the provinces level and also those sent to the national level, and existing mapping files. In this research, a high concentration has been on analyzing the national documents: published target plans such as PARPA plan and Maternal Mortality Reduction Operational Plan. Other available kinds of documents or texts were collected from province health directorates and the MoH and then analyzed.

The primary documents used in the permitting process are reports taken from SIMP Software at national and province levels, and also the province and national level annual reports. The analysis of data gathered was both qualitative and quantitative.

I was free to study the databases in all the Provincial Directorates including Zambézia province. This was extremely useful when planning, developing and setting up the GIS System, and selecting the indicators to include in the first prototype. For example, in all provinces I confirmed the existence of the indicators (presented in Annex A) in the SISPROG and SIMP databases.

4.3.5. Prototyping the Geographical Information System Software

One of my objectives was to provide a GIS system to be used by decision-makers in the DCH. Prototyping is an activity and method within evolutionary system development. Hence, the system design is closely tied to the existing workflow. This strategy was chosen so as to minimize system complexity and the users fear of change. The ethnographic methods presented above helped to document the existing software with sufficient detail as to identify important application status levels and data flows.

It is hard to prototype a GIS system in a laboratory setting. So, together with a small team of Master students' researchers, we wrote a proposal to develop this GIS. The prototyping of the GIS Software involved all process of system development including:

- o uses requirement specification and analysis;

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- o study the existing databases and database design of the structure of the database to be used by the proposed GIS system;
- o populate the database with data taken from the Excel files used by the Ministry of Health (SIMP Software) to analyze their service provision; and,
- o Prototype development.

Given the nature of the project and my use of it in the context of this thesis, the focus is not on a detailed usage study, but on understanding the opportunities and challenges in order to build and interpret guidelines related to strategies to be used by countries that require using this technology.

The different prototypes delivered during this study served as input for comments from the decision-makers from the DCH. The initial prototypes were geared towards new users, focused on defining the needs for GIS. The later prototypes were focused on showing the decision-makers how their spatial limitations should be forwarded using GIS.

4.4. Data Analysis Techniques

The purpose of data analysis is to develop an understanding or interpretation of answers to the basic question of "what is going on here?" The process of data analysis as described by Agar (1980) has a cyclical character:

> *You lean something ("collect some data"), then you try to make sense out of it ("analysis"), then you go back and see if the interpretation makes sense in light of new experience ("collect more data"), then you refine your interpretation ("more analysis"), and so on. Thus, the process is dialectic, not linear(Agar, 1980).*

The process of data analysis was performed continuously as the study proceeded. For example, after getting the first requirements from the users at the MoH, I had to develop analysis in order to find the best way of storing the non-spatial data.

I then discussed my interpretations with the users to get their comments. Data analysis was conducted with many of the stakeholders and also other researchers. Data analysis consisted of grouping observed and written material into first-order data (or the constructions of interviewees and, in certain cases - for example observation – constructions of the researcher) and second-order analytical concepts, which were informed by theory. The

analysis of first-order data derived from interviews was thus inevitably constrained by the interpretation of the researcher.

Nonetheless, attempts were made to minimize bias, both in data collection by conducting interviews in as unstructured a manner as possible, and through sustained interaction over the 10 months period of the research. This provided an opportunity to develop more of a background understanding of the organizational context, which added some depth to the analysis of the interview data. The concerns of interviewees as presented were therefore as unsolicited as possible by the researcher - notwithstanding, of course, the possibility of a 'double hermeneutic' effect inherent in any interpretive research setting.

The way of reviewing data collected was through triangulation, which aimed to obtain confirmation of findings through convergence of different perspective. This involved testing one source of information against another to improve the quality and accuracy of findings before drawing any conclusions. This included comparing the explanations of power structures drawn from formal documents, member descriptions, observation, etc. The use of this technique helped me in analyzing the data as the research went on. So, the isolated findings that were not supported by other sources of data were either disregarded or served as the basis for further investigation.

4.5. Summary

In this chapter I have presented a detailed account of the research philosophy, strategy and methodology according to which I conducted this research. To achieve the objectives of this research proposed in chapter 1, the study was divided into: interviews, observations, and document analysis. I have also reviewed literature on different issues such as system development, social system perspective, etc. I also learnt about the existing information system. This chapter has also presented also the theory about action research methods, the data collection tools, and finally the data analysis techniques used in this study.

CHAPTER V   CASE STUDY DESCRIPTION

The research, as described in the methodology section, was conducted within an Action Research Approach Framework, in order to build theory, knowledge, and practical action by engaging with the world in the context of practice. This fieldwork description is related to a research study which took place within a project framework in the Ministry of Health in the Department of Community Health (DCH) in Mozambique. This project aimed to design, develop and implement a national level spatial database, a GIS for the DCH. The research was set under the umbrella of the HISP research project, with which I have been deeply and directly involved in strategic planning, implementation, software prototyping, institutional development and training activities.

The thesis study was carried out in the period from May 2004 to March 2005 and comprised a team of three Master degree students and one person from the MoH. Both they were responsible for the activities related to the development of the GIS system (DCH_GIS). This process was supervised by four persons, one from the MoH and two from the University of Oslo and one from Eduardo Mondlane University.

In order to create this software application, a database containing non-spatial information was created. In addition, a spatial database was also developed, linked to the non-spatial database, on top of which an application was developed. The development of this tool started within the HISP in India. To classy out this process the source code of the system was provided by HISP India; we then customized it in order to fit user needs in Mozambique. Thus, in this chapter I present the assessment, the situation analysis, and actions taken in this thesis project. The main work of this thesis was done at national level, the Ministry of Health (MoH) because the use of information within the health structure in Mozambique is not so decentralized and the information system is designed to support monitoring from the top level. In addition, work was done in three provinces during the prototype development process aiming at getting feedback from users. So, the chapter is organized as follows: section 5.1 presents the situation analysis in Mozambique, its five subsections help to understand the design and implementation processes of the GIS systems; and section 5.2 presents the implementation lessons learned from the Brazil experience. This development process is now described.

5.1. **Situation Analysis: GIS System Design and Implementation in Mozambique**

This section aims to discuss the empirical data collected from the fieldwork carried out in the three provinces that I have referred before (Gaza, Inhambane and Zambézia) and the MoH, by conducting interviews, observations, document and data analysis and training health professionals from May 2004 and March 2005. The situation analysis started with an understanding of the social dynamics within the MoH, followed by specification of the Community Health professional's needs. During this process, data was collected in order to develop a better prototype, one that better fits user requirements. This process is described in the sections below.

5.1.1. **Understanding Social Dynamics**

A stakeholder analysis was done as first step of the study, aiming at identifying all those groups, institutions and individuals having interests in, control over, derive benefits or suffer consequences from the particular situation of GIS design, development and use. This analysis was meant to list all these stakeholders, determine their level of power and relationships. This helped in finding out all the institutions that we have contacted during the process regarding obtaining of spatial data, routine data, etc. Thus, I also identified local decision-making structures or the flow of information within the DCH, from province directorates to the MoH.

The analysis of documents, interviews and observations helped me to find out that many departments within the MoH are socially stratified; and knowing the different interests of the various members helped in organizing their participation in the development process. Undertaking this provided a frame of reference that helped dealing with various issues (such as consequences of action taken and management of conflicts among the stakeholders) which emerged during the development process.

This analysis required doing a preliminary assessment of the different interests at stake and understanding whether these embody latent or open conflicts, and space for mutual cooperation. The detailed description of the stakeholders and the development process is presented in the following sections.

5.1.2. **Analysis of User Requirements**

The health system organizational structure in Mozambique is decentralized, in a way that health services are offered at health facilities level. The information system is designed at national level and its main purpose is to support the monitoring process from the top level.

To ensure that a speedy utilization of GIS is quickly undertaken, the system was initially confined to the users needs in a limited geographic administrative area, the DCH at national level. To better define those needs, a questionnaire containing 34 questions was prepared and the plan was to distribute it to staff members within the DCH at national level and the DCH and DIS at province level.

The responses to the questionnaires and the interviews provided useful information concerning the data sets in use, and how they need to be incorporated in the non-spatial database.

The interviews also helped to identify two distinct groups: staff with no experience with GIS technology, and staff with some spatial experience who were primarily interested in accessing specific data sets. Thus, the interviews appeared as a way that provided an opportunity for non-experienced users to become more familiar with GIS capabilities and to know how it could be of use to them.

The observations, questionnaires and interviews showed that health staff from the DCH at the national and province levels was very interested in GIS technology. Based on that, a decision was made to make presentations and show the results of the GIS software prototype at each available opportunity and later conduct training sessions that addressed the needs of people in the two groups. For instance, the HISP team organized computer training to the health staff in Inhambane, where I also demonstrated the GIS application and they had the opportunity to make comments on it (see Figure 5.1).

The initial presentation session within the provinces was geared towards new users, focused on defining the needs for GIS. The two later sessions focused on understanding the capabilities of the analysis and how the results should be changed in order to provide international standards on the outputs.

| Figure 5.1: A GIS demonstration session for health staff in Inhambane | Figure 5.2: A data analysis training course for health staff In Inhambane |

These sessions helped to define the needs for the health sector to identify the weakness of the SIMP Software. For example, maternal mortality data presentation standards fixed by WHO recommend that this data has to be presented in 100,000 population basis. However, in Mozambique the SIMP system presents this in percentage. This clearly indicates that SIMP is contradicts stipulated standards.

The data collected from this field shows that there are shortages of computer expertise, particularly at province and district levels (see Figure 5.2). In order to have a same view regarding health information/data presentation data analysis courses must be promoted. As seen on Table 5.1, 100% of the health staff that filled the questionnaire at national level has been attending data analysis courses, while at province level few people have taken data analysis courses.

I also attended a 10 days EPI Info course for health workers at the DCH, at national level, in December 2004, and another 10 days course for health staff in Inhambane. From these courses I confirmed the shortage of computer knowledge within the health staff in the provinces and districts, because this course helped to assess the computer skills of the health staff at the DCH within the MoH and provinces. It also helped me to find out the type of analysis they usually carry out and how they do it. The examples from course sessions helped in identifying the kind of analysis they make and how they carry it out.

Table 5.1: Number of interviews who responded the questions

	MoH	GAZA	INHAMBANE	ZAMBEZIA
Number of questionnaires provided	**20**	**10**	**10**	**1**
Number of questionnaires answered	**10**	**7**	**5**	**1**
Have been trained in data analysis	10	4	0	1
Have ICT facilities	10	8	5	1
Have GPS	0	0	1	0
Use Graphs and Tables to represent data	8	5	5	1
Use maps	4	1	1	1
Have eared about software for data analysis	8	4	1	1
Have used a software for data analysis	8	3	1	1
Store your data into a database	3	5	3	1
Would like to use GIS maps to help on analyzing their data	4	6	2	1
Have eared about GIS software	1	3	2	1
Have used a GIS System	0	0	0	0

From the interviews and observations carried out from the field it is clear that health staff get limited opportunities to apply their training knowledge in practice. For example, one of the statistics officers in Gaza province, when I asked whether he had been trained in any computer program that helped him analyze his data, he said:

> "…I was trained in EPI Info but after the course I came back to my daily work and never applied the know-how I got in the course."

He added,

> "…sometimes we require using those software but we do not even have any software that handle data analysis installed in our computers..."

The lack of opportunities to implement their knowledge in practice impedes the capabilities of the health staff to do data analysis, other than nominal use to make chart or graph.

As a result of the issues focused earlier in this section most of the statistics officers around health facilities, districts and provinces are not capable of carrying out analysis using those packages, even worse is that they only rely on the analysis that MoH requests from them. On table 5.1 one can see that many of them use a computer mainly to write documents, and play games, rather than carrying out data analysis activities.

During the fieldwork in the provinces, I observed examples of local use of information, especially at provincial health directorates. However, the national health information system does not encourage such local initiatives. For example, when asked about the kind of analysis they would like to see incorporated into the GIS system none of them named a single analysis for their local use, apart from those requested by the MoH. This mean that the analysis requested by MoH is enough to analyze their activities but experience show that those are not enough, there are a lot of analysis that they are asked to present at annual meetings of the provincial directorate that are not included in the list of routine analysis.

Through the interviews and questionnaires a number of important system requirements for design were identified. Other requirements were taken from the documents provided by the users. A list of some of these requirements is summarized below.

o The system should allow analysis on the main indicators. Comparisons between indicators and data elements should also be allowed. Mainly as requirement related to mother and child mortality, the system should provide ways of helping decision-makers address this issue through accessibility analysis.

o The DCH needs the national level planning department to coordinate data standards across all administration levels, so data that will be used in the database for the DCH_GIS must come through this department. This is important to maintain consistency in the data used by the MoH.

o Management procedures and resources for overseeing data quality, such as systematic inspection of location and attribution during or after installation, need to be strengthened. This includes the need for documentation and updating of the official base map. To ensure data quality, inspections are required.

o Procedural norms need to be established, such as standardization of minimum data sets and types collected across the departments. The varying quality of data, mostly poor, was evident through the fieldwork. To maintain consistency on data across the MoH data must be taken from SIMP software. This data is meant to be the official data in MoH. However, much data coming from this system is not representative meaning that changes must be done to the data collection database.

o The system should be scaleable to accommodate heavy use, given the large volume of data processed per year in the health facilities.

o   The system should significantly reduce the human effort involved in permit processing and/or additional resources should be made available to shoulder added burdens. Observation and interviews revealed that processing permits was not considered a desirable task.

While designing the questionnaire and interviews templates I planned to conduct interviews following the questionnaires. However, I could not fulfill the idea of carrying out interviews after filling the questionnaire due to several reasons which will be discussed in the section below.

For example, at Gaza provincial health department, when I went to the Adolescents section for interviews the person in charge said that she was new in that section and so could not fill in the questionnaire. In Inhambane province, there were a few people working and they told me that they were busy. I therefore, left the questionnaire and collected it two days later, and scheduled an interview with the DCH consultant one hour later. At that time, the DCH consultant was preparing an analysis of maternal mortality data, and refused my request to review the analysis report on the grounds of privacy, even though the data was collected on an aggregated, rather than individual basis. Consequently, I spent hours there waiting for the interview, but used the available time to observe the work practices of the staff in the office.

In Zambézia province, given that I had not brought with me a formal letter saying that I was doing work at DCH in the MoH, I was not allowed to interview the health workers or to show the prototype of the system and obtain their feedback. However, because I knew the head of the planning department, I informally showed him the software prototype. He liked it, and made some comments and asked me to produce maps for him to include in his annual report. Because I did not have the data on Zambézia province in the database I could not do it. In these visits, I tried to ask questions to aid analysis of issues related to: quality control, data verification, completeness of data collection, data accuracy and precision. The purpose of these questions was to inscribe the same or agreed methods for carrying out these activities.

The database for the DCH was designed to have two components: the monitoring and the spatial. After providing a broad overview of the development process, the design of the spatial and non-spatial (monitoring) databases is described in the subsections below.

5.1.3. **Design and Prototyping the GIS System**

According to the Ministry of Health 2001-2010 Strategic Plan, government aims for the health sector by the 2025 are to increase accessibility of health facilities for the community, include the community in the decision-making process, increase feedback, reduce maternal and child mortality, strengthen equity in health service provision and health information systems, etc. If this is the aim, then decision-makers should consider community as the focal point, meaning that the non-spatial data sets should be available at different levels and it should be essential to organize the non-spatial data at the lowest unit. The higher levels could then be abstracted from the lowest unit whenever required. But five years passed after the design of the strategic plan, and although work is being done, the reporting system continues to work in the same manner.

The Conceptual Design (CD) phase of the GIS helped to define the application needs and the end objective of the application. Generally, this was a statement of end needs defined fuzzily, which crystallized and evolved over time within the broad framework of needs. However, the clearer and well defined the CD, the easier it is for logical designing of the GIS database. Some of the key issues that merit consideration for the CD are listed below:

o Specifying the ultimate use of the GIS database as a single statement. The important aspect here was the management of a particular resource, facility, etc and thus the statement would generally include the various management activities.

o Specifying the level or detail of GIS database which indicates the scale or level of the data contents of the database. A database designed for national level would require far more details than one designed for the province or district level applications.

o Specifying the spatial elements of GIS database, which depends upon the end user, helps to define the spatial datasets that will populate the database.

o Defining the non-spatial elements of the database which are the non-spatial datasets that would populate the GIS database.

o Identifying the source of spatial and non-spatial data which is known as an important design issue, as it brings forth the details of the data collection activity and also helps to identify the needs for data generation.

To understand the nature of GIS data and the inherent problems with data collection (quality, verification, etc.), it was necessary for me to achieve "ownership" of the project

and data. The activities of collecting, entering, querying, analyzing and outputting geographic and attribute data, including the translation of language from English to Portuguese helped in understanding the development philosophy of the system for supporting further developments.

The input data required by the DCH system fall into four categories a) geographic data, b) health related data, c) demographic data, and d) other data/parameters such as water and schools data. Geographic data should be available before the health data, so that the geographic database is built; whereas the rest of the data are made available during the health data and hence they are real-time data.

5.1.3.1. **Spatial Database Development**

In order to design a database structure that provides for maximum flexibility, my rule-of-thumb was to place as much data as possible in the non-spatial database, and to use the spatial database to store only the explicitly spatial data. This way of doing provides more flexibility because the non-spatial data is already known by the user. No additional work in learning how to enter non-spatial data will be required because they already know it. For the user, it will be easier to manipulate what they already know.

Spatial database consists of a *dbf.* project and its associated data files that represent information from a map which have been prepared either by field survey or through the interpretation and verification of remotely sensed data. Examples of maps are soil survey, geological, land use and village boundaries. Much of these maps are available in analog form, and it is only late that some of this map information is available directly in digital format. Thus, the incorporation of these maps into a GIS depends upon whether it is in analog or digital format - each of which has to be handled differently.

A key consideration in the spatial database design was in deciding which data should exactly be stored in the GIS, and which in the relational database, so as to include a wide range of GIS data. Each table in the spatial database contains a theme identifying all of the "locations" referenced in the companion non-spatial database.

The spatial elements of this work were mainly made of maps obtained from different sources (see Table 5.2). In order to set up the spatial database, work was done by the research team in identifying where to find maps required to the project.

There were two options available to obtain spatial data; one was to buy or rent spatial data from public organizations or private companies; the other is to construct the spatial database from scratch. Given the costs, time and expertise required to build the spatial database from scratch, the first option was seen more practical. This also helps to reduce redundancies created by developing new datasets.

Table 5.2: List of Spatial data and their sources

MAP/LAYER	SOURCE	TYPE	SCALE	COSTS
Health Facility	MoH	Point	1:50,000	Free
	INE	Point	1:50,000 & 1:250,000	$25
Floods	Internet	Line	1:50,000	Free
Province	Internet, MoH	Polygon	1:50,000 & 1:250,000	Free
Lakes	MoH	Polygon	1:50,000	Free
River	MoH	Line	1:50,000	Free
Roads network	MoH	Line	1:50,000	Free
Administration/District Boundary	MoH, Intenet	Polygon	1:50,000 & 1:250,000	Free

As such, it was important to identify the different institutions that were using GIS system within the public sector and for what purpose. We found seven institutions using GIS system. For the first phase of the study we identified four namely: the Ministry of Education and Culture (MINEC), the National Institute of Statistics (INE), the National Institute of Geography or National Geography and Cadastre Directorate (DINAGECA) and the Ministry of Health (MoH). Several reasons guided the process of choosing those institutions which includes accessibility and being official sellers of spatial data.

We started the process by visiting MINEC in order to understand what they are using maps for and see if they could share maps with us. Unfortunately, we did not succeed because they told us that they were getting the maps from INE for free, and were not allowed to share the spatial data with anyone.

Following MINEC we visited INE. We found that parts of the spatial data were obtained from DINAGECA, and others were produced in-house. Effort was made to convince them

to share spatial data with us. They allowed to buy only the spatial maps made by them which were related to health facilities location for two provinces (Manica and Gaza), made in 2003 for a cost of about USD 25, 00 (or 500.000,00 MZM)

Our main aim was to obtain reliable spatial data which could be used to help addressing user needs/requirements presented in section 5.1.2. Walking around the different entities who could probably share their experience with us, we visited DINAGECA, a national institute which deals with spatial data and is allowed to sell maps. There we found all required spatial data, excluding health facilities location. As we did in all other places, we asked for data sharing. The total cost of the required maps was around USD 6.000.

After getting all the information, we presented the findings to the DCH. By that time we heard that work was done within the National Health Institute[4] related to spatial data. So, as next step we contacted the person in charge of that work and he provided us with the maps he had that could help us in the GIS development process. Those maps dated back to 1997. I also consulted electronic spatial data clearing-houses through which I identified spatial data related to country, province and district boundaries, NGO locations and flood locations related to year 2000. I then downloaded for free those spatial data from the website.

Spatial data obtained from the institutions visited which I have referred above was used to analyze the outcomes of the GIS prototyping system.

Analyzing the spatial data collected from the sources already referred we found that each of the maps had its own problem. These problems are summarized in Table 5.3.

Based on the spatial information presented, a template was created as a reference layer including district boundaries, rivers, etc. This template was then used for the component themes digitization. The template was created using spatial data for one province and then their structure was reutilized for digitalizing maps of other provinces. The digitalization process included:

o Digitization of features: unfortunately, where the necessary data were not available, we created them manually using GIS. And errors inside individual maps were already corrected.

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[4] National Health Institute is a institute under the Ministry of health

o Coverage editing: the digitized coverage was processed for digitization errors such as dangles, constituting the overshoots or undershoots, and labels for polygons. This constitutes obtaining a report of these errors and then a manual editing of these features.

o Derived map: we created population density maps including the 5 and 10 km buffers around the health facilities. Those were used to calculate, for example, the number or percentage of population living within 5 or 10 km from health facilities.

o Attribute coding verification: The attribute codes for the different categories (districts, provinces, health facilities, etc.) were then verified and additional attributes (feature name, description etc.) added into the feature database. It was only after this procedure that the theme coverage was ready for GIS analysis. This process was not that easy because information was missing in the map. For example, the exercise of showing population density of a district in a map requires the area of the district (polygon). However, the maps did not come with area of the district. Therefore, additional work was done, which comprised in adding a field in the table.

Table 5.3: List of Spatial data, age and respective problems

MAP/LAYER	AGE	PROBLEMS
Health Facility	1997	• health facilities wrongly geo-referenced. • missing information/not updated
	2003	• include more data than what really exists. • incomplete data
Floods	unknown	• missing information/not updated
Province	1997, unknown	• missing information/not updated
Lakes	1997	• missing information/not updated
River	1997	• missing information/not updated
Roads network	1997	• missing information/not updated
Administration/District Boundary	1997, unknown	• missing information/not updated

The next step in the procedure was the appending or mosaicking of the different mapsheets new attributes which can help into a single theme map for the whole extent. In the section which is just ending in here, I have presented issues related to accessibility of maps. In the next section I will show how the maps were cleaned up.

Cleaning Data

Analyzing the information collected from the field which is somehow presented in Tables 5.2 and 5.3, we see that the spatial data exist in a variety of formats and has variable quality attributes. As part of the study, we also cleaned records which migrated from a SIMP system to the non-spatial database. During this process we were able to identify and correct errors of commission and omission, as well as a number of integrity issues which added significant value to the data.

Throughout this process a set of standard data acquisition procedures were identified to facilitate a consistent and reliable utility data management system. Several requirements such as the ones listed below were identified and followed:

o The spatial data were geo-referenced so that utility locations can be associated with public maps. Given the prior requirement to produce a GIS platform for the DCH and the evidence that current practices do not produce suitable spatial and non-spatial data, it was required that the Department of Information System (DIS) of the MoH be involved and in charge of these activities. As a result of this requirement, fields were created. For example, aiming at maximizing the integrity of the spatial database in the district boundary table, a field storing the province code was created.

o The data must be standardized across departments in the MoH. Because data in use within the national system is in different formats (SIMP system produces excel format, SISPROG produces dbf format), and as a way of producing a consistent countrywide system, data will need to be collected and made available in a common format. The use of data coming from SIMP system during the prototyping process is a result of analyze of this requirement. The standardization of the spatial data consisted in using data in the same format which consisted in shape files of 1:50000 scale.

The integration of map layers occurred in the design phase. While building the user interface it was necessary to split the country map into province map layer. The integration workflow process was all embedded into scripts into the VB 6.0 code over the user interface. By doing this, the user is allowed to choose which province he/she wants to work with. For example, Figure 5.3a) below contains on the left side, a list view with national and province levels representation. When a specific province is selected from the list their respective properties and map is shown on the right side.
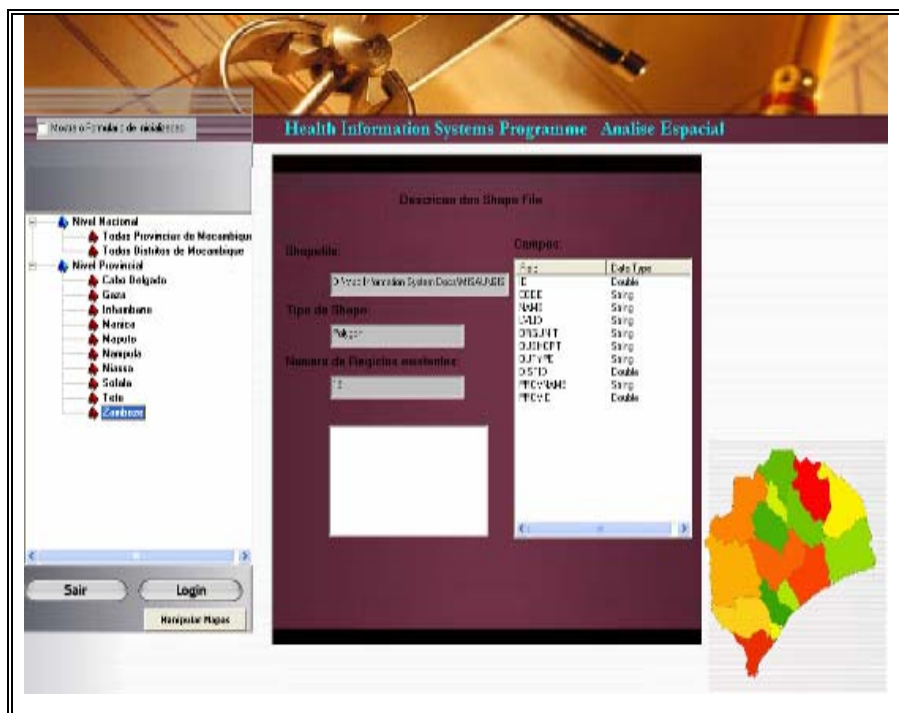
Figure 5.3a Screen shots of the system

After this process, the user interface handles himself the activities of building the linkages between the spatial and non-spatial database. For example, from Figure 5.3a) when the province is selected and the Login button pressed, the Figure 5.3 b) pops up, which contains the selected province information. From this window a couple o spatial analysis can be made, ranging from map manipulation (buttons on the right side) to data (which includes routine and semi-permanent, indicators, survey and demographic) analysis (buttons on the left side).

However, there are problems that we identified that were difficult to sort out. For example, in Gaza province the spatial information related to health facility we got from INE contained errors. While presenting the DCH_GIS results and because it was so easy to see whether there is any problem or not, we asked the reasons for that to the health decision-makers who attended the presentation. In replay, one senior health manager explained by saying that it was because, while geo-referencing they worked with local community participation and the community considers any place where they can be treated, as health facility. That means the INE staff geo-referenced the health facility without taking into account the classification of health facility set by the MoH. As we can see, this is a geo-referencing problem and to correct this problem a survey was required, because of time and resources we did not carry out this task.
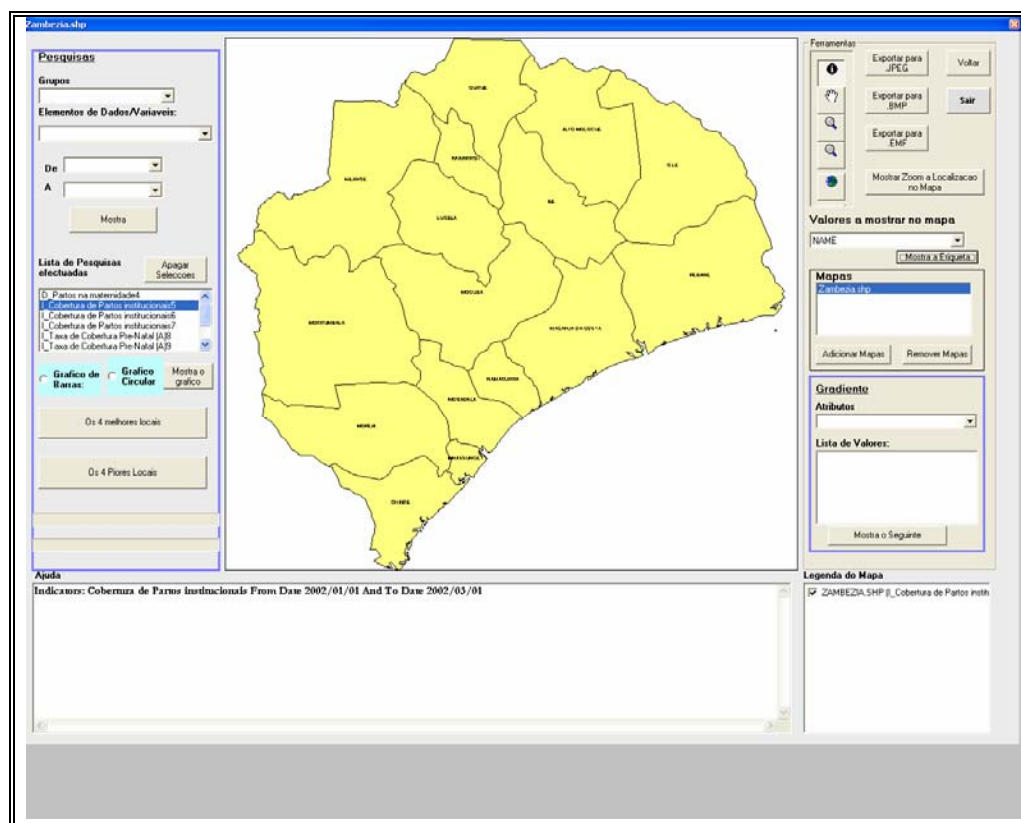
Figure 5.3b: Screen shots of the system

5.1.3.2. **Non-spatial Database Development**

Non-spatial data is complementary to spatial data and describes what is at a point, along a line or in a polygon, such as socio-economic characteristics obtained from the census or other sources. The attributes of a soil category, for example, could be the depth of soil, texture, erosion, drainage etc and for a geological category could be the rock type, its age, major composition, etc. The socio-economic characteristics could be the demographic data, occupation data for a village or traffic volume data for roads in a city, etc. The non-spatial data used for this study was mainly available in tabular records in analog form (excel sheets and paper form) and need to be converted into digital format for incorporation in GIS.

The structure for the DCH_GIS non-spatial database was designed to be simple and flexible, so as to accommodate a wide range of data types. All categories of health and resource-use data of the DCH_GIS were stored in the same manner, making it easy to expand the structure in the future to accommodate additional categories of data. The structure allows for variation in the level of detail provided for each variable or data element. The design has also been kept simple in an effort to ensure that the system can be supported and maintained once the development or implementation is complete.

The creation of the non-spatial database to fulfill the user needs followed the steps bellow:

- o   Identification and collection of non-spatial data elements
- o   Editing the non-spatial data attributes
- o   Transformation of all data obtained in a suitable standard digital form

Identification and collection of non-spatial data elements

As a first step to data collection a list of 125 indicators they would like to see represented on maps was provided (see Annex A) by the DCH. The list was a collection of indicators used by each section within the DCH. Analysis of those indicators was made in order to identify the sources of the data elements that are used to calculate those indicators. Some of those indicators need population data to be calculated. Census-data from the Census 1997, and other from Demographic Health Survey (DHS) 2003 obtained from INE were included in the list of non-spatial data and later populated into the database.

As referred before during the interviews, the interviewees recommended further potential interviewees and analysis. Thus, in order to understand possible problems that could arise related to the population figures used by MoH (which could be different from that collected in INE), the DCH recommended to use the population data from census to calculate indicators and compare these with those coming from the DIS within the MoH. Health related data from the period of 2001 to 2004, as the national level DCH requested to start from, about the number of health facilities in each village; number of health workers and health services, were included into the analysis because they were also used to calculate the indicators.

To carry out the indicator calculation there was a need to identify the sources of each data element used to calculate every indicator. As a result of this, three main information systems within the health information system (see Table 5.4) were identified.

The result of the analysis of the information systems presented on Table 5.4, shows that SIMP is the only system that is officially being used by MoH to report to different entities (public and private) the health status of Mozambique. DCH asked us to use only data coming from SIMP, as it was the nationally recognized official data. So, data from SIMP which was relevant to the health staff at the DCH was selected to be incorporated into the

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non-spatial database. To find out what is relevant and not relevant for the health staff at the DCH, we compared data elements from SIMP with data elements used to calculate the indicators given to us by the DCH. A summary of this analysis is presented in Annex D.

Table 5.4: Countrywide Health Information Systems used by MoH.

NAME OF IS	DESCRIPTION
SISPROG	A computerized legacy health information system used only to enter some of the monthly data which comes from the district, and to transfer this data to SIMP part of SIS; SISPROG is being used at the province and national levels. The purpose of the system is reporting and analyzing of monthly medical information, and storing of infrastructure data; that is all the health units, districts, provinces, related data to health units and provinces.
SIMP	System used at national and province levels to process, analyse and generate reports. It extracts data from SISPROG and BES (a system storing weekly notifyable diseases) to use as input. Some of the data are entered in the SIMP from the monthly report received from the districts. This is used to make comparison between activities of the districts in a particular year for particular data elements. The information generated from SIMP is aggregated, which masks facility level information.
DHIS (SIS.D in Portuguese)	The District Health Information Software, developed by the Health Information Systems Program (HISP) team. DHIS is a flexible software programme that allows the entry of routine anonymous service delivery data from health care facilities so that it can be converted into indicators to monitor service delivery. This can store any kind of data and its flexibility is much accentually so any data element can be added to the database and while this is done is a matter of linking each facility that performs the activity resumed by that data element.

Because the DHIS (SIS.D) database can accommodate any kind of data given its flexibility, and aiming to reduce the development time, and also because this database responds to the needs presented by the DCH, and following the MoH strategic plan 2001-2010, DHIS database was chosen to accommodate the non-spatial data. There are other reasons for that. One can be because this database is open, therefore an indicator, data element, can be added at any time a feature that is not available in other systems. Another reason is the feature to drill down around the lower level. The DHIS is based on the district, meaning that the lowest level of data is the health facility, so it is much easier to help the decision-making process using this software, rather than, for example, SIMP, which is based at province level, showing data up to the district, meaning that all the health facilities are seen in the same manner.

The DHIS database was then aligned in order to handle the data coming from SIMP. As presented above, the SIMP software stores data in Excel format and much of the data are

aggregated, while DHIS database can handle health data at any level of aggregation from heath facility to province level. The lowest level of data presented by SIMP is the district, meaning that data are aggregated from health facilities. From that, it is impossible to know from which health facility the figures presented at the district level come from. For example, if we aim to make decision of improving the health status based on access to health care by the community using those figures can be difficult.

To populate the non-spatial database it was required to extract data from SIMP to the DHIS. Because SIMP and DHIS were designed to handle data at different levels, it was required to standardize the levels. The DHIS information levels were reduced from 5 to 4 levels. Thus, instead of having the health facility as lowest level we now have the district.

Since we were working at national level, we first provided national level analysis of data, but afterwards it was necessary to drill down to the province and then to the district and health facility levels. So, while starting to analyze the health related non-spatial data and the requirements presented by the DCH at national level, health staff problems start to arise. For example, the health decision-makers at national level needed to make analysis from the national level and drill down to the facility level. As already referred although the DHIS database presents data up to the facility level it was not possible to fulfill this requirement because the data used to populate the DCH_GIS non-spatial database was taken from SIMP. Of course those analyses were shown using data from DHIS, using examples of fictitious data collected from health facilities by the DHIS system.

Editing the non-spatial data attributes.

After getting all the non-spatial data from SIMP, we had to start entering into DHIS manually. For that, we prepared the structure of the database by changing the original database structure (see Figure 5.4) and aligned it with the SIMP database hierarchical structure (see Figure 5.4, part A).
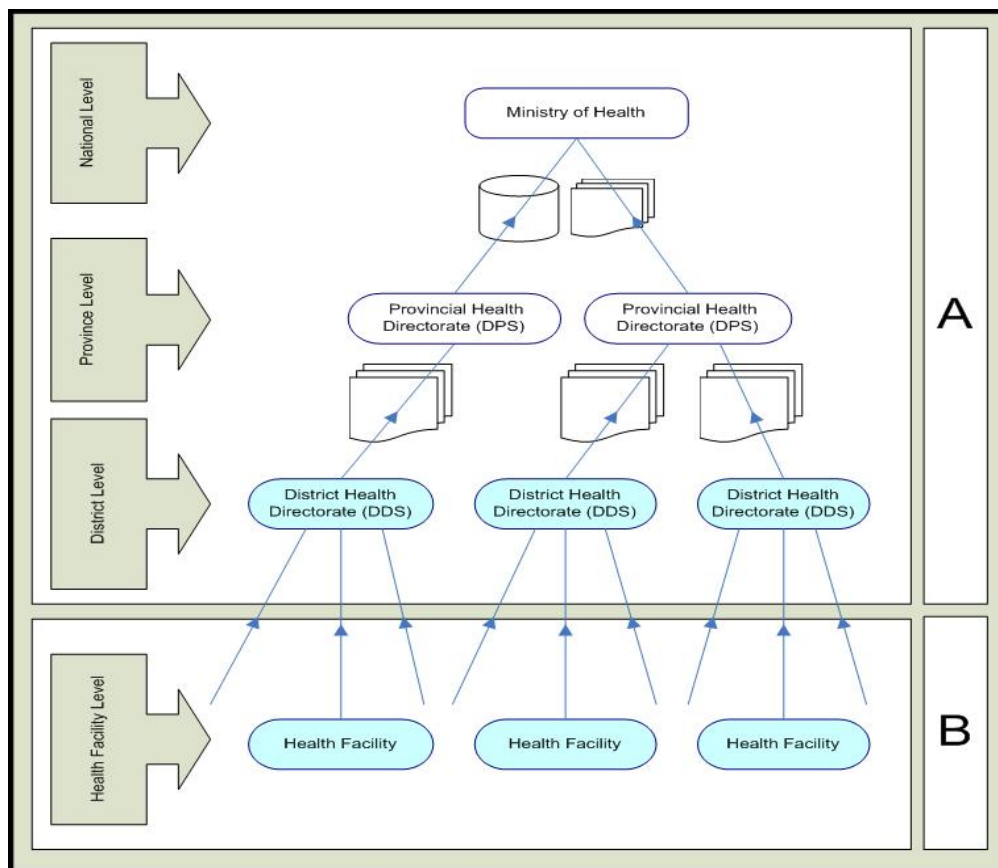
Figure 5.4: Information Flow in Mozambique Health System

Because the data from SIMP excel sheet was locked, it was difficult to manipulate automatic export functionality. So, the non-spatial data was entered into the database manually. We are not able to schedule an appointment with the person responsible for SIMP, a Dutch expatriate, in order to discuss with him what could be the way to provide data to the DCH_GIS non-spatial database automatically. We tried it many times and it was hard to schedule anything, given that he was either in meetings, busy or traveling. The easiest way we found was only to enter data manually while negotiating a right standard format of the data to the database.

After defining all non-spatial variables, five (5) persons were hired to enter the district level data. The research team entered the province level data and validated and verified the accuracy of the data entered.

To carry out this activity the research team did the same process used to enter data, which is manually, by checking field by field in the database compared with the value into the Excel sheet. There were some digitalization errors; to correct this, data was entered again. We did

not face problems because the people who entered the data were of computer background. This process took approximately 5 months.

All data elements used to calculate the indicators presented in Annex A were defined. The result of this analysis is presented on Table b, Annex D. In this table it is also presented two columns that say whether the indicator is new or old. The DCH is adding new indicators that will help them measure their health services performance. We also added community, socio-economic data elements, and population groups.

Transformation of all data obtained in a suitable standard digital form

All the non-spatial data obtained from different sources were organized, and needed to be transformed into a digital form in order to be related to spatial data. Thus, all the data was entered into the DHIS.

Considering the way GIS system will be used within the MoH, looking to future scalability as referred before, we decided not to store much data in the spatial database. This relationship between non-spatial and spatial data was included directly into the system code, so the system was responsible for relating both databases. As a result, much data has to be manipulated in an easy interface of non-spatial database leaving the spatial database, which requires advantage and expensive tools to manipulate, with as little data as possible.

5.1.3.3.**System Architecture: Defining relations between spatial and non-spatial data**

Another important aspect of the database design concerns the linkage between spatial and non-spatial data; in such a way that every attribute data item entered into the relational database needs to be explicitly geo-referenced.

Figure 5.5 below shows the overall architecture of the DCH_GIS system, including the various interconnected components.

1. User Interface: Developed in Visual Basic 6.0; this component provides a user-friendly interface to the data and functions of the DCH_GIS assisting the communication between

the user and the system. The user interface was developed by an ESRI[5] component called MapObject version 2.0, which allows adding maps to applications. MapObject can be combined with components from other vendors, such as graphics, multimedia, and database objects. Then the applications built can be tailored for the specific requirements of end-users.
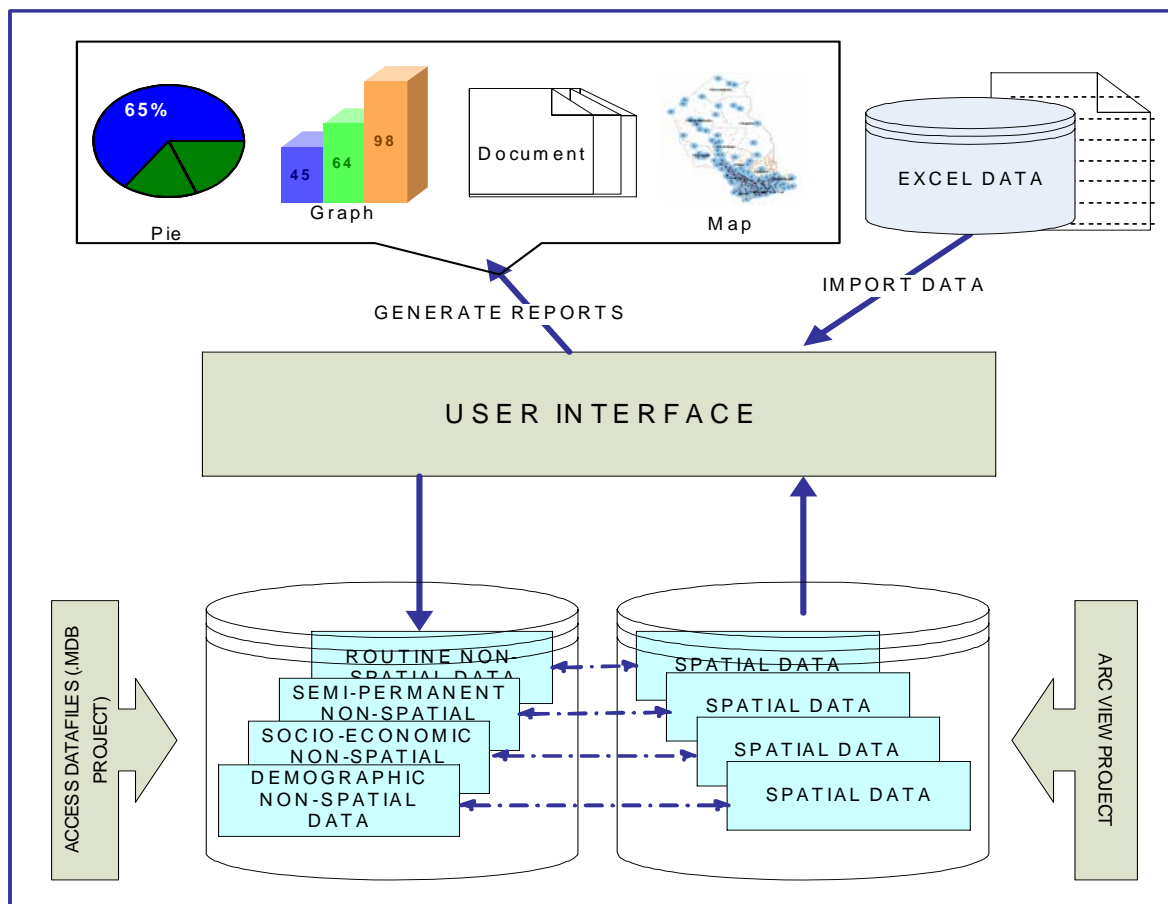
Figure 5.5: System Architecture of the DCH GIS System

MapObject comprises an ActiveX control (OCX) called the Map control and a set of over forty-five ActiveX Automation objects. It is for use in industry standard Windows programming environments. Programs built with MapObject will run on Windows 95, 98 and Windows NT 4 or higher.

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[5] Founded in 1969, ESRI is a rapidly growing company with more than 2,800 employees worldwide. Have offices throughout the United States and in Asia, Australia, Canada, Europe, and South America. Today ESRI software is installed at over 300,000 client sites worldwide. Their goal is to provide public, private, and educational organizations with a system that will allow accomplishing tasks more quickly and managing and using geographic information systems.

The MapObject object tool that we have used to establish the linkage between the non-spatial and spatial data helped to perform a set of functions within the system. The following features were implemented in the DCH_GIS:

- o Display a map with multiple map layers, such as roads, streams and boundaries.
- o Pan and zoom throughout a map.
- o Draw graphic features such as points, lines, ellipses, rectangles and polygons.
- o Draw descriptive text.
- o Identify features on a map by pointing at them.
- o Select features along lines and inside boxes, areas, polygons, and circles.
- o Select features within a specified distance of other features.
- o Select features with an SQL expression.
- o Calculate basic statistics on selected features.
- o Query attribute data associated with selected features.
- o Render features with thematic methods such as value maps, class breaks, dot density, and charts.
- o Label features with text from field values.
- o Create new shape files.
- o Type in an address and find a location on a map.

The MapObject component has been embedded in a program written in Visual Basic 6.0 that allows the DCH_GIS User Interface to communicate with the spatial data (ArcGIS) files. It also connects each non-spatial database to its corresponding project file in ArcGIS, which enables the ability to view the DCH data, to generate reports and, for administrators, to import data and customize the system. At present the DCH User Interface is common to all users, although it could be customized for individual administrators in each district, province, or directorate in the future, as required.

The original interface was first developed by the HISP team in India, which was customized for the Mozambican context. This required changing the language and the structure of the HIS. The HIS system in India comprises the structure of 6 levels and Mozambique 5 levels, meaning the structured levels of the information flow.

It was easy to deal with this because the application was prepared to be used by the same database as the original database used in India. The existing difference between them was the structure of the HIS and the needs of the decision-makers in both countries. What we did was to prepare the database in order to fit the health structure in Mozambique and inscribe the health decision-makers needs into the system.

During the development process the prototyping approach was used. Then, at every stage of the development the system was presented to the user in order to get feedback. From these presentations needs were added to the system; it was also important that they should be added to inscribe the user needs to the system. That is why it was important to get ownership of the system even, for the development team.

2. Routine Non-Spatial Data. The routine health related data for each district or province is stored in separate tables in Microsoft Access. In general, there is only one database file for all the non-spatial data. If we want to compare two or more different districts or provinces, views of the database containing the required information is provided to the system and their results presented in maps.

3. Spatial Data. The spatial data for each district or province is stored in a separate ArcGIS 8.x project file (shape file), according to the type of analysis being made. Meaning that the user interface has incorporated scripts that allow the user to select the kind of analysis they would like to perform.

The relation method in GIS is used to relate the same spatial entity to different non-spatial entities based on a link key. The one-to-one relationship can be defined for each entity in the spatial and non-spatial tables. Apart from this, the entity hierarchy can also be "forced" into all spatial datasets so as to be able to extract spatial feature information - either in spatial or as non-spatial tabular format.

The system design is closely tied to the existing workflow. This strategy was chosen so as to minimize system complexity and the fear of change, two conditions that have been documented in the literature as leading to implementation failure. Based on the data acquisition procedures and the requirements identified, it was determined that a centralized data entry system should be used. All of the procedures that were identified as affecting utility data documentation fit these requirements.

5.1.4. **Evaluation of the Results**

This section presents an evaluation of the different issues regarding the development of the GIS system. The geographic and monitoring data have been imported to the developed system. A DCH_GIS management information system has thus been developed that

provides the user with information useful in health fighting. The system output products take several forms (maps, tables, graphs, and text). All these can be obtained and stored either in digital form or in hard-copies (i.e. print-outs).

Figures 5.6 and 5.7 present two typical working screens of the developed system. Each of the screens consists of a) a graphics area which displays pictures generated by the system; b) a dialogue area which assists the communication between the user and the system; and c) a series of buttons in pull-down menus that performs all tasks desired by the user.
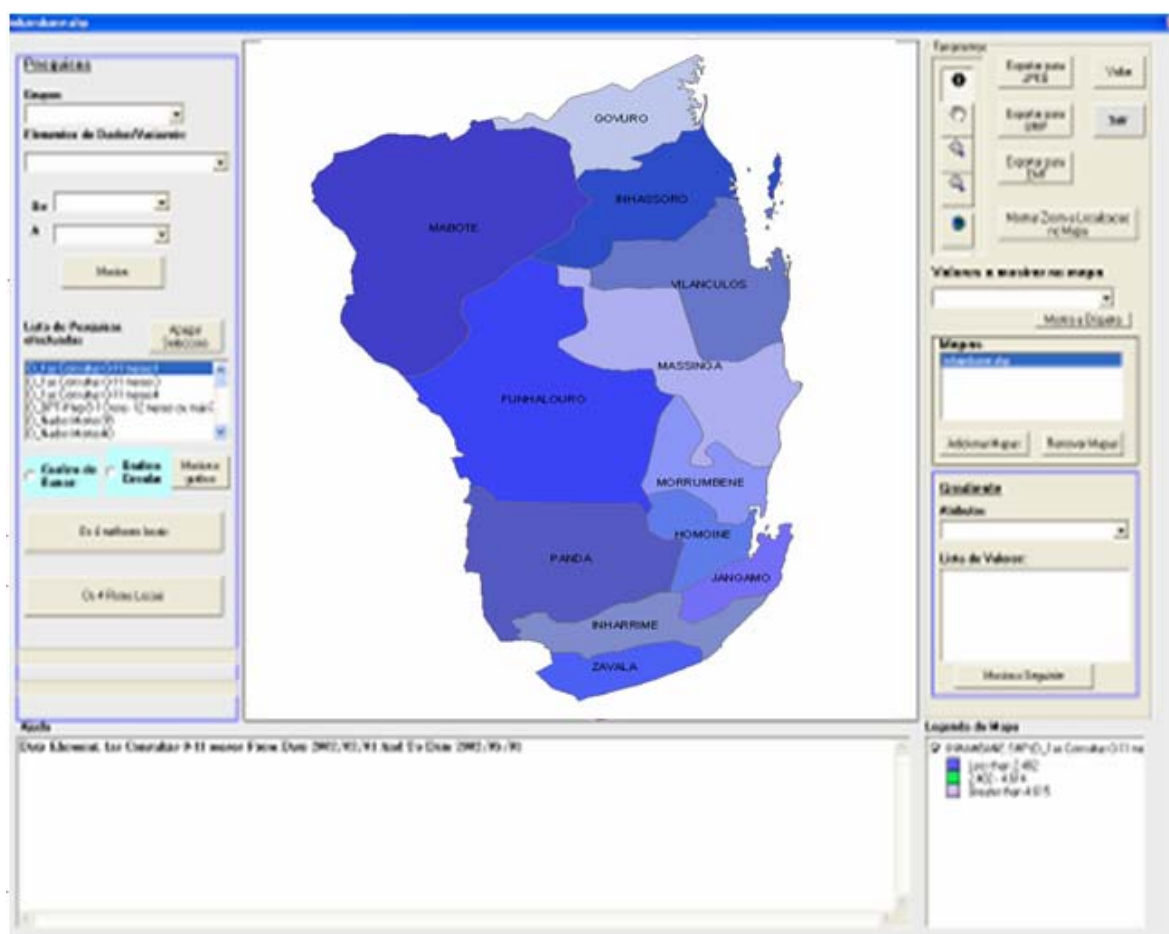
Figure 5.6: District level analysis working screens of the DCH_GIS system

In the context of the study that this system is being developed, it is intended to analyze issues related to mother and child mortality. By selecting the specific options commands from the Figure 5.6 and 5.7, users can automatically display the GIS (spatial and/or non-spatial) data associated with the currently loaded database. Additionally, the DCH_GIS System automatically links data from the non-spatial database with the appropriate layer/theme in the GIS. This feature is critical to the integration of spatial and non-spatial

data in the system, as it allows users to associate the location of specific spatial sites on the ArcGIS theme with the corresponding records in the non-spatial database.

Although the piloting process of the system in the DCH at national level involved leading edge technology and was therefore technically challenging, its successful completion clearly demonstrated the capabilities of the DCH_GIS system physical design. It also showed that the design effectively addresses DCH_GIS system goals.
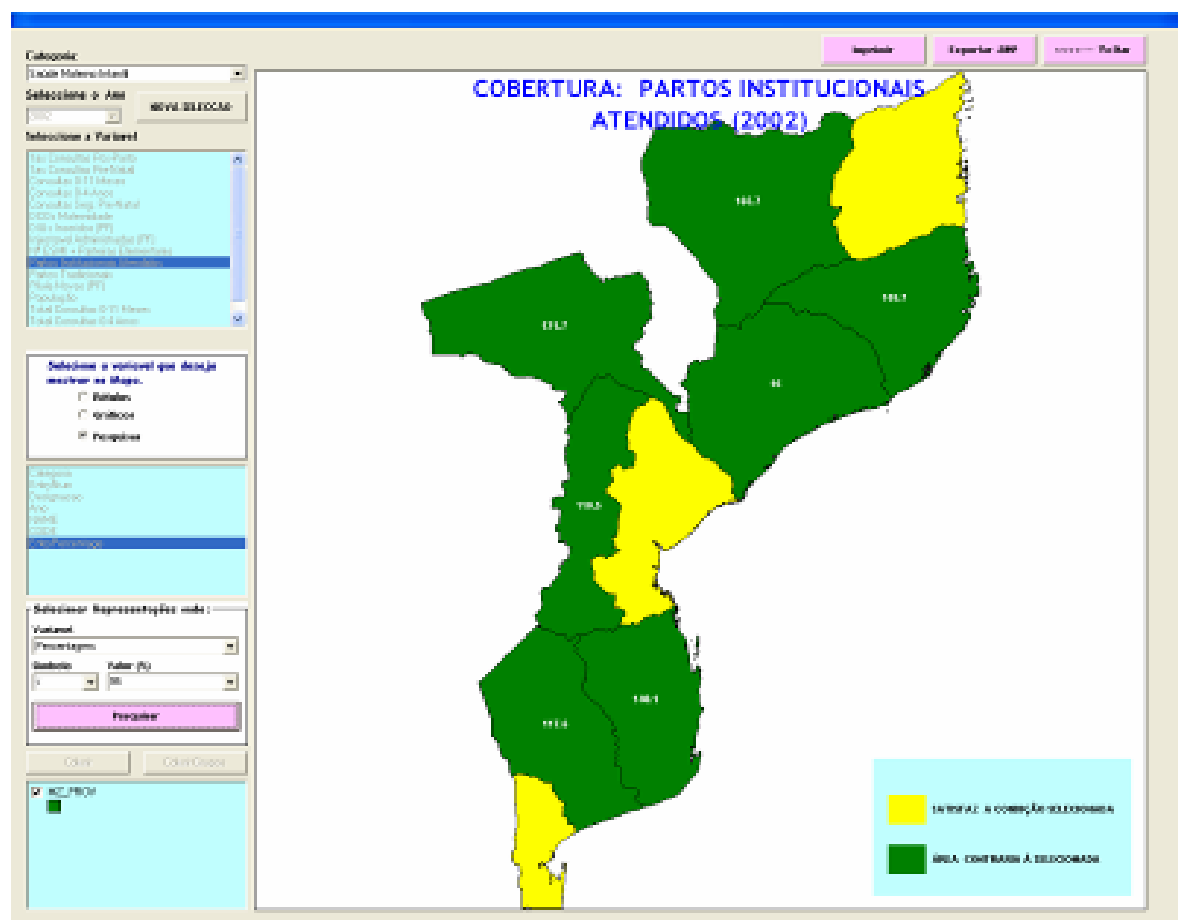
Figure 5.7: Province level analysis working screen

It also demonstrated that the requirements of decision-makers regarding monitoring support could be met using this technology. From the developed software a numerous number of health care analysis can be performed, including analysis aiming to understand births, deaths, communicable diseases prevention (immunization rates), and health facilities accessibility issues.

Births: Births are reported by law. Many communities, health facilities and districts, etc. use birth data derived from these reports as measures of communities and public health. Local health departments having access to such data can use GIS to show measures such as

prenatal care and rate of low birth weight for neighborhoods within their jurisdictions. In addition, local health departments and their partners can use birth data to estimate future school enrollments and distribute government funding for education. Figure 5.8 compares institutional delivery in the period between January to March with post-partum attendance one moth later, i.e., from February to April, in Inhambane province.

◼ Less than 21 ◼ 21 - 25 ◼ 26 - 30 ◼ Greater than 31 a) Percentage of Institutional Delivery from January to March 2002 (in %), (Source: DCH_GIS Prototype)	◼ Less than 30 ◼ 30 - 39 ◼ 40 - 49 ◼ Greater than 50 b) Coverage of Post-Partum consult from February to April 2002 (in %), (Source: DCH_GIS Prototype)
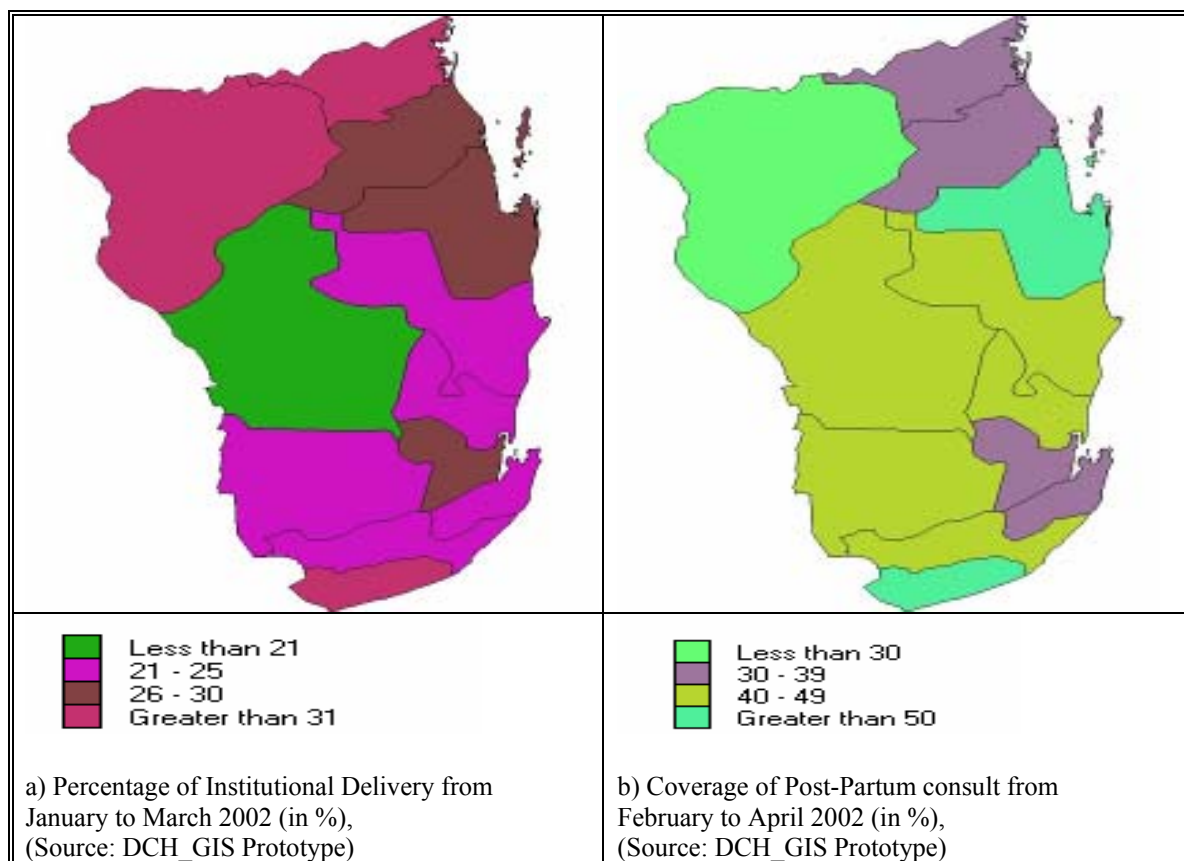
Figure 5.8: Comparing Institutional Delivery with Post-Partum Consult

From Figure 5.8 we can compare the institutional delivery in a district with the post-partum situation in the same district. As shown in the key, the Mabote district (top left), the institutional delivery coverage is greater than 31 %, while the post-partum consultant coverage is less than 30 %. Based on this analyze discussion can be started aiming at understanding the reasons why mother does not come to health facilities after delivery.

Deaths: Mortality reporting shares many strengths and limitations birth reporting. Like births, deaths are reported by law. For example, for a study on the relationship between an environmental exposure and a specific cause of maternal death, you will need to study the cause of death beforehand, and for that the study of traffic lines is required, the distance

between the communities to the maternity, etc. Figure 5.9 shows a comparison between districts regarding institutional delivery from January to March in Inhambane province

The example showed in Figure 5.9 can help to compare the institutional delivery in the district presented in a) with, for example, maternal mortality. As shown in Figure 5.9 a) Mabote district (top left), has an institutional delivery coverage greater than 31 %, while for example Funhalouro district has a coverage of less than 21%, while both have three health facilities.

a) Coverage of Institutional Delivery from January to March 2002 (in %), (Source: DCH_GIS Prototype)

b) Integrated Layers (Source: DCH_GIS Prototype)
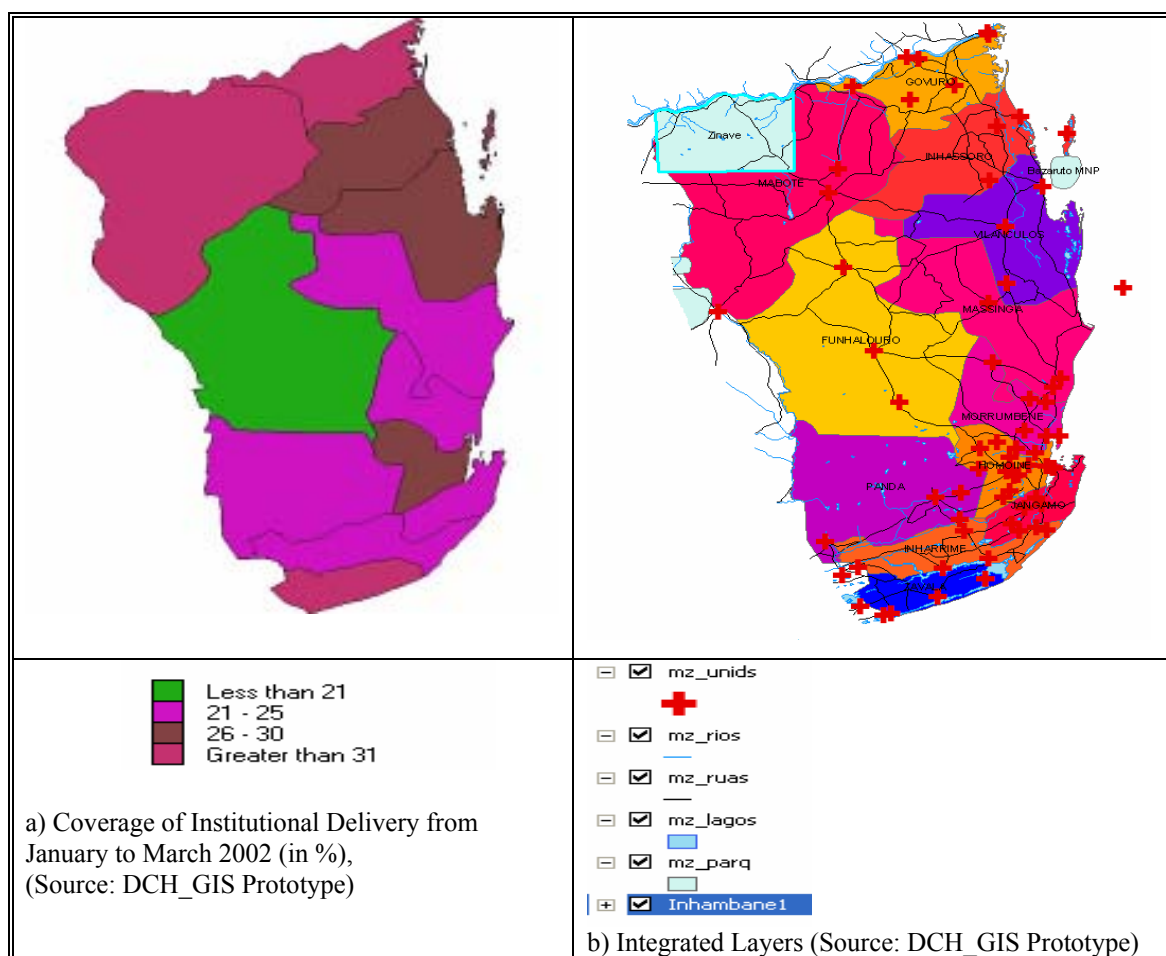
Figure 5.9: Comparing Institutional Delivery with Maternal Mortality

If we want to understand the reasons for that, analysis and discussions need to take place. In this way, the Figure b) helps to clarify that analysis. One conclusion can guide us to understand the total population data of each district. Another conclusion can guide us to see the accessibility of health facilities. As seen in the b) part of Figure 5.9 above the Mabote district has more roads (represented in black lines - mz_ruas) than Funhalouro district.

Access to primary care: To develop comprehensive community health improvement plans, public health practitioners must address the degree of access to health care for vulnerable population in their communities. One aspect of access is the physical accessibility of health care resource within a community. The DCH decision makers can now use the developed GIS system to map the location of health care facilities, especially in relation to transportation roads. The example (in Figure 5.10) below shows the availability of health facilities in relation with two layer level roads in Gaza province (Right), while the figure on left shows population analyzed by buffer of 5 km and 10 km.
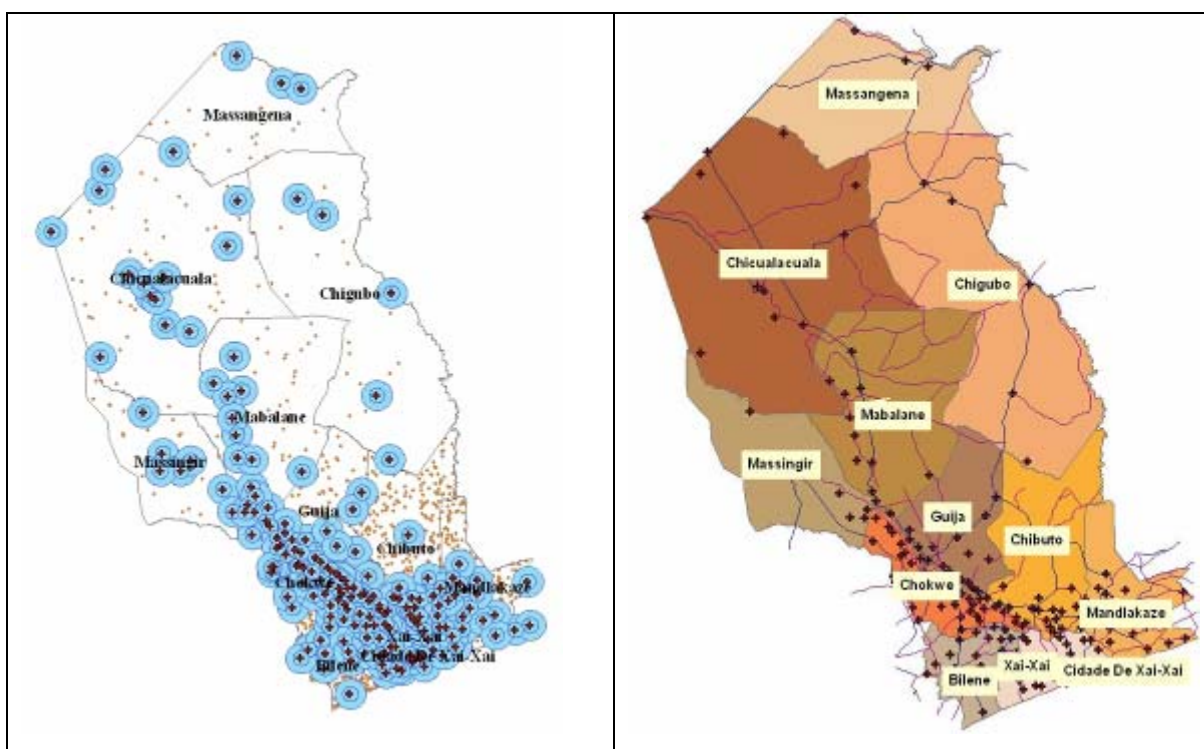
Figure 5.10: Buffer Analysis - Population distribution across health facilities (Left), and Access analysis by major and secondary roads (Right). (Source: DCH GIS Prototype)

Communicable disease prevention: Immunization rates: The MoH has established immunization registries to improve immunization rates of pre-schools-aged children, especially children under two years of age. The statutes within the HIS in Mozambique require health care providers to report immunizations that they provide to young children. Public health practitioners can use GIS to study and report immunization rates. This information is extremely useful for targeting immunization outreached efforts. The example represented in Figure 5.10 and 5.11 shows the immunization coverage around the provinces in year 2003 in Mozambique. The Figure 5.11 shows the national level coverage of BCG vaccine. Figure 5.11 is a result of drilling down the BCG situation from national to provincial levels.

The same process can be done at district level. As presented in Figures 5.10 and 5.11 the GIS prototype was used to show BCG coverage of each province (Figure 5.10), and then Gaza province was selected and drilled down to the district (see Figure 5.11). This helped to understand how province figures are distributed among the districts. A specific district can be selected and displayed the spread of the BCG coverage of each health facility. Here I am not presenting this example because, as referred before, the non-spatial data used was taken from SIMP software.

Figure 5.11a: BCB coverage in year 2003 (Source: DCH_GIS Prototype)

Less than 1.225
1.225 - 1.547
1.548 - 1.870
Greater than 1.871

Figure 5.11b: BCG Coverage in year 2003 in Gaza Province, (Source: DCH GIS Prototype)
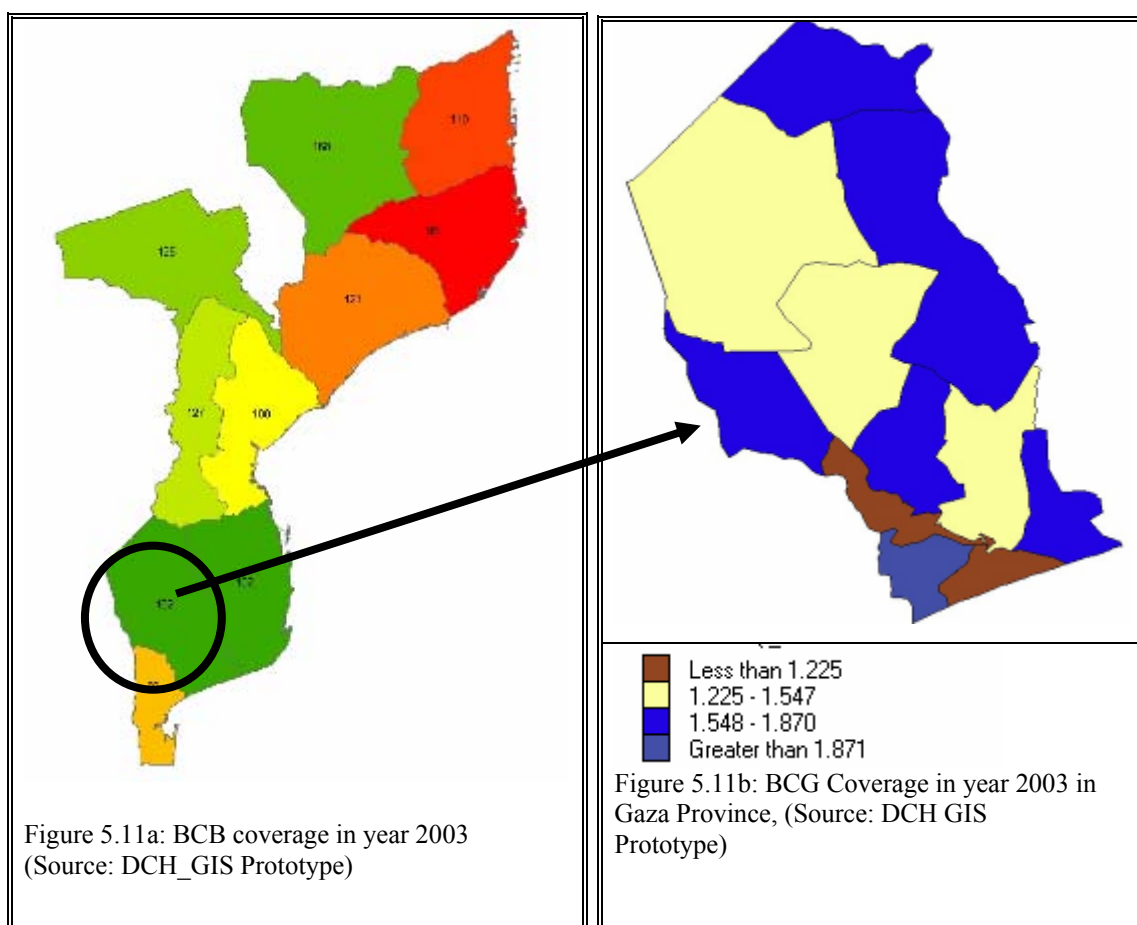
Figure 5.11: Analyzing BCG coverage at province level and drilling to district level.

5.1.5. **Lesson Learned and Future Challenges**

Like any other new promising technology, this work comes with limitations and potential challengers related to data availability, data quality and costs, community definitions, confidentiality, and misinterpretation of results. In a way of forwarding issues that surrounded the development process in one of the presentation made to the decision makers the commitment were to by new spatial data including the process of cleaning the maps in order to more precisely have the results come closer to reality.

Data quality and availability

As with any analysis, useful output is dependent on useful input. Many important data sets are not available in the current application. For example, comparing the table of indicators (Annex A) provided by the health decision-makers of the DCH with the table listing the sources of data required calculating those indicators (Table a) and b) in Annex C), we can see that several indicators are new and many of them are not present in the reports generated by the official information systems within the HIS. Regarding the data related to maternal child, analyzing the indicators provided we see that many of them cannot be calculated because data collection tools do not incorporate data elements to calculate those indicators. The available data sometimes comes from sources that are not trustable and with a lot of missing data as reports are often sent with numerous blank fields (see Figures 5.12).

Figure 5.12: Format mod. SIS – D03 taken from Inhambane province. (Photographer: Zeferino Saugene)

In relation to the maternal and child mortality data, there are many problems related to the process of their registration while the mother is under treatment within the health facilities. Other problems are related to data collected within the NHIS, which is not enough to calculate the indicators provided by the health decision-.makers of the DCH. As shown in

Figure 5.13, the maternal death data is aggregated by district and they only record the number of deaths (See Figure 5.13 b).

Figure 5.13 a): Front side of the Maternal and Child health form used by health district workers to register data.

Figure 5.13 b): Back side of the Maternal and Child Health form used for the health district workers to register data.

Figure 5.13: Data collection tools in use within the NHIS to report Maternal and Child Health

Based on the interview of the person in charge of mother and child health programme within the WHO representative in Mozambique I understood that the WHO gets maternal mortality data directly from the provinces using the form presented in Figure 5.14. The information collected using this form can be used to calculate many of the indicators that we could not calculate using the information taken from SIMP software. However, the WHO form has the same problems of getting data up to the district level. The MoH and WHO

representation can coordinate efforts to build a common data collection tool. Thus, the WHO data can be later collected from MoH.

Figure 5.14: Data collection tool in use within the provinces to report maternal death which is later reported directly to the WHO representation.

As shown in Figure 5.12 the Funhalouro data collected form comes with errors. From the fieldwork, I also understood that all the data received either from district or province is revised, validated and corrected by provincial health workers and sometimes by the planning department and national level. This process includes providing data in a good format to be entered into SISPROG legacy system. The pictures show district health workers with a folder showing us the paper forms received from the health facilities and which were corrected.

Figure 5.15: Community Health Personnel in Bilene district in Gaza province.
(Photographer: Zeferino Saugene)

Inaccuracies were also found in vital data, including of birth and mortality data that are no reported or are underreported. There are many reasons for that including the inexistence of infrastructure that can handle this process mainly at health and district level and community level by the traditional birth attendants (TBA). For example, in Bilene-Macia district we found the following data representation (see Figures 5.16a, 5.16b, and 5.16c).
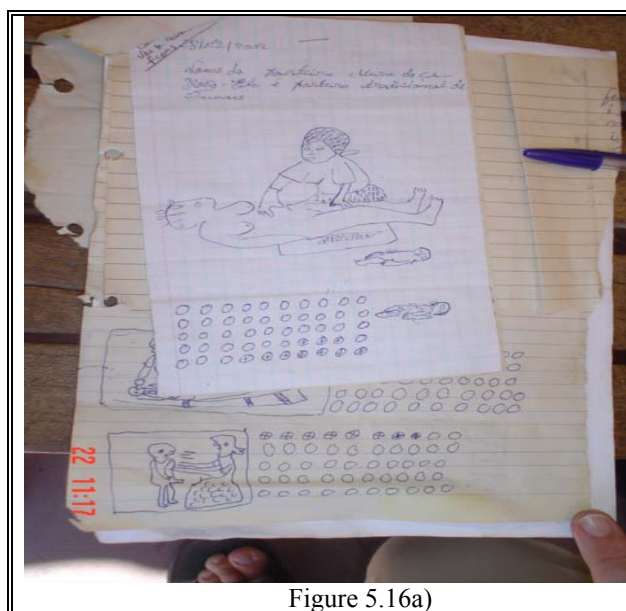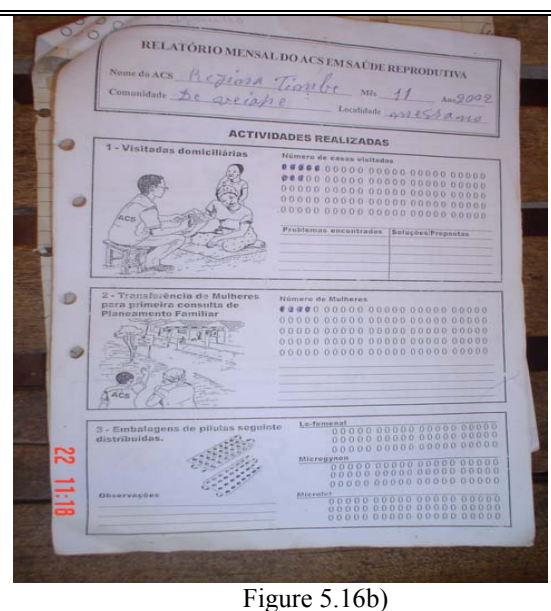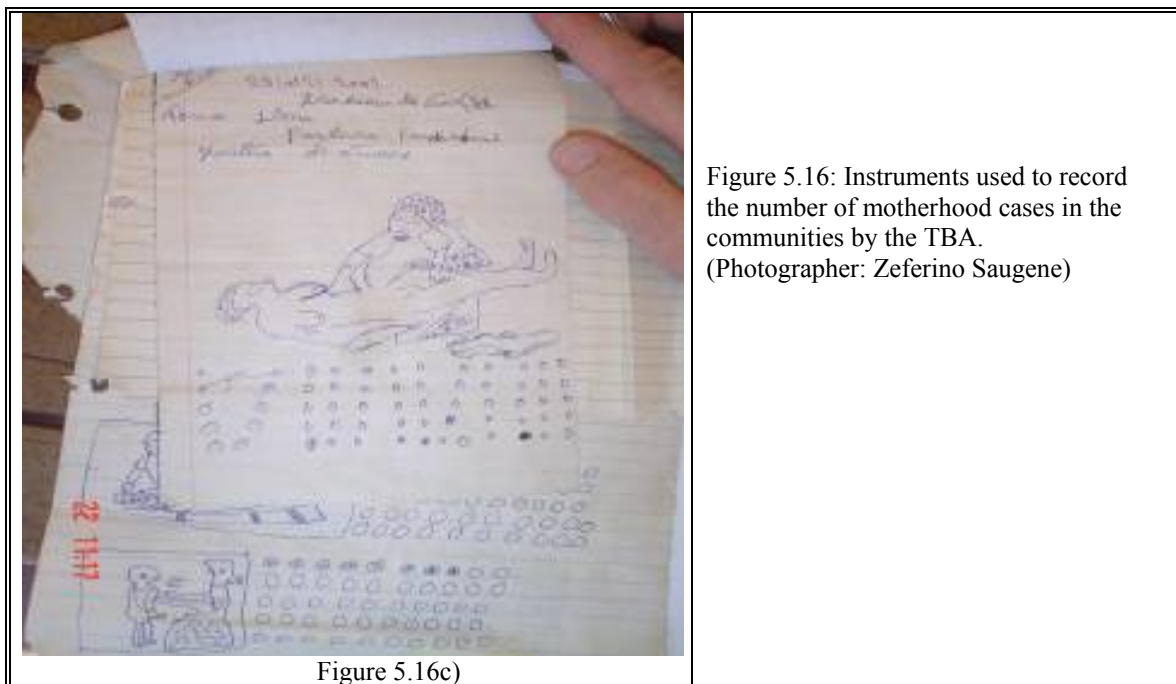

| Figure 5.16a) | Figure 5.16b) |

Figure 5.16: Instruments used to record the number of motherhood cases in the communities by the TBA.
(Photographer: Zeferino Saugene)

Figure 5.16c)

There are international standards for non-spatial health data. However, these standards are not reflected in all information systems, making difficult to obtain uniform data. At this time the MoH did not adopted national standards for spatial data. For example, this system is presenting maternal death indicators in percentage while the WHO suggests using base 100,000 while presenting those data.

Regarding spatial data I found that where current and unclassified maps exist, they are usually of different scales aggravating the problem of sharing information efficiently among various sectors. Digital representation of spatial data is even rarer due to the lack of appropriate equipment and trained staff; few entities are ready to begin generating digital spatial databases as the task is seen to be too large, too costly and too complex both technically and administratively. The design and implementation of a workable spatial data infrastructure is often a dream for the future. An example of this can be the already referred related to the health facilities taken from INE that the total number of them is much bigger then the number that exists at the MoH.

Confidentiality

Because of different problems which I have discussed in section 5.1.3, spatial data is not available to everyone. In many cases the spatial data is in the form of unscaled sketches. Where maps exist they are often out dated and are classified as restricted.

The balance between the public right to health-related information and the individual right to privacy poses a significant limitation for public health professionals intending to share health-related data with community. This can be understand from the example referred before related to the consultant working in the DCH in Inhambane province when I asked to provide to me analysis on maternal mortality that he was carrying out.

What happens many times with spatial data in organizations is to put their information directly into spatial database. This often makes institutions to think twice when another institution comes and asks for sharing spatial data. Because they have their own information in there which sometimes can be confidential information, the institutions can be reluctant to sharing their spatial data. I do not think that this was the case of the institutions we visited (MINEC and INE). However, one way of avoiding such kind of problems is to build a non-spatial database where the confidential data is stored and relate it to the spatial database using any GIS system.

Misinterpretation of results

The elegance of GIS technology is that it integrates many complex data sets into an easily understandable picture, a map that can be customized to diverse users. However, if the results presented in maps are not understood, this can impact on the conclusions made.

The powerful tools of GIS can easily lead to misinformation and misinterpretation, particularly by someone unfamiliar with their use. Ecological fallacies, problems of scales, and propagation of error are frequent, and should be given serious consideration (Monmonier l99l). The consequence is a setup of misunderstanding and misuse. As a way of cultivating spatial analysis within the health setting in the first stages of this study we concentrated in building the DCH_GIS in order to provide the same outputs as the SIMP system is providing.

The conceptual models used by SIMP for example did not follow open standard perspective so it differs in significant manner from any other systems within the HIS in Mozambique. Simple mappings between this systems model with other systems is not currently possible which means that in order to map these systems the models must be modified. This is sometimes difficult and may result in incorrect use of available data and misinterpretation of model results.

Poorly graphed results can be very misleading, and we must take care to ensure that published graphs show correct trends and results, and are not confusing. Quite simply, a poor graph can lead to misinterpretation of results, and ultimately poor decision making. The majority of graphs used in this DCH_GIS results are pie or bar graphs, which makes it easier to set and follow standards, because the health staff is already familiar with this kind of analysis.

As part of ongoing quality control, there is a need to regularly consult users to ensure that statistics continue to be presented to users in the most readable and understandable format. We also need to monitor standard practice in other statistical agencies to ensure that the results presented by the DCH_GIS meet accepted international standards.

Information use

The health systems organizational structure is decentralized, in a way that health services are offered at health facility level and the health district directorates administer local health units. However, the information use is not so decentralized as the structure seems to indicate.

The DCH_GIS system was designed at the national level and its main purpose is to support monitoring from the top level. However, as a way of providing the same interpretation and output to the health staff, standards have been incorporated into the system outputs. These ensure that we present results clearly and consistently.

From the findings we have found that the health staff is familiar with the use of different kinds of data presentation such as graphs, tables and maps. From Figure 5.17 we can see examples of local use of data through different types of data analysis.

In DCH_GIS there are nine main thematic layers linked to more than 5000 record database; all layers are not showed simultaneously, every layer is shown by enlargement.

Figure 5.17: Analysis by the statistics officer. (Photographer: Zeferino Saugene)

Every layer can be shown or hidden by the "Layer Control". Thematic layers are so divided in areas and sub-areas:

Services
  o Health facilities
Roads
  o Railway
  o State roads
  o Secondary roads
Politics
  o Provinces
  o Districts
  o Cities

In the list, rivers, lakes and parks are also added. There is correct analysis of data; the map can be dragged, enlarged, minimized and it is possible to interact with the map by toolbar buttons and the right button mouse menu. Every object in layers can be selected to visualize details.

For example, enlarging the map of Inhambane and selecting the "health service" service, the window will appear containing a list of the hospitals, ambulatories and clinics, and at same time, these services will be visualized on the map with its icon. Clicking on a component of the list, this will be centered on the map. Selecting the object on the map it will be possible to visualize the information. With the help of this technology information will be transformed into a need for the user. Clearly, problems can be identified and corrected.

5.2. **Learning from Brazil Experience on GIS Implementation**

From the paragraphs presented in chapter II related to Brazil spatial infrastructure, it is clearly understandable that Brazil is one of the most advanced countries using GIS technologies in the world. Based on that, and also because Brazil and Mozambique are two close countries with similarities in language, etc., it was important for us to learn more about their experiences in terms of how or which strategy they adopted while building and/or institutionalizing their GIS tools and knowledge. So, as part of the study, I also visited Brazil. The result of the visit is presented in the following paragraphs.

In Brazil I visited six institutions which included: National Institute of Geospatial research (INPE), a Belo Horizonte ICT company (PRODABEL), Minas Gerais Federal University (UFMG), Belo Horizonte Municipality, Belo Horizonte Town Planning and a health district office. All of these institutions use GIS systems in their daily work. Some of them develop software, while others only consume this technology.

In INPE, UFMG, Belo Horizonte Town planning and health district office we interviewed only one person. In Belo Horizonte Municipality, PRODABEL and health district several persons with different background were interviewed (See Figures 5.18, 5.19, 5.20 and 5.21).

From these interviews I found that, for example, the INPE team developed **TerraLib**, an open-source GIS component library, which enables quick development of custom-built applications using spatial databases. Currently, such capabilities are only available by means of proprietary solutions such as COM components available in products such as MapObjects, GeoMedia and ARC/INFO-8. These components are based on transitional technologies that either duplicate in memory the data available in the DBMS or use additional access mechanisms such as ArcSDE. **TerraLib** aims to improve on such capabilities by providing direct access to a spatial database without unnecessary middleware. This resource would make a positive impact by allowing researchers and solution developer's access to a wider range of tools than what is currently offered by the commercial companies. In a similar approach to Linux and subsequent open source software efforts, they recognize that such development does not happen by spontaneous growth.

Based on this open-source GIS component library software applications were developed which includes the TerraView software. The TerraView software is being used in many

organizations which include for example the Belo Horizonte Municipality and the district health offices. The municipality is using these GIS system to monitor education, health, illegal drugs distribution, transportations and traffic, urban planning, socio-economic indicators, water and sewage networks, urban cadastre, land use, and parceling (see Figure 5.18).
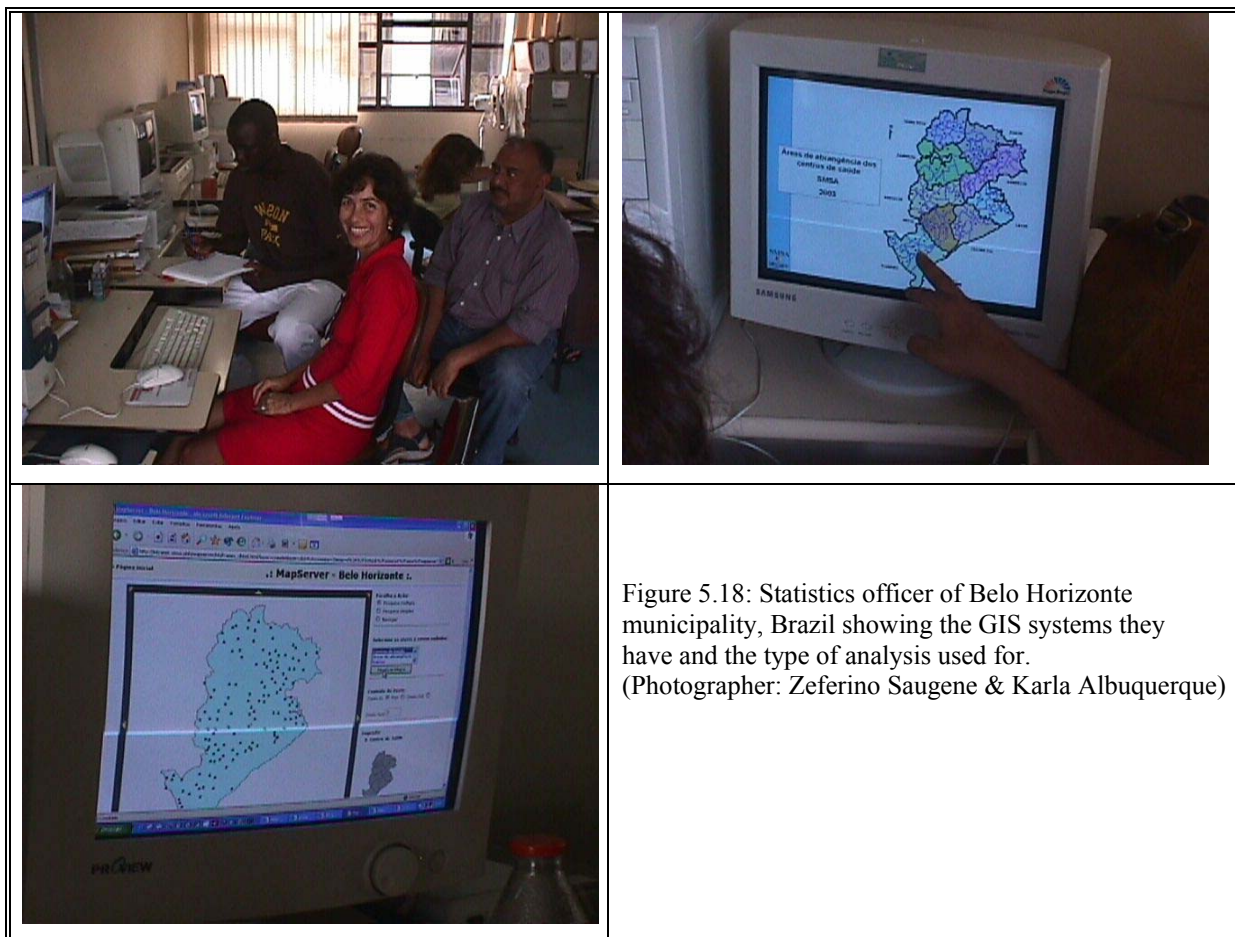

Figure 5.18: Statistics officer of Belo Horizonte municipality, Brazil showing the GIS systems they have and the type of analysis used for.
(Photographer: Zeferino Saugene & Karla Albuquerque)

For example, the Health Department of the city of Belo Horizonte, with PRODABEL's support, has implemented a system for infant mortality surveillance in high-risk areas. The system, based on GIS techniques processes social and demographic data generated by many institutions, using geography as a common frame of reference.

The importance of the system is to provide help in the decision-making process, favoring the discussion and evaluation of specific public policies. The goal was to reduce infant mortality ratios. Belo Horizonte, which has a population of more than two million, has about 345,000 (17.2%) people living in high-risk neighborhoods, which corresponds to only 3% of the city's total area. With the Infant Mortality Surveillance Program, the children that

run the highest risk in the first year of life, due to low birth weigh, children born to adolescent or illiterate mothers, or newborns in favela (slam) regions receive individualized care from health centers.

Geo-processing is thus used to produce this distribution, through geographic localization of a newborn's residence, therefore assigning the follow-up responsibility to the more geographically adequate health care unit. Counting only on the simple presence and orientation provided by health care professionals, the program is expected to reduce many avoidable deaths (pneumonia, diarrhea, malnutrition) among children less than one year of age. Since the beginning of the program, the infant mortality rate has reduced by 35%. A couple of other spatial analysis software used by the municipality includes the RGUI, TerraView, MapInfo, GeoDA, SisGeoW, MapServer.

These GIS systems are being used also at Health District level. The district is routinely using MapInfo based GIS for developing maps around the pattern of spread of dengue fever etc. The interview results showed that the use of maps in the heath district was ongoing before the use of non-spatial based systems.

Figure 5.19: Visiting one of the health district offices in Belo Horizonte.(Photographer: Karla Albuquerque)

Figure 5.20: Looking at the analysis made at the health district office level in Belo Horizonte. (Photographer: Karla Albuquerque)

This set of geographical application and other types, which are either operational, or under various stages of design and development, represent the most wide-ranging set of applications among local governments throughout Brazil. The design and development of this urban GIS-based applications and management of the city's digital geographic database in under the responsibility of PRODABEL, a municipal level information technology

company. PRODABEL is strongly involved in developing activities ranging non-spatial applications and spatial applications within the Municipality. They have developed a very mature spatial infrastructure for city planning, including health (see Figure 5.21).

From the interviews and observation taken during the study it was clear that the institutions that are consuming GIS systems developed in-house such as the health municipality are running those systems with little support from PRODABEL. This means that, those institutions are becoming more independent from the system developers.

Based on the findings of the study in Brazil, lessons can be learned regarding the GIS adoption. From those lessons I summarize the following:

o Challenges faced by GIS implementers in developing countries cannot be addressed solely by improving the traditional mechanisms of foreign aid. It is necessary to build a situation where people from these countries actively cooperate to share resources and knowledge and to build information technology solutions that are meaningful to them.

o We cannot rely on international technology transfer and instead we have to build in-house expertise over a long period of time. Setting up an organization which is completely dedicated to the development of geo-processing expertise to support municipal administration influenced the successfulness of the project. Being organizationally within the structure of the municipal administration, they are in a better position to understand user needs as compared to international consultants. Also, since they are physically co-located with the other departments, they are always at hand to respond to the queries of the users thus providing the much needed technical support which also helps a sense of self-confidence for the users to engage in this new and complex technology.

o Another interesting feature of this experience is the systematic and integrated manner in which they have gone about to build a database for the needs of the city. In many GIS projects in developing countries we find that the problems of data is not given the necessary importance, and we find that different departments go about trying in their own individual and compartmentalized way to develop their database. In contrast, at PRODABEL, the first task of the GIS exercise was seen as creating a comprehensive database.

o Any other important feature was the team of geo-processing professionals picked from several departments of the company, in such a way that specialists from the various

technological areas involved could adequately assess and develop a technology that was essentially unknown at that point. The team included system analysts, data modeling, and data administration; application development specialists with understanding of different domain areas; experts in computer graphics and digital image processing; and urban cadastre.

Figure 5.21: Looking at different technologies used by Prodabel on generating maps and spatial analysis. (Photographer: Karla Albuquerque)

5.3. **Summary**

This chapter presented a description of the issues related to the process of development of the GIS system prototype for the DCH at the Ministry of Health in Mozambique.

Being supported by interviews, discussions, analysis of document collected in the field, and questionnaires I have described here the different issues related to health care and ICT adoption in Mozambique and Brazil. In this chapter I have also illustrated different experiences of adoption and use of ICT within these two countries.

These findings will be used in the next chapter for analysis of field results, based on the framework conceptualized in chapter three.

CHAPTER VI   ANALYSIS OF FINDINGS

GIS solutions being developed nowadays and integrating a number of systems across organizations and geographical borders, in many respects are significally different from traditional ISs. To succeed with the establishment of such solutions new understandings and development strategies and approaches are needed. Such new issues should be based on perspectives seeing such solutions as web of II, as well as social systems. In this chapter, I will discuss these issues in relation to the practical findings of this thesis. However, the aspects which I will discuss here are obtained from practical experiences in implementation of GIS systems and they are not all necessarily applicable in all developing countries. I believe there are other problems of implementation of GIS systems, as well as the ones discussed in this chapter. This chapter is arranged as follows: section 6.1 introduces the chapter by discussing issues related to the process of development of the GIS prototype; in section 6.2 the information infrastructure perspective is discussed; the section 6.3 examines issues related to the integration process; and finally section 6.4 discusses issues that have to be taken into account during the institutionalization process of the system.

6.1.   Development of a DCH GIS Prototype

By analyzing the findings of this study presented in Chapters 1, 3 and 5, it is clear that geospatial information is needed by a wide variety of users with both global and domestic requirements. In addition to the problems described in Chapter 5, which hampered the DCH_GIS development process, Chilundo (2004) pointed to several other problems, including the lack of integration of the vertical systems in use by the departments within the MoH.

In addition to that, from this thesis finding I have encountered different limitations faced by health decision-makers which are related to inexistence of data that could help in addressing spatial related problems.

All levels of HIS are currently hampered by a general lack of *standardization* on data and process. There is significant redundancy of data. Information on maternal and child mortality data, for instance, may be entered in SISPROG system and transferred to the SIMP software at the province levels and the same data entered in each stand alone system

within the province with ample opportunities for mismatching, as the spreadsheet used by the DCH in Inhambane province.

This study highlighted also that there are currently many different systems within the NHIS. Most of these systems are legacy systems. However, departments' needs cannot be addressed by using data/information from each single system. There is a need for a consolidation of these systems by an integrated environment that could combine these stand-alone systems.

6.1.1. Inscribing User Needs in the GIS Technology

The study showed that the health staff within the NHIS in Mozambique still relies on hardcopy maps, tables and charts and employs manual overlays to integrate and analyze information from other domains to support decision making process. Some users have state-of-the-art automated information tools, but lack the types of data and area coverage's needed to support their missions. Within NHIS, today's warriors deal with long lead times for the production and delivery of standard data, and they must also deal with the inability to effectively integrate data from stove piped information flows.

The DCH_GIS development process started with a set of the health decision-makers needs that development team wanted to *inscribe* in the software. These needs were *translated* into concrete *inscriptions* through key principles laid down during the development of the prototype. This includes supporting the hierarchy of essential data sets, allowing users to add, modify, or delete data elements and indicators.

From this thesis findings we can see that the ICT users within the HIS, and also the external ICT users which includes members of the Ministry of Education and Culture, members of the INE, and as well as the community (see Figure 6.1), together represent a diverse set of missions including environmental analysis, diplomatic readiness, and strategic deployment. Despite the diversity of needs, all of these users share the requirement for a common set of geospatial information. This information must be detailed enough to support the analysis of trends, serve as the frame of reference for the fusion of information from other domains, and support rapid intensification with more detailed geospatial information to meet the users requirements.

Within the DCH in MoH, the inscription of the user needs into standards (existing and new) is illustrated by focusing on the standardization of the DCH_GIS user requirements together with the HIS practices. This process involved a sequence of negotiations between the participants in the development process. For instance, during the development process negotiations occurred between the development team and the ICT users within the MoH, where the actors proposed and argued for different possible translation alternatives. Each alternative inscribed different programs of actions. The negotiations produced a general consensus, as translation alternatives reflect interests differently. Thus, the interests were aligned - about the need for standards, the fight about what these standards should look like and how they should be included into the software system. This race was seemingly neutral and technical discussion about which technology fitted the needs best.
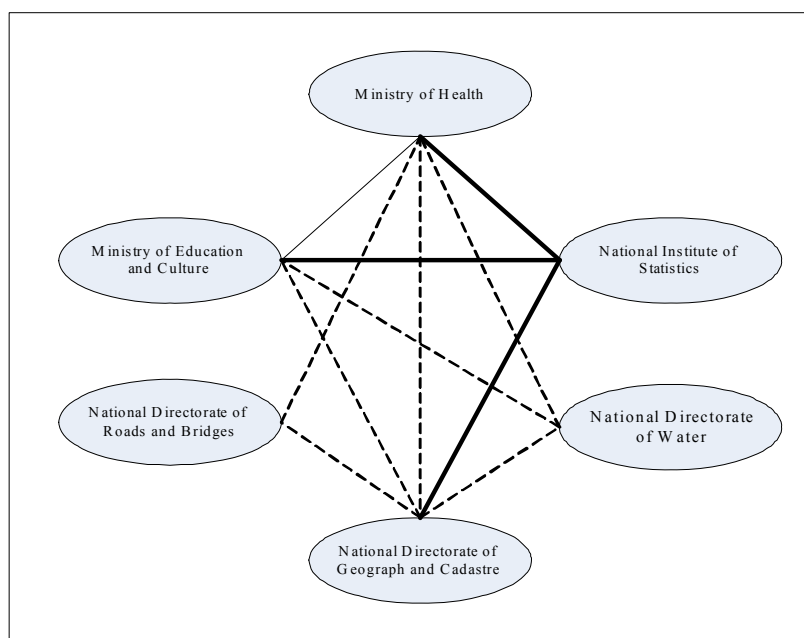
The dot lines connecting institutions in this figure indicate the linkages that are supposed to be between the institutions in order to address spatial related problems, while the other indicate the contacted institutions and the linkage between them.

Figure 6.1: Fully Distributed Network

However, this was a race between different actors involved into the GIS development process, including also the decision-makers from the MoH. In this discussion, since there was a shortage of GIS experts from the MoH side, it seems that most of them choose the most generic strategy, namely to first look for the technology which seemed most beneficial for them and, subsequently, enrolling this GIS technology into their own actor-network as an ally. Appealing to the symbolic character, technology makes it possible to disguise non-technical interests as well as technical arguments.

6.1.2. Keeping the Users in Focus: The User Challenge

Public health information systems are not designed for ICT users, but for addressing their needs/challenges. These needs/challenges are not only for them but are related to community needs. However, public health information systems in Mozambique have in historical perspective as they have been developed by departments, programs, or monopolies to serve these programs, or departments' needs. This study showed that the fragmented systems are not providing enough information for decision-makers to support their decisions. For that, there was a need for an integration perspective in understanding the decision-makers challenges which were introduced by this study aiming to build a GIS system. It has also made possible for the system to focus not only on the available information, but also on the kinds of information they require for the decision-making process.

As referred in the literature, section 3.5, Participatory Design (PD) of the Scandinavian school and other approaches to design, as for example contextual design, have focused on inclusion of users in design to reveal their needs. This implies not only designing for the user, but with and by the user. However, when stakeholder perspectives differ greatly, participation is not always easy to manage. In this study, considerable effort to align the user's interests was carried out by all the actors/participants in order to focus on the objectives of the system, and not let the implementation be delayed. Clearly, this management loop is not an easy approach to follow, but does offer a powerful means for developing policies capable of responding to changing environmental conditions in a controlled, transparent fashion. So, we have been supported by the ANT concept of *alignment*, which according to Callon (1991) is achieved through the translation of interests and the enrolment of actors into network by making the translations your own and adjusting towards the unification between networks.

The software prototype development was done by a team of three-person and conduit for the participative interaction with different users, including a team of four supervisors. The first prototype was released for validation of the user needs, and went through a series of very rapid prototype cycles.

Being complex and multi-disciplinary in nature, the establishment of the DCH_GIS required inputs from a wide range of installed bases (infrastructures). This infrastructure must

provide the collection and management of requirements for geospatial information, acquire data and produce new information in response to the requirements, manage the information, ensure ease of access and dissemination, and develop common tools that will allow users to accurately exploit and apply geospatial information in their decision making process. There was a need in this study to understand the installed bases more carefully.

6.2. Understanding the Existing Web of Information Infrastructure (technical and institutional installed base)

The people, data, tools and processes used to build the DCH_GIS system can be collectively referred to as an information system. Because multiple stakeholders were involved, a more precise term is multi-stakeholder information system, information network or, simply, information Infrastructure. Hanseth (2002) *defines information infrastructure (II) with the following keywords: shareable, common, enabling, physical embodiment of an architecture, enduring, scale and economically sustainable.* From this study we can see for instance, in order to analyze maternal deaths, either using a map system or table, the DCH may engage in transactions with several other units. Thus, to analyze the cause of maternal mortality figure in a map, the map from DINAGECA must communicate with a number of spatial and non-spatial databases which includes information from MoH, INE, National Directorate of Roads and Bridges, etc. The various forms of information exchange between these stakeholders are overlapping and interconnected. This process requires also an evolving, open and heterogeneous behavior. Then, all the process is turned into infrastructure and distinguishes from simple stand-alone applications.

Considering the HIS as an II environment, the design of the GIS systems took advantage of already existing technology and practices, the *installed base*, as the only alternative. In Chapter 5 of this study I have discussed how the process of making spatial and non-spatial database occurred. It is evident that the process was strongly influenced with the existing data/information. Just to quote an example, we can see that the existing spatial and non-spatial information obtained from INE, MoH was used to build the DCH_GIS system as a spatial database in the case of the maps and as non-spatial database in the case of the DHIS. Those installed bases (spatial and non-spatial) are composed of different technical and non-technical factors which include people, ISs, procedures, data, functional, relational and symbolic relations and use practices.

As referred before, the installed bases influenced the system ability to accommodate changes in such a way that the DCH_GIS inherited from the existing systems an installed base of strong and long lasting standards. As a way of enabling the well functioning parts to continue to develop on their own, while unsatisfactory parts are addressed, *cultivation* approach form II was used. The cultivation approach states that only such areas that function poorly or do not match the envisioned organization should be changed. In the case of DCH_GIS, innovations have to be agreed upon and integrated in standards as well as existing networks.

6.2.1. Stakeholders Roles: The Power of the Existing Installed base

As presented in Chapter 5, the DCH department benefits from data managed by others and this also happens between the MoH and other institutions as shown in Figure 6.1. For instance, to understand maternal mortality problems the DCH decision-makers will get routine data from Department Planning (DoP) within the MoH. However, the DoP is getting those data from the provinces and the provinces from the districts and finally the districts are getting from the health facility. If the health decision-maker wants to analyze this problem spatially, the National Directorate of Roads and Bridges maps needs to be employed to analyze a transportation problem and human population figures managed by the National Statistics Institute (INE) may be used to know the total population of the region.

However, a variety of the institutional actors referred in Chapter 5 of this study which is summarized in Figure 6.1, serve as custodians of different kinds of maps. Their installed base is seen to be constituted by maps, the practices that govern their storage, update, distribution, access, etc, and the technologies and standards that are used for supporting these practices. Gaining access to this essential data was difficult and expensive due non-availability of metadata and costs, even from within separate parts of the same institution. The difficulties of sharing information are magnified because data exchange is viewed as counter to an organization's interests, or even dangerous. Hence it was frustrated by political, organizational and even personal barriers.

As discussed in this thesis finding, the DCH_GIS was designed independently from the existing IS, so it facilitates the cultivation process. The design was influenced by the already existing systems, work practices, and procedures. For the non-spatial database creation for

example, the DHIS database application was used to store the non-spatial data. This DHIS has embedded in it procedures that must be followed by the user in order to Add, Update or Delete an indicator or even a data element. Procedures also have been set up that must help in creating an indicator (see Figure 6.2). Meaning that in order to use the DHIS database there is a need to follow the practices, rules/procedures that have already been inscribed into the database. In addition, the history of the installed base within the MoH, including the IS that are being used within the departments presented in Table 5.4, in Chapter 5, played a dominant role in the decision taken whether to use one or another.

Figure 6.2: DHIS indicator definition window

The ESRI tool, *MapObject*, used to build the user interface for the DCH_GIS system (see Figure 5.5, Chapter 5) has on its own standards, procedures, name conventions, language, etc. All this has been considered in this study as an installed base, which influenced the development process. In order to develop the system, it was required to inscribe first the tool behaviours/standards into the developer knowledge. For instance, in order to use the version 2.0 of *MapObject*, MS Visual Basic 6.0 programming skills was required. Also regarding spatial and non-spatial databases, this tool has embedded a method called *Relate ()* which functioned as an installed base that the developer had to learn about.

Institutions like the MINEC, Ministry of Agriculture and INE, which are the powerful custodians of spatial data, have historically acted in a compartmentalized manner, with

limited sharing of data or applications with other agencies. As the study shows in Chapter 5, the political process that we have embedded in order to get maps, and cited security concerns to limit the access to maps, not only for citizens and private sector, but also to other government agencies. So, while the existing installed base indeed technically has the potential to contribute to the development of the DCH_GIS, it needs a lot of hard work, especially with respect to institutional practices, to make it effective in practice.

The two institutions have separate spatial databases which we considered in this study as strong installed bases of disparate and outdated spatial datasets. Within the MoH, these installed base also include work practices and strong cultures on data presentation.

The spatial inputs of all these institutions as shown in Tables 5.2 and 5.3 in Chapter 5 are drawn from similar sources, though during different time periods. Technical issues surrounding standards, the accuracy of data, thematic coverage and diversity of non-spatial data sources used in each institution constitute islands of infrastructure that impedes easy sharing and integration of data. Institutional issues arising from data ownership and technical competition also contribute to the strength of these islands. Addressing these islands effects is no trivial matter, and requires building software for transforming the data in each institution to the same standard, a gateway. Building a gateway will make it easy to share data of different standards which in future can be translated to the Spatial Data Infrastructure (SDI).

However, the institutions in Figure 6.1 have their ISs which are artifacts intended to facilitate users work. For example, in this study the users contributed to the achievement of the objectives by supporting the enforcement of organizational rules, polices (maternal mortality reduction) and constraints. Thus, understanding from a purely technical perspective did not help us, and then there was a need to see them from a social system perspective.

6.2.2. Geospatial information technology as a social process

From this thesis study, we view information not only as a product but as a process as well. The output information that can be taken from the GIS system is seen as a product resulting from the processing of (raw) data to answer a question. In relation to this study, information as a process can be viewed at two different levels. The first level is the domain of geo-

information technology in its narrow, technical sense; how data were processed into information or, rather, how data were processed into other data. Because how data acquires meaning and thus provide an answer to a question is not (fully) explained at this level. An alternative view that sees information as an interpretative process of giving meaning to observable facts through the collection and analysis of data about these facts was used. The second is the level of individual human perceptive, psychological, and cognitive processes. Individual users' needs were studied at this level. For example, while integrating the different activities of health care sector, multiple actors with non-overlapping interests were presented. Some of these actors are local (within the MoH), some national (the institutions presented in Figure 6.1), and some international (for example the WHO). Each of these actors has their own interest and work practices, the alignment of their needs (integration) was considered as a change. They should not be perceived as primarily a technical issue, it is a complex and politically charged activity where multiple institutional influences and different, possibly completing, rationalities need to be aligned. Consequently, most users' needs were studied within a social rather than a pure individual context. In the same way, the health infrastructure was seen as member of a large social system, as well as the social system itself.

Tracing a network of actors through interaction intermediaries can generate one variety of useful information for evaluating GIS implementation. Another perspective can consider the interactions and negotiations that revolve around a particular social element. For instance during the development of the DCH_GIS, while considering the interaction of the social and the technical, it was tempting to consider the potential effect caused to either the social or the technical aspect of the situation.

The development of DCH_GIS was clearly influenced by the social interaction within the HIS in Mozambique and, of course, the decision taken from this system has the potential to configure the social environment.

6.3.   Data Integration: Integrating different infrastructures

This study aims to analyze the Maternal and Child situation in Mozambique, as a case study, in order to find technological mechanisms that can help the health decision makers to develop their decisions based on reliable/trustable information. The next sections will

discuss issues that are not technological but have to be understood in gathering data related to maternal mortality.

6.3.1. Maternal and Child Mortality

For many years public health staff in Mozambique has been struggling in order to produce results regarding reduction of Maternal and Child Mortality. Plans for Maternal Mortality Reduction have been made by many institutions such as "Plano Operacional 2002-2005 para Redução de Mortalidade Maternal e Perinatal" by the MoH in the year 2000, and other from outside the MoH, such as "Absolute Poverty Reduction Action Plan (PARPA) 2000-2004" by the Ministry of Finance.

However, these efforts are not producing the desired results. For example, Table 6.1 is showing the results for years 2003 and 2004 of the important indicators related to health services delivery which were presented in the PARPA document plan. Comparing the results presented in this table with those presented as a plan to be achieved by PARPA for the year 2004, there are some gaps. This means that in some situation the results were reached for instance, 98% national coverage for immunization of children aged 0-23 months against polio and DTP. In other situations the result is above the required for example the postnatal consultations which was planned to be around 50% was increased to 60,6 %. However, in other situations the problems still remain under the expected. Analyzing the indicators related to maternal and child mortality (see Table 6.1), we can see that, for instance, the maternal mortality is still high. The goal set by PARPA was to reduce to under 100/1000 live births, but in 2004 as shown in the table, the intra-hospital maternal mortality rate is 200/100,000 live births.

In the same table, there are situations where the percentage is above 100%, for instance, the women ante-natal consultation coverage, coverage for immunization of children under one against tuberculosis, and first consultation for infants 0-11 month's coverage. Reasons of that were discussed by different researchers for instance, (Mukama, 2003), (Lungo, 2003) and (Macueve, 2003) point out that health workers do not exactly know the advantages of filling the forms with the real data. Consensual reasons come from the side related to cultural problems within the NHIS, i.e., the health staff, in order to show that he/she is doing well in their work, they "cook" data. This was one of the reasons why, for example in this study, the DCH asked to populate the non-spatial database with data from SIMP. Then

the question that will arise is "should we trust the other data", that seems to be within the range?

Table 6.1 Selected indicators from PARPA, 2000

COMPONENT	OBJECTIVE	TARGET	CURRENT SITUATION (1999)	2004
Expand Access and Better Health Care	To make good quality health care accessible to disadvantaged groups.	Expand coverage and access to good quality basic health services, especially in rural areas.	-	No Information
	Increase access and quality of health care for women.	Reduce Intra-Hospital Maternal Mortality Rate to <100/100,000 live births		200/100,000
		90% of women ante-natal consultation coverage	84%	111,1%
		Increase institutional deliveries to 50%	37%	46,8%
		Increase postnatal consultations to 50%	40%	60,6%
		Increase coverage of women protected by family planning to 12%	7%	12%
	Improve infant and under-five health care	Reduce Under-Five Mortality Rate to <200/1000 live births	219/1000	25/1000
		Maintain first consultation for infants 0-11 months coverage at 98%	98%	145,1%
		Increase first consultation coverage for children 0-4 years to 60%	46%	53,4%
		Achieve 95% coverage for immunisation of children 9-23 months against measles.	86%	94,9%
		Reach 60% national coverage immunisation against tetanus for women of fertile age.	32%	60%

As referred in this thesis finding, the MoH a review of the indicators years ago, aiming to answer effectively the problems that arise related to health care. From this review, a couple of new indicators have been added. The column named New in Table b) in Annex C shows the result of this revision. However, up to now the MoH has not introduced within the NHIS data collection tools that can be used to calculate those indicators.

The MoH have also recognized the existence of different factors that can cause the pregnant mother to delay for a delivery that is not been taken into consideration in the paper forms in

use within the NHIS. So, aiming at understanding those factors in the list of new indicators presented in Table a) in Annex A, a couple of them are related to Maternal and Child Mortality evaluation or Emergency Obstetric Care (EmOC). Those indicators can be grouped using a simple model called The 3 Delays (Figure 6.3).
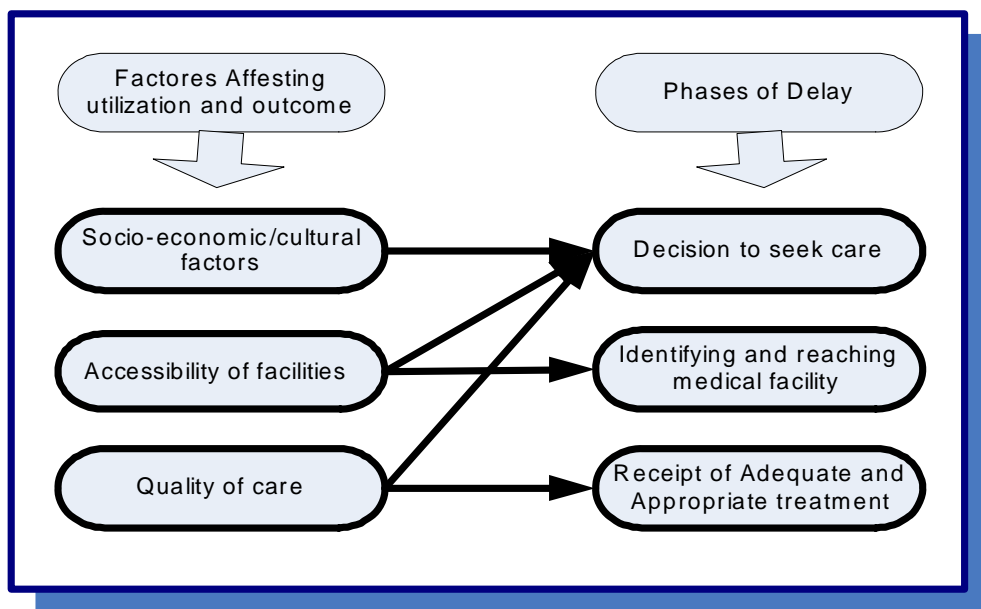

Figure 6.3: The 3 Delays Model (Adapted from Maine *et al.*, 1997)

This model specifies the three types of delay that contribute to the likelihood of maternal death; delay in deciding to seek care; delay in reaching a treatment facility; and delay in receiving adequate treatment at the facility. These many factors influence the Maternal Mortality.

Three years after the discussions around the indicators have started, the MoH have not yet set data collection tools to be used for this purpose. The NHIS is still using the form SIS Mod B07 (Figures 5.13, Chapter 5) to collect maternal and child health data. Comparing the data elements in the forms presented in this figure with the new indicators definition presented in Table b) in Annex C and also with the form presented in Figure 5.14, Chapter 5, we can clearly see that what is being collected does not include data necessary to understand "The 3 Delays Model", i.e. data necessary to analyze EmOC. For example, to control Maternal Health the NHIS is collecting and disseminating data on number of deaths. However, as discussed earlier to control maternal mortality we need to understand all issues presented by "The 3 Delays Model". This shows that the data collected by this form cannot help the MoH to reduce Maternal Mortality. So, there is an urgent need to set up a collection tool.

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The discussion above proves that there is a need to strengthen the HIS in Mozambique by providing more resources to health workers at lower levels. This can include, for example, the use of computer tools at low levels of HIS. In addition, in the case of EmOC indicators discussed earlier in this section and in Chapter 5, there is a need for new data collection tool.

Based on my understanding of the problems that are being faced with the MoH and being inspired by the form used by the WHO in Mozambique to collect data on EmOC (see Figure 5.14, Chapter 5), I am suggesting the following form (see Figure 6.4) to be used as data collection tool within the NHIS. This form should replace the back side of the form SIS Mod B07 or the table in the end of the form presented in Figure 5.13 b), in Chapter 5.

In the proposed data collection form (Figure 6.4), I only present selected causes of death among pregnant woman. I am proposing it to be used to enter data at the district, and province levels. Of course, the data entry form for the facility level should be revised in such a way as to reflect the changes suggested in the form in Figure 6.4.

As shown in Figure 6.3, the EmOC services are necessary if maternal mortality is to be reduced, but they are not sufficient. Even when services are functioning well, women with obstetric complications face a variety of barriers to using them. Some of these barriers are economic - e.g., lack of money to pay for transport or services. Some are cultural – e.g., low value placed on women's lives. Some are geographic – e.g., long distances and poor roads.

Anything that cause delay in getting treatment may cost women their lives. Understanding all these issues requires an integrated view and because some of these factors are related to geography this issue must be taken into account. Thus, the attributes database systems in use within the MoH cannot, on their own, address these issues, and a GIS system is needed.

REPUBLICA DE MOCAMBIQUE						
MINISTERIO DA SAUDE						
RESUMO DE CASOS DE MORTES MATERNAS						
DISTRITO/PROVINCIA DE _____						
					MES __/200_	
UNIDADE SANITARIA/ DISTRITO	CAUSAS DIRECTAS DA MORTE			Total	CAUSAS INDIRECTAS DA MORTE		Total
	Ruptura Uterina	Gravidez Ectopica	Hemorragia Ante- Parto	...	Intoxicação por Medicamentos Tradicionais	Anemia	...
Total de Mortes Maternas							

Figure 6.4: The Proposed data collection tool (District and Province Level)

From this study we have also found that the following factors contribute to the understanding of the reasons for the high maternal mortality:

- **Lack of coordination**

It has been recognized that the health sector in Mozambique alone cannot solve the problem of maternal and child mortality, without support of other sectors. Efforts only by the health sector will have limited effects on reducing maternal and child mortality. There are a lot of initiatives in Mozambique aiming to reduce the maternal mortality, but these are working as "stand-alone" with little communication or cooperation with other institutions. Efforts of all

sectors must be coordinated in order to have the desired effect. For instance, if a community is informed and educated about maternal complications, but the transport problems are not resolved, mothers will continue to die unnecessarily. If transport is available and affordable, but health services have not been strengthened to handle obstetric complications, not only will maternal mortality continue to occur, but communities will become disillusioned with their health services.

- **Lack of spatial analysis of health data**

In health data, there is a need to analyze those data taking into account their geographic nature rather than only the usual non-spatial data. Once the decision to seek care has been made, the woman must reach a facility where EmOC is available. The distance to the health facility, availability and efficiency of transportation, and cost of health care and transportation all influence people's readiness to seek care. These issues must be understood together and not separately if the reduction of maternal mortality has to occur. GIS tools can help analyze such issues in an integrated manner.

- **Lack of health personnel**

While there is a lack of all these medical doctors, as presented in section 2.1.2, Chapter 2, there is a need to focus on the Traditional Birth Attendant (TBA) by making them part of strategy. Surely TBAs can conduct a clean, safe delivery and identify complications at an early stage. This can help get women on route earlier to obtain care. It's important the women deliver in hospitals; having overcome barriers related to the first two delays (reach a medical facility and receive treatment). The number of trained staff, availability of drugs and supplies, and the general conditions of the facilities usually influences the maternal mortality. A GIS can help to analyze the resource availability in different locations.

- **Insufficient information**

Not much is known about parts of the maternal health problem to make rational decisions. For example where, when under what circumstances are women dying at other times during pregnancy, and how can they receive services in a timely manner, are a list of issues that the HIS data in Mozambique does not answer. When mother's death occurs, what arises now is the information that is recorded to be reported to the decision-makers. This is a high level of

all the HIS. As discussed in the findings of this thesis, the information that is recorded within the health structure is not enough for health decision-makers to understand the causes of, for example, the prevalence of high maternal mortality. There is a need for revising the data collection tools in order to provide decision-makers with correct, reliable and exact information.

In this study, I have recognized that there is a need to integrate, exchange, and interpolate for building various scenarios from (non-)spatial information in order to address many of the health staff challenges. This integrated system will provide seemless decision support based on shared data using various forms of predictive modeling. In a way of studying this integrated environment, during this study different issues were approached and will be discussed in the following sections.

6.3.2. Why Need a Geospatial Information Infrastructure

As described in this thesis, the availability of spatial health information is poor. In many cases the spatial data is in the form of unscaled sketches. Where maps exist they are often out dated or classified as restricted information and access by public departments is very difficult, if not impossible. Where current and unclassified maps exist, they are usually of different scales, imperfectly georeferenced, aggravating the problem of sharing information efficiently among various sectors of the health institutions and abroad. Digital representation of spatial data is even rarer due to the lack of appropriate equipment and trained staff; few institutions are ready to begin generating digital spatial databases as the task is seen to be too large, too costly and too complex both technically and administratively. The design and implementation of a workable spatial data infrastructure is often a dream for the future.

Therefore, the exact demarcation of much of the health facilities is impossible. Most information about health facility and utilities are in the experienced hands of key personnel in separate departments. The utilities and health facilities that are marked on maps are rarely up-dated. In most cases, the actual location of these service lines is different from the location appearing on those maps. Agencies responsible for the provision of different infrastructure maintain their own maps usually showing only the location of infrastructure under their control. These maps are often only in the form of sketches that are interpretable only by the staff of these organizations.

As described in the literature, the Geospatial Information Infrastructure (GII) brings advantages by contributing to interoperability while providing a sharable global information set of logically consistent information, captured to standard definitions and rules, on a common geometry, of sufficient reliability to be the basis for all future intensification. It also supports the development of approved interoperable applications, applications that have been certified to maintain data accuracy and data integrity.

To bring the health sector into the knowledge so that the full value of data, information, and knowledge is used in real time to support care delivery and other health goals, an integrated infrastructure allowing interoperability and scalability is essential. Consequentially, there is a need for cooperation between those institutions (see Figure 6.1) in order to reduce efforts and one way of doing it is build an integrated environment. Figure 6.5 illustrates how Figure 6.1 can be rectified by the addition of an integration view (central coordinating hub). Note that the hub is drawn with a dotted line to convey its representative nature: it may be, simply, a committee of stakeholders.

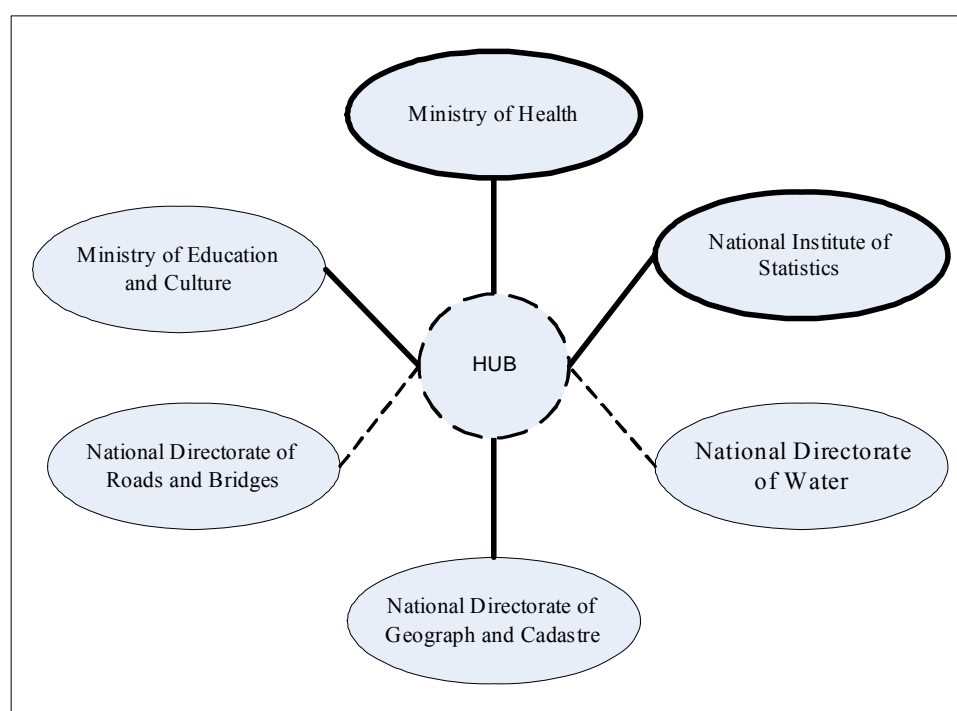Figure 6.5: An integrated view of infrastructures

The hub differs from other stakeholders in the network by focusing on services rather than data (i.e. a facilitating role). For instance, as I referred in this study, by the end of year 2004 a discussion around data standards was held between the MoH and the INE. Meaning that effort to avoid having different characteristics in data is being emphasized. With this

linkage, other institutions that are linked to each of these institutions will benefit from this initiative and this will help them on thinking in a best way (standards) of sharing their data.

Because of multiplicity of agencies that can be involved in GIS and also because their individual data requirements vary widely in terms of map scale, graphic elements, data accuracy and data currency, there is a need for a adoption of common standards even knowing that their adoption is difficult, especially in countries like Mozambique.

6.3.3. Standardization of II: The Role and Importance of II Standards

From the findings of this study I have understood that information cannot be spread unless it is based on shared standards. Those standards are just one element, linked to a number of other elements, technical and non-technical, in their network. As presented in the findings of this study, installed base, within the NHIS had differing data (formats, standards, sources, etc.); also the contacted institutions had strongly differing data standards, including spatial data.

In order to build the DCH_GIS system, standards that were already inscribed into their existing ISs which refer, for example, to agreed methods of collecting, structuring and communicating non-spatial data between health staffs were aligned into the IS. To carry out this it was necessary for us to agree with the standards to be used. An example of agreed standards between the development team and the health staff is the use of data coming from SIMP software. This was one way of inscribing a shared standard that was already in use within the NHIS into the new system. The non-spatial database has now incorporated these national standards. Within this framework, standards were seen as interfaces and gateways for communication between relatively independent actors across the NHIS.

As referred in Chapter 5 of this thesis, data coming from the SIMP software is not following the standards proposed by WHO. This reduces the range of applications for which this data can be used. If the data/information is available in standard formats based on standard collection methodologies, users can absorb them more easily into their work. We can also add in the advantage list the possibility of comparing indicator easily without additional work in converting the map scales, for example. However, if standards are not applied, data may be perceived as incompatible, inappropriately focused or otherwise unusable.

The non-existence of culture of sharing spatial data between departments within the NHIS and also between institutions (including ministries), made the process of development been characterized by negotiation and tinkering in order to propose acceptable standards to all the users within the NHIS. The decision of using DHIS as non-spatial database results from this negotiation process. This process also affected the institutions that exchange data with the Ministry.

As stated before, discussions between the MoH and INE aiming on building standards on non-spatial data have been started. Knowing that the problems faced by decision-makers within the NHIS and the INE staff are also related to geography, there is a need to think not only in non-spatial data standards for but also about the definitions of standards spatial data.

The basic concept taken is that *Standardization* of II (Hanseth & Monteiro, 1997) where emphasis has been on building standards which has a lot in common with socio-technical processes of negotiation involved with appropriating any piece of technology. In this sense, then, it corresponds roughly to closure, stabilization and alignment. For instance, the question of non-spatial data standard existing within the HIS influenced the development process. As a result, the work practices (routines, reports, etc.) within the DCH in the NHIS were inscribed into the GIS system as discussed in section 6.1.1. Agreement about the map scale at the very beginning of spatial infrastructure development was important as it determined the application areas. In practice, gaining agreement was very difficult due to different users needs.

By the time this work was being done a pilot project was run, aiming at improving technology utilization among government agencies. This process is being supported by an initiative that aims to develop a government portal. This portal will help to open the minds of managers of these institutions in issues related to information sharing as the development process will involve discussion between the governmental institutions. This project can help the institutions to think on standards that can be used to resolve problems regarding data presentation, sharing etc.

In general, nowadays in Mozambique there is little sharing of data between the government institutions. This problem becomes stronger when we talk about spatial information. In my point of view, I think this happens because the government has not yet adopted national

standards on (non-)spatial data. These standards, if defined should allow (non-) spatial data to be shared and used by other institutions without additional work.

However, it is important to know the advantages that Mozambique will benefit with the adoption of international standards. Form instance, Brazil is one developing country and one of the biggest open source development country in the world and the biggest from the Portuguese speaking countries. If for example Brazilian standards are adopted, a lot of advantages can be taken from that. The institutions in Mozambique will benefit from their systems (see Figure 6.7) and their support. There is a lot to be learned from them, and this could be a good chance to learn from Brazil including challenges and opportunities. Their experience in setting up GIS system such as how to make the team of the geo-processing professionals, the integrated manner in which they build their software, dedicating a complete organization to the development of geo-processing expertise, etc. can be clearly adopted.
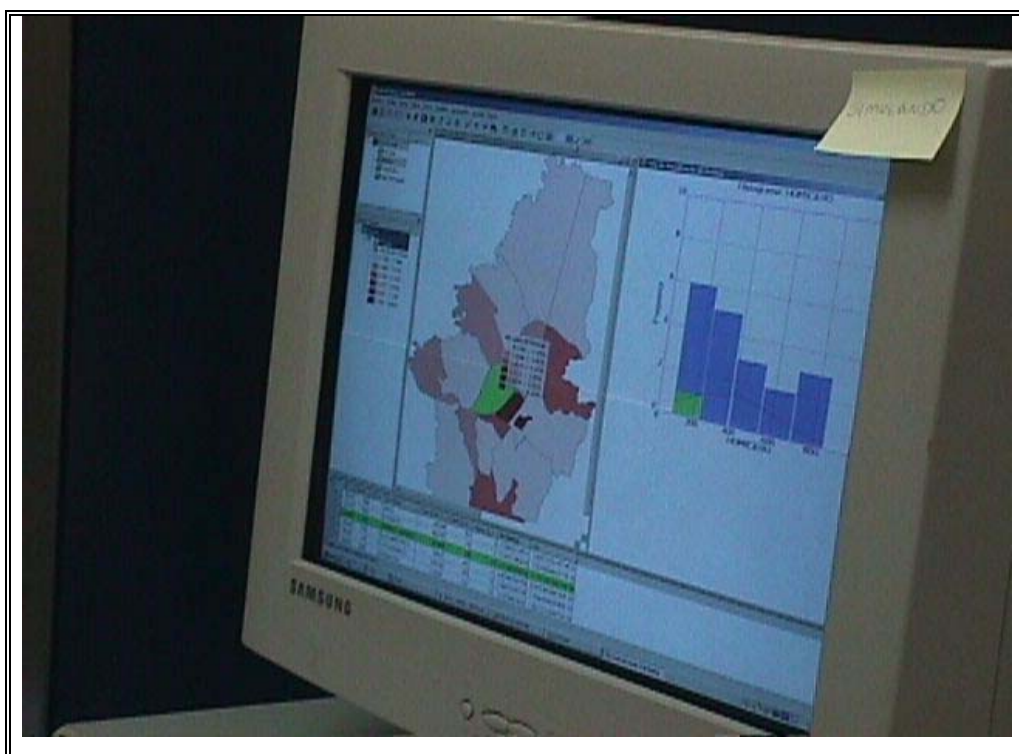
Figure 6.6: Screen of the TerraView open source software developed by SAUDAVEL team in Brazil. (Photographer: Zeferino Saugene)

Another important advantage of adopting standards from Brazil is, for example, is the opportunity of using their open source GIS systems (Figure 6.7), which reflects a developing country experience. By benefiting from their software, ICT users in Mozambique will receive from on-line support in language, experience, etc.

6.3.4. Developing a GIS System from a Cultivation Perspective

When introducing changes, the work environment of the system was taken into account as is locked to organizational (MoH) and individual (DCH) complexities, which form the installed base that heavily shaped the change. Therefore, a cultivation strategy as suggested by the II thinking seems more appropriate to apply in such chaotic setting where the spatial needs are frequently changing. As shown by this study, the spatial needs were frequently changed as the development was carried out while the health workers became aware of the opportunities of GIS technology.

The basic concept taken is that of *cultivation (Aanestad & Hanseth, 2000),* where emphasis is on starting small, taking incremental steps, and building upon what is working rather than trying to design new things from scratch. This concept of cultivation turns to focus on the limits of human control. Considering the technological systems within the NHIS implies that we focus on the role of existing technology, the installed base, as an actor in the development process.

The perspective of cultivations to system development emphasizes the necessity of working close to the user in order to develop useful systems. The idea of using the cultivation approach influenced us throughout this study. Studying the DCH from a cultivation perspective, made us realize that it would be much more costly and disruptive to actively change the work rather than the technology supporting it. This perspective helped us to also understand the necessity to be able to build the DCH_GIS on what already exists. Viewing the DCH_GIS development through a cultivation perspective, helped to design the new information infrastructure using a gradual process, bottom up and incrementally developed. In this process of development, the integration view both with the existing systems as well as new systems is at the core.

Thus, cultivation as a design strategy facilitates the process whereby the actors were enabled to translate their needs into the transforming information network. The cultivation perspective has also helped to decide on finding a better framework for analysis, as well as on how to structure the resulting design in order to make the proposed changes possible to implement.

6.4.   Institutionalization of the DCH GIS System

This section will give a broader discussion on issues that can hamper the institutionalization of a GIS system. The discussion here is based on literature and also on practical experience and challenges that other developing countries have faced while developing the GIS system.

6.4.1. Understanding Political Issues

In the issues of data sharing discussed in the above sections, the problem for most GIS users is to know who owns the data and what rights they have to use the data. There are also issues of integrating datasets for the purposes of analysis and what rights exist for passing such derived data on to third parties. The problem of ownership and copyright also lead in the vexed question of ownership of an 'added value' dataset and to legal issues of responsibility for data accuracy, currency and use.

As referred, the HIS in Mozambique was revised in 1989 in order to simplify and integrate the various existing programs. The SIMP software for example was built by the MoH in order to address these problems. However, in order to allow donors direct control over the funds, some of the departments have traditionally developed their own systems organized as stand-alone, vertical programmes, often targeted to address specific health problems and inflexible systems. Within these systems different datasets are being collected, there are multiple channels for information flow, and widely varying practices of use of the data. Driving through an integrated environment there is a need to join efforts from each departments/institutions which has data to be shared for handling the decisions. However, for this purposes legal questions related to the liability of those systems and who is responsible for quality of the results produced will arise. Different political issues have surrounded the development of the DCH_GIS system, for instance, while searching for maps, and also during the interview process.

In order to succeed regarding GIS institutionalization, a strategy for a basic framework for reaching information agreement or joint-venture between geo-information systems, must consider data rights - legislation to establish data ownership rights must be developed. Consideration must be given to matters such as access to source data and databases; funding - how should that default affect the obligations of the other participants, what treatments should be available, and what effect does default have on the overall thrust of the project;

disputes - ownership of the intellectual property rights in such production and new added information and confidentiality and privacy of information.

These are issues which arise in situations where there is a need for an integrated information system such as a GIS, which requires data from different sources. For instance, when the systems are not made with integration concepts in mind, more work will be necessary in order to share the resources used by these systems. Some examples can be addressed by systems like SIMP, which is a very difficult problem to deal with. Other fragmented systems are: BES report number of incidents of Malaria and deaths, and SISPROG reports this data, as well. Due to the characteristic of the systems this information is not compared at all. SISPROG deals with prevention of sickness, while BES deals with sickness, and it would be good to compare the two databases to see how well the prevention is working. To get approved from the developers of these systems in order to share their source code or scripts of part of the system is a political issue that must be clearly planned/agreed from the beginning of the work.

In order to have an efficient GIS operational it is important to start with basic data collection. This requires time which few managers either have available or are willing to commit as the benefits derived are not immediate. There often appears to be a political urgency, which negates long term planning. For example, it is often stated that the GIS must be operational in, say, two years, but since this is virtually impossible, an appropriate strategy is not implemented thereby resulting in little progress ten years later. Making use of high resolution remote sensing provides great potential to alleviate some of these problems for medium and small scale GIS applications. By using this source of information, the MoH or other institutions will have the potential of saving time and money as they avoid the intermediate step of establishing manual map systems. Thus, the MoH will have the opportunity to learn from other institutions mistakes to start their own process avoiding those mistakes.

The bureaucratic procedures for approval and procurement of technology by the user are often very cumbersome. If there is a need to start a GIS project, a great deal of patience and energy is measured to find a way through the political system to obtain support and funding, prepare and evaluate tenders, award contracts and take delivery of the system. During the development process we experienced this issue while getting a feedback from the user. The process was too long and is full of uncertainty. The bureaucratic way that we had to follow

in order to understand users' requirements was also strongly influenced by procedures set by structures that are not easy to be change.

6.4.2. Understanding Cultural Issues

Cultural beliefs and expectations influence the things we do to stay healthy, the way we feel about our bodies, the way we experience pain, the way we behave when we are sick, the actions we take to get help, and the providers from whom we seek care.

The methodology used for the case studied in this thesis enabled us, as analysts, to understand the culture of the people who are likely to use the system and to design the system so that it matches their needs. User participation in the process helped more on understanding the culture not only of the user but also of the entire working environment, the HIS. Their traditions were studied and inscribed into the system through the knowledge gained with a high level of user participation into the development process. This process helped in avoiding major cultural differences the between computer system and system user.
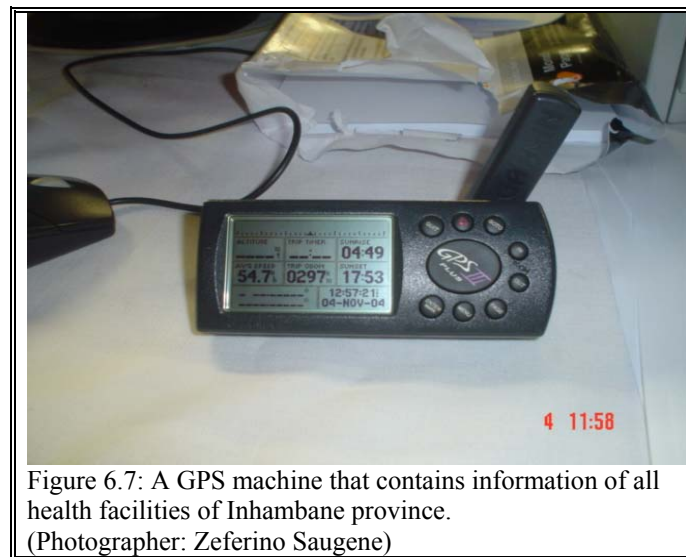
Here, we view such cultural clashes and a variety of strategies for eliminating the negative consequences as they apply to the user. This view helped on examining/understanding the importance of culture in the way people define, react to, and address their problems, injury and health risks.

6.4.3. Understanding Infrastructure Issues

Within the MoH, digital representation of spatial data is increasingly rare due to the lack of appropriate equipment and trained staff. Departments are not ready to begin generating digital spatial databases as the task is seen to be too large, too costly and too complex both technically and administratively. For example, because of experience in using GPS and other GIS technologies and also because of inadequate infrastructure the province directorate in Inhambane have all the health facilities geo-referred since a couple of months, but the information is still in this GPS machine (Figure 6.8).

On the other hand, as referred before, the institutions responsible for the provision of different infrastructure maintain their own maps usually showing only the location of infrastructure under their control. And to get an agreement from them in order to share spatial data will sometimes require availability of an infrastructure that supports those data

when the technology used to manage them is of different generation. The format and structure for holding geographic information is likely to differ between computer systems.

Figure 6.7: A GPS machine that contains information of all health facilities of Inhambane province.
(Photographer: Zeferino Saugene)

As seen in the GIS development for the DCH, data obtained from INE has different codes while compared with those obtained from MoH which are different from that used in the SIMP software. To address this problem, we included columns/fields, ProvinceID and DistrictID, on the spatial database manual. But, if there is an agreement between the two institutions in sharing data, they must have the same infrastructure or at least their infrastructure must be communicable.

As for the development process, we did not face software problems because we used a free license of *MapObject 2.0* from ESRI. There are, however, low cost desktop GIS software packages, with some of them being available through Internet at no cost. Such systems do not require specialized hardware, have simple, easily learnt interfaces, provide the essential spatial data handling procedures required of GIS software and allow rapid visualization of information in a spatial context. In particular, they are good for raising awareness and gaining experience. These simple desktops with low cost GIS provide an important way forward for developing countries. However, most of this imported programs and manuals are written in English, but most of the users, particularly the decision-makers, have limited understanding of English.

These challenging issues can be reduced if the institutions adopt international standards. Then, they can easily benefit from work that was already done by other institutions, like for example open source software developed by INPE in Brazil, which I have discussed in this

study. In this case, the gains will be in technology, experience and language. Adopting infrastructure standards from other developing countries advanced in spatial data utilizations, countries will benefit by getting more support, using their software with low cost, etc.

6.4.4. User Participation as a Factor for Institutionalization

User participation can be justified on practical grounds in that it aids greatly in requirements determination and heightens user satisfaction and "ownership" of the resulting system. Participation was the major factor during the development phase of the DCH_GIS, and can support institutionalization of this geo-information technology. This leads to the question regarding conditions for participation in the institutionalization of geo-information technology.

The development philosophy of this study was based on cultivating participative approaches and creating collaborative mechanisms between HIS top, middle and lower level decision-makers. For example, to develop a hands-on understanding of the health IS, preliminary work was done by a multidisciplinary HISP team which includes senior IS researchers, PhD students in computer sciences and medicine and international masters' students of IS and public health. This team was responsible for implementing an action-oriented research to apply participatory approaches through training and education of managers, doctors and health workers. These activities aimed at (i) improving the working knowledge of computer usage in general and health IS in particular, (ii) building realistic expectations of the DHIS application, and (iii) minimizing resistance to change. This was done through organizing several seminars, workshops and training sessions in three provinces where HISP was being implemented. The HISP team played an important mediating role in facilitating interaction and communication between the MoH staff and province and district level field workers. Such interaction has historically not existed in the past and the presence of the HISP team seen as being relatively "neutral", helped to diffuse some of the historically existing gaps due to power structures.

Authors (such as Iles & Sutherland, 2001) have argued that successful projects for change are often conducted by middle management, who often seek the benefits of new technologies while resisting extensive organizational changes. However, GIS is being often used at both local and national levels for demographic and socio-economic studies where

there is little participation of local people in the implementation phase. This makes GIS a tool for the researchers, planners and policy makers, rather than a tool for local people.

The availability of information is very important to a GIS. Whenever information availability is restricted, the GIS utility suffers. Hence, the usual inclination of an organization or department to monopolize its own information is one of the major obstacles to a successful institutionalization of GIS. Therefore, one of the problems detected in developing a GIS may involve conflict with the bureaucracy that hinders the information flow. Thus, the institutionalization process without participation can lead to issues such as those that I have referred before, regarding the problems of the maps from INE related to the wrong number of health facilities, or differences between data from INE and MoH.

Hence, community participation is important but we must be careful on choosing who is going to participate. Analyzing this situation, we can easily see that the wrong health facility geo-referencing process in Gaza province referred in Chapter 5, was heavily influenced by the community participation. On the other hand, problems associated with the existence of health facilities within the ocean are influenced by the way technology has been used or by the absence of participation of GIS technology experts. There is a need to see GIS as a tool in a participatory process rather than as technology in its own right.

CHAPTER VII   DISCUSSION AND CONCLUSION

This chapter offers a discussion of the key empirical findings presented in Chapter 5. The chapter responds to the research questions and objectives as presented in Chapter 1. The study responds also to the need of health information reform particularly in developing countries. I approached the problems domain with the following four research questions:

(1) What are the current major limitations of the information systems for the decision-makers?

(2) What challenges are there when using spatial information to address challenges of public health decision makers with focus on maternal mortality?

(3) What are the approaches to address these challengers? And,

(4) What strategies can be developed to implement GIS technology for health management in Mozambique?

To answer these research questions, I set the following research objectives:

(1) To assess the health information system in Mozambique;

(2) To look for approaches to development and institutionalization of GIS system in developing countries;

(3) To develop a prototype of a GIS-based information system for the study area and demonstrate applications of its use for the analysis of various health care decision-makers problems;

(4) To suggest strategies and ideas on how to strengthen health information systems at local, district, province, and national levels, more generally to improve decision-making procedures through the use of GIS system in Mozambique;

(5) To assess the progress of the GIS systems in Brazil in order to identify learning gathered that could guide the adoption of this technology in Mozambique and other developing countries; and

(6) Formulate recommendations to be followed by health decision-makers in developing countries when dealing with spatial related problems.

This chapter is arranged as follows: section 7.1 introduces the chapter by discussing issues related to the process of conceptualization, design and implementation of a DCH_GIS system. The benefits, challenges and strategies for implementing the DCH_GIS system are

discussed. This section brings a discussion which helps to answer the research questions of this study. In section 7.2, the limitations of the research are presented. Section 7.3 presents the research contributions; in section 7.4, the conclusions and recommendations are presented; and finally section 7.5 suggests future research focus.

7.1. Conceptualization, Design and Implementation of a GIS System in a HIS

This section identifies how the learning gathered in some developing countries, including Brazil, can be sensitively applied to guide the adoption of GIS system in Mozambique and other developing countries. From the findings presented in chapter 5, we can see that the use of ICT by public sectors institutions in Mozambique is similar to many other developing countries.

7.1.1. Health Care Decision-makers Limitations

In Section 2.1.3 of Chapter 2, I presented a couple of problems that health decision-makers in Mozambique are facing. These include rapidly growing populations, and severe resource constraints; rational allocation of scarce resources is difficult and is dependent on the size of catchment populations; expensive hospital-based health care systems are protected by strong vested interests, reorientation is mainly rhetorical, and primary health care is making only slow progress; people suffer from environmental diseases to a far greater extent and, at the same time, have poor access to quality health care. They are also at risk of succumbing to other health conditions, which may be due to their lifestyle (smoking, HIV/AIDS) or their life stage (infancy, pregnancy, old age).

Several other weaknesses further restrict the usefulness of the HIS in Mozambique. Some highly desirable information, such as population-based epidemiology, service quality data, and socio-cultural information, is not being collected. Problems also exist in the flow of information from the field, including delays, non-reporting, non-response, and a generally unsatisfactory quality of generated data. For example, the results in this study show that data collected by the NHIS from caesarean activities is not sufficient to calculate the different indicators that help the health decision-makers to support their decisions. Including delivery in a health facility in the logistic regression rendered the low values, suggesting that the trend toward a decline of caesarean section rates is partly linked to a decline in access to health services. This shows the lack of progress of "Safe Motherhood" programmes in countries where maternal mortality is extremely high like Mozambique.

The discussion presented in Chapter 3, Section 3.2.3, shows that many questions concerning the provision of health care are related to space, the question *where*. The argument is based on the fact that: people are distributed in space and they are not evenly distributed; health problems vary in space and so do the needs of the people; etc. The questions related to where health care centers should be situated and what services they should offer to answer efficiently the needs of populations varying in numbers, densities, and health problems, usually challenges the decision-makers. Moreover, current reporting is largely restricted to acute and brief illness episodes in people fit and affluent enough to seek care at a health facility; those who live far away, are too sick to travel, are worried about cost implications, or are chronically sick and disabled and have little to benefit from a visit remain "invisible", neglected by the service system and overlooked by planners.

Whatever the conditions, the DCH in the MoH is responsible for providing treatment and prevention methods and, where possible, addressing the factors that resulted in the disease being present. However, the DCH rely on systems, whether they are paper or computer-based, to capture disease data, and on infrastructure and staff to collect, manage and analyze the data, and to disseminate the results to the appropriate people in good time. As referred before, for a variety of reasons, some or all of these are often not present, resulting in disease data not being collected, and treatment and control measures therefore being inadequate.

However, decision-makers time is becoming increasingly valuable and they cannot afford to waste it by wading through pages of reports to extract the substance. They need brief presentations, focused on pertinent comparisons. When such reports are available, they often present conventional comparisons, such as the value of an indicator in terms of a theoretical reference, often defined at the central level, or a comparison of a variable from one year to the next. It is often more efficient in terms of management to make comparisons between similar health care structures or neighboring regions.

To effectively implement their policies, the DCH also needs to know the spatial distribution and number of people they are serving and this information is often out of date and not available at appropriate scales. For example, the DCH decision-makers are concerned with planning and implementing maternal mortality reduction programmes that work and are most likely to achieve the desired impact. Simply having enough EmOC facilities is not sufficient; other factors have to be taken into account, such as their geographic distribution,

their catchment area, etc. If all comprehensive EmOC facilities are clustered in urban areas, a large number of women - especially those living in rural areas - will be unable to access services in a timely manner. Unlike many other indicators, the indicator represented below (see Table 7.1) can only be measured by performing spatial analysis with the use of a map or an interactive Geographic Information System (GIS). Then, increasingly I believe that enormous progress in public health can be made by better understanding the links between health and the human and physical environment.

From the discussions presented in chapters 5, 6 related to the database systems in use within the NHIS, and the discussions in the earlier paragraphs of this section, we can see that the health decision-makers are plagued by many limitations.

Table 7.1: Example of spatial analysis indicator

Indicator	Definition	Mode of Measurement	Optimal Level
Geographic distribution of EmOC facilities	Assessment (by map or GIS), or actual measurement, of physical accessibility to EmOC facilities	Spatial analysis conducted with use of GIS, or proportion of households within 2 hours of a basic EmOC facility	Ideally, all basic EmOC facilities are within two hours travel time and comprehensive EmOC facilities are within 12 hours travel time for women of reproductive age

Based on the benefits of GIS presented over the different chapters in this study, I acknowledge the importance of graphs and maps in the presentation of results and refer to the value of mapping. GIS does in fact, meet this need by enabling routinely collected data to be presented easily and attractively. This process is by no means new and merely replaces the conventional map displayed in the offices of district medical officers on which the health posts are represented by pins of various colors. Nevertheless, GIS provides an advantage, inasmuch as it facilitates what Sandiford *et al.* (1992), calls the "ritualization" of the interpretation of routine data. For example, it is not the fact that the nurse regularly takes the patient's temperature that will enable the surgeon to detect a postoperative infection, but the fact that the information is plotted on a chart and regularly examined at the patient's bed. Being able to keep track of these factors in order to prevent adverse situations and implement effective control and treatment measures can be greatly assisted by the use of maps.

7.1.2. Implementation Approaches

Successful implementation of a GIS depends on many factors. Of these, a comprehensive plan is critical. The effort that must be expended in analysis and planning depends on a number of factors:

- o The size of the organization and the number of functions that the GIS is to support.
- o The extent to which general computer systems and systems planning expertise exists.

There are many approaches to system design and implementation. Some of these have been discussed in Chapter 3, Section 3.2.5. The approach used in this study to address the limitations of the health decision-makers presented in the above section was based on undertaking a pilot project. The pilot project permitted first-hand experience in the development of a GIS without having to make large commitments of funds, time, or significant organizational change. It also served as a test phase where technical feasibility and practicality of GIS applications were determined. This approach was based on constructing a working GIS model or prototype of the system to be worked with and evaluated by the end-users.

Experience and knowledge were obtained during the pilot project. A prototype of the system was built for users and technical reviewers to criticize and modify. The need for standards, organizational impact and interfaces to existing data was then suggested, determined and tested. In general, the reasons for using a pilot project approach were:

- o Prove technical feasibility.
- o Demonstrate project capabilities to skeptics.
- o Evaluate database design/data sources.
- o Evaluate/test equipment.
- o Determine effects on or help resolve organizational issues.

Because of shortage of GIS experts within the MoH in general and DCH in particular, at the first stages of the GIS development the impetus for implementation occurs at the technical level. Enthusiasm to embrace a new technology leads the developer to a focus on hardware acquisition, software implementation, and data capture without real consideration of the functions relevant to the organization. The emphasis was on inscribing the existing

processes to the new system. Management and organizational aspects (and impacts) tended to be ignored. While the GIS system was being introduced within the MoH, more people became aware of the technology. At this stage, the attention was then given to the organizational issues.

7.1.3. The Benefits, Challenges and Strategies for Implementing GIS System

As many HIS carry reform processes, the drive for reform coincided with a revolution in ICT. The computer has knocked at doors, even in the most reluctant countries. In my study, the following benefits were experienced through participation in prototyping the DCH_GIS system in Mozambique.

- o Improving programme efficiency by processing and analyzing large amounts of data quickly;
- o Producing a wide variety of outputs and feedback reports targeted for many levels of the health system from a single data set or by combined data sets;
- o Improving analysis and information presentation to facilitate data interpretation and use for decision-making;
- o Providing "factual information" about the location of resources (health facilities, etc), human or natural;
- o Analyzing the geographical distribution of the population; and
- o Improving analysis and information preparation to facilitate data interpretation and use for decision-making. All funny graphs, tables, charts and maps in this thesis could not be made without the use computer databases, the DCH_GIS and DHIS.

As discussed in Chapter 3, the introduction of GIS is very similar to other IT. However, the way computer technology is implemented in developing countries has been questioned by many studies. An organization dealing with geo-referenced information may initiate GIS to realize the gain, but effort (in time, money, resources) is required to switch from conventional means to GIS.

This study shows that there are several reasons for this: people cause more problems than technology, things (technology and user expectations) change increasingly rapidly, uncertainty is always present, interdependence is inescapable, and there are considerable

differences in national or even province, district and health facility cultures. The constraints of implementing the GIS prototype result of this study are related to:

o The expenses for establishment of GIS are relatively high, not only because of digitalization of maps but also for the reason that GIS are expensive computer tools which require good data, good organized and a high level of skills to be used effectively;

o All electronic systems require stable power-suppliers, good air-conditioned housing free from damp and bugs, and an environment in which an orderly state of affairs can be maintained. These conditions can be found in capital cities of the provinces but less common in many districts and health facilities. Apart from the cost of providing and housing the GIS, the greatest problems regarding infrastructures are probably those associated with collecting, updating and storing the data;

o With the introduction of GIS, many users will normally be supplied with data from a variety of sources. There is a great shortage of persons with GIS expertise in Mozambique. This makes it necessary to develop new and complex organizational relations to obtain a good flow of data. Strategy for this is to involve experienced staff with different backgrounds.

o Initiating GIS changes the way in which the organization operates. Consequently, the problems addressed affect virtually all phases of the organization hierarchy and operational paradigms. The idea of building databases of a country resources and of using that information to help plan and direct the future development of the country concerned is only possible within a context of collective commitment and political stability;

o Problems related to technology are on the one hand associated with licenses, support services and copyright in areas far away from easily available commercial support. On the other hand, are associated with technology transfer, the software which was designed for one place and can not be fully used in other places;

o To build an operational GIS system which provides tangible benefits can take a long period, and reasons can be technological but often are organizational, and if the users are not actively involved in the process of change the project can be a disaster. It can also be problematic for an organization to handle the long data establishment period; this often leads to frustration due to the long period between investment times and the realization of the value; and,

o Data is at the heart of any analysis. Very often an effective implementation of GIS is severely vulnerable by the limited availability of useful geographical data. Two aspects lead to this problem, namely: the existence of data and the accessibility of existing data. The first problem is concerned with maps which are scarce because making maps as well as updating them is a costly and time consuming activity and in countries like Mozambique much more difficult due to financial constraints. Also information from maps, information about physical and socioeconomic features tends to be scarce, obtaining these types of data need field surveys which are time consuming and expensive. The aspect regarding the lack of accessibility of data is derived from the fact that different existing data sets tend to be hard to combine. In some cases, a combination of data sets even proves to be impossible. One reason for this is that often the newly established GIS projects function as isolated islands of innovation.

The legacy databases systems, SISPROG and SIMP, presented in Table 5.5 of Chapter 5, demonstrate how lack of appropriate implementation strategy could create more problems of reporting health delivery services. In my study, the challenges for implementing GIS system is not only technical issues but also social.

Taking the example of the HIS project in Mozambique again, the HISP team and I spent many days between June and December 2004 in Inhambane and Gaza provinces analyzing SISPROG and SIMP data, and configuring and training the new DHIS database interface. The two database systems, SISPROG and SIMP were running with problems. So, it was often difficult to manipulate data in this system. This also happens with health workers when entering data into SISPROG, for example.

Other challenges include:

Absence of spatial data standards within the institutions in Mozambique: Information technology development leads to the adoption of some standards which change the way the broad community of institutional users of IS operate. They are key factors to the process of data integration and bringing together disparate data sets.

The discussion presented in Sections 5.1.3 and 6.3 of Chapters 5, 6 respectively, shows that spatial data in the institutions under this study are not the result of a coordinated effort to

address information needs of the decision makers. The problem of running parallel spatial system with non-matching data has a lot of problems. While the aim of spatial data infrastructure is to help the decision makers in supporting their decisions, there is a need for coordination between the institutions because a lot of these institutions need to share data in order to support their decisions.

Absence of Socio-Technical perspectives while developing HIS: As referred to in Chapters 5 and 6, the problems with the IS actually used within the MoH clearly show importance of taking an organizational perspective. Following other systems experience, treating GIS from a purely technological perspective is unlikely to be a particularly successful approach. GIS will not, of course, in itself solve the problems of development. Therefore, the institutional and others issues resulting from adopting the developed countries model are to be closely examined with respect to their culture. As a result, IS research has over the years increasingly emphasized that people and organizational aspects are as important as the technology related components.

Lack of Data Sharing Culture: This study findings presented in Chapter 5 clearly shows that the impediments due the poor data sharing magnified in the case of spatial data. The lack of knowledge about the determinants of a willingness to share spatial data and their interactions makes it difficult to address the possible bottlenecks effectively. Potential spatial data users may have difficulty finding, or gaining access to, relevant spatial data because of a lack of institutional co-ordination. It is difficult to serve the growing diversity of users with new technology when data dissemination is hampered by narrow security restrictions of data.

One of the fundamental problems is the lack of awareness of the value of spatial data and information and a wider definition of security that can include issues other than military ones, such as the need and use of spatial data for economic, educational, cultural, social and political systems. This lack of awareness has resulted in the lack of availability and accessibility of spatial data to facilitate regional cooperation.

The lack of availability and accessibility to the reliable datasets results in the duplication of effort to collect data, which exist, but is either unavailable or unknown to the current project.

7.1.4. Implementation Strategies

Currently, health decision-makers in Mozambique are provided with very limited resources and power to support their decisions due to lack of accurate data. In the project we underscored the use of GIS in order to address the problems facing health decision-makers daily work.

In order to succeed in the process of initiating GIS technology in Mozambique it was important first to disseminate it. Two main phases characterized this process: initiation and implementation. The "initiation" phase involved gathering information about GIS technology, evaluating the information against organizational needs, and calculating costs and benefits of the technology. The "implementation" phase encompasses installment of software technology, database development, system development, and test of the GIS prototype.

However, as discussed in Section 3.2.5, Chapter 3, the effects that the introduction of GIS has on an organization may result in the need for restructuring. The prudent, realistic approach usually requires a balance between remodeling the organization to accommodate GIS and shaping GIS to suit the needs of the organization. As presented in Chapters 5 and 6 the GIS system resulted from this study was developed following a prototyping approach.

Along the different chapters of this thesis I have argued for the existence of geography in most of health data. Because geography is everywhere, use of GIS typically includes material drawn from different sources and GIS can potentially underpin all decisions within and between organizations. Succeeding in these circumstances is not easy. For these reasons, effective GIS implementation requires understanding of management issues.

Consequently, planning should not limited to the DCH itself, but external users, DIS (data suppliers), and others departments and institutions should be included. The introduction of those parts of HIS concerned with the introduction of the new technologies, "the participation approach", helped on introducing motivation, building competence, and promoting maturity within the health workers. In this way, it is important to draw the expertise from potential stakeholders (professionals who know the tasks, executives who know the organization, staff, and system specialists and/ or external consultants).

Achieving support from decision-makers and higher level management was a crucial prerequisite for initiating development of a GIS. Their involvement was of extreme

importance, as organizational related problems (politics, culture, etc) including all those discussed above were avoided.

Relationships with possible stakeholders from the first stages of the process produced assessments which lead to compile an overview of actual and potential users giving support in avoiding the resistance for change, and mentality and data constraints.

The strategy used in the process of the development of the DCH_GIS was also based on the "four S" strategy. The use of this strategy helped in addressing the different constraints of GIS adoption presented in the Chapters 3 and 7, Sections 3.3 and 7.1.3 respectively. Following the "four S" strategy on implementing GIS for health management in Mozambique we identified a department within the MoH and a dataset (Mother and Child Health, and Immunization) according to the user requirements as a pilot study for the first phase.

7.2. Limitations of the Research

It is important to critically evaluate the results and the whole study. The present study has certain limitations that need to be taken into account when considering the study and its contributions. The powerful results of this study have been presented in Chapter 5. However, some of these limitations can be seen as fruitful avenues for future research under the same theme. Firstly, the primary limitation during execution of the Pilot Project was the fact that maps are scarcely available and hardly used in within the public sector in general and particularly within the health structure. This is important, as the development of a GIS relies primarily on spatial data.

Secondly, at present only a fraction of health resources (e.g. health facilities) records have been geo-referenced and the last level on spatial data is the district. Much of spatial analyses required by the health decision-makers need geo-referenced community level data. Because GIS is based on computer technology and requires computerized flow of information it means that during the execution of the Pilot Project the information flow to and from all other data sources had to be either improvised or abandoned.

The combination of spatial and non-spatial data related to Maternal Mortality is limited by the type of data. As explained in the Chapters 5 and 6, there is a need of a lot of good non-spatial data in addition to the spatial for conducting analysis. While some data is available, a

lot of data has to be generated by the users for their use. Sometimes collection of field data could turn out to be time consuming and expensive. Data collected must be accurate and meet the correct formats. For example, one need to make sure that all the "layers" of data displayed are in the same units (feet/meters) and the projections and datum's match. Without this the analysis will not be correct.

Thirdly, the pilot project team sought to develop the GIS with involvement of the health staff, but interaction and involvement of senior staff was limited within the provinces by the demands of their day to day work. Thus, more senior staff has had less opportunity to input their suggestion as to how the GIS might address the practical needs of the different sections.

And finally, applications of a GIS-based information system shown in this thesis have the potential to make decisions with respect to health care service more efficient and transparent. Although the development of the GIS information-system for the DCH in Mozambique was, on purpose, low profile, the lessons learnt are clear. A number of barriers that hamper GIS implementation like lack of knowledge in GIS and limited software and hardware resources in local institutions need to be overcome. However, lack of interest among key decision-makers to understand and use available information appeared to be the most limiting factor in establishing an operational GIS-based information system as an integral part of the NHIS activities. The low response of the province decision-makers reveals and confirms the need to pay sufficient attention to issues of utilization of GIS in actual government in addition to issues of implementation.

7.3. Research Contributions

This thesis presents an approach and a prototyping system for implementing a spatial decision support system by building on theories and conceptual frameworks drawn from many different sources. In this study, health, social science and information system development literature has thus been used to bring their concepts and viewpoints into the GIS development for health care decision-making discussion. In the following section, I will summarize the most important theoretical, practical and methodological contributions that this study has made to the health informatics system development research.

The main field of study that this research has aimed at contributing to is the health information system (see Chapter 3). In terms of the knowledge and new insights that this research has generated to the field of health information system and perhaps also to software development field, one of the most important contributions concerns the entire purpose of this study; to promote awareness of the availability, use and benefits of spatial data from the health community perspective.

By studying health information systems in the emerging GIS technology, this study provides quite valuable insights into the scope of interest that health information system addresses. Most importantly, the theme addressed in this study has added to our knowledge of the importance of understanding health problems from the spatial perspective. As was argued in theoretical discussions presented in Chapters 1 and 3, current health information system research in Mozambique has not paid enough attention to the essence of the spatial side of health data.

The elaboration of the spatial health information system development conducted in this study resulted in identifying different concepts such as *inscription, translation, installed base* and *cultivation* presented in Chapter 3. Each concept represents an important issue from the health information system perspective in relation to different development situations. These identified concepts were further elaborated in Chapter 6 by discussing how the elements had been considered in current research study. On the basis of this discussion, it can be seen that these concepts have gained more attention in the DCH_GIS development.

This study has been exceptional in combining sociological research approach with software development approach, conducted by an IT professional. The main research methodology applied in this study, is on its own a contribution as this demonstrates how participatory action research can be carried out in actual practice executing an information system research.

Furthermore, the study examined the formation and operation of knowledge sharing relationships in public sector information technology innovations. The research sought to identify the dimensions and dynamics of inter-organizational networks as the frameworks of knowledge exchange in information system development and implementation. All of these innovations depended on the sharing of knowledge in order to create information systems that span organization boundaries.

The results of this research represent contributions to both the scientific understanding of information technology development and to the direct improvement of government operations. The intervention supported in part by this research project, produced a prototype GIS information systems which will be moved into full production status and expanded beyond its original scope.

The GIS prototype system assumes particular significance, since a number of input data and maps used in carrying out spatial analysis and displaying the results such as property maps and health services provided for a facility can be obtained from a GIS database. Spatial features of a GIS are exploited to perform a number of analyses. Thus, the main contributions made in this context can be listed as:

- o Development of methods to extract geographic data and maps and process them so that they can be used in decision-making;
- o Development of methods based on the spatial features of a GIS that enable precise computation of for example the EmOC facilities location. The spatial features can also be applied to identify streams, lakes, and mountains to automate a number of important decisions such as designs of health facilities and bridges.

A number of data sets are used as inputs to GIS system. In this study, a GIS-based method is developed to directly extract input data sets from a GIS, which can be used during the analysis. This allows application of the model for decisions using maps.

7.4. Conclusion and Recommendations

This section discusses the last aim of this thesis which is described in section 1 and in the beginning of this section, stated as:

> (6) Formulate recommendations to be followed by health decision-makers in developing countries when dealing with spatial related problems.

Before coming to the actual recommendations, some concluding remarks are to be made.

Throughout this thesis I have raised a number of issues that I believe must be faced in any country to develop and implement its information systems, namely GIS programs. GIS and the underlying spatial data infrastructures and technologies being adopted in the developed

world have the potential of significantly contributing to resolving many of the health decision-makers urgent issues and problems in the developing world. The implementation of GIS technology should carefully consider the nature of the developing countries with respect to its socio-economic priorities and cultural character, thus preventing any conflicts with the inherited values. On the other hand GIS vendors are requested not only introducing the GIS technology but also to share the responsibilities of educating society and to play a major role in making the GIS a useful tool for social development.

By reviewing the environment in developing countries, this thesis has attempted to understand and explain the problems and issues in applying spatial information technologies, often taken for granted in the institutions of the developed world. The thesis reviews the DCH_GIS system project as an example to highlight the issues and to suggest some generic strategies.

The main conclusion from this research is that the development of a digital large scale based map as basic spatial infrastructure for a range of GIS applications is very difficult to achieve for many countries in the short to medium term. The main limitations are lack of resources and trained personnel, inefficient bureaucratic processes, lack of data, and lack of hardware and software vendor support.

In addition, it is suggested that small-scale projects or business based GIS are the best option to introduce the GIS concept to institutions to gain acceptance of the technology, as shown by the DCH_GIS example in this thesis.

It seems that GIS are being used for health by a number of countries in various areas of specialization. Their potential has been clearly demonstrated in a number of research projects. However, I feel that if a GIS is to be introduced as a tool to aid control programs, then such applications should be subject to rigorous evaluation. This is essential especially for developing countries which must make judicious choices given the limited resources. For instance, if a GIS is to be used in the Maternal and Child Mortality reduction program within the MoH, then computerization of the Maternal and Child Mortality activities needs to take place. Such activities require an enormous amount of resources, both in terms of hardware and human resources. Unless there is sufficient scientific evidence to show that GIS applications help in reducing Maternal and Child Mortality via a better decision support system and implementation of such decisions, it would be an arduous task to convince both

policy-makers and control personnel of the need to use GIS applications in disease control programs.

Furthermore, for a proper understanding of the real life situation it is important not to focus on GIS in local government only but rather on how GIS can contribute to make the organization function better. GIS should not be seen as "just a program with which one can make nice maps" but GIS should be an integral part of the whole information system of an organization. GIS should be seen as supporting "service" for increasing the accessibility and exchange of information within the organization but surely also to the "customers" of the organizations. The success or hampering factors within a local government unit will not differ much from the factors in other organizations in developing countries. Although of course, one should keep the regional differences between the developing countries in mind, when general statements are to be made

Towards nationwide GIS implementation, there are certain areas of priorities to be set and steps followed accordingly. DCH_GIS experiences reveal that creation of a National Spatial Database Infrastructure (NSDI) is the most important step towards achieving the goal of a nationwide GIS implementation. This is the most crucial aspect in terms of its technical, methodological, organizational and resources required. The Government of Mozambique has already initiated in this direction by creating a National Directorate for Geographic and Cadastre (DINAGECA). However, task force consisting of experts from major government and non-government institutions dealing with the spatial data are disperse meaning that there is a need for collaborative framework, a NSDI, which can be composed by a team of experts from those institutions.

So, from the concluding remarks presented above there is a need for structural study in this field - the question emerges as "what can be done as follow-up to the study". A good starting point for further action can be forwarded following the recommendations summarized below. These are grouped in the three groups.

Weak analysis of data

The health information system should implement paper forms as suggested in this study to collect data related to EmOC activities. The data elements related to EmOC activities have been tested in District Health Information Software (DHIS) and works fine, so I would

recommend the health information system in Mozambique to adopt the DHIS as this software as proved capable of being used as health data analysis tool at all levels of the system.

As recommended in many reviews of health information system, I will also recommend that the legacy information systems should be scrapped away. Effort should then be taken to secure the data locked in these old systems.

It is obvious that infrastructure policy in surveying and mapping should be thoroughly looked into and changed to suit the development of the country. The following is important to be taken into account:

- o Digitized data of unrestricted maps should be made available on payment without any restriction;
- o Maps that help in the analysis of health problems (such as community level) should be produced;
- o GPS receivers should continue to be available without any restriction, at least within the health sector; and
- o Surveying and mapping infrastructure should get top priority and enough funds. Provinces should be made responsible for all developmental surveying and mapping in their provinces.

Developing humanly acceptable information systems

All social scientists and human-computer interaction professionals engaged in the production and implementation of software know the importance of being involved from the outset. However, we continually face the problem of being seen as "testers" or evaluators who by necessity cannot be employed until there is "something" there for us to test, and this "something" must be built first by the designers. The database systems that are being used within the health information system presented in Table 5.5, Chapter 5, are a good example, which shows that the developers of those systems did not take into account socio-technical concepts.

For further development and/or institutionalization of the prototyping system resulting from this thesis study, the Ministry of Health should place emphasis on the key socio-technical

concepts of designing for human values. Clearly, the lessons taken from this thesis project are not simple to learn, but the discussions presented around the different issues represent a means for socio-technical perspectives to impact design practices in the immediate term.

- o Practical hints and tips;
- o Derive participation through clear stakeholder analysis;
- o Expose designers to the context of use for the tools they are developing; and
- o Continually revise criteria for acceptance through user involvement.

Absence of spatial data standards within the institutions in Mozambique

Based on the issues discussed in this study I additionally suggest that the institutions dealing with spatial-related problems should work together in order to develop national data sharing environment, NSDI, that includes all participants as equal numbers, and strive to broaden the use of technology, available data and technological resources throughout the nation. The establishment of the NSDI of the country following the shared database policy will go a long way helping many areas of research, administration and planning. It will eventually lead towards development of a nationwide GIS in the country. The factors that have contributed significantly in the development of DCH_GIS can be evaluated and subsequent recommendations can be made.

The NSDI has to take leadership in implementing a data sharing agreement among its members that outlines the organizational structures and responsibilities within the planned data sharing environment. In addition, borrowing from the experiences of other countries like for example Brazil and available resources, the NSDI should work with its members to implement data and Metadata standards for sharing data. The NSDI should work with its members to implement a monitoring system that will ensure that all members participate fairly and equally, and that validate processes, technologies and data standards to ensure smooth operations and ongoing access to information. The NSDI should work with its members to build common data layers that are beneficial at both national and state level.

The last recommendation is that the NSDI staff should be composed by professionals of different backgrounds. Thus, their experience can be shared among all of them

7.5. Future Research Directions

I have been very fortunate, along this study and all my MSc period, to have collaborated with researchers across a variety of subjects/fields and application domains within computer science. This inter-disciplinary experience has certainly provided me with a strong motivation and the technical background required, contributing to many fundamental aspects of computer science. I have learned that there is more work to be done towards the proposed GIS prototype, both in practice and theoretical settings. To build a more complete GIS system, we need to follow what I have recommended, taking into consideration the discussion around what I have learned from Brazil, presented in Chapter 5.

Another interesting research study could continue by understanding what must be done in relation to Mozambican maps in order to use the Open Source software "TerraView". Or, for development purposes, how can TerraLib library be incorporated into the GIS developed?

As a long term research, it will be important to: increase awareness on the current and potential value of the NSDI and on the plans to develop it among the public, private professionals from both rural and urban areas; establish through legislation a national goal to create and maintain a robust NSDI; create a private, non-profit National Spatial Data Council modeled on the NSDI charters, with appropriate representation at all levels of government and private sector; retain a central committee linked to the National Spatial Data Council to coordinate central Geographic Information under the NSDI.

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ANNEXES

Annex A: List of Indicators provided by the Department of Community Health

CATEGORY	NUMBER	INDICATOR
SAUDE MATERNA	1	Proporção de US que prestam COEB
	2	Proporção de US que prestam COEB
	3	Cobertura dos partos institucionais em US de COEB e COEC
	4	Necessidades satisfeitas em coe
	5	Cobertura de cesarianas
	6	Taxa de letalidade por complicação obstétrica
	7	Cobertura de consultas pré natais
	8	N.º médio de visitas por grávidas
	9	Percentagem detectada de alto risco
	10	Cobertura anti-tetânica
	11	Cobertura institucional de partos por ano
	12	Cobertura de partos na comunidade por ano
	13	Cobertura pós parto no ano
	14	Mortalidade materna institucional no ano
	15	Proporção de mortes maternas directas institucionais
	16	Nati-mortalidade institucional por ano
	17	Nati-mortalidade institucional com foco positivo á entrada por ano
	18	Taxa de prevalência anticoncepcional
	19	Taxa de novas utentes de planeamento familiar por ano
	20	Casais protegidos ano por depo-provera
	21	Casais protegidos ano por Pílulas
	22	Casais protegidos ano por DIU
	23	% de US que oferecem serviços PF
	24	% de comités de MM/PN em funcionamento
	25	Proporção de casos devido de aborto
	26	Sero-prevalência de sífilis nas grávidas
	27	Percentagem de gravidas testadas para sífilis
	28	Proporção das Maternidades com ESMI
	29	Percentagem das US que oferecem serviço de aconselhamento para violência do género

CATEGORY	NUMBER	INDICATOR
SAUDE ESCOLAR E DO ADOLESENTE	30	**% de províncias com o programa multisectorial de SSRAJ/HIV/SIDA em implementação**
	31	**% de US's com serviços específicos para adolescentes e jovens.**
	32	**Percentagem de técnicos de saúde formados e prestando serviços de acordo com as normas instituidas pelo programa .**
	33	**Percentagem de SAAJ's equipados d'ãcordo com padrões nacionaisxano**
	34	**% de adolescentes e jovens (10-24 anos) por sexo com a 1a relação sexual protegida**
	35	**% de adolescentes com última relação sexual protegida**
	36	**% de adolescentes de 10-14 e de 15-19 anos que ficaram grávidas**
	37	**Percentagem de nascimentos desejados naquele momento em adolescentes dos 10-19 anos**
	38	**Percentagem de nascimentos institucionais em adolescentes dos 10-19 anos**
	39	**% de abortos atendidos em adolescentes dos 10-19 anos**
	40	**% de complicações de aborto em adolescentes (10-19 anos) nas US**
	41	**Percentagem de novos clientes adolescentes e jovens que visitam os SAAJ's**
	42	**% de clientes adolescentes e jovens (10-24 anos) nos SAAJ's que recebem assistência às ITS (informação, aconselhamento, tratamento) e ao HIV/SIDA**
	43	**Proporção de saajs avaliados como amigos de adolescente e jovem de acordo com o padrão de SAAJ**
	44	**% de adolescentes e jovens (10-24 anos) que referem satisfação com os serviços de SSRAJ/HIV/SIDA**
	45	**% de escolas (EP1 e EP2) implementando o pacote básico do programa de Saúde Escolar**
	46	**% de alunos e professores que têm conhecimento em SSR/HIV/SIDA**
	47	**% de escolas (EP1 e EP2) visitadas no âmbito do Programa de Saúde Escolar**
SAUDE MENTAL	48	**Morbilidade por TMC (Transtornos Mentais e de Comportamento) no atendimento externo**
	49	**Morbilidade Hospitalar por TMC**
	50	**Distribuição dos principais TMC por grupo etario e sexo**
	51	**Distribuicao de tentativas de suicídio por grupo etario e sexo**
	52	**Distribuicao de Suicídios por grupo etario e sexo**
	53	**Prevalencia de consumidores abusivos de tabaco, alcool e outras drogas por idade e sexo**
SAUDE INFANTIL	54	**Consulta 0-11 meses para consulta da criança sadia**
	55	**Morbilidade específica (ih), (pneumonia, diarreia, malária, anemia, sarampo, malnutrição e HIV/SIDA)**
	56	**Mortalidade específica (ih), por pneumonia, diarreia, malária, anemia, sarampo, malnutrição e HIV/SIDA**
	57	**% de US c/ Trabalhadores de Saúde treinados em AIDI**
	58	**Percentagem de US tipo 1-2 que tem Quinino e Cloranfenicol para tratamento de pré-referência em AIDI**
	59	**Percentagem de US do tipo 1-2 que fazem Quinino e Cloranfenicol (pré-referência)**
	60	**Percentagem de crianças observadas pelos três sinais de perigo (Nao beber, nao mamar e convulsoes/ inconsciencia), segundo a AIDI**
	61	**Percentagem de cumprimento de avaliação integrada da criança segundo a AIDI**
	62	**Percentagem de crianças observadas devido a presença de tosse, diarreia e febre**
	63	**Percentagem de crianças cujo peso foi observado no Cartão de Saúde da Criança durante a consulta AIDI**
	64	**Percentagem de crianças necessitadas de antibiótico e/ou um anti-malárico orais prescritos correctamente**
	65	**Percentagem de crianças precisando de referência (assistência num outro nível de atendimento) que estão correctamente referidas.**
	66	**Percentagem de crianças a quem foi prescrita medicação oral cujo acompanhante está informado sobre como administrar o tratamento**
	67	**Taxa de Mortalidade Neonatal**

CATEGORY	NUMBER	INDICATOR
SAUDE ORAL	68	% de extracções dentárias
	69	% de obturações dentárias
	70	% de doentes com Tartarectomias realizadas
	71	% de doentes com Alveolites diagnosticadas
	72	Prevalência de casos de Noma em crianças dos 2 a 10 anos
	73	Prevalência de cárie dentária nos grupos etários 5-6, 12-15 e dos 35-44 anos
	74	Prevalência de gengivites nos grupos etários 5-6, 12-15 e dos 35-44 anos
	75	% de casos de Traumatismo maxilo- facial notificados nos Hospitais.
PROGRAMA DE TRANSMISSAO VERTICAL	76	% mulheres gravidas aconselhadas no GATV-PTV
	77	% de mulheres gravidas que testadas
	78	% de mulheres gravidas HIV +
	79	% de mulheres gravidas SP que receberam preventivo Profilaxia da malária com Sulfadoxina-Pyrimetamina intermitente.
	80	% de mulheres gravidas SP que receberam Mebendazol
	81	% Mulheres SP Suplemento de multivitaminas, vitamina A.
	82	% Mulheres gravidas SP recebendo Cotrimoxazol, (grávidas sintomáticas)
	83	% de mulheres gravidas SP que receberam nevirapina para levar para casa
	84	% de mulheres gravidas SP em TARV
	85	% de mulheres gravidas SP com curso curto AZT + NVP
	86	% de mulheres que assistem palestra em grupo
PROGRAMA ALARGADO DE VACINACAO	87	Taxa de cobertura de BCG
	88	Taxa de cobertura (Sarampo)
	89	Taxa de cobertura de (dpthepb 3)
	90	Taxa de cobertura de POLIO 3
	91	TC de gravidez protegida (GP)
	92	Lista de distritos com as taxas de cobertura agru- padas (<50%,50-79% e 80%-100%e >100%
	93	% Criancas completamente vacnadas < 1 ano idade Gestão do Prog.
	94	% contribuicao de vacinacao das brigadas móveis em relacao aos resultados totais
	95	Indice de quebra vacinal
	96	Taxa de disperdicio de vacinas
	97	% de unidades sanitarias com rotura de stocks de vaccinas
	98	% de unidades sanitarias com rotura de stock de petroleo
	99	% de US's com rotura de stocks de AD Seringas
	100	% de US's com rotura de stocks de caixas inceneradoras
	101	% de postos fixos de vainacao om geleiras a funcionar

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CATEGORY	NUMBER	INDICATOR
NUTRICAO	102	Percentagem de Crescimento
	103	Insuficiente (CI) nas criança dos 0-59 meses
	104	Percentagem de Baixo Peso a NASENSA (BPN)
	105	Cobertura Vit A 1a dose; 2a dose (para ser incluído na nova ficha PAV)
	106	Cobertura de Vit A durante o parto
	107	Suplementação c/ Sulfato Ferroso & Ácido Fólico (mulheres grávidas)
	108	Taxa de Cobertura de suplementação com óleo iodado (em Niassa e Tete)
	109	Suplementação com Sulfato Ferroso às crianças dos 6-23 meses
	110	Cobertura de Consumo do Sal Iodado ao nível dos Agregados Familiares (AF).
	111	Número de internamentos por malnutrição nas Enfermarias de Pediatria
	112	Letalidade por malnutrição nas Enfermarias de Pediatria
	113	Desnutrição Aguda/Actual: Peso/Altura (0-59 meses)
	114	Desnutrição Crónica: Altura/Idade (0-59meses)
	115	Desnutrição Aguda/Actual: Peso/Idade (0-59meses)
	116	Proporção de Mulheres com Altura < 145cm
	117	Índice de Massa Corporal em mulheres idade fértil (15-49 anos) entrevistadas : IMC
	118	Anemia/ Deficiência de ferro
	119	Deficiência de Vitamina A
	120	Prevalência de Cegueira Nocturna nas Mulheres grávidas
	121	Deficiência de Iodo (71,0% de crianças em idade escolar sofrem de bócio, média Niassa e Tete)
REPARTICAO PARA EDUAÇÃO EM SAUDE PUBLICA	122	% de U.S com CLS´s em funcionamento (são considerados CLS´s funcionários que desenvolvem actividade comunitária na área de saúde
	123	% de escolas implementando o pacote básico do programa de saúde Escolar por Distrito
	124	% de Criancas, exclusivamente amamentadas com leite materno dos 0-4 mêses de idade
	125	Porporção de criancas que recebem alimentação suplementar, apartir dos 4 mêses

'

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Annex B: Template of the Survey Questionnaire carried out during the study

<div align="center">

MINISTÉRIO DA SAÚDE
DIREÇÃO NACIONAL DE SAÚDE
DEPARTAMENTO DE SAÚDE DA COMUNIDADE

QUESTIONÁRIO

</div>

O presente questionário está sendo desencadeado no âmbito de desenvolvimento de um Sistema de Informação Geográfica para o Departamento de Saúde da Comunidade, Ministério da Saúde e direcções Provinciais. Destina-se principalmente ao pessoal de Saúde, particularmente aos funcionários deste Departamento a nível do Ministério e das Direcções Provinciais de Saúde. Para tal, o grupo de desenvolvimento solicita aos digníssimos, que preencham o presente questionário com letra legível fornecendo todos os elementos correctos e precisos.

1. Nome: _____

2. Email:_____

3. Telefone:_____   Celular:_____

4. Sexo *(Marque com X)*:   Masc ☐   Fem ☐

5. Habilitações Literárias. *(Marque com X)*

    ☐ Primário   ☐ Básico   ☐ Médio   ☐ Superior

6. Área de Formação:_____

7. Departamento/Secção de Trabalho:_____

8. Tempo de serviço no Sector de Saúde: *(Risque a opção que satisfaça a sua resposta)*

    ☐ Anos/Meses

9. Categoria Ocupacional:_____

10. Função que exerce ou

    Cargo:_____

11. A quanto tempo exerce a função? *(Assinale com X a opção que satisfaça a sua resposta(Anos/Meses))*

    ☐ Ano(s)/Mese(s)

12. Tem alguma formação específica na área da Saúde? *(Marque com X)*

    ☐ Sim, qual? _____

    ☐ Não

13. Que capacitação já teve em termos de análise de dados:

    ☐ Capacitação em EPI Info

☐ Capacitação em SPSS

☐ Capacitação em Excel Avançado/Tabelas Dinâmicas (PivotTable)

☐ Outras _____

_____

_____

_____

14. Quantos destes equipamentos existem, operacionais, na sua Secção de trabalho?

a) ☐ Computadores

b) ☐ Impressoras

c) ☐ GPS (Global Positioning System)

15. Caso tenha preenchido um valor superior a 0 (Zero) na alinea a) do número anterior, diga se tem tido acesso a este computador?

☐ Sim   ☐ Não

16. Se a resposta a alinea anterior for Sim, indique três (3) actividades principais que faz com o computador.

_____

_____

_____

_____

17. De que nível imediatamente inferior provém os Dados de Saúde que tem utilizado? *(Marque com X)*

☐ Nacional (Ministério), Indique o Departamento _____

☐ DPS (Direcção Provincia de Saúde)

☐ DDS (Direcção Distrital de Saúde)

☐ Unidade Sanitária.

18. Como tem sido os Dados de Saúde que recebe dos níveis inferiores? *(Marque com X)*

☐ Correctos

☐ Completos

☐ Confiáveis/Fiáveis

☐ A tempo e hora

19. A que representações tem recorrido para apresentar a informação estatátistica nos relatórios de trabalho da sua Secção? *(Marque com X)*

☐ Mapas

☐ Gráficos

☐ Tabelas

☐ Outro, qual?_____

20. Tem tido acesso a Mapas digitais? *(Marque com X)*

☐ Sim   ☐ Não

21. Se a resposta da pergunta anterior for "Sim", qual é frequencia de obtenção de tais mapas. *(Marque com X)*

☐ Muito Elevada

☐ Elevada

☐ Razoável

☐ Baixa

☐ Péssima

22. Já ouviu falar de pacotes de Tratamento de Dados através de mapas, Qual(ais)? *(Marque com X)*

☐ EPI Info   ☐ ArcView   ☐ ArcMap

☐ ArcGIS   ☐ ArcExplorer   ☐ AutoCAD

☐ Outro,qual(ais)?_____

_____

23. Já teve contacto com algum(ns) dos pacotes mencionados na alinea anterior? *(Marque com X)*

☐ Sim   ☐ Não

24. Caso a resposta da alinea anterior seja "Sim", indique quais pacotes. *(Marque com X)*

☐ EPI Info   ☐ ArcView   ☐ ArcMap

☐ ArcGIS   ☐ ArcExplorer   ☐ AutoCAD

☐ Outro,qual(ais)?_____

_____

25. Na sua Secção de Trabalho tem utilizado um algum Sistema de Informação Computadorizado como fonte de dados ou para armazenamento e/ou manipulação da informação? *(Marque com X)*

☐ Sim   ☐ Não

26. Caso a resposta seja "Não", onde tem armazenado a informação e como tem manipulado a mesma?_____

_____

_____

_____

_____

_____

27. Caso a resposta seja "Sim" Assinale com X o(s) Sistema(s) de Informação que tem utilizado.

☐ SISProg

☐ SIMP

☐ BES

☐ Base de Dados do AIDI

☐ SIS.D

☐ Outro_____

_____.

28. Se tem usado o(s) sistema(s) que assinalou na questão anterior, como fonte de dados, diga se tem tido a possibilidade de tirar a informação com sucesso.

☐ Sim   ☐ Não

29. Que recurso tem usado para transferir a informação deste(s) Sistema(s)? *(Marque com X)*

☐ Disquete

☐ Memória Flash

☐ Disco (CDs)

☐ Outro. Qual?_____

30. O sistema que tem utilizado no seu Departamento/Secção permite-lhe automaticamente representar os dados que estão na base de dados através de algum dos recursos abaixo (Marque com X a opção que lhe permite representar os dados).

a)   ☐ Mapas

b)   ☐ Gráficos

c)   ☐ Tabelas

d)   ☐ Outro. Qual?_____

31. Se lhe fosse dada a opção de escolha de uma facilidade de representar a informação, que tipo de representação gostaria que lhe fosse proporcionada? *(Marque com X)*

a)   ☐ Mapas

b)   ☐ Gráficos

c)   ☐ Tabelas

d)   ☐ Outro. Qual?_____

32. Em alguma ocasião ouviu falar de Sistemas de Informação Geográfica (GIS – Geographical Information Systems)? *(Marque com X)*

☐ Sim   ☐ Não

33. Já teve contacto com algum Sistema de Informação Geográfica? *(Marque com X)*

☐ Sim   ☐ Não

34. Se fosse providenciado um Sistema de Informação Geográfica ao seu Departamento/Secção que informação gostaria que o sistema proporcionasse?

Liste o tipo de analises que gostaria de fazer e que os resultados fossem representados em mapas agrupados por Província ou mesmo Distrito.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Annex C: PARPA Health Indicators

a)   Values of health indicators that have to be accomplished by 2004 from PARPA plan.

COMPONENT	OBJECTIVE	TARGET	CURRENT SITUATION (1999)	2000	2001-2003	2004
Expand Access and Better Health Care	To make good quality health care accessible to disadvantaged groups.	Expand coverage and access to good quality basic health services, especially in rural areas.	-	-		Expand Access
	Increase access and quality of health care for women.	Reduce Intra-Hospital Maternal Mortality Rate to <100/100,000 live births				
		90% of women ante-natal consultation coverage	84%	%		90%
		Increase institutional deliveries to 50%	37%	41%		50%
		Increase postnatal consultations to 50%	40%	43%		50%
		Increase coverage of women protected by family planning to 12%	7%	9%		12%
	Improve infant and under-five health care	Reduce Under-Five Mortality Rate to <200/1000 live births	219/1000	-		<200/1000
		Maintain first consultation for infants 0-11 months coverage at 98%	98%	Update demographic data (Projections)		98%
		Increase first consultation coverage for children 0-4 years to 60%	46%	-		69%
	Prevent the main endemic diseases affecting children through immunization.	Ensure that 75% of children born over the next 10 years have complete immunisation before they are one year old.	-	11 provincial seminars on immunization held		75%
		Maintain 98% national coverage for immunisation of children under one against tuberculosis.	98%	%		98%
		Reach 98% national coverage for immunisation of children aged 0-23 months against polio and DTP	87%	%		98%
		Achieve 95% coverage for immunisation of children 9-23 months against measles.	86%	%		98%
		Reach 60% national coverage immunisation against tetanus for women of fertile age.	32%	%		60%
	Improve the health of young people and adolescent through school health activities	Establish appropriate health services to meet the reproductive health needs of the adolescent.	4 treatment centers for adolescent created	Increase the number of adolescent treatment centers to 7 - 3 seminars on youth and adolescent health		10 Health service centres created.
Nutrition	Reduce the prevalence of incidence of micronutrient deficiencies (iodine, Vitamin A, iron) in children and women of fertile age	Distribute Vitamin A capsules to all children aged 6-59 months brought for consultations	Distribution of capsules on immunization days	Distribution of capsules during the month of special attention (April)		idem

b)   Values of health indicators that have been accomplished by 2004 related to PARPA

COMPONENT	OBJECTIVE	TARGET	CURRENT SITUATION (1999)	2003	2004
Expand Access and Better Health Care	To make good quality health care accessible to disadvantaged groups.	Expand coverage and access to good quality basic health services, especially in rural areas.	-	-	No Information
	Increase access and quality of health care for women.	Reduce Intra-Hospital Maternal Mortality Rate to <100/100,000 live births		200/100,000	200/100,000
		90% of women ante-natal consultation coverage	84%	109,9%	111,1%
		Increase institutional deliveries to 50%	37%	45,1%	46,8%
		Increase postnatal consultations to 50%	40%	57,5%	60,6%
		Increase coverage of women protected by family planning to 12%	7%	%	12%
	Improve infant and under-five health care	Reduce Under-Five Mortality Rate to <200/1000 live births	219/1000	26/1000	25/1000
		Maintain first consultation for infants 0-11 months coverage at 98%	98%	145,4%	145,1%
		Increase first consultation coverage for children 0-4 years to 60%	46%	55,6%	53,4%
	Prevent the main endemic diseases affecting children through immunization.	Ensure that 75% of children born over the next 10 years have complete immunisation before they are one year old.	-	%	75%
		Maintain 98% national coverage for immunisation of children under one against tuberculosis.	98%	111,1%	117,4%
		Reach 98% national coverage for immunisation of children aged 0-23 months against polio and DTP	87%	%	98%
		Achieve 95% coverage for immunisation of children 9-23 months against measles.	86%	96,7%	94,9%
		Reach 60% national coverage immunisation against tetanus for women of fertile age.	32%	%	60%
	Improve the health of young people and adolescent through school health activities	Establish appropriate health services to meet the reproductive health needs of the adolescent.	4 treatment centers for adolescent created	-	No Information

Annex D: Sources of Indicators

a) Source of selected indicator

CATEGORY	INDICATOR	SOURCE		
		SISPROG	SIMP	SIS.D
Saúde Materna	Proporção de US que prestam COEB			
	Proporção de US que prestam COEC			
	Cobertura dos partos institucionais em US de COEB e COEC			
	Cobertura de cesarianas			x
	Cobertura de consultas pré natais		x	x
	N.º médio de visitas por grávidas			
	Cobertura institucional de partos por ano		x	x
	Cobertura de partos na comunidade por ano			x
	Mortalidade materna institucional no ano	x	x	x
	Proporção de mortes maternas directas institucionais			
	Nati-mortalidade institucional por ano		x	x
	Nati-mortalidade institucional com foco positivo á entrada por ano		x	x
Saúde Infantil	Consulta 0-11 meses para consulta da criança sadia		x	x
	Percentagem de crianças necessitadas de antibiótico e/ou um anti-malárico orais prescritos correctamente			
	Taxa de Mortalidade Neonatal		x	x
Programa Alargado de Vacinação	Taxa de cobertura de BCG	x	x	x
	Taxa de cobertura (Sarampo)	x	x	x
	Taxa de cobertura de POLIO 3	x	x	x
	TC de gravidez protegida (GP)			
	Lista de distritos com as taxas de cobertura agrupadas (<50%,50-79% e 80%-100%e >100%			
	% Crianças completamente vacinadas < 1 ano idade Gestão do Prog.	x	x	x
	% contribuição de vacinação das brigadas móveis em relação aos resultados totais			
	% de postos fixos de vacinação com geleiras a funcionar			x

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b)   Data elements used to calculate the selected indicator

INDICATOR	DEFINITION	NEW OR OLD	
		Old	New
Cobertura dos partos institucionais em US de COEB e COEC	Nº de partos realizados em US com COEB e COEC		X
	Tot. de partos esperados na população		
Cobertura das necessidades de COE	Nº de ♀ tratadas com complicações x 100		X
	Nº esperados de ♀ com complicações		
Cobertura de cesarianas	Tot. de Cesarianas realizadas x 100		X
	Tot. de partos esperados na população		
Cobertura Pré Natal no ano	Nº de 1ª Consulta Pré Natal x 100	X	
	Nº estimado de grávidas		
% de partos assistidos por pessoal qualificado	Nº de partos Institucionais no sector publico + privado x 100		X
	Nº estimado de partos		
Cobertura Institucional de partos por ano	Nº de partos Institucionais no sector publico x 100	X	
	Nº estimado de partos		
Mortalidade Materna Institucional no ano	Nº de Mortes Maternas x 100.000	X	
	Nº de Nados Vivos		
Proporção de mortes maternas directas institucionais	Nº de Mortes Maternas Directas		X
	Nº Total de Mortes Maternas		
Nati- Mortalidade institucional por ano	Nº de nados mortos x 100.000	X	
	Nº de Nados Vivos + nados mortos		
Nati- Mortalidade institucional com foco positivo á entrada por ano	Nº de nados mortos com F+ entrada x 100.000	X	
	Nº de Nados Vivos + nados mortos com F+		
Proporção de mortes maternas devido a complicação de aborto	Nº de Mortes Maternas por complicação de aborto		X
	Nº Total de Mortes Maternas		