UNIVERSITY OF OSLO
Department of Informatics

Introducing Geographical Information Systems for Health Care in Developing Countries: Challenges and Approaches – A case study from Mozambique

An action research study

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Master Thesis

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DEDICATION

To my husband Roberto and our daughter Erica
To the memory of my father Joaquim Ginger
ABSTRACT

The research is based on understanding the challenges related to the design, development and implementation of a GIS tool for health care in developing countries. Specifically, the study analyses how the GIS application developed in one context can be adapted and introduced in the current health information system for decision making support in the process of planning and monitoring of health services. Another objective of the thesis was to analyze approaches to customize and adapt software developed in one country to another country context.

The research was conducted in team of three master students within the framework of Health Information System Program (HISP). The research setting was provided by the Community Health Department (CHD), within the health sector of Mozambique. In addition to empirical work carried out in the headquarters in Maputo, field work was also conducted in the two provinces of Gaza and Inhambane in order to answer the two research questions that guided the study, namely: What are the potential challenges to the development and introduction of a GIS application within the health sector in developing countries? and; How can a GIS application developed for one context be effectively customized for another?

A case study research design within an action research framework was used with a focus on the Ministry of Health generally, and the CHD more specifically. The challenges experienced during the process were studied using qualitative research methods that helped to inform both the data collection methods and analysis. Participatory action research was used for facilitating the software development through a prototyping approach. The aims of the action research effort were to both enable the practical success of the implementation, and also simultaneously help generate scientific knowledge about these implementation challenges.

The adoption of GIS involves the interplay of human, organizational and technical aspects, which cannot be easily separated, and requires them to be considered in relation to each other. Thus, to analyze problems addressed in this thesis, I drew upon theories and concepts in three areas: GIS as socio-technical systems, Information Infrastructure and Actor Network Theory. While the socio-technical perspective helped to provide the broad perspective underlying the
research, Actor Network Theory helped to unpack the complexity inherent in such implementation process. Finally, the concepts of installed base and cultivation drawn from Information Infrastructure theory helped to understand respectively the challenges of history in introducing new systems (like the GIS) and (cultivation) approaches to deal with these challenges.

This thesis has made both theoretical and practical contributions towards the implementation of GIS technology for the health care context of developing countries like Mozambique. The following theoretical contributions were made: (1) identification of approaches for the design of GIS applications for the health sector and potentially also to others like education, in the context of developing countries; (2) unpacking the conceptual relationship between the installed base and approaches to their cultivation; (3) emphasizing the socio-technical nature of the installed base; (4) emphasizing how the development of the spatial database is dependent on the non-spatial installed base; (5) unpacking the multi-level nature of the installed base, and how various technical and institutional aspects are embroiled at each level; and, (6) elaborating on mechanisms for cultivation including the strategy of using gateways to link incompatible components; and, (7) developing an approach for the customization of software developed in one country to another country context.

The following practical contributions were made: (1) the development of the GIS application, by linking the non-spatial and spatial components; (2) for supporting ongoing initiatives of HIS reform in the CHD within the Ministry of Health; (3) for developing awareness about the potential of the GIS technology and also about the challenges to making it work effectively in practice. (4) practically supports the implementation of HISP in Mozambique.

Key words: Geographic information system, health information system, developing countries, information infrastructure, socio-technical system, installed base and cultivation.
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List of acronyms used

AIDS     Acquired Immune Deficiency Syndrome
ANT      Actor Network Theory
CHD      Community Health Department
DDS      Direcção Distrital de Saúde
DHIS     District Health Information Software
DPS      Direcção Provincial de Saúde
ESRI     Environmental Systems Research Institute
FRELIMO  Frente de Libertação de Moçambique
GII      Geographic Information Infrastructure
GIS      Geographic Information System
HIS      Health Information System
HISP     Health Information System Project
HIV      Human Immune Deficiency Virus
ICT      Information and Communication Technology
II       Infrastructures
IS       Information System
INE      Instituto Nacional de Estatística
INPE     National Institute of Geospatial Research
MISAU    Ministério de Saúde (Ministry of Health of Mozambique)
NHIS     National Health Information System
NGO      Non-Governmental Organization
PARPA    Plano de Acção para Redução de Pobreza Absoluta
PDA      Personal Digital Assistants
PAV      Program Alargado de Vacinações
RENAMO   Resistência Nacional de Moçambique
SMI      Saúde Manterna Infantil
SIMP     Sistema Integrado de Monitorização e Planificação
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>TB</td>
<td>Tuberculoses</td>
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<tr>
<td>TIN</td>
<td>Triangulated Irregular Network</td>
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<tr>
<td>UNAIDS</td>
<td>United Nations Program on HIV/AIDS</td>
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<td>WHO</td>
<td>World Health Organization</td>
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1 Introduction

1.1 Introduction

The economic recession in Eastern and Southern African countries began in the 1970's, accelerated in the 1980's, and is still taking its toll in the mid and post 1990's (Gilson 1995). This recession has resulted in increased levels of poverty and greater inequalities between groups in many of these countries, with particular implications on the health sector. Examples of this are the AIDS pandemic, the resurgence of communicable diseases such as cholera, dysentery, malaria, tuberculosis and large scale complex disasters that have further stretched the already constrained economies (Olowu 2001). As a way to struggle with these problems, health sector reforms have been the subject of increasing attention of health planners over the previous decades. Considerable pressure is being exerted from the international community on governments in developing countries to restructure and reform their health systems (Berman and Bossert 2000). Thus, evaluating health systems performance, health reforms and decentralisation in particular are important concerns for both policy makers and health technocrats. Recent efforts in health systems reform have been associated with addressing different conditions and environmental factors, which influence the health systems, such as human resources capacity development and infrastructure. The critical elements of these health sector reforms include the following: (a) Health Information System (HIS) decentralization; (b) human resource development; (c) health care financing; (e) management and organization; and, (f) donor co-ordination (Mwaluko and Pazvakavambwa 1996).

The drive for HIS reform has also coincided with a revolution in Information and Communication Technology (ICT), and has resulted in the introduction of computers and development of computer-based information systems in various government departments, including that of health. Therefore, there are various types of ICT projects being attempted as part of these reform efforts, and many examples have been reported, including of Personal Digital Assistants (PDAs) by auxiliary nurse midwives in Andhra Pradesh, India.
Chapter 1: Introduction

(Cecchine and Scott 2003), the use of telemedicine (Adler 2000, Martínez et al. 2004) and of the computerization of routine HIS (Lippeveld and Sauerborn 2000, UNDP 2001, Braa et al. 2004). The use of PDAs has been reported to reduce the redundant paperwork and improve data accuracy, contributing to improved motivation level of nurses, and also making more effective the information flows to the upper levels of the administration. Similarly, the use of large, complex, and expensive projects like telemedicine are promoted to bridge the physical distance between patients and medical specialist around the world. Such applications, which literally means “medicine at a distance” has been slower to come into routine use, both in developed (Aanestad 2002) and also in developing countries (Adler 2000). Aanestad studied the use of broadband network technologies, which allowed high-quality audio and video transmissions from live operations to be transmitted in real-time in major Norwegian hospitals. However, such infrastructure is not available in most developing countries because of both technological and cost constraints. Trying to address these constraints, there have been attempts to implement such technology using low cost telemedicine kits designed and built to address developing countries’ needs (Adler 2000).

Lippeveld and Sapirie (2000) argue that one of the main objectives of many typical HIS development projects is the computerization of important data to be managed, monitored, and analyzed. However, in developing countries, the outcomes of these technical reforms efforts are generally subject to much debate, with the benefits being realized still lagging far from the technology potentialities. Researchers, based on empirical evidence from various developing countries, have pointed to various reasons contributing to this unrealized potential including politics, infrastructure, human resources constraints, institutional conditions, and design approaches (Heeks 1999, Berman and Bossert 2000, Sahay and Avgerou 2002). A particular challenge with HIS applications concerns the dominant focus on technical aspects while ignoring to a great extent social and organizational factors (Heeks 1999), a point also emphasized by various researchers (for example, Lippeveld and Sauerborn 2000, Simwanza and Church 2001, Braa et al. 2001, Franco et al. 2002, Mosse and Sahay 2003).

Another ICT that is currently gaining increasing visibility and importance in the context of many developing countries is Geographic Information System (GIS), which is the focus of this thesis. Various researchers such as Sauerborn and Karam (2000), Frerichs (2000), Sadiq et al. (2002), have endorsed the potential significance of GIS technology in many
areas including health. According to White (2002), over ninety percent of the health issues have a spatial component as they are unequivocally related to human activities which are inherently spatial based. Human beings exist within a spatial structure moving around and interacting with each other (White 2002). Data related to health services provision are usually “tied to a specific area such as the catchment area of a health centre, or a health district, or to a geographic point (pharmacy, village, or hospital)” (Sauerborn and Karam 2000:213). For this reason, GIS technology can potentially be a suitable tool for supporting health management processes, as they enable the computerized handling of geographically defined data, their entry, storage, analysis and presentation. In this way, a GIS tool can potentially be used to help managers and decision-makers in the process of planning and monitoring of health services provision based on the geographical spread of populations.

Despite the potential that GIS technology provides for health management, its practical benefits remain largely unrealized, as is the case with other ICTs. The process of effective design and implementation of GIS systems in developing countries still remains a challenge due to various existing socio, economic, political and organizational conditions (Peter and Bossert 2000). These challenges are especially magnified in countries like Mozambique where the ICT capacity is not strong, and conditions to handle spatial technologies (such as infrastructure and human resources capacity) are even lower. The present research thus seeks to contribute to this challenge of trying to realize the practical benefits of GIS in the context of the health sector in Mozambique. I adopt a socio-technical system perspective to study the various challenges raised while designing, developing and introducing GIS tool into the health sector. Such a perspective emphasizes the interrelation of the technical and social elements, and the socio-political context within which the implementation is situated (Walsham et al. 1988). This perspective is drawn upon to both understand the challenges and also to address them during the course of developing a prototype for supporting decision-makers within the Mozambican health system.

1.2 The research problem

The main purpose of health information is to improve health care delivery by supporting effective planning, management and evaluation of health services. Nevertheless, effective information systems (IS) to support those processes are limited in many developing countries, and existing data being generated are often irrelevant, of poor quality, and the
data produced not linked to a reference population (Lippeveld 2001). Moreover, the information is rarely used for evidence-based decision-making. Mozambique is not an exception with respect to these problems, and the current HIS is facing serious problems that have implications for coherent health planning and management. As is the case in most developing countries, the HIS in Mozambique also tends to be program-based (e.g. malaria control program, HIV/AIDS, TB, mother and child health, family planning, drugs etc.) each having their own IS with little coordination internally and also with other programmes (Chilundo 2004, Braa et al. 2001). Data reaches the national level of particular programmes in an aggregated form and typically in paper form that makes the possibility of conducting analysis for individual health facilities or health districts very limited. Furthermore, data storage takes place in different locations and levels, making its effective retrieval very problematic. These data are stored in different formats, making its use problematic for the target personnel. Due to this fragmentation of the ISs, it is not possible to effectively deliver the data needed for health management, and decisions are usually made with limited informational inputs (Sauerborn and Lippeveld 2000).

A study conducted by Braa et al. (2001) emphasized the existence of multiple problems with the Mozambique HIS, including poor feedback routines from provinces to districts and from districts to health facilities, limited local use of information for action, and lack of training and support. The capacity for collecting, compiling, analyzing, interpreting and disseminating the appropriate information for decision-making is very poor. The local use of information can potentially help in HIS improvement. For example, if the district directorates could make comparisons between health units with respect to their services provisions, such as in which health units more or less cases on a certain disease are registered, and which units requires more support. This information can be used to discuss with the provincial level their resources requirements. In the same way, the province can carry out similar analysis and potentially negotiate with the national level based on the current situation in each province as well in districts. Thus, the national level can gain a more realistic picture of the overall needs of the country.

In addition, decision-makers need to understand exactly where the problems lies and how services should be distributed based on the geographical distribution of the population. For example, the management of maternal deaths, reflected in the indicators of the maternal mortality rate, can potentially be better supported through the effective use of geographic
information. If planners have information about the geographical spread of pregnant women and also of existing health units, they can take intervention action. Such action can include steps to improve transportation or strengthen outreach support to try to deal with the problem of poor access and with it, at least to some extent, the maternal mortality problem.

Particularly within the Community Health Department (CHD) of the Ministry of Health in Mozambique, which is the empirical focus of this thesis, health managers need to know what level of services have been given to a particular community, which populations are under risk, the underlying reasons, and the accessibility of services in terms of distances and road conditions. The managers would also want to correlate disease prevalence with environmental conditions of particular areas, such as the distribution of lakes, rivers, streams, watersheds, dams, dumps, mountains, etc. In addition, they would like to correlate collected health indicators with the ones established by the Absolute Poverty Reduction Action Plan (PARPA) of the Ministry of Finance. GIS technology could potentially be used to make such spatial correlations and their representations. However, the challenge is on how to develop, implement and deploy the technology in the existing conditions of data, technology infrastructure, people, and institutions. This discussion provides the backdrop to introduce the research objectives of the thesis.

1.3 Research objectives

The objective of this research is to understand the challenges related to the design, development and implementation of a GIS tool in developing countries, particularly for the CHD within the health sector of Mozambique. Specifically, the research seeks to understand how GIS technology can be applied to support decision-makers in the CHD in the process of planning and monitoring of health services provision. With this aim, the following research questions guiding this thesis are articulated:

- What are the potential challenges to the development and introduction of a GIS application within the health sector in developing countries?
- How can a GIS application developed for one context be effectively customized for another?
1.4 Research settings and methods

This research is situated within the Health Information System Program (HISP), a global research and development network on HIS initiated by the University of Oslo in Norway, and partners in South Africa in 1994. In Mozambique, HISP was initiated through the establishment of an interdisciplinary team in 1999, of which I became member in 2004. As a member of the HISP team, I had the opportunity to visit health facilities in health districts, and make detailed observations of the work settings and associated practices. This exposure helped to develop a deeper understanding of the problem domain, and to make my research objectives more focused.

In this research, a case study approach was used with a focus on the Ministry of Health generally, and the CHD more specifically. The PAV (Programa Alargado de Vacinações, in Portuguese) and SMI (Saúde Manterna-Infantil, in Portuguese), and are specific health programs of the CHD dealing with immunization, and mother and child care, respectively. The present study was conducted in a team, and while another student (Saugene 2005) focused on the SMI data, my primary focus was on PAV. The study was conducted in the health department headquarters located within the Ministry of Health in Maputo. In addition to this, fieldwork was conducted in two provinces, Gaza and Inhambane prior to the study at the department headquarters. One of the objectives of the fieldwork was to make an analysis of the situation related to the current HIS and how the prototyped software system of HISP called District Health Information Software (DHIS) was currently being used in the district and provincial levels. This analysis was important, as the DHIS software also provided the non-spatial component for the GIS tool. A prototype application that was designed for health care sector in India was customized to the Mozambique context.

The challenges experienced during this process were studied using qualitative research methods that help to inform both the data collection methods and analysis. The methods for data collection included interviews/meetings and document analysis. Participatory action research was used for facilitating the software development process, and the feedback received from the users on earlier versions of the prototype also provided important inputs into the study.
1.5 Personal motivation

In general, GIS in health care can be used as a tool to provide information and analysis to help answer many questions such as identifying areas in which a certain disease is prevalent and what may be the causes of that disease. Such analysis can help to identify where to give additional resources based on the spatial spread of needs and priorities. This will help to inform questions on where to locate new health units or hospitals; and to identify the health status of a population, for example in which area the infant mortality rate is high. Based on an understanding of this assumed potential of spatial data, I developed an interest to apply the knowledge I obtained during the GIS course at the University of Oslo. I was motivated towards applying the knowledge to try and address the practical problems being experienced by the Ministry of Health of Mozambique, particularly issues such as maternal mortality and immunization coverage in which Mozambique has one of the most adverse rates in the world. Wanting to try and contribute to addressing these problems in my country, I decided to focus on this topic.

1.6 Conceptual framework and theoretical perspective

To analyze and discuss the problems addressed in this thesis, I draw upon theories and concepts in three areas: GIS as socio-technical systems, Information Infrastructure, and Actor-Network Theory. I provide the underlying rationale for these choices, and how these three domains are inter-related with respect to the objectives of my thesis.

1.6.1 Socio-technical systems as a perspective to study GIS

Experiences with computer-based information systems make it clear that the critical issues in implementation of these systems are also social and organizational, and not only technical. Various researchers have emphasized that ISs should not be regarded as technical systems with behavioural implications, but are better conceptualised as social systems in which technology is one of the elements of a larger interconnected and heterogeneous network (Walsham et al. 1988, Anderson 1997, Lippeveld and Saperie 2000). Thus, designing or developing a system not only involves technological aspects but also the need to address the complexity involved with respect to the social, cultural, political and contextual aspects. Heeks et al. (1999) argue that a successful implementation of HIS in developing countries must match its environment in relation to its contextual conditions. Based on such thinking, I have, therefore, adopted a socio-technical systems
perspective to study the process of GIS implementation in the health sector, which helps to understand the ongoing negotiations required between the different actors, and also the accompanying organizational changes that need to be put in place. This introduction process involves the interplay of human, organizational and technical aspects, which cannot be easily separated and requires them to be considered in interrelation to each other. A key focus is on understanding the existing work practices, the different actors (within the CHD and the broader Mozambican health system), their interrelationships, and how these intersect with the efforts of introducing a new technology like GIS. Given the multiplicity of different actors, complexity is inherent in this process of introducing technology mediated change. To further help unpack this complexity, I draw upon some ideas from Actor Network Theory (ANT). Some key ideas drawn from ANT are now outlined.

1.6.2 Actor Network Theory

Actor Network Theory is a theory that can be used for understanding the complexity related to the technical, social and organizational factors that surround and influence IS implementation in a given setting. I have drawn upon two key ideas from ANT, namely that of a network and its heterogeneity. In ANT terms, a network represents a collection of humans, institutions, texts, graphical representations, and technical artifacts, each with their different interests. Different actors try to convince others so as to create an alignment of the interests of these actors with their own (Monteiro 2000). ANT emphasizes the heterogeneity that is inherent when humans and non-humans, technical and non-technical elements are linked together. ANT emphasizes the need to take this heterogeneity in totality, and focus on the relations and interplay between these elements, rather than on each actor separately. When viewing ISs through ANT, they can be seen as large actor-networks that include the existing systems, technologies, work procedures, users, and so on.

In the context of this thesis, ANT helps to emphasize the socio-technical nature of the process of implementing GIS tool, and the need to understand the role of different actors, including the technology itself. ANT helps to provide a framework to understand the contextual situation inherent in the implementation process by emphasizing the involvement of a multiplicity of actors and their competing interests.
1.6.3 Information Infrastructure

Hanseth and Monteiro (1998) use the term ‘Information infrastructures (II)’ to explain that II are something bigger than traditional ISs, groupware, and stand-alone applications. Furthermore, IIs are considered as always already existing, and which can never be developed from scratch. When developing a new infrastructure, it will always need to be integrated into an existing one, thereby extending others or replacing or improving one part of another infrastructure. The concept of cultivation from II theory helps to emphasize that the development of the new components has to fit into the old the installed base (Hanseth 2002). This installed base, in addition to the technical, also comprises of existing systems, work processes, users, and organization procedures and structures. My focus on II theory, particularly the concept of cultivation and installed base, helped me to understand how whilst developing the new GIS tool, we should respect the existing legacy systems, work procedures and routines. Development of the new need to be incrementally improved by “cultivating” the existing HIS, through incorporating the processes of spatial analyses into it. In this way, the new system helps to challenge the existing ways of working (non-map based), and potentially should contribute to its improvement. The cultivation approach represents a slow process of organizational change through negotiating and brokering between actors at different levels.

This research takes a social-technical systems perspective to study the challenges that arose while introducing GIS technology into the health sector using a cultivation approach. Such a perspective emphasizes the interconnectedness of the technical and social elements, and the socio-historic and political contexts within which the implementation is situated (Walsham 1993). These three theoretical concepts (socio-technical, ANT and II) taken together has helped to develop a context sensitive and social-informed understanding of the challenges and approaches in introducing a GIS tool in the CHD in Mozambique.

1.7 Empirical setting

As pointed out earlier, the research setting was provided by the CHD within the health sector of Mozambique. In addition to the primary focus on the headquarters in Maputo, empirical work was also conducted in the two provinces of Gaza and Inhambane. An action research methodology, within the framework of the HISP initiative, was used with respect to the design, development and introduction of GIS in the CHD. The aims of the
action research were to both enable the practical success of the implementation, and also simultaneously help generate scientific knowledge about these implementation challenges. Analysis of these processes was addressed using theories and concepts from the domains of information infrastructure, actor network theories, and a social technical systems perspective to study GIS. Qualitative research methods were primarily used to conduct this research, and further details of the empirical setting are provided in chapter 3, while that of the research approach in chapter 4.

1.8 Expected contributions

This thesis is expected to primarily contribute to the domain of GIS implementation in developing countries, with a focus on the health sector. This contribution is in both theoretical and practical terms. Theoretically, the challenges of implementing GIS for health care applications in developing countries has not been adequately addressed in IS/HIS research, and my thesis helps to contribute to this domain. Practically, the research contributes to support ongoing initiatives of HIS reform in the CHD within Ministry of Health, where the application developed in this study is being customized according to the needs of the CHD. This study also practically contributes to the design of the GIS tool and the manuals for its use to facilitate its use by health managers in the CHD. As a part of HISP, this research also practically contributes to the project implementation in Mozambique.

1.9 Structure of the Thesis

The thesis is organized in seven chapters as follows. After this introductory chapter, in Chapter 2, I present the literature review and the theories used to guide the collection and analysis of empirical data. Then follows chapters 3 and 4, where research settings and the methods used are described. The case study is described in chapter 5, which is followed by the analysis and discussion of the empirical findings. Finally, in chapter seven, I draw some brief conclusions arising from this thesis.
This chapter presents a review of relevant literature that supports this research, which is followed by the presentation of the conceptual framework that is used for the analysis and discussion of the empirical findings. The literature review is divided into two parts: (1) A discussion on the problems and opportunities related to IS in developing countries in general, and to HIS in particular. (2) A discussion on GIS technology, its potential, application areas and challenges in their implementation in developing countries. The conceptual framework developed in this chapter describes the approach to study the existing situation, emphasizing the complexity related to the implementation of the GIS project. I adopt a socio-technical perspective on ISs to analyse the complex interlinking of the technology and the social setting in which the technology is being introduced. Actor Network Theory (ANT) is used to identify the different actors involved, their relationship and how their different interests contribute to the complexity of the GIS project implementation process.

The rest of the chapter is organized as follows. Section 2.1 presents a discussion on HIS in developing countries. Section 2.2 presents a discussion on GIS data modeling including different spatial data representation formats. A discussion of the challenges of GIS implementation in developing countries is presented in section 2.3. Section 2.4 presents the concept of socio-technical systems as a perspective to study IS and GIS in organizations. Then ANT and some of its key concepts drawn upon in this thesis are presented in section 2.5. In section 2.6, I discuss the information infrastructure theory and argue for it to be appropriate to analyze GIS implementation. Finally, I describe system development as a cultivation process in section 2.7, as it is relevant to the empirical approach used in this thesis.

2.1 HIS in developing countries: ongoing challenges of implementation

Historically, developing countries have been facing serious economic crisis, with associated adverse implications on the health status of their population. In trying to address this adverse
health condition, governments are acknowledging the importance of developing effective HIS to monitor the health system and better support the management of health services provision (Mwaluko and Pazvakavambwa 1996). Economic problems contribute to an existing situation of inadequate infrastructure and resources. The dynamic nature of the political situation, the deeply rooted bureaucratic organizational structures, and the influences of the donor agencies, are some of the other contextual conditions that also shape the effectiveness of HIS in developing countries (HMN 2005).

Various researchers have identified several problems associated with HIS in developing countries, including inappropriate procedures of data collection, analysis and information use (Lippeveld and Sauerborn 2000, Lippeveld 2001). Such weak procedures result in both poor quality of data and also duplication of work of the field level health staff responsible for the collection of data. There is a proliferation of health programs and their associated information systems, which contributes to a wastage of resources as the same data gets collected repeatedly in parallel information systems. This multiplicity also contributes to inappropriate reporting systems, limited feedback routines, and overall poor use of the data being collected (Sauerborn et al. 2000).

The above problems identified more broadly in developing countries, have also been described by various researchers to be historically present in Mozambique. Problems of poor reporting, weak data management at both the district and provincial levels, poor feedback and nearly non-existent use of information to support local action have been repeatedly identified by various researchers (for example, Braa et al. 2003, Chilundo 2004, Mosse 2005). There are problems because data is aggregated up to the district or provincial levels which makes it difficult to conduct analyses related to sub-district levels, which also serves as a serious impediment to the effective use of HIS (Braa et al. 2003).

Generally, attempts are being made by national, state and local governments to introduce various reforms in the health sector, including decentralization, integration of different health programs, strengthening of management practices, and the introduction of ICTs to support the HIS (Lippeveld et al. 2000). However, the existing procedures of data collection, processing
and reporting, and a weak information culture constrain the effective deployment of technology. Many developing countries are lacking necessary infrastructure and skills to effectively operate the technology. For example, in Mozambique, while the spread of computers and Internet to the provincial capitals and major districts is gradually becoming visible, however its effective use is slowed down by the lack of IT skilled people (who prefer to stay in the capital cities and not the rural areas), and poor infrastructure including electricity, roads, and transportation (Braa et al. 2001, Mosse 2005). Similarity, in Tanzania, although the level of IT adoption has been described to be increasing since the eighties, the value obtained from its implementation in the health sector has been constrained by a variety of factors, including the lack of transport and communication infrastructure, and human resources constraints (Kimaro and Splettstoesser 2000, Lungo 2003).

Most developing countries have their health systems characterized by parallel programme-based (such as for HIV/AIDS and TB) or service oriented (such as MCH and family planning) systems. These parallel systems often arise because of the focus of donor agencies to support particular diseases or services that are of interest to them rather than the routine district-based HIS. This multiplicity contributes to a fragmentation of the HIS characterized by redundancies and inconsistencies in data collection procedures where the same data are collected many times for different systems. In addition to contributing to poor quality HIS, the already burdened health workers are subjected to increased workload and shortage of time to provide care to the community. Lack of decentralization, the use of top-down management approaches, the steady aggregation and poor quality of data, implies that the field staff have limited motivation to work with the HIS (Lippevel 2001, Franco et al. 2002), as they don’t see the data to reflect their local needs. As Mwaluko and Pazvakavambwa (1996) argue:

The decision on how much data is collected, processed, presented, by whom, to whom, when, etc. are dictated from the centre, and the grass-root level health worker therefore collects it because it is needed by those above.

(Mwaluko and Pazvakavambwa 1996:168)

Realizing the potential of ICTs to improve the efficiency of the existing poor quality HIS, many developing countries are in the process of making significant investments in hardware, software and capacity building efforts around their HIS (Lippeveld and Sauerborn 2000).
However, effective implementation of these systems still remains a challenge due to various existing socio, economic, political and organizational conditions (Peter and Bossert 2000). For example, the costs of purchase of computers and their maintenance (printer cartridges, paper, technical support) are often prohibitive (Lippeveld 2001). There is typically the problem of limited number of skilled personnel, high human capital costs of installing, training, operating and maintaining ICTs which is estimated to be ten times that of the acquisition cost of the computer itself (Heeks and Kenny 2002). Lippeveld and Saporie (2000) have argued that the success of HIS reform efforts depends not only on technical improvements but also on introducing relevant changes in the political, socio-cultural, and administrative conditions. However, unfortunately we often find that the focus of the investments focus is primarily on technology, and an equal emphasis is not provided on the organizational issues. This asymmetry in focus has been described by various researchers to contribute to the unrealized potential of the promise offered by ICTs (Heeks 1999).

The challenges of implementing HIS in developing countries described above are also very much evident, and arguably magnified, in the case of GIS technology for both social and technical reasons. In the next section, I provide a brief description of GIS technology, followed by an analysis of some of its associated implementation challenges.

### 2.2 Geographic Information Systems

Geographic Information Systems (GIS) can be defined as “a set of elements that allow the computerized handling of geographically defined data, their entry, storage, analysis and presentation (Eastman et al. 1993 cited in Sauerborn and Karam 2000:214). GIS are a special class of IS that keep track not only of events, activities, and things, but also of where these events, activities, and things happen or exist. Thus, GIS differs from other types of ISs in their capability to manage huge quantities of data, the need to integrate spatial and non-spatial attribute information into one system, and to allow access to data based on location. A GIS has the potential to provide, in addition to the more narrowly defined concept of a decision support system, a unifying framework for the assembly of spatial data, visualization of spatial (map-based) data patterns not immediately evident in non-spatial data, and subsequent analysis of spatial patterned relationships (Hall et al. 1997). These features make GIS a potentially promising
tool for both strategic planning support, and also for tactical decision support and operational management (Calla and Koett 1997).

The core component of any GIS tool is the underlying data model, which is “a set of constructs for describing and representing selected aspects of the real world in a computer” (Longley et al. 2001:184). A data model provides system developers and users with a common understanding and reference point. For developers, a data model is the means to present an application domain in terms of location. For users, it provides a description of the structure of the system, independent of specific items of data or details of the particular application (Puri 2003). When modeling the real world and representing it with GIS, the entities with the same geometric type are grouped together (for example, all point entities such as health units and schools, or lines like rivers and roads). A collection of entities of the same geometric type is referred to as a class or layer. According to Longley et al. (2001), all GIS applications include a core data model that is built on one or more GIS data models. They write:

> Several geographic data models have been used in GIS including computer-aided design, graphical (non-topologic), image, raster/grid, vector/geo-relational topologic, triangulated irregular network (TIN) and objects. (Longley et al. 2001:186).

In these geographic data models, raster and vector data models are most commonly used by developers (Longley et al. 2001). In a raster data model, real world objects are presented using an array of cells or pixels. Raster data are usually stored as an array of grid values, with metadata about the array held in a file header. Typical metadata comprises the geographic coordinate of the upper-left corner of the grid, the cell size, and the number of row and column elements. The array itself is usually stored as a compressed file or as a record in a database management system. There are different compression techniques, including run-length, wavelet and block encoding. Data encoding using raster data models are particularly useful to create backdrop maps that can help to communicate a lot of information quickly. Raster models are also widely used for analytical applications such as disease dispersion modeling, surface water floor analysis, store location modeling and environmental protection. The common sources of raster data are remote sensing satellites and imagery.
The vector data model has been more widely implemented in GIS than raster models. This is because of the precise nature of its presentation method, its storage efficiency, the quality of cartographic output, and the availability of functional tools for operations like map projection, overlay and analysis. In the vector data model, each object in the real world is first classified into a geometric type, that is, a point, a line or a polygon. Points are recorded as a single coordinate pairs, lines as a series of ordered coordinate pairs, and polygons as one or more line segments that close to form an area. The coordinate can have two to four dimensions. Two dimensions represent location and the other two, attributes such as height and time. The sources of vector data include social and environmental activities such as land survey. For example, in implementing GIS for health, health units can be presented as points, roads and rivers are presented as lines and health districts are presented as polygons.

Generally, GIS applications are being used extensively in various social, economic and business domains, and some examples are listed below:

- **Social services provision**: Where to establish new schools, hospitals and clinics, and how services such as water should be distributed?
- **Infrastructure and transportation**: Where should new buildings and connecting road networks be made?
- **Rescue services**: How can rescue departments and ambulance services most easily reach affected areas?
- **Tax maps**: Identification of ownership data by land plots.
- **Land-use planning**: For classifying land according to the possible uses.
- **Environmental conservation**: To help manage forest cover and biodiversity, including resources on soil types, annual rainfall, vegetation, land use and ownerships.
- **Law enforcement**: To help allocate police resources and facilities to areas based on the intensity of crime in different areas.
- **Conducting virtual diplomacy**: GIS can be used to aid diplomacy. An example given by the former US vice President Al Gore is given below (1998):

  “…To support the Bosnia peace negotiations, the Pentagon developed a virtual-reality landscape that allowed the negotiators to take a simulated aerial tour of the proposed borders. At one point in the negotiations, the Serbian President agreed to wider
After this broader overview of what a GIS is, its underlying modeling methods, and some potential application areas, I discuss more specifically the role of GIS in health.

### 2.2.1 GIS and health services provision

The use of maps in mapping health outcomes was identified many years ago. John Snow, a British doctor, used principles of medical geography to locate the source of a cholera epidemic in London in the mid-19th century (Frerichs 2000). Since then, examples of displaying diseases patterns on maps have evolved with time (Sauerborn and Karam 2000), and this has received a further boost through the introduction of computers, the use of digitalized maps, and appropriate software. For example, accessibility to health facilities can be easily technically calculated and described cartographically, using a variety of available spatial models that allow an evaluation of the relation between health service supply and demand points. Understanding the nature of access and factors influencing it can help to formulate decisions on reallocating resources between health facilities and/or closing existing or opening new facilities.

In general, the analysis and interpretation of health data are influenced by several factors, the most important being related to locations (Blom and Savolainen 2003). For example, to understand which areas have high prevalence of particular diseases, the distribution of health facilities and their access, and the possible sources of diseases in relation to conditions of environmental sanitation, and so on. Such information can help in planning resources allocation, building of infrastructure, and for taking action on disease surveillance. In this way, information is required about where the resources are, how they function, how they change over time and how much it costs to make them available. GIS can support health managers to plan and take decisions to help provide answers for the where related questions that underlie health management.
Chapter 2: Literature review and conceptual framework

The main reason for using GIS in the health sector arises from the manner in which maps provide an added dimension to data analysis thereby helping in visualizing complex patterns and relationships (Sadiq et al. 2002). The ability of displaying both health information such as indicators and the spatial data such as health facility locations in the same system makes GIS a useful tool for monitoring and decision support. This is because maps can easily reveal inequities in the allocation of resources, the performance of health services and compare health outcomes. Generically, maps can display information from more than one sector creating an opportunity to share data from different sources. For example, GIS-based decision support tools were developed using the same architecture and database (Hall et al. 1997) for monitoring the access of target populations to health services (AccessPla), another for education planning (EduPlan), and a third for tourism site planning (TourPlan). The tools satisfied the stated design requirements for successful decision support in general, and spatial decision support in particular. The tools, intended to be used in developing countries, were developed, respectively, using data from Costa Rica and Chile.

In Mozambique, the focus of this thesis, resources are unevenly distributed, for example between urban and rural areas (Chao and Kostermans 2002). Conducting analyses that will easily make this inequity visible will require the integration of data on health status and population, both based on their geographical distribution. The GIS application can potentially provide an ideal solution for such tasks and allow health managers to make analyses that were previously too expensive or technically impossible to perform. The GIS tool can help give potential answers to health planners or describe scenarios for questions like: where to provide additional facilities and staff?; where to locate new health facilities?; and, which areas have high infant mortality and maternal mortality rates? For example, related to the spread of cholera in a certain area, health managers would like to take immediate actions by sending ambulances and medicines and also identify causes for the spread of the disease. However, such information can be usefully mapped if the necessary data required to perform those operations are available and reliable.

Despite the undoubted potential that GIS has to support management activities in various sectors, including health care, its effective implementation in developing countries is constrained by many factors, some of which are discussed in the next section.
2.3 GIS implementation in developing countries: ongoing challenges

The importance of social and institutional influences on GIS implementation is currently being acknowledged even in the Western countries (Martin 1998). Institutional issues are described to be at the root of many GIS implementation failures, rather than technical aspects. These include for example, poor project planning and management, inadequate attention to changes in the institutional culture, and the lack of coordination and cooperation between organizations (Levinsohn 1989). As GIS has been produced, designed and used initially in the Western world, it is inherently inscribed with Western assumptions of time, space and coordination. Thus, when this technology is attempted to be introduced in the context of developing countries, cultural differences with respect to concepts of time, scale, detail, distance, becomes important. These differences have been described to have adverse implications on implementation of GIS project in the context of the Indian forestry sector (Sahay 1998). He writes:

Time and space are crucial practices for understanding the context and also to describe the social practices that surround the use of IT which contribute to both maintain and also change the social context.

(Sahay 1998: 149).

The application of GIS in non-Western contexts, thus requires a context sensitive approach, and involves a variety of modifications to suit local needs, in a manner that is compatible with the interaction between the technology and the specific social or institutional setting. The scope for such context specific approaches has been argued by Levinsohn (1989) as follows:

The scope of the GIS implementation is governed by the institutional setting into which the system is to be implemented…. If the GIS is to achieve the potential that has been ascribed to it, greater emphasis must be placed on dealing with institutional concerns and organizations must put greater effort into planning and change management.

(Levinsohn 1989:492, 498)

Despite the various challenges in effectively implementing GIS, its value has being recognized, and the numbers of GIS start-up firms have increased each year in the United States of America and Canada almost ten times since 1980 (Levinsohn 1989). However, in developing countries like Mozambique, the efforts to develop a GIS user base and also an industry are still at a very initial stage. Since the socio-economic contexts of the developed nations are relatively different from those existing in developing countries, GIS must respond
to different realities and priorities. This introduces significant problems of technology transfer, applications and adaptations, which require the adoption of more indigenous approaches to develop and implement GIS (Taylor 1991). India is an example of a country where such efforts are ongoing:

A considerable amount of scientific effort has focused on the development of indigenous software packages rather than depending on foreign vendors for GIS software needs.

(Sahay and Walsham 1997:100).

However, the capacity to develop such local and indigenous efforts in practice is very difficult and constrained by various existing conditions. In the next section, I discuss some of these constraints.

### 2.3.1 Organizational constraints

Various researchers have highlighted a number of institutional factors, especially within government organizations, that significantly influence the effective use of GIS in developing countries (Somers 1989, Al Romaithi 1997, Sahay and Walsham 1997, etc.). For example, the existing bureaucratic structures and culture of government agencies impedes the process of establishing a GIS database which requires the coordination of multiple departments, who often don’t have prior experience with maps, GIS or even computers. In developing countries, government organizations tend to work in a very compartmentalized manner, making the sharing of data and other technical and organizational resources problematic (Sahay and Walsham 1997). The technical constraints of GIS are often more easier to solve than organizational ones. While acquiring and installing new equipment and software modules could potentially solve technical problems, human factors have different consequences and cannot be easily addressed (Calla and Koett 1997). Levinson (1989) points to some other institutional considerations in the planning of GIS projects, such as whether the system is single or multi-purpose; whether the system involves more than one agency; will the GIS be used to automate line or support functions; who is the system being developed for; and the extent of integration required with other organizational functions.

Sometimes introducing new technology means relocation and replacing of staff members, which may not be a straightforward process, generating unexpected problems which are
difficult to predict or control (Wilson 1995). Staff may prefer the existing situation and counter attempts to make changes. Somers (1989) recommends some methodologies for introducing and maintaining changes, such as the following:

- Effectiveness of a change is related to the degree to which members take part in the planning and implementing of change.
- To change the behaviour of any level of an organization, complementary and reinforcing changes must be made at other levels.
- Both formal and informal organizations must be considered in the planning of change.
- Incremental organizational changes may be made after the first operational phase of a new GIS technology.

For this purpose, theories that take a socio-technical perspective and analyze the interconnection between human and non-human actors are more appropriate to study GIS implementation as compared to theories that emphasize only the social or only the technical. Such a thinking is now been largely accepted by the IS research community (Walsham and Sahay 1996, Hanseth and Monteiro 1998, Orlikowski and Iacomo 2001, etc.)

### 2.3.2 Data constraints

Lack of suitable GIS datasets has been repeatedly mentioned as constituting a major constraint in the implementation of GIS in developing countries (ESRI 2003). Effective implementation is disadvantaged by the limited availability of useful data, since the power of GIS application relies on the scope and quality of data used. Such constraints are magnified in contexts such as the health sector, which traditionally have not used maps in their everyday work. The effectiveness of GIS technology depends on the degree of relevance of the input data. However, data are often non-existent, and when existing are often hard to find due to poor data sharing culture and a lack of institutional commitment to provide data. The main reason is the bureaucratic apathy towards such requests displayed by the concerned holding institutions that restrict access to maps, often legitimized by national security and defense concerns (Fox 1991). This politics around the lack of dissemination of the basic map data to agencies outside the government institutions ensures that the use of this technology for most applications
continues to be largely confined to selected scientific departments in most developing countries.

Displaying health information in maps implies aggregation of different sorts of information, both spatial and non-spatial, in order to provide an improved basis for planning, decision-making and action through the use of GIS technology. However, data for spatial features like roads, lakes, rivers and so on are usually not available in the health sector, and need to be obtained from other departments like public works and planning. Such sharing is difficult to do in practice because of the reluctance of organizations to share data with others, and sometimes even within internal departments. This reluctance stems from a variety of reasons, including the lack of knowledge of what is available in other organizations, concerns of national security and confidentiality of data, and the fear of loss of power (Sahay and Walsham 1997). Furthermore, lack of required standards for data exchange between organizations also impedes data sharing. Also, socio-economic data (like population) is not often generally available in digital form, requiring the need to conduct extensive field surveys and ground truthing activities (Zeller 2002). When available, data is often not in their appropriate formats and scales, making it difficult to integrate the data into the GIS application. Due to the weak culture and mechanisms for sharing of data and applications, various departments try to develop applications from scratch. As Sahay and Walsham (1997) argue:

The problems associated with data sharing are sufficiently severe, in both technical and organizational terms, that it is common in practice for the data in GIS applications to be developed from scratch, even when they are available elsewhere.

(Sahay and Walsham 1997: 104)

While data sharing is desirable, the lack of compatibility in relation to collection, storage, processing and transmission between organizations make it costly. It is very costly and a time consuming process to generate and check the accuracy of data, whether by remote sensing, aerial survey or census type approaches, and to keep them updated as conditions change (Sahay and Walsham 1997, Teefelen et al, (1992). However, most developing countries do not have their own satellites, and remote sensing data often can only be purchased from developed countries. Furthermore, latest imagery data are often not available for public use.
2.3.3 Lack of data exchange standards

To fully realize the capability and benefits of GIS technology, spatial data needs to be shared and systems must be designed and used by multiple organizations. For example, a GIS decision support system is designed to use more than one spatial reference data set overlaid on the same map. For this, spatial data from different institutions are required, but are often not forthcoming, especially in the context of developing countries.

Data exchange standards have a key role to play for facilitating the integration of data sets from various distributed sources or organizations. Using national or international data standards can potentially reduce project costs by sharing data, resulting in lower costs for obtaining and maintaining data. Using standards can also allow the transfer of digital information between different systems while preserving the meaning of the data being transferred, supporting efforts to update a database using multiple sources (ESRI 2003). Setting standards for data exchange is crucial for the establishment and maintenance of both the technical and institutional infrastructure enabling data sharing (Alspach 1998). However, many organizations or sectors collect, store, process, and transmit data without following any formal standards, which makes difficult the possibility of sharing data, and resulting in duplication of work and data of poor quality.

The format and structure for holding spatial information can be different between computer systems, so the exchange of information requires the use of standardized formats. The way of addressing or storing the non-spatial data can also differ from one organization to another, even though when related to the same data. Alternatively standards may be developed at national or international levels and may be adopted by agreements to regulate a wider community (Alspach 1998). Eventually such standards should be part of a country's legalization process, that is, standards should be based on the needs of a particular country or project. For example, geographic data at the country level showing general data about location of places does not need to be as accurate as community or district level data showing land ownership. Thus, scale of the geographic data is directly dependent on needs. For example, information at the country level is aggregated and small-scale (large area) maps are sufficient to give appropriate context to the information. Other information at community level need not
be much aggregated and requires a large-scale (small area) map to show relevant context. To deal with this diversity of standards, formats, scales etc, the Environmental System Research Institute (ESRI) has developed its products (Arc View, MapInfo, etc) based on open standards to ensure a high level of interoperability across platforms, databases, development languages, and applications.

It is recognized that more than two thirds of the costs associated with spatial data processing systems are consumed in the building, maintaining, processing and transferring of data from one database to another (Al Romaithi 1997). Such problems and challenges are magnified in the context of developing countries that typically use software and hardware systems imported from developed countries with limited flexibility to modify and integrate systems obtained from different vendors.

2.3.4 Education and training constraints

In spite of the increased proliferation of technology in developing countries, including the number of training institutes, the number of people that have mastered computer skills are still low (Zeller 2002). As a result, the capacity of these countries to take advantage of the potential of new technologies and integrate them into improved services provision remains limited. As Lippeveld (2001) argues, many countries have introduced computer equipment at the district level with attempts to strengthen HIS management, but have no qualified staff to maintain the software and hardware. More generally, Macome (2003) discusses such problems in the context of Mozambique:

This tremendous shortage emphasizes that the ICT skills shortage has been and will continue to be one of the most serious challenges to the process of adoption and use of ICT within the country, and in particular, in public sector organizations.

(Macome 2003:38)

Since GIS technology is technically quite different from general purpose applications like Microsoft Office, its successful implementation and use fundamentally requires technicians with specialized skills who can operate the GIS application. Thus, the GIS system implementation in developing countries is constrained, as the level of illiteracy is high. In addition, there is the problem of training and skills transfer, which is also reported as being
very crucial because of the lack of expertise in most developing countries (Budic 1999). Thus, training and skills transfer is an issue that should remain an important consideration for the entire life of a GIS application in any organization. For example, after the design of the GIS tool for land management in an organization in Colombia, the implementation team recognized that there were no staff members who were capable of operating the GIS independently (Calla and Koett 1997), risking to make the organization consultant dependent. In spite of GIS being rapidly being used for different purposes, the shortage of GIS skilled staff is still evident in the developed world, and this shortage is even more magnified in developing countries (Teeffelen et al., 1993). For example, in Mozambique while there are GIS project implementations ongoing in health, education, and some other sectors, the numbers of skilled people are only a handful, a condition that seriously impedes the projects. Despite a spatial research centre being created, the output of specialists is far less than their demand. In most of cases, training programs, if available, are normally carried out as part of software training packages (Budic 1999) and not integrated with the work practices that surround the use of the GIS technology. Language is another problem, since most of the imported programs and manuals are written in English. This causes problems for most users who have limited understanding of English from non-English speaking countries like Mozambique.

GIS is a complex tool in the sense that it comprises knowledge from multiple domains, including computer technologies, organizational and application contexts. However, in the current university structure of most developing countries, GIS courses are not part of their curriculum, making these countries dependent on very expensive and short-term international consultants. The lack of GIS agencies that can provide professionals with required skills serves as a major impediment to the adoption of this technology in developing countries. Given the low level of GIS related skills, it is important for applications to be designed in a simple and easy to use manner, so that end users can interact with all features of the software environment through an easy graphical user interface. However, lack of sensitivity to the needs of users and the adoption of strong technical approaches to design, often result in the development of complexly designed systems which remains inaccessible to the average user. In many institutional and social settings in developing countries, the culture of using paper-
based maps is weak, and thus users find it difficult to relate to the map outputs produced by the GIS.

2.3.5 Cost constraints
Lack of funding has been reported as a key impediment to GIS implementation in developing countries (Budic 1997), including its use and maintenance. Generally, in the initial stages of implementation, it is difficult to evaluate the exact functionalities required for the GIS to be used, which makes difficult the process of identifying which software and hardware shall be most suitable. Also, for GIS applications to work effectively there needs to be a working non-spatial database in place to which the GIS has to be linked. Lewis (2005) describes this point in the domain of the health sector, where in Mozambique there were challenges to introducing GIS for community health because the basic non-spatial data was not well organized, and as such a lot of work was needed before the GIS could be linked to it. These issues make GIS different from the traditional IS design and their cost evaluation, as it is dependent on other systems being in place. During the initial implementation of GIS in the country, the costs of creating digitalized maps are prohibitive if it has to be done for a single application or institution. However, as argued earlier, the system of developing cost and sharing mechanisms across institutions is a non-trivial task.

The need for building local knowledge to address cost concerns and also to decrease international dependency has been identified in some developing countries like China, Brazil and India. For example, China has demonstrated the effectiveness of applying raster-based data sets to environmental problems, in a cost-effective and technically suitable way as compared to the vector-based systems used typically in Western models (Taylor 1991). In India, four types of indigenous GIS packages have been developed by different research groups, which are more inexpensive in comparison with those imported from developed countries (Sahay and Walsham 1997). Brazil also has a strong focus on developing open source based GIS such as TerraLib software, which potentially enables quick development of custom-built applications using spatial databases developed by Brazilian National Institute of Geospatial research (INPE).
In summary, I have discussed various institutional, technical, financial, human and data related constraints in the implementation of GIS technology in the context of developing countries. With this backdrop, in the next section, I articulate a perspective of “GIS as socio-technical systems” as an analytical lens to study my problem domain. This perspective is now articulated below.

2.4 Theoretical perspective: GIS as socio-technical systems

Information system consists of number of components, including technology (hardware, software, data, network, etc), social settings (including people, business processes, politics, economics, culture, organizations, management, and other artifacts), and the phenomena that emerges from the interactions between the technical and the social (Lee 1999). IS are influenced by their environment, infrastructure (the organizational structure, tools, training, users), the socio-cultural, and economic issues. Given this multiplicity of influences, IS implementation are thus dependent on the interplay of human, organizational and technical aspects, which are not easily separable, and need to be considered in terms of their interrelationships. Walsham et al. (1998) describe the study of this complex interlinking through a socio-technical systems approach where technology is only one of the elements in a broader network. Orlikowski and Iacono (2001) also conceptualize technology as a tool that alters the social relations. They further argue that:

> Following the introduction of new technologies, social roles may change, hierarchies may become more or less salient, business processes may be modified, and communication may require choices among different media and tasks.

(Orlikowski and Iacono 2001:124).

Given the inseparable relationship between technology and its social context, researchers have empirically argued that the same technology can have varying consequences in different organizational settings. For example, a study conducted by Barley (1989) in implementing the same technology (CT scanners) in different hospitals in USA, revealed different outcomes. Such comparative research helps to emphasize the relations between the social setting and technology, and that IS, are best understood as socio-technical systems. The underlying assumption followed here is that the processes of change within these social systems are
linked to the broader context, shaped by the relationship between human actions and the social systems.

Like ISs in general, HIS can also be conceptualized as a subsystem of a larger social system, established and running in a situated context. Currently, various national, state and local governments are making attempts to introduce ICTs to strengthen their HIS (Lippeveld et al. 2000). However, that potential of ICTs can only be realized if the HIS are effectively developed and implemented (Heeks et al. 1999). Even though there are reported Health Care Information Systems success stories from around the world, there are also increasing evidence of failures in both the private (Heeks et al. 1999) and the public sector (Heeks and Davies 1999). Various reasons have been identified for these failures, and are often related to the complexity inherent in the HIS. Without considering this complexity, it is inadequate to argue that health data is of poor quality, or is incomplete and untimely. To make a more qualified evaluation of an HIS, it needs to be examined in relation to its surrounding social and political context. Therefore, HIS cannot be understood independently of the people around it, their social relationships, their culture and the work practices that they are engaged in.

Like HIS in general, GIS is also a complex technology whose implementation in a given context is shaped by many factors. GIS for health care applications come with a magnified degree of complexity as it involves the integration of the non-spatial HIS with the spatial component in order to aid analysis and display of data in order to support decision-making (Lewis 2005).

In summary, it can be seen that even in the context of developed countries, different social and institutional conditions influence IS and GIS implementation. For example, introducing institutional changes to support the GIS adoption is complex both in the context of developing and developed countries. GIS is a context sensitive tool, which makes its successful implementation dependent on many factors. This is in contrast to thinking in traditional IS research where system development is concerned primarily with the technical issues of hardware and software, and emphasizing the role of human factors and the surrounding context. In this socio-technical systems perspective, the focus on ANT and information
infrastructure theory has been identified as an approach to understand the complexities involved. In the next section, I briefly discuss some basic concepts of the ANT approach.

2.5 Actor Network Theory

ANT aims to describe and explain how a society of human and non-human actors are tied into a network which is built and maintained in order to achieve a particular goal. It provides a language to describe how, where and to what extent technology influences human behavior (Monteiro 1999). Actor-network research started out in the sociology of science and technology domain for tracing heterogeneous networks of actors and their interactions involved in the production of science and technology (Martin 2000). Researchers in this tradition have argued that knowledge is a social product rather than something generated through the operation of a privileged scientific method. And, in particular, "knowledge" (generalized from knowledge to agents, social institutions, technology and organizations) might be seen as a product or an effect of a network of heterogeneous elements (Law 1992). In this way, ANT is applied by various researchers to examine more than just the technological system, or just the social system, but the phenomena that emerges when the two interact (Lee 2001). Thus, ANT is useful for studies of IS in situations where interactions of social, technological and also political issues are regarded as particularly important, and analyzed in an interconnected rather than in an independent manner. In the same way, Monteiro (2000) describes ANT as a strategy for unpacking the complexity of the networks and making a complex situation more understandable through the use of some key theoretical concepts.

One important concept of ANT is that of a heterogeneous network. This lies at the heart of ANT, and is a way of suggesting that society, organizations, agents and technology are all effects generated in patterned networks of diverse (not simply human) elements. Law’s (1992) argument is that indeed we would not have a society at all if it were not for the heterogeneity of the networks of the social. So in this view, the task of sociology is to characterize these networks in their heterogeneity, and to explore how it is that they come to be patterned to generate effects like organizations, inequality and power. Drawing upon this concept, I conceptualize the health sector also not as one homogeneous entity, but a complex body of organizations, professional interests, technologies, knowledge and interests. It comprises both
small, geographically spread primary health units and large centralized and more complex hospitals. In developing countries like Mozambique heterogeneity arises from the number of relevant international and local political institutions involved with responsibilities for budgets, planning and controlling health care provision. The primary health care sector is thus full of complexity, which the introduction of new technologies like GIS needs to deal with.

In a network, actors interact with and influence each other simultaneously. Interactions between actors are the core and primary building blocks of actor-networks and their many manifestations are called translations. Between human actors, translation involves building commitment and the negotiation of shared interests. In general, actors from the outset have diverse interests, which require to be translated, re-interpreted, re-presented or appropriated into one’s own (Monteiro 1998). In this way, there can be ongoing multiple processes of translation, each with its own unique characteristics and outcomes, to be translated into specific needs. In turn, specific needs need to be further translated into more general and unified needs working towards the same solution (Monteiro 2000). Inscriptions explain how designers’ assumptions about the future use of a technology are inscribed into its design (Hanseth and Monteiro 1998). Inscriptions are given a concrete content because they represent interests inscribed into a material form. For example, spatial and non-spatial data resources in a GIS are inscriptions that link the technology to the actor-network and representations. The maps, data layers, and reports generated at the GIS links information consumers to the GIS actor-network.

Another important theoretical element in describing an actor-network is flexibility. The flexibility of inscriptions varies, some structure the pattern of use strongly, others weakly (Hanseth and Monteiro 1998). Research suggests that actor-networks will continue to exist because there is confusion, instability and incoherence. Flexibility and “fluidity” may be crucial in balancing the demands from multiple loosely connected and incoherent networks (De Laet and Mol 2001). They use the example of the Zimbabwe Bush Pump to argue that good technologies may well be those which incorporate the possibility of their own breakdowns, which have the flexibility to deploy alternative components, and which continue to work to some extent even if some bolt falls out or the user community changes.
Many researchers have emphasized the use of ANT in many domains in developing and also in developed countries. For example in Scandinavia academics have applied ANT through concepts of sociology of translation and inscriptions to study information infrastructures (Hanseth and Monteiro 1997, Monteiro 2000). By considering the actors participating in the implementation and operation of GIS as components of an actor network, some researchers have used ANT to develop a broader understanding of GIS implementation by analyzing various institutional, political and technical linkages (Martin 1998, Martin 2000). ANT was also used as a basis for studying the evolution process of a Web browser technology (Faraj et al. 2004), and the processes of inscribing, translating and framing that clarify how actors interact with each other and to the browser. Despite being applied in different domains of IS implementation, however, ANT has also been criticized for its emphasis on symmetry to both human and non-humans (Walsham 1997). Law (1992) argues that this principle of symmetry represents an analytical stance, rather than an ethical position. Hanseth et al. (2004) further argue that all networks are also different, and so are different technological artifacts and humans, at least in terms of roles they play in organizations and social life.

My motivation for using ANT comes from the fact that it provides a theoretical framework for understanding the socio-technical complexity surrounding a technology, for example GIS in the context of health. In the process of GIS system development, ANT firstly helps to emphasize the heterogeneous nature of the networks that surround a GIS application. After describing ANT’s role in helping understand complexity within a social setting, I discuss how information infrastructure theory provides us with a set of concepts to analyze GIS development.

2.6 Information infrastructure (II)
II can be seen as an extension of thinking around ANT, specifically to help analyze complex and interconnected systems as contrasted from traditional ISs. While IIs are designed to be enabling, shared and open, traditional IS are seen to be designed for a specific group of users and for a specific problem (Hanseth 2002). IIs are applied in IS research to analyze not independent but networked systems in which development is not controlled by any one actor.
(Hanseth and Monteiro 2004). The II perspective emphasizes that the social and technical are not separable and are instead constituted and constitutive of one another. Hanseth (2002) draws upon the example of the Internet to describe the characteristics of IIIs as being shared, open, enabling and a heterogeneous installed base. IIIs are thus not built to support one application for a pre-defined set of users, but to provide an enabling environment in which a variety of applications and user communities can increase, and the infrastructure can evolve to support changing needs. Evolving means that infrastructures evolve continuously over time through a process of adding new elements and improving on the existing, but integrated with the old. Open in the sense that, infrastructures are open to incorporating new users and applications. There is no border regarding the number of elements it may include, the number of users that may use it, or the number of use areas that it may support. There are technically no limitations in terms of who can participate and contribute to its design and development. Infrastructures are shared in the sense that, it is the one and the same single object used by different actors in the community (although it may appear differently). When an infrastructure in designed and integrated to the existing one, it shares resources. The infrastructures are heterogeneous in a way that they include components of different kinds, technological and non-technological as well as human, social, and organizational aspects.

An interesting point about infrastructures is that they are never built from scratch (Hanseth 2002), that is, new infrastructures are always designed as extensions and improvements of existing ones. In this way, the new components have to fit into the old, the installed base. Monteiro (1998), in his analysis of the scaling of the Internet, describes the installed base to be constituted of hosts, routers, users’ experience and practices, backbones and specifications.

Concepts of cultivation and installed base have been adopted as guiding principles to understand the challenge of change (relating to GIS) in this thesis. The installed base comprises the existing systems, work processes, users and organization procedures that govern the overall process of cultivation. Consequently, the present installed base carries the heritage of (and is affected by) the former installed base.
My focus on II theory is particularly on the concept of installed base, and how the development of the GIS is influenced by the existing systems, work procedures and routines. The GIS tool for health is meant to support decision making by incorporating spatial analysis of data that are part of the existing HIS. In this way, the new system is also involved in the process of improving new ways of working. In the next section, I first argue that GIS for health are better conceptualized as GII, and then develop specific implications for my theoretical analysis.

### 2.6.1 Conceptualizing GIS for health as a Geographic Information Infrastructure (GII)

Analyzing GIS implementation in health needs to consider GIS as a part of larger heterogeneous socio-technical network encompassing humans, technological components and institutions. The design of a GIS, that is of the new system, must respect the installed base, that is, the already existing HIS, reporting procedures, systems, technologies and users. Specifically, the linkage between the GIS and the existing IS needs to be understood where the GIS application should represent an open shared, evolving and heterogeneous installed base.

In the context of the health sector, GIS is **heterogeneous networks** as it is constituted of technical (hardware, software, data) social (health staff, politics, economics, organizations, management, donors and other artifacts) and their interconnections. For example, a number of organizations and participants including the Ministry of Health, and international agencies such as WHO, World Bank, and so on, deal with spatial and demographic data. A GIS for health application is **shared** in the sense that it supports information sharing amongst a large community of different users or organizations with different needs. For example, information can be shared by different users for health program management, disease surveillance, health infrastructures management, and international health planning (such as WHO), etc. These users represent different departments, and with varying procedures, practices and interests. A GIS system is **open**, since it is not limited to the number of users, application nodes in the network and other technological components for particular user groups. For example the data can be used for spatial analyses in different sectors and department within health sector and in other public areas like education. A GIS application is **flexible**, since it can be used for information analyses for different purposes, supporting decision-making and resources
planning, and evolving over time, that is, allowing new functionalities to be added or deleted as required. Hanseth and Monteiro (1998) have emphasized that there is no clear definition for II and there are different kinds of infrastructures (global such as Internet, sectors and corporate). Thus, GIS for health sector, it is argued, GIS is better conceptualized as a GII, rather than a traditional IS.

In summary, I have argued how a GIS application for health represents the characteristics of an II; and can thus be conceptualized as GII. With this guiding theoretical assumption, I argue how the development of such an infrastructure requires the process of system development to be one of cultivation process.

2.7 System development as a cultivation process

Development of IIs is a complex task, as it is no longer just about developing a single software application. Cultivation has been argued by researchers (Hanseth and Monteiro 1998, and Hanseth and Monteiro 2004) as an appropriate approach for the development of an II. The concept of cultivation draws our focus on the limits of rational human control, and technological systems are seen as organisms with a life of their own, with their own inertial forces originating in the existing technology itself, i.e. the installed base (Hanseth 2002). The cultivation process also emphasizes the slow process of organizational change involving negotiating and political brokering between actors at multiple levels. Braa and Hedberg (2002) refer to the continuous process of defining standards for healthcare in South Africa as cultivation. They argue:

By cultivation, we mean a slow, incremental, bottom-up process of aligning actors by enabling translation of their interests and gradually transforming social structures and information infrastructures where the resources already available form the base. The precise outcome of the design process is not given, but is negotiated within a broader set of goals.

(Braa and Hedberg 2002:116)

Challenges are encountered when developing new infrastructure or changing the existing ones. First, how to get a self-reinforcing process started that will enable the installed base to start growing. Second, when infrastructures start growing, it might lead into a lock-in situation (Hanseth 2002), because when the installed base becomes well aligned, it increasingly takes
on an irreversible nature. The lock-in effect represents a dilemma in evolving an II as it creates inertia and with it a conservative influence. The use flexibility makes it less likely that a lock-in situation will occur (Hanseth 2002). Given the inherently interconnected nature of IIs to the installed base, the whole network cannot change instantly, and design strategies need to link the old and the new in an “interoperable” way.

The challenge is how to prevent entering into a lock-in, and how to exit from it once entered. To prevent the lock-in situation, Hanseth (2002) suggests the design of the infrastructures to be flexible in terms of use and change. However, the strategies for changing the existing II into the new one must be developed together with necessary gateway technologies linking the old and the new (Hanseth 2002), and in an evolutionary and incremental manner.

An evolutionary strategy consists of changing a small part of the network, and then making sure that the newly added parts work together. Then move on to change the next small part. This means that the change is spread out over time, each step being small, thereby attempting to align the network of actors. This strategy has the advantage of reducing the possibility of failure as Heeks et al. (1999) point out, the higher the degree of change, the higher is the chance of failure (Heeks 1999). Furthermore, the advantage of this approach is that users are never confronted by major change but have only to cope with small incremental steps, and also enrolls user participation. In developing countries, a participative approach for systems development is given as a fundamental strategy for reducing gaps between the systems design and reality (Heeks et al. 1999), and creating local ownership and commitment.

In summary, the following concepts taken together - GIS as a socio-technical system, ANT, installed base and cultivation from II theory - help to develop a context sensitive and socially-informed understanding the implementation challenges of GIS for the health sector in a developing country context like Mozambique. Similar conceptualization, it can be argued, can also be applied to other developing country contexts, and also to sectors other than health. While these concepts will continue to be significant in other contexts, they will differ in the particularities of their characteristics and how they play out over time. In the next chapter, I present the background of the socio-historical and political context of Mozambique that
situates the study in relation to how the health care services provision has historically been influenced by various conditions.
In this chapter, I describe the research settings. The chapter is divided into two main sections. Section 3.1 presents the country’s background, including a brief description of the geographic, demographic, and socio-economic profiles. The section also describes the health care services provision, and what are some of the historical influences that have shaped it. Section 3.2 presents a situation analysis of the HIS, including the organizational structure responsible for its management, and of the health services more broadly. Problems associated with the existing HIS are also discussed, as they have a significant influence on the implementation of the GIS project that is the focus of this thesis.

3.1. Mozambique: a brief background
The study was conducted in Mozambique, which is a Portuguese speaking country located in Southern Africa. Mozambique is bordered by South Africa, Swaziland, Zimbabwe, Zambia, Malawi, Tanzania and the Indian Ocean. The country is divided administratively into eleven provinces, which are subdivided into 131 districts. Figure 3.1 shows the map of Mozambique with the 11 province divisions. The country’s population is estimated to be 18.9 millions for the year 2004 based on the National Census of 1997 (INE, 1999).
Mozambique was a colony of Portugal for almost 477 years, a historical condition, which also had a significant influence of the creation and focus of the health infrastructure. The colonization period started on 1498 with the arrival of the Portuguese navigator Vasco da Gama on the Mozambican coast and continued until 1975. The Portuguese people were mainly in the islands and the coast of the northern provinces, because they were primarily interested in exploring the fertile lands for agriculture and an easy access to export products to Europe.

Following the departure of the Portuguese in 1974, Mozambique faced a prolonged and intense civil war between 1980 and 1992, contributing to make it one of the poorest countries in Sub-Saharan Africa (Chao and Kostermans 2002). This prolonged war promoted material and human destruction across most of the country, including social infrastructures such as of health care and education. The health facilities, especially in the rural areas, already marginalized because of the colonial rule, were further largely destroyed, leading to a
magnification of the uneven distribution of health facilities between the urban and rural areas. Despite the government’s subsequent attempts to redress this imbalance, the effects of the war are still being experienced till today. The health status of Mozambican people is among the poorest in the world (Chao and Kostermans 2002:3). Basic health indicators are lower than the average for Sub-Saharan Africa, especially for infectious and parasitic diseases, diarrhea, acute respiratory infection, measles, malaria, tuberculosis, child malnutrition and sexually transmitted diseases including HIV/AIDS (Chao and Kostermans 2002, Chilundo 2004). Mozambique’s three basic health status indicators - infant mortality rate, under-five child mortality, and maternal mortality rates are the worst compared with other sub-Saharan African countries. A comparative summary of key indicators is provided in Table 3.1 below.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Mozambique</th>
<th>Malawi</th>
<th>Zambia</th>
<th>Zimbabwe</th>
<th>Sub-Saharan Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP - 2002</td>
<td>195</td>
<td>177</td>
<td>361</td>
<td>639</td>
<td>N:A</td>
</tr>
<tr>
<td>Life Expectancy at birth 2002</td>
<td>38.5</td>
<td>37.8</td>
<td>32.7</td>
<td>33.9</td>
<td>46.3</td>
</tr>
<tr>
<td>Infant mortality rate (per 1000 births) - 2002</td>
<td>125</td>
<td>114</td>
<td>108</td>
<td>76</td>
<td>108</td>
</tr>
<tr>
<td>Mortality rate under 5 years (per 1000 live births) - 2002</td>
<td>197</td>
<td>183</td>
<td>192</td>
<td>123</td>
<td>178</td>
</tr>
<tr>
<td>Maternal mortality rate (per 100,000 live births) - 2002</td>
<td>1100</td>
<td>1100</td>
<td>650</td>
<td>700</td>
<td>N:A.</td>
</tr>
<tr>
<td>Low birth weight - 1995-2002</td>
<td>26</td>
<td>25</td>
<td>28</td>
<td>13</td>
<td>N:A</td>
</tr>
<tr>
<td>Adult HIV prevalence % - 1999</td>
<td>13.2</td>
<td>15.9</td>
<td>19.95</td>
<td>25</td>
<td>8.57</td>
</tr>
<tr>
<td>Internet uses (per 1000) - 2002</td>
<td>2.7</td>
<td>2.6</td>
<td>4.8</td>
<td>4.3</td>
<td>N:A.</td>
</tr>
<tr>
<td>Telephone mainlines (per 1000 people) 2002</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>24</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 3.1: Indicators of Mozambique compared with sub-Saharan African countries. Source: adapted from Human development report 2004 except HIV prevalence that comes from UNAIDS 2000b. GDP – Gross Domestic Product.

Following the civil war, the Peace Accord between the two main political parties (FRELIMO and RENAMO) was signed in October 1992 leading to the country starting on the road to a

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1 FRELIMO - Mozambican Liberation Front.

2 RENAMO – National Mozambican Resistance
democratic form of political governance. Following this, restructuring of the National Health System (NHS) and services delivery (Chao and Kostermans 2002) started the Health Sector Recovery Program. Many of the destroyed health facilities were rehabilitated and new ones were built. Many health posts were upgraded to health centers with maternity facilities providing both preventive and curative services.

According to the 1997 poverty assessment carried in the country (REPUBLIC OF MOZAMBIQUE 2001), approximately 70% of the population currently lives in absolute poverty. The following determinants of poverty in Mozambique were identified by this assessment:

- Slow economic growth until the beginning of the 1990s;
- Poor levels of education of economically active members of households, especially women;
- Low productivity in the family agricultural sector;
- Lack of employment opportunities in the agricultural sector and elsewhere; and,
- Poor development of basic infrastructure in rural areas.

Other studies carried out, for example (World Bank 2004) have also emphasized factors such as the isolation of rural communities due to lack of adequate roads and communication facilities, with adverse implications on the integration of rural markets and consequently also on the sale of agricultural surpluses. This poor infrastructure and integration of rural communities into the national services provision is also starkly evident in the health sector where large segments of the population to not have easy access to governmental health care facilities (Chao and Kostermans 2002). This lack of access is significantly responsible for the poor health indicators, for example Mozambique has one of the highest maternal mortality rates in the world, and also the percentage of institutional deliveries is well below acceptable standards (Mwaluko and Pazvakavambwa 1996)

Based on the 1997 poverty assessment, the government developed an Action Plan for Reduction of Absolute Poverty (PARPA) for five years (2000 - 2004). PARPA was later put in action for the 2001- 2005 period, with a view to recognize the importance of medium and
long-term measures to fight poverty through policy development to sustain rapid and broad-based economic growth. The specific objective is to reduce the incidence of absolute poverty from 70% in 1997 to less than 60% by 2005 and less than 50% by the end of this decade (REPUBLIC OF MOZAMBIQUE 2001).

The strategic plan prioritizes education, health, agriculture and rural development, the development of basic infrastructure, good governance and improved macroeconomic and financial management. The poverty strategy plan specifically intends to:

- Generate rapid and sustainable economic growth;
- Invest in human capital through improved delivery and quality of social services; and,
- Develop a program including safety nets that fosters the social and economic integration of the most vulnerable groups.

The goal of the current health policy is to ensure reliable access to quality health care for all Mozambicans (Chao and Kostermans 2002). To achieve this, the following objectives have been articulated by the policy document:

- To reduce mortality, morbidity and suffering, especially among high risk groups such as women, children and all those displaced due to the war and natural disasters;
- To keep primary health care as the basis for the provision of good quality and sustainable health care and make it accessible to the majority of the population; and,
- To develop the Ministry of Health technical and managerial capacity for planning, implementing and evaluating health care and support services.

In summary, the colonial rule and the subsequent civil war have had adverse implications on the health status of the country, both with respect to access to and quality of health services. In the next section, I first describe in broad terms how the National Health System, including its HIS, is organized in Mozambique, following which I provide a more specific assessment of the HIS and some of its existing limitations.
3.2 Organization of the National Health Service and Health Information in Mozambique

The Mozambique National System is organized over four levels of the health care structure that is schematically depicted in Figure 3.2 below, and then subsequently described.

- **Primary health care** is made up of health post and health centers. This level provides health care to the majority of the population in peripheral areas, and is also the entry point for patients into the National health information system, responsible for providing data on basic health care;

- **Secondary health care** is comprised of the district health centers or rural hospitals. This level provides more specialized health services and health care support to all health facilities within the district. This level is responsible for supervising the functioning of the primary level, and to coordinate the activities between the Ministry of Health and other health care providing organizations such as NGOs within the district. In addition, this level provides health care to the referral patients from the primary levels. The specialized services include emergency care.
Chapter 3: Research settings

and surgeries such as non-complex obstetric and trauma interventions. The number of health facilities at the primary level in each district varies from 5 to 15. Not all districts have a rural hospital, and these only have health centers. In most districts, only one doctor is allocated for the entire district, due to the very small number of medical doctors in the country;

**Tertiary health care** is comprised of specialized provincial hospitals and other hospitals. This level provides support, supervision and is responsible for the coordination of all health activities in the province. In each province, there is a provincial hospital that is the most sophisticated health entity in the region for providing curative services including surgeries. The provincial hospital is the most well-equipped health facility in the province and is comprised of staff specialists who provide complex services such as internal medicine, general surgeries, pediatrics, obstetrics, genecology, dentistry, and ophthalmology.

**Quaternary health care** is made up by the central hospitals and other specialized hospitals. The central hospitals provide specialized services such as neurosurgery, orthopedic, plastic surgery and cardio-vascular surgery amongst the more complex treatments. The central hospital is the most well equipped health facility in the country. The quaternary level is also responsible for planning, programming, administration and evaluating the national health programs based on the analysis of epidemiological, demographic and health statistical data. There are three central hospitals (Nampula, Beira and Maputo) in the country distributed geographically around the three regions, North, Center and South respectively. The Maputo central hospital located in the capital city is the best equipped and serving as the main referral health facility in Mozambique. Patients who cannot be treated here and have the financial resources, often are sent abroad, mostly to South Africa, to receive health care.

Corresponding to these four levels, the HIS also encompasses this structure. Health data are primarily collected at the health facilities and health posts and sent to the District Directorate of Health (DDS). Basically, the health workers at their respective working places are responsible for the basic data collection as well as to their daily routine activities of providing health care to the large numbers of population visiting them from the community. The DDS, which is responsible for overseeing all health facilities within a particular district, including
the HIS, aggregates the data received from the health facilities and produces reports on a monthly basis that are sent to the Provincial Directorate of Health (DPS). The DPS, which is responsible for the management of all health activities within a particular province, including the HIS, then summarizes the district based reports, further aggregates them by districts, and sends the province level reports to the national level in the Planning Department. Figure 3.3 below summarizes the flow of information from the health facility to the national levels.

Figure 3.3: Flow of information from the health facility level to the national level. Source: Fieldwork at the Ministry of Health headquarters, February 2004 – February 2005.

At the central level, one brochure is typically produced each year, containing demographic, social, economic and epidemiological data and also related to resources and activities of the health sector as well as their efficacy and efficiency. The information system at the health facility and district levels is paper-based. However, some districts in three selected provinces (Xai-Xai and Chokwe in Gaza, Maxixe in Inhambane and Cuamba in Niassa) are in the process of prototyping and deploying the District Health Information Software (DHIS). At the
provincial level, the health data are stored in a computer system using spreadsheets and text documents. In the next section, I describe some of the characteristics of the existing HIS.

3.2.1 HIS in Mozambique: a situation analysis

Prior to the independence of Mozambique in 1974, the HIS was composed of several subsystems, that is each health program had their separate reporting information systems especially at the province and national levels. These systems were functioning without adequate coordination and were controlled by different authorities, namely the donor agencies (MISAU 2003). In 1979, the Ministry of Health developed and established a National Health Information System (NHIS), whose scope was defined so as to be capable of collecting health data from all the health facilities, including those in the peripheral areas.

The NHIS was identified to be characterized by several limitations, such as gaps, and the compilation of incorrect, incomplete and untimely data (MISAU 2003). The NHIS was revised in 1989 in order to make it a more appropriate tool to inform and support decision-making at the different hierarchical levels of the national health services. This included a detailed assessment of the registry books, definition and selection of relevant health indicators, design and testing of new data collection and reporting tools, creation of human resource capacity, evaluation, implementation and follow-up of the system. The NHIS was designed to handle information for both primary and secondary levels of the health programs such as mother and child health, and immunization, and also about infrastructure of health facilities, beds, vehicles, and electricity. The NHIS also include information about the human resources status.

As part of these reform efforts, the first national computer based HIS was introduced in 1992 (Kimaro and Nhampossa 2005, Braa et al. 2001), installed at the national level and also the eleven provincial directorates. The system was aimed to facilitate reporting activities about health programs from the districts via the provinces to the national level, including the various vertical health programs like immunization, family planning and drug distribution. Basically, the system was designed to support the needs for information at the national level and it largely excluded the needs of the provincial and district levels.

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3 Health post and health centres
4 Rural hospitals
Despite these reforms, researchers have described that the health data was still primarily flowing from the district and province levels to the national level without being integrated in the NHIS, and very poor routines of feedback and supervision of data quality (Braa et al. 2001). As the data flows up, it is successively aggregated, making the analysis at the disaggregated level impossible. For example, at province level, the data are aggregated by districts and it is not possible to see the situation in the health facilities. Similarly, at the national level, it is not possible for them to see the situation in particular districts as the data are aggregated by provinces. As a result of this, it becomes difficult to target the interventions and resources in particular areas and facilities where it is most required.

There is an absence of an integrated and common database, and a majority of the health programs and their associated information systems are running as isolated, stand alone systems causing a great degree of fragmentation. For example, routine data from tuberculosis, malaria and HIV/AIDS are not coordinated and their reporting structures are outside that of the Health Information Department (Chilundo and Aanestad 2003). As a result, it becomes close to impossible for the national managers to get an overall and holistic picture of the national disease status with adverse consequences on decisions relating to resources allocation and the planning of interventions.

Another significant problem identified by researchers has been the proliferation of legacy systems that have historically arisen because of the uncoordinated efforts of different donors at varying points of time to create their own IS. This has been described by Nhampossa (2005) to have contributed to the development of a “spaghetti of IS”, and as a result, the existing systems are unable to provide health managers with information on essential indicators which would cross-link different resources with activities, such as relating to different health programs.

Another problem constraining the flow of reports from one level to another is the inadequate condition of the roads and transportation infrastructure. For example, the communication between health facilities in Cumba district mainly takes place by a person going on a bicycle, which consumes many hours (Mosse 2005). During periods of rain and floods, the
communication cannot physically take place, and this leads to an irregular pattern of information exchange. Communication depends on many external conditions, often out of control of the health officers. The distance between the DDS and the health facilities also constrains data reporting since the health facilities are supposed to send the data using their own resources. They do not have proper transport facilities resulting in significant delays and missing reports of health reports in the district.

Shortage of staff, both in terms of numbers and skills is another significant problem facing the HIS. The health staff are extremely overworked, and have to respond to both the administrative needs (including the responsibilities of data collection and reporting) in addition to providing health care to the community.

In summary, I have discussed above the problems that are influencing the HIS. These contribute to the existence of a HIS with the following problems:

- **In completeness:** There is no guarantee that all health units send reports to the district health office.
- **In correctness:** The data are most of the time incorrect. Health workers allocated at the health facilities are usually overloaded and hence may neglect data collection in favor of service provision. Therefore the information reported is not necessarily in harmony with what was actually required.
- **Untimely:** The specified dates when the data or report should be sent to upper level are not always followed.
- **Lack of feedback:** The lower levels which send monthly reports to the higher levels seldom receive feedback related to the work they have done and reported.

In summary, I have presented the research setting, including the research background that helps to situate the study in terms of its context, history, and current status of the health sector. All these issues directly influence the implementation of the GIS project, which is a focus of this thesis. In the next chapter, I describe the research approach and methods used in this research.
In this chapter, I present the research methods that were used for the collection and analysis of the empirical data. A case study research design within an action research framework was adopted in this study. Participatory action research was used to support the implementation of a GIS application as a health care support tool at the CHD, Ministry of Health. Qualitative research methods were used for data collection and analysis. The chapter is organized as follows. In section 4.1, I present the research design. Section 4.2 presents the research approach and section 4.3 presents the research methods used.

4.1 Research design

In this research, a case study approach was used to study of the process of implementing the GIS as a health care tool at the CHD of the Ministry of Health Mozambique. The study period was from May 2004 to February 2005. Case study research is an approach for bringing an understanding of a complex phenomenon such as the design and development of an IS or a GIS within a multi-level setting of the health sector. A case study approach emphasizes the need for a detailed contextual analysis of a limited number of events or conditions and their relationships. Yin (1984) defines case study research as follows:

An empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used”  
(Yin 1984:23).

The case study method was chosen in this research because of the focus on the analysis of the social and cultural influences on the development and adoption of the technology within the Mozambique health sector. The research is situated within the framework of HISP – Health Information System Program, which is an ongoing action research aimed to develop a global network on HIS in various developing countries including Mozambique. As a member of the
Chapter 4: Research approach and software development

HISP team, I had the opportunity to visit health districts in two provinces of Gaza and Inhambane, where I made detailed observations of the work settings, and conducted interviews with different actors involved in the health sector. This helped me to develop a deeper understanding of the problems related to the current HIS, and help guide the prototyping process of the GIS tool for the CHD. The study then follows the framework of a participatory action research approach, which is briefly described in the next section.

4.2 Research approach

Baskerville (1999) describes action research as an approach grounded in practical action, aimed at solving an immediate problem situation while carefully informing theory. Thus, action research is an approach that allows the introduction of changes and an observation of the effects of the changes. When an action in a particular social setting is taken, a response is recorded. The data captured as the result of that change are usually relevant to that particular social setting (Baskerville and Wood-Harper 2002). In this research, we aimed to introduce the GIS for health care tool that will help the spatial analysis of health data by managers at the CHD and to study the consequences of the introduced changes. Action research was appropriate for this study as it emphasizes study and changes, that is, it seeks to introduce interventions and improvements in the study context as well as increasing researchers’ understanding of the subject to be studied (Elden and Chisholm 1993). In this way, action research was applicable for understanding the GIS enabled changes (or not) within the CHD.

The theoretical assumption of action research is that action is a way to build theory, knowledge, and practical action by engagement with the world in the context of practice, where: (a) the researcher is actively involved, with expected benefits for both the researcher and the organization; (b) the knowledge obtained could be immediately applied; and, (c) the research is a cyclical process linking theory and practice (Baskerville and Wood-Harper 2002: 136). In participatory action research, responsibilities are shared between the researcher and the participants, that is, those who ‘own’ the problem are also involved in defining the problems and searching for solutions (Elden and Chisholm 1993). Health managers at the CHD and other staff at the Ministry of Health were the main participants in the research and the “owners” of the problem. Their participation was very important for identifying
prerequisites for the project as well as for planning its implementation. Participatory action research emphasizes mutual learning between the researchers and the practitioners (Elden and Chisholm 1993).

Baskerville (1999) describes action research as a cyclical process comprising the following phases: diagnosing, action planning, action taking, evaluating, and specifying learning. The adaptation of these phases to this research is depicted in figure 4.1 below and then discussed.

Fig 4.1: The cyclical research process: GIS tool for health care implementation.

(a) **Diagnosing** corresponds to the identification of the primary problems that are the underlying causes of the organization’s desire for change (Baskerville and Wood-Harper 2002). This phase refers to the period when I conducted fieldwork in the two provinces of
Gaza and Inhambane in March 2004 to assess the existing HIS. This included also developing interpretations of the CHD users’ needs through interviews and discussions on the system requirements with the director of the CHD and also other staff. The spreadsheet based software SIMP, used for data storage and reporting at the Ministry of Health was analyzed. Conducting a literature review on research relating to HIS in Mozambique, reading official documents from the Ministry of Health both prior to and during the research, and the early stages of information situation analysis in this research, also contributed to the diagnosing process.

(b) **Planning** corresponds to specifying organizational actions that should be attempted to relieve or improve the primary problems identified. The identification of the planned actions is guided by the theoretical framework, which indicates both some desired future state for the organization and the changes required to achieve it. This refers to the process of analysing and identifying information and user needs for project implementation. After understanding the problems related to the absence of spatial analysis of data, the GIS tool for health care support was proposed to the CHD as a solution to improve the situation. The theoretical assumption was that spatial analysis of data could help the CHD managers to better identify where the problems exist, and in the planning of interventions. For example, managers could use the GIS tool to identify how accessible a clinic was for the population by computing the average distance of travel.

Both parties, that is, us (representing academia) and the CHD managers (representing the practitioners) were involved in this process of planning. This especially involved the active participation of the Director of CHD, for example in guiding us on where to get the maps required, and identifying which non-spatial database should be used for linking with the GIS. Also, the different categories of data analysis within the department were identified, as well as the kind of the interpretations the CHD would like to make with such analyses. The team was given a list of indicators that were used within the department for each programme for identification of the data elements. Regarding the non-spatial data, the Director of the CHD indicated the necessity of using the data that comes from the SIMP software because they are also used to prepare the national reports in MISAU. However, as the research was part of the
HISP program, and also that we did not have the source code and database structure of the SIMP software, it was agreed to use the DHIS software as non-spatial database. Two different areas of data related to PAV (for immunization) and SMI (mother and child health care) were suggested by the Director of the CHD for our analytical focus.

(c) Action taking phase involves the process of the design and presentation of the GIS application to the CHD and populating the non-spatial database with health data. Various presentations were made at different stages of the project, with the early stages meant to acquire the project acceptance as well as advancing steps to get access to the relevant people and data for the project implementation. The later prototypes of the GIS application were developed and presented to the CHD as a prototyping strategy of the development process. The development process was mainly around the customization of the GIS application that was initially designed for the Indian health sector and brought by one of our research team member, an Indian, to Mozambique.

The process also involved the collection of maps and creating the spatial database. Different alternatives for obtaining maps were explored, including approaching the National Institute of Statistics, the Ministry of Education and later within MISAU from a GIS expert who worked for the WHO. The action-taking phase also involved creating the non-spatial database, which was the customized DHIS database built only for this purpose. The database was populated with data from the SIMP software that were manually entered in the new database over six months. For this purpose, a team of three data entry people were hired, one from MISAU and two from the University of Eduardo Mondlane (UEM).

(d) Evaluation this is an ongoing process of assessing the project implementation and receiving feedback from the health managers that were involved in the project. This was the result of the discussions following the presentations of different versions of the prototypes where both parties involved discussed the outcome and the limitation of each prototype. The results were very useful inputs to the building of the next prototypes. Up to the time of writing this thesis, the process of design is still underway and so also the evaluation and learning. In spite of the use of data that was not accurate, the prototypes can be called successful since
there was successive improvements in both the customised GIS application and in the collection of maps and the creation of the non-spatial database with each stage of presentation. The project also created user enthusiasm and commitment to the project, for example, the Director of the CHD continued to encourage us as he saw the potential and evolution of the project. The process also enhanced mutual learning, the researchers learned about GIS technology and its implementation for health, while the CHD staff got exposed to the new technology.

(e) Specifying learning the last phase for this action research cycle, corresponding to the thesis writing, which helps to consolidate the findings and its documentation. It is hoped that this document can then be used in further research into implementation. In addition to the conceptual learning, there is also practical learning that has taken place. The development of the application, giving presentations to the health officials, doing some training, gaining feedback etc, can all be seen as steps of learning and their articulation. This helps to enable learning for both sides, and contributes to some improvements on the ground.

4.3 Qualitative research methods
In this research, qualitative methods were used for the data collection and empirical data generation. Qualitative methods are very useful for understanding the organized character of a social phenomenon, by providing insights to the way people work and the reasons to why they work that way (Anderson and Aydin 1994). Understanding the information situation analysis, identifying user and software requirements, and the process of software customization, involved the study of the context to which the processes were undertaken. Therefore, qualitative methods proved to be appropriate in this situation. A combination of methods was used, including interviews, meetings, and document analysis and system presentation (alternatives prototypes). Strauss and Corbin (1998) describe such a combination approach to be useful for supplementary, complementary, informational, developmental, and other reasons (Strauss and Corbin 1998).
4.3.1 Interviews and meetings

Interviews, presentations and discussions in meetings were very important methods to collect the necessary information on the real situation and to understand the project requirements as well as the user requirements. Initially, non-structured interviews in the form of conversations with the available people were conducted at the Ministry of Health. This was done as a way to understand the health related dilemmas as well as to know the existing strengths and information related problems facing the sector, for example the present problem of high maternal mortality rate in Mozambique. These interviews were also important to gain more knowledge about health related concepts, for example about health indicators and coverage.

Subsequent interviews took place during meetings and presentations. Four presentations and discussions on the GIS prototype were conducted. Other meetings and discussions were conducted with future system users, that is, the health program managers mainly responsible for planning project implementation, and to clearly identify their requirements and expectations regarding the system to be developed. I also conducted two non-structured interviews in the PAV Section with the staff who deal with the immunization data. I asked them about how they performed their daily work, what kind of analysis they made, and how the GIS tool could be useful. In total, I conducted four presentations and discussions, and 12 interviews with health managers and future system uses. All the interviews and meetings were in Portuguese, which is the official language of Mozambique. Relevant excerpts from these interviews were later translated to English by the researcher for the purpose of thesis writing.

Non-structured interviews and discussions proved to be a powerful way to get the necessary information, and also to build the motivation that led to the subsequent formal project acceptance. Semi-structured interviews and discussions were useful because they gave freedom to those who knew the situation to explain it using their terms, as compared to the short and closed answers that are required in structured interviews. Silverman (2001) argues the usefulness of semi-structured interviews, explaining that they give more freedom to both the interviewer and interviewee to ask and give further elaborations, and provides a better way to obtain a more authentic understanding of people’s experiences (Silverman 2001).
4.3.2 Document and software analysis

Documents are very important in collecting qualitative data. In this case study, document and software analyses were used for data collection and interpretation process. Comparisons were made between the situation analyzed through the software, what was recorded in the documents, and what people said about the situation. These different perspectives helped to develop a relatively broader understanding of the larger cultural and social-technical context in which the study was situated. Atkinson and Coffey (2000) argue:

> If we wish to understand how organizations work and how people work in them, then we cannot afford to ignore their various activities as readers and writers. Moreover if we wish to understand how the organizations function, then we also need to take account of the role of recording, filling, archiving and retrieving information.

(Atkinson and Coffey 2000:46).

Various documents were studied including monthly and annual reports provided by the CHD, and also the existing and also newly proposed data collection and reports format. From this analysis, I understood the problem of legacy systems that influenced the existing information flows. I also analyzed the SIMP software that was used in MISAU, and the DHIS software that was going to be used for the GIS application.

Other secondary sources of data studied related to relevant literature on HIS and GIS implementation in developing countries. Especially relevant was the PHD, Masters theses and other journal publications of Mozambican researchers, and also the official MISAU documents including books and electronic articles. I also visited official websites for some government institutions including National Institute of Statistics (INE) at: http://www.ine.gov.mz, from where I obtained data on the distribution of the population over the country.

4.3.3 Fieldwork documentation

I used field notes to document the interviews, discussions and my analysis of several documents. My data were primarily ‘words’ supplemented with written materials, which I organized as field notes. By the end of the day, I organized the field notes taken, making comparisons between what was reported and what I analysed from the documents. This helped
in making me gradually more familiar with some basic and important health concepts such as how the indicators were calculated, as well as in understanding the related problems like discrepancies between the extracted data from SIMP and the data collected at the province. The fieldwork notes were also important inputs for the next day of fieldwork or for planning the next stage of the research. For example, by organizing my fieldwork, which I conducted earlier in Inhambane and Gaza provinces, I could design my fieldwork at the CHD in a more realistic way. The documented field notes were also helpful to assist the research team in making strategies for project implementation; for example, on how to collect maps from different institutions.

4.3.4 System prototyping
Prototypes are ‘instruments’ used within the software development process, and different kinds of prototypes are employed to achieve different goals. The advantage with prototyping is that the resulting system is more easily used and maintained than as compared to system development using other kinds of methods. User needs and problems are detected earlier and the design is potentially of higher quality and requires less effort to be used (Sommerville 2001). A system presentation through prototypes was chosen as a way to minimize system complexity and the fear of change, which users may have. However, the prototyping of the GIS software involved different cycles, where the spatial and non-spatial systems were modified, changed and customized according to the CHD’s socio-technical conditions. This includes the proposal writing stage for development of the GIS tool for heath care support, language translations and the difficult process of data gathering and the population of the database.

4.4 Data analysis
The process of data analysis was undertaken in parallel with the conduct of the empirical research. The focus was on understanding the current HIS, its characteristics and the existing working practices and how these influenced the GIS development and implementation. In the prior field research in two provinces Gaza and Inhambane, the DHIS software used was analyzed, which was important to understand the GIS application design. For example, in the
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health facilities and health directorates were the DHIS software was installed, I used to observe and check the data to see when was the last time data was entered into the system. When I found that data was not up to date, that is the DHIS software was not being used, I asked the health staff the reasons for this. Various reasons were provided including the absence of formal orders to do so, existing work load, the legacy systems and inadequate infrastructure. This helped me to develop a deeper understanding of how the work practices were shaped and its influences on the introduction of the GIS application to support HIS. While analyzing and writing up the findings from this research, the reading of available literature helped to further develop a theoretical basis to understand the current HIS, information flows and the relationship between the work practices and the GIS system introduction.

In subsequent visits to the field research, particularly in the CHD Ministry of health, the analysis of the empirical data collected were discussed with various staff including research advisors, health managers and other health staff. In addition to understanding user requirements, the various discussions helped to gain and understand feedback to our analysis, which helped to further enriches the understanding process. Basically, the data analysis process consisted of grouping observations and other data, discuss them with other researchers and also with the Health department staff. This process of discussion helped to develop coherence in my interpretations, and a stronger background understanding of the organizational context. Thus, a process of cultivation can be seen to characterize the analytical work, where inputs were coming from various sources including user comments and reviews, literature reading, presentation of system prototypes, and informal conversations with other researchers and researches advisors.

Qualitative methods were applied within an action research framework, and this was in line with the HISP approach more generally, which has been described as the networks of action (Braa and Blobel 2003). This is briefly presented in the next section.
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4.5 HISP experience in information systems development

The Health Information System Project (HISP) is a research and development project, which was established in 1994 by researchers from the University of Oslo Norway and universities of Western Cape and Cape Town in South Africa (Braa et al. 2004). HISP has developed free and open source software, the District Health Information Software (DHIS), which can be used to conduct analysis of health data principally at the health district. DHIS is Microsoft based running in Microsoft Windows and Microsoft Office (Access and Excel). The project is now going on in several developing countries, at different levels of implementation, including South Africa, Mozambique, India, Tanzania, Ethiopia, Malawi, Mongolia, Cuba, Nigeria and China (Braa et al. 2004). South Africa has adopted the HISP strategies, processes, and the software as the national standard since 1999 (Braa et al. 2004). In Mozambique the software was prototyped and is now deployed in some districts of the three provinces of Gaza, Inhambane and Niassa.

1. HISP was introduced in Mozambique through the Eduardo Mondlane University in collaboration with the Ministry of Health of Mozambique in 1999 (Braa et al. 2001). The philosophy behind HISP was to facilitate and encourage local analysis and use of information, empowering local authorities and strengthening horizontal flows of information and knowledge (Lungo 2003). Thus, the primary goals of HISP has been described as “development of essential data sets and standards for primary health care data, and development of a software supporting the implementation and use of such data sets” (Braa et al. 2004:118). Thus, enabling the design, implementation, and sustainability of HIS following a participatory approach to support local management of healthcare delivery and information flows in selected health facilities, districts, and provinces, and its further spread within and across developing countries. The project implementation started with three pilot districts located in three different provinces namely Chokwe District in Gaza Province, Maxixe District in Inhambane Province and Cuamba District in Niassa Province (Braa et al. 2001).

The project is being implemented and has involved the full translation of the DHIS software into Portuguese, creating training manuals in Portuguese, populating the DHIS database with health data, and maintaining an up-to-date list of the health facilities in the three pilot sites.
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(Lungo 2003). Based on my empirical analysis of the HISP implementation process in two provinces of Gaza and Inhambane conducted in March 2004, I argue that this implementation has not been a straightforward process. For example, the existence of other legacy software being used at the provincial levels are making the DHIS software to be unused, since the reports being sent to the national level are generated using those legacy systems. This also has an impact on the new GIS tool that is being developed, since the application is expected to use the data from the DHIS software.

In conclusion, in this chapter, I have presented my research design and approach, qualitative research methods used including data collection techniques, data analysis and the HISP experience in HIS development. In the next chapter, I present a detailed description of the case study followed by its analysis.
In this chapter, I describe the case study developed based on the fieldwork conducted at the Community Health Department (CHD) of the Ministry of Health, Mozambique. I begin by giving an overview of the case background. The findings presented here, are mainly from the interviews with the people working at the CHD, from what I observed at the work settings, and the analysis of secondary material, including documents and software. The chapter is organized as follows. Following the background to the case presented in section 5.1, I provide a brief description of the main participants in the research. In section 5.2, I present the research environment built during the course of the action research. The situation analysis and the process of collecting the maps that were used in the GIS application are presented in section 5.3. Section 5.4 presents a discussion on the process of the GIS application development divided into three sub-sections: the process of building the non-spatial database (5.4.1); the process of building the spatial database (5.4.2); and, the process of software customization (5.4.3). Finally in section 5.5, I present a short discussion on the evaluation of the application by the CHD.

5.1 Background
This study aimed to develop a GIS-based spatial analysis tool for the Ministry of Health (MISAU – Ministério de Saúde in Portuguese). The tool was expected to be used by the managers in the CHD mainly to monitor the spatial distribution of diseases, and to conduct spatial analysis of the quality and quantity of services provided such as PAV (Programa Alargado de Vacinação) and SMI (Saúde Materna Infantil) in relation to the distribution of infrastructure including the health facilities. In addition, the tool will be used to generate maps that can be used in MISAU for several reports and presentations, for example the maps were intended to be used in making presentations in national meetings, and also in reporting the activities of the CHD for international donors.

The project was conducted through a team of three students as a part of their Masters thesis. The three students are members of the HISP program in respective countries, two in
Mozambique (including myself) and one in India. Structurally, in each country that HISP is introduced, it is through collaboration agreements between the University of Oslo (Norway), local universities and the Ministries of Health. The key components of the collaboration include health information design and development; education and training; and financial support (Braa et al. 2004). Thus, the aim of the Masters program was to draw theoretically upon the studies at the Department of Informatics at University of Oslo with funding from the Norwegian government, and empirically upon the HISP project. The action research adopted helped to link there theoretical and practical components.

The Ministry of Health comprises of four directorates: Administration and Management; Planning and Cooperation; Human Resources; and, National Health. The Directorate of Planning and Cooperation consists of three departments: Cooperation; Planning; and, Health Information. The Department of Planning is responsible for the health data collection and reporting. The National Health Directorate contains the CHD and the Pharmacy Department. The work presented in the thesis is related to the CHD. The next section provides a brief description about the CHD and its programs.

5.1.1 The Community Health Department (CHD): the potential of GIS

The CHD is responsible for the organization and monitoring of health services provision to the community. The health services include vaccinations for the children and mothers, nutrition, health education, antenatal and postnatal care, and public health education. The PAV and SMI are subsections under the CHD that deal with immunization, and mother and child care respectively.

The CHD is one of the main targets of the health sector reform, including strengthening the provision of primary health care and to decrease mother, child and youth mortality rates within the community. Mother and child health as well as adolescent health care are designated priority areas for the CHD. According to a MISAU report of 2003, the specific objectives of the CHD are as follows:

- To provide attention to the preventive and curative health care as a way to increase the quality and the coverage of the services provided;
- To develop, promote and support active community participation in health programs; and,
• To strengthen the coordination between sections within and outside MISAU.

To fulfill these objectives, the CHD has developed a list of indicators that can be categorized into three areas namely: mother health care; adolescent health care; and, infantile health care. Appendix A shows the list of indicators from these three areas. Indicators are the most important analysis information which helps to represent the performance of health facility, district, province or country in relation a particular service, such as infant mortality rate (IMR), maternal mortality rate (MMR), and other performance indicators like immunization coverage, etc. These indicators are generally calculated using specific formulas and measured as a percentage or rate. For example, immunization is measured as coverage and maternal mortality is measured as rate. It is through the use of indicators that comparisons can be made about performance between facilities, districts, provinces and countries.

Currently, the CHD is using the national level routine data provided by the Department of Planning, which collects and analyses these data using SIMP software. This software was developed in house by a foreign expert employed by MISAU at the Department of Planning, and was seen at that time as a temporary solution to store and process health data from different programs. Subsequently, the software was implemented in all provinces and at the national level in 2001. SIMP software can be described as integration and planning tool, designed locally by MISAU as a temporary solution for monitoring and planning purposes. This tool was made to handle data from provincial up to national levels. It is basically a set of spreadsheets that captures data from other systems and integrates into one, and technically does not support the validation rules in data entry and does not enable the local analysis of data. SIMP collects data in different tables from SISPROG, and some are manually entered, as SISPROG is not handling all the data forms that have been identified after its initial design (Nhampossa 2005).

The staff at the CHD calculates the coverage of PAV services by comparing the calculated targets with the total number of children who were vaccinated for a particular type of vaccine for each district or province in a particular time period. Based on this, they classify the immunization coverage of the districts or province into three categories: “Bad”,

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1 Sistema Integrado de Monitorização e Planificação in Portuguese
“Reasonable” or “Good”. This analysis is conducted every month and year producing monthly and annual reports for all the districts and provinces. However, this analysis cannot provide easy and effective answers to questions regarding the geographical distribution of the services, such as:

- What is the immunization coverage for each district for different periods?
- Which age groups get what level of services from which areas, and which group or areas are not well covered?
- What is the level of accessibility of each health facility in terms of roads and distance?
- What is the geographical distribution of health facilities in relation to the population distribution in each particular province? and,
- Why do some provinces and districts achieve a high coverage while others do not?

The use of the GIS application can potentially provide a better means of such analysis through the use of maps that can show relationships between spatial parameters such as roads and the distribution of health facilities, and non-spatial attributes such as maternal and infant mortality rates. This potential of GIS to support the various services being provided by the CHD was well recognized by the Director. He thus was the primary motivator in initiating this project, giving the research team detailed suggestions on how to proceed, helping to solve operational problems as they arose, for example in the access of maps, and then at the end in making the evaluation of the application developed by us.

5.2 Building the research environment

Following a participatory action research approach, the research team consisted of both academics and practitioners. The academic side comprised of the three masters students including myself, who were also the developers of the GIS application. The team of students was supported by three research supervisors, one from the University of Eduardo Mondlane and two from the University of Oslo. At MISAU, the Director of CHD and other officials were involved in both the process of studying the project requirements and planning, and helping to solve operational problems as and when they arose.

To help organize access, the software development team (comprising of the three masters students) arranged to contact the responsible persons at the MISAU with the authority to
initiate the GIS project at the national level. As a starting point, an informal meeting was conducted in May 2004 with the Director of the CHD. Following this meeting, a series of meetings and presentations were conducted aiming at studying the CHD requirements as well as to gain acceptance of MISAU. In this process, the Director of Planning also acted as a facilitator to the project establishing necessary contacts with the important persons and institutions, for example to aid the access to maps.

5.3 Situation Analysis and identifying user and software needs

It is imperative that the needs of the end-users are defined and understood before building any GIS application. A good understanding and prioritization of explicit needs can be translated into data and application requirements. However, there is also the need to impart a degree of flexibility into the process to keep the space for incorporating evolving and new needs.

During the time of my entry to the fieldwork, I had a brief exposure of the problems facing MISAU related to the HIS. However, this limited exposure could not give me wider view of the real situation, and hence I had to conduct a deeper analysis of the situation thereby exploring the experiences from those people who were working in the real situation. The brief picture of the HIS I had was mainly obtained from the study of relevant literature, and also relevant reports from MISAU. The general understanding of the problems is also drawn from the experience of the fieldwork I conducted prior to the project of GIS development. This early experience is briefly discussed in the next subsection.

5.3.1 Previous relevant experience

Prior to this study, I participated in two weeks of fieldwork experience in two provinces of Gaza and Inhambane between 15 and 26 of March 2004. The main objective of this study was to conduct a situation analysis of the existing information systems thereby exploring the procedures and tools used to collect and store data; how the data was transmitted within and from the local to the upper levels, and how the data was being disseminated and used. This analysis helped to identify more broadly the problems related to the current HIS and how the prototyped software system DHIS was being used, and also could potentially be used, at the district and provincial levels.
In this fieldwork, we (HISP team members, and Master students including myself) intended to present the GIS application that was designed for the health care sector in India. This was to show what was being done in India and how it could be adapted to Mozambique. The presentations were made to the provincial and district health managers, while at the same time we were analyzing the real use of DHIS software, and how the design of the GIS application could be based on and be integrated with the DHIS software. During the fieldwork, we realized that the health managers were very interested in how the GIS application could be potentially used to draw the maps to show the real situation of each province, even though we used data that was not updated. The potential and attractiveness of maps for them was evident. For example, the picture of BCG rate in Gaza province in the period of two year (2001 and 2002) categorized in districts was illustrative (see Figure 5.1 below shows one screen shot of the GIS application used during the presentation in Gaza province), and the managers asked for more of such maps.
5.3.2 Information situation analysis and maps collection

To help organize access to data, the software development team first arranged to contact the responsible persons at the MISAU with the authority to initiate the GIS project at the national level. As a starting point, an informal meeting was conducted in May 2004 with the Director of the CHD. In this meeting, we discussed our plans to introduce the GIS technology and we presented the GIS application developed in India that could be customized for use in Mozambique. This GIS application was originally designed by one of the Indian Masters student who was also part of the research team in Mozambique. This application was still in the process of being improved, and still has not yet reached a stage of full scale field level implementation in India.

After this presentation, the Director of the CHD showed great interest in the project idea and was actively involved in the project, taking necessary steps to provide access to relevant people and data. We started by preparing a formal project proposal in English (see Appendix B) that was later translated into Portuguese. In writing this proposal, we were
assisted by the Professors from the University of Oslo and from the University of Eduardo Mondlane who were also supervising the research. The Portuguese version of the proposal was then submitted to the CHD, that was later accepted and the project continued with support from the Ministry of Health.

In order to gain knowledge of the work practices at the CHD, we were given some relevant departmental documents, including monthly provincial reports, annual department reports and the books showing guidelines, and the new list of indicators, which were still in the roll-out process at the time of this study. Many of these indicators could not be calculated because the relevant data required for its calculation was not being collected through the SIMP software (that was used to compile the routine health data nationally). Table 5.1 shows one of the lists of the revised indicators for PAV program, about half of which were new and not covered in the SIMP software.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Definition</th>
<th>Indicador Continua?</th>
<th>Situation</th>
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<tr>
<td>Taxa de cobertura BCG)</td>
<td>TC BCG= Crianças vacinadas x 100 Nr. Total de crianças (G.alvo) A % de referencia é 90%</td>
<td>S</td>
<td>Collected</td>
</tr>
<tr>
<td>Taxa de cobertura (Sarampo)</td>
<td>TC VAS= Crianças vacinadas x 100 Nr. Total de crianças (G.alvo) A % de referencia é 80%</td>
<td>S</td>
<td>Collected</td>
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<tr>
<td>Taxa de cobertura de (DPT HepB 3)</td>
<td>TCDPT HepB3 = Crianças vacinadas x 100 Nr. Total de crianças (G.alvo) A % de referencia é 80%</td>
<td>S</td>
<td>Collected</td>
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<tr>
<td>Taxa de cobertura de POLIO 3</td>
<td>TC Polio3= Crianças vacinadas x 100 Nr. Total de crianças (G.alvo) A % de referencia é 80%</td>
<td>S</td>
<td>Collected</td>
</tr>
<tr>
<td>% Crianças completamente vacinadas&lt; 1 ano idade</td>
<td>CCSV= nr crianças vacinadas &lt; 1 ano x 100 nr. Total de crianças &lt; 1 ano de idade A % de referencia é 80%</td>
<td>S</td>
<td>Collected</td>
</tr>
<tr>
<td>TC de gravidez Protegida GP)</td>
<td>GP= Nr. Grávidas com 2 ou mais doses de Vat X 100 Nr. Total de grávidas previstas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Indice de quebra vacinal

\[ IQ = \frac{DPTHepB1 - DPTHepB3}{DPTHepatiteB1} \]

% de distritos com as taxas de cobertura agrupadas (<50%,50-79% e 80%+)

\[ \text{Nr. de distritos distribuídos de acordo com as taxas de cobertura dentro de um determinado intervalo dividido pelo nr. Total de distritos, multiplicado por 100, por cada antígeno.} \]

Taxa de desperdício

\[ TD = \frac{\text{Doses desperdiçadas-doses aplicadas} \times 100}{\text{Total de doses desperdicas}} \]

% contribuição de vacinação das brigadas móveis

\[ \% \text{ b.m.} = \frac{\text{Aplicadas h.m. x 100}}{\text{Total aplicadas (pf+ h.m.)}} \]

% de áreas visitadas pelas brigadas móveis

\[ \% \text{áreas visitadas} = \frac{\text{nr. áreas visitadas x 100}}{\text{nr total de áreas planificadas}} \]

% de unidades sanitárias com ruptura de stock de vacina

\[ \% \text{US's c/ rupt.} = \frac{\text{Nr. US's c/ ruptura stock x100}}{\text{Nr. Total de US's existentes}} \]

% de unidades sanitárias com ruptura de stock de petróleo

\[ \% \text{US's c/ rupt.} = \frac{\text{Nr. US's c/ ruptura stock x100}}{\text{Nr. Total de US's existentes}} \]

% de US's com ruptura de stock de AD seringas

\[ \% \text{US's c/rupt.} = \frac{\text{Nr de US's com ruptura stock x100}}{\text{Nr. Total de US's existentes}} \]

% de US's com ruptura de stock de Caixas incineradoras

\[ \% \text{US's c/rupt.} = \frac{\text{Nr de US's com ruptura stock x100}}{\text{Nr. Total de US's existentes}} \]

% de postos fixos de vacinação com geleia avariadas

\[ \% \text{PF} = \frac{\text{nr. total PF c/ geleia avariadas x100}}{\text{Nr. Total de postos fixos existentes}} \]

% de novos postos fixos de vacinação por abrir

\[ \text{Novos p. fixos x100} \]

Table 5.1: List of revised indicators from PAV Programme. Source: Fieldwork at the Community Health Department, May 2004 – February 2005.

We were also advised (by the Director of CHD) to use the MISAU library as another source of useful materials to supplement what we had. However, this library was not very helpful because it did not have up-to-date materials regarding our needs. The library officer told us that the most updated and important books and others documents were kept in the managers’ offices and not the library, and were not early accessible.

The team also participated in several meetings scheduled by MISAU with us. The ongoing discussions helped to raise the awareness of the GIS potential to the health managers in MISAU and hence make the project attractive to the managers. Through these meetings, the software development team also became more familiar to some basic and important community health concepts, and also about the procedures, routines, and formats for data collection and reporting. For example, the significance of the data displayed during the presentations had different interpretations to us and to the health managers. Since we (the software development team) had a background in informatics, we had a very limited exposure to public health. Discussions with the CHD staff helped us to develop at least some working knowledge of the terminology used, for example, the concept of indicators.
and coverage. These meetings helped us realize the need to have some basic concepts from the public health that could provide a common ground for understanding the real situation as well as to enable us to effectively communicate with the CHD staff. Since the process of developing the system’s specifications needed to be influenced by the working staff, their active participation was seen as compulsory. This would also help to create an enhanced mutual learning environment in which the researchers and practitioners could learn from each other.

Subsequently, in April 2004 we conducted a formal meeting at the CHD. Considering the importance of the project, the Director of CHD invited the Director of Planning and the HIS Section staff to attend, as a means to get broader support for GIS from the different stakeholders within MISAU. In this meeting, the Director of Planning mentioned that there were some ongoing GIS projects in other sites in Mozambique, including for Poverty Reduction through food and livelihood security in Zambézia Province, and to control malaria also in the province. The projects, we were told, were adopted to help analyse themes such as the influence of land degradation on incidence of infectious diseases, situating human health in land-based notions of sustainable development, and identifying correlations between environmental health care and land-based Poverty Reduction policies. Another project mentioned by the Director of Planning was on Capacity Building in geographic information for Sustainable Development at the Geographic Information Centre of the Catholic University of Mozambique (CIG-UCM)² in Sofala Province. The core issue in this project was to try to establish a well-trained and well-equipped GIS-Centre within the University in Beira to undertake training on GIS and Remote Sensing. During this meeting, it was realized by us that all the maps used in these projects were provided by INE. The Director of Planning suggested that we should contact the staff of INE in order to share the experiences and resources (maps) of these ongoing projects. The Director also suggested that the software development team should contact the Ministry of Education, as they were involved in a GIS project for mapping schools in the country.

We then visited the Ministry of Education in May 2004, where we met the Director of the GIS project with the aim to develop a closer relationship and to know what technology they used and how it was used. The Director of the project then showed us the application

² Centro de Informação Geográfica – Universidade Católica de Moçambique in Portuguese
software they used. This software uses Microsoft Access platform for non-spatial data and MapInfo for spatial data to help map the schools in different provinces. The Ministry of Education used maps from INE, although for various reasons they said it not possible for them to share it with us. However, through this interaction we at least gained knowledge about the project and its operation. In October 2004, we started to incrementally incorporate the requirements from the CHD and build the spatial database. The maps used for this had been obtained by us earlier during the GIS course offered at Department of Informatics, University of Oslo in Fall 2003. This data had been obtained originally from INE in a CD containing 1997 census data.

5.4 System Design and prototyping

In this section, I explain the process of building the spatial and non-spatial databases and how they were linked. From the initial stages of the study, the CHD had emphasized the need to use only the official data given in their reports at the national level. The data was trusted by them because it was the only official data, which was provided by the SIMP software to the Department of Planning. The main aim of our proposed application was to use the available data in the GIS application in order to support the spatial monitoring and decision-making processes at the CHD. Therefore, there was a need to study the SIMP software since it was the main source of the non-spatial data required by us for our application.

5.4.1 Building the non-spatial database

The SIMP software, the key non-spatial data source for the project was studied by the research team. This software is an integrating spreadsheet system that was implemented in all provinces and at the national level. In addition to the routine health data, the SIMP software includes financial logistics and the epidemiological data. While the process of studying the SIMP software was going on, other activities such as customizing the GIS application was taking place in parallel. These activities started in May and continued up to October 2004. Despite the SIMP software being installed and used at MISAU, access to the source code was still controlled by the foreign expert who developed the software. The process of getting to know the source code and how to use the SIMP software was strongly dependent on its developer. Moreover, the software required a zip drive for its operation and we did not know that in advance. We usually used to try and install the software from
the flash disks. The installation processes usually looked to be proper, but the software would then crash while it was being used. We finally realized in September 2004, three months after the first installation, that this was caused by bad installation mainly because of the use of non-zip disks. Unfortunately, the developer did not mention this to us before, apparently for the reason to keep control of the source code, and in the process we lost valuable time.

After the successful installation of the software, the team worked on attempts to link the SIMP directly to the GIS application. In October 2004, one month since we began working with the SIMP software, we realized that it was not possible to link it to the GIS application, as SIMP software did not use any database but only spreadsheets to store data. Furthermore, we could not access the SIMP software source code software since it was password protected. Also, SIMP did not support the calculation and reporting of most of the new indicators. Therefore, this solution of linking SIMP to the GIS was unfeasible, and we decided to adapt an alternative solution to use the DHIS software because of the structure of non-spatial data as well as the fact that it was database based.

The GIS application that we were using was originally designed to get the non-spatial data from the DHIS software. Therefore, this alternative solution to import data from the SIMP software to DHIS was very practical and feasible. However, this linking could not be done easily, since there was no readily available data, and required the development of an additional routine to enable direct import of data from SIMP to DHIS. However, in absence of access to the SIMP source code, we could not automate this process and therefore, opted to manually enter the data from SIMP to DHIS. As a strategic solution, a new database was created to handle data only for the CHD. In this database, we used districts as the lowest level in the DHIS software hierarchical structure instead of health facilities, mainly because the SIMP software did not handle data at the health facility level. Figure 5.2 shows different sources of data to build the GIS application. Non-spatial (PAV and SMI) data manually was entered from SIMP into the non-spatial database built under the DHIS structure, and also other relevant data such as population.
The non-spatial data was populated into the DHIS database including the population data from the 1997 census and routine data for SMI and PAV from 2001 to 2003 (imported from the SIMP software). To perform the data entry task we first hired three people, one from MISAU and two from the Department of Informatics at the University of Eduardo Mondlane (UEM). Soon, the two students we hired lost interest to continue, and later the person from MISAU did the same. This data entry team worked on the project for two months from June to July. We later hired other two students from UEM to finish the process of data entry. Simultaneously we were involved in the process of data validation, under the responsibility of the two Mozambican master students, as a way to guarantee the accuracy of the data in the software, since the manual tasks were always errors prone to a certain degree. This was done manually by comparing the data from the source SIMP software and the destination non-spatial database.
The data for infrastructure and human resources were not entered because they were not well organized in the SIMP software. For example, the number of health facilities and doctors were summarized at the provincial level making it difficult to know exactly to which district a health facility belonged, or in which hospital a doctor worked. It is important to have such data at the health facility level, as this is the point of delivery of services and thus is more useful here than the higher level for operational support.

During this period of data entry, we developed a temporary database populated with the provincial data that showed the annual summary reports for the provinces. This database was used for presentation purposes to the CHD as a part of the prototyping process in order to maintain the credibility we already had. The non-spatial database used to generate the maps (for example Figure 5.3) was summarized annually for each province. For example, this figure shows the maternal mortality rate in the country for the year 2001 grouped in four categories, and was displayed during the presentation.
Figure 5.3: A map produced by the GIS application showing the maternal mortality rate for 2001 in all provinces.

5.4.2 Building the spatial database

In the initial stages of this process, the team tried to identify the kind of spatial analyses required by the department and how to interpret the analyses. This was done as a way to understand useful non-spatial data required to support their spatial analyses. For that purpose, there was the need to identify the required maps, collect them from the specified sources, followed by the processing of those obtained maps. The developer team, early on with the support of the CHD, conducted the process of identifying the required analyses and obtaining the maps simultaneously.

We started by working with some maps, which were first used in the GIS course offered by the Department of Informatics in University of Oslo, Norway in Autumn 2003. Even though we knew that these maps were not complete and outdated, we decided to use them for the sake of prototyping in order to continue the good relationship that we had established with the CHD. To build up the GIS database, Map Object 2.2 software (an
ESRI product) was used, for the reason of its low cost compared with other ESRI products like Arc Object. Those software packages were already installed in our laptops while taking the GIS course in Oslo.

We later met the Ministry of Education officials in May 2004 as part of the process of getting updated maps. In this meeting, we were not able to get the maps but were advised to contact and use maps from INE. Then we contacted INE from where we obtained maps for two provinces (Nampula and Gaza) that showed the health facilities distribution. With the supervision of a Norwegian GIS researcher from the Department of Informatics, University of Oslo, we started to work on processing those maps.

The work was mainly to harmonize the two databases; the spatial maps database and the non-spatial database in order to have common fields that will be used for the linking process. The common fields that were considered were the health facilities’ names and IDs to provide communication between the two databases. This was done for each province and each district as well as for each health facility in each map respectively. This harmonizing process was done in order to clean the map data obtained from INE. The biggest problem faced in the data cleaning process was the existence of large number of health facilities in the spatial map database as compared to that reflected in the non-spatial database.

To tackle this problem, we decided to go to DINAGECA\(^3\), the official institution in Mozambique dealing with maps. However, it was not possible to get the maps from there because they were very expensive. The cost of the map set for the whole country was about 6,000 USD, which was beyond the scope of our project. We therefore came back to the original maps we were using, (the data obtained from INE) trying to figure out the source of problems in these maps. The Director of Planning, later in February 2005, told the software development team that this problem was because INE was not using the national standards of health facilities categorization. The Director explained that INE staff usually went to the field and asked the residents about where the health facilities are located. The residents would sometime point to houses of other local residents from where they might

\(^3\) Direcção Nacional de Geografia e Cadastro in Portuguese, which now is called Direcção Nacional de Terras (DINATE)
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obtain some health care help. The INE staff marked these houses as health facilities on the map, thus leading to a gross inflation of the numbers of official health facilities.

After the largely ineffective process of getting the updated maps, five months later in July 2004, the Director of CHD advised us to meet the GIS expert at MISAU who worked with the World Health Organization (WHO) on a GIS pilot study conducted in fifteen districts in Mozambique. From him we obtained the following map entities: Lakes, parks, roads, location of health facilities, rivers, airports, provincial and district boundaries at 1:50000 scale for the whole country. However, these data were not very reliable since they were last updated in 1997. Since 1997, many events have happened; the country was affected by natural hazards such as floods, tropical storms and bush fires, the most catastrophic one being the 2000 floods. Some roads were closed and new ones were created, some health facilities did not exist any more and many new ones have been constructed, and significant migration had also taken place. All these attributes had changed significantly over time. The GIS expert explained:

_There is no reliable information from the MISAU. There is a need to be careful with the kind of data which we are trying to show on maps since the GIS application is nonsense without updated data._

_(GIS Expert, MISAU, July 2004)_

However, we were forced to use the same maps since we could not get other maps. The problem of using these outdated maps was made visible during our presentation to the CHD in February 2005. For example, one of the maps used in the presentation like the one in Figure 5.4 aroused the manager’s attention in terms of the percentage of the number of health facilities that were displayed. After realizing that significant number of health facilities were not accessible (in terms of roads), the managers concluded that there were problems regarding the number of health units reported in the INE maps.
After that meeting, the Director of Planning promised to provide us with the list of current health facilities known in MISAU. More or less one year after the project initiation, the managers at the CHD were now more aware of how helpful the GIS application could be to support their everyday work.

With the spatial data we had, we created several map layers and we also conducted different processing tasks like creation of the common field to enable communication with the non-spatial data, cleaning the irrelevant data such as the codification used by INE that differs from the one used in MISAU, which is summarized in Table 5.2. From the country map, we generated the province boundaries and from the province maps we generated the district boundaries. From these maps, we could show other layers such as the roads, parks, lakes, rivers, the health facilities as well as categories of the health facilities. From the health facility distribution maps, we generated: (a) Health post points, (b) Health centre points, (c) Rural hospital points, and, (d) Provincial hospital points.
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<table>
<thead>
<tr>
<th>Map</th>
<th>Process taken</th>
<th>Results of the process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country map with province boundaries</td>
<td>Cleaned, fields added</td>
<td>Field added</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Source</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OrgUnit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Province name from DHIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orgunitshort</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Province short name</td>
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<tr>
<td></td>
<td></td>
<td>Orgunit type</td>
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<tr>
<td></td>
<td></td>
<td>Province</td>
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<tr>
<td></td>
<td></td>
<td>Orgunity ID</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Province ID from DHIS</td>
</tr>
<tr>
<td>Province map with district boundaries</td>
<td>Shape file creation for each province and fields added</td>
<td>Orgunit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>District name from DHIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orgunitshort</td>
</tr>
<tr>
<td></td>
<td></td>
<td>District short name</td>
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<tr>
<td></td>
<td></td>
<td>Orgunit type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Health district</td>
</tr>
<tr>
<td></td>
<td></td>
<td>District ID</td>
</tr>
<tr>
<td></td>
<td></td>
<td>District ID from DHIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Province name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Province name from DHIS</td>
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<tr>
<td></td>
<td></td>
<td>Province ID</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Province ID from DHIS</td>
</tr>
<tr>
<td>Health facilities distribution</td>
<td>Shape files creation for each health facility category</td>
<td>Health post points</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Health centers points</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rural hospitals points</td>
</tr>
</tbody>
</table>

Table 5.2: List of the spatial data attributes created in the fieldwork.

5.4.3 Software customization

The team started the process of software customization in the early stages of the project, including the translation of the software from English to Portuguese. Even though the DHIS is a multi language software that makes the database changing automatic depending on the computer settings, this feature when connected to the DHIS database does not support the GIS application. Therefore, the team decided to manually change the language through the process of redesigning the forms in the software. The process also involved changing the layout of some screens, especially the main screen. To exemplify, I present below Figure 5.5, which shows the original Indian main screen and Figure 5.6 that shows the subsequently customized Mozambican main screen.
Figure 5.5: The original main screen that used in the GIS application
In the customization process, the adaptation of the organization structure was not a straightforward task. The DHIS database used in Mozambique consists of five levels: health facility, district, provincial, national level and a *dummy* national level. In contrast, the Indian health management structure consists of six levels and are all represented in the DHIS database that was used for the GIS application. The lack of the health facility data from SIMP led to the reduction of the number of levels to three with the district being the lowest level. We therefore introduced two *dummy* levels in order to have a five level structure, *dummy* national and *dummy* district. In addition, the lack of updated maps and the use of maps that were not communicating with the non-spatial data, constrained the process in terms of time. The development team couldn’t get the work done by the middle of June, because of the hard task of harmonizing the data, and this process ended up partially in October.

The GIS application we were using was developed using Microsoft Visual Basic 6.0 and used Map Object 2.2 as the mapping software for its operation. Figure 5.7 shows the structure of the GIS application, including the non-spatial data from DHIS, spatial data through Map Object 2.2, and the different iterations between the user and the GIS application. The user is able to do several operations such as data entry, updating and can

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Figure 5.6: The main screen in the GIS application customized for the use in Mozambique.
also run queries of in the database. Similarly, the GIS application can provide user with charts, query results and so on.

![Figure 5.7: Structure of the GIS application.](image)

The application mainly uses the following spatial and non-spatial health data shown in the Table 5.3. In addition, it uses the semi-permanent data like population, target populations for PAV and SMI programs.

<table>
<thead>
<tr>
<th>Spatial data</th>
<th>Non spatial data (2001-2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maps</td>
<td></td>
</tr>
<tr>
<td>Country map</td>
<td>SMI data</td>
</tr>
<tr>
<td>Province maps</td>
<td>Mother and child health indicators</td>
</tr>
<tr>
<td>District maps</td>
<td></td>
</tr>
<tr>
<td>Attributes</td>
<td></td>
</tr>
<tr>
<td>Lakes</td>
<td>PAV data</td>
</tr>
<tr>
<td>Roads</td>
<td>Immunization indicators</td>
</tr>
<tr>
<td>Rivers</td>
<td></td>
</tr>
<tr>
<td>Health facilities</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.3: Spatial and non-spatial data that were used in the GIS application.
5.5 Feedback from the CHD

From the meetings conducted, we realized that more stakeholders, and not just the CHD Director, were interested in the GIS application tool. During the fieldwork, I found repeated comments by people talking about the advantages of using the GIS application. Gradually, the health workers at the CHD, specifically from the PAV section, including the Director, started to take a more active part in encouraging the continuation of the project and provided us with necessary support. For example, following the software presentation and evaluation in February 2005, the Director of CHD expressed regret on why they did not buy the updated maps in the initial stages of the project. Therefore, he requested the Director of Planning to buy the maps from DENAGECA. However, this has not yet been done. The Minister of Health was new, and the Director of Planning said that he needed to wait until the new Minister takes place and gets involved in the whole process. In addition to this, he asked the team to quickly populate the database with 2004 data so that he can use it to produce the 2004 national reports using maps. Additionally, the recommendation made from DCH were towards the training of identified staff in the department, scaling the application to three provinces, establishing mechanisms for sustainability through budgets, infrastructure, staff, reports, etc and strengthening the data sources. He also suggested incorporating the weekly epidemiological data from the BES programme.

It was also suggested to establish a linkage between Brazil and Mozambique. One of the software development team members along with the research supervisor from the Department of Informatics in University of Oslo had visited Belo Horizonte, Brasil in January 2005 to study the GIS system for nearly two weeks. Brasil is a more advanced country with respect to GIS systems and is also focusing strongly on the development of open source GIS system. Building a relationship between two countries would be helpful for Mozambique, which is in its initial stage of using GIS. Such a sharing of software between the two countries is made possible because of the use of the common language of Portuguese.

In conclusion, in this chapter, I have presented a description of my case study detailing the research, which included the research background and environment, situation and needs analysis, the system design and prototyping process, and its evaluation and further
advancement. In the next chapter, I present the analysis and discussion of this case study relating to the design and implementation of the GIS tool for the CHD, MISAU.
This chapter presents the analysis of the case study relating to the design and implementation of the GIS tool for health care support at the CHD, MISAU. The study has helped to emphasize the importance of a socio-technical perspective rather than a traditional technical one to study the GIS implementation process. The GIS application under study cannot be seen as a new technological tool independent of the context in which it is used, but has to be conceptualized in relation to other artifacts that together make up the complex health information infrastructure. Concepts from ANT and information Infrastructure theory are used to emphasize the complexity that surrounds the particular application under study. The infrastructure focus helps to acknowledge the importance of the installed base, and the cultivation approach provides insights into how to integrate the new application with the existing installed base. The thesis started with the following research questions: (1) what are the potential challenges to the development and introduction of a GIS application within the health sector in developing countries? and, (2) how can a GIS application developed for one context be effectively customized for another?

In trying to answer these questions, the rest of this chapter is divided into three sections. In section 6.1, I discuss the importance of the existing installed base and how it influenced the process of system development. In section 6.2, I provide a brief understanding of the cultivation process as applied during the system development process. This helps to outline the approaches to address the challenges identified in 6.1. In section 6.3, I present the synthesis of the empirical analyses.

6.1 Understanding the existing installed base

A key characteristic of information infrastructures is that they evolve over an extended period of time, where the existing infrastructure, the installed base, strongly influences how the evolution process proceeds, and also how the existing can be extended or improved (Hanseth 2002). The evolution of the new infrastructure must carefully consider how the “new” can better fit with the old and extended accordingly. As argued in chapter 2, a GIS for health
application is better conceptualized as an information infrastructure rather than a traditional IS because of the infrastructural characteristics it reflects relating to it being shared, evolving, open and heterogeneous. Such a perspective helps us to view the GIS application as a shared resource, which should not place artificial limits on the number of users, and also on applications. For example, the GIS tool should support CHD managers to monitor and evaluate particular health care services such as SMI and PAV, but also should support the monitoring of infectious diseases (BES), and HIV/AIDS, which come under the purview of department of Epidemiology and Endemics. The provision (or not) of these services will have direct implications on how the systems are used by international agencies like WHO and UNAIDS. There are thus various potential applications of the GIS shared resource across different levels and health programs.

The existing HIS, including the existing forms, reports and reporting procedures, the technology, the work and organizational procedures, together can be seen to comprise of the installed base. Such a perspective sees the network as a socio-technical entity rather than merely technical, and the different elements of the installed base, are interrelated, loosely and/or tightly, and can be seen to mutually influence each other. This installed base together within the structure of the related institutions and organizational procedures surrounding the HIS, form a heterogeneous socio-technical network of actors and their multiplicity of interests. The different actors try to enroll and align the interest of others with their own (Hanseth and Monteiro 1998). For example, Walsham and Sahay (1997) drew upon ANT to analyze the implementation of GIS for forestry management in India. In their analysis, they describe the inability of the central ministry to enroll the interests of the district officers, which contributed to the failure of creating sustainable networks with adverse implications on the implementation processes.

In the case study presented in this thesis, our key interest was to design, develop and implement a GIS tool, and attempt to align the interests of various stakeholders. The implementation was intended to be initially within the CHD, and the procedures that surround its use such as developing the practice of using maps for the monitoring of programs like PAV and SMI. For example, the CHD managers would need to think of the particular issues they
deal with on an everyday basis, such as monitoring of immunization coverage, in spatial terms, and use the map based representations as inputs to their decision making processes. Making this shift is not easy to do for various reasons relating to the history and tradition of how things have been done in the past in the CHD, which is understood using the concept of the installed base. In our case, two key elements can be seen as significantly constituting the installed base; the existing paper forms and the surrounding procedures of their use; and, the SIMP software.

**Existing paper forms and surrounding work practices:** As a starting point, we analyzed several paper forms being currently used at the CHD, which also were in the process of improvement and reform, such as incorporating the collection of new monitoring and evaluation indicators. The existing paper forms can be seen as very important actors, as a major use of the GIS application identified by the CHD Director was to be the spatial analysis and presentation of these newly articulated national indicators. However, the calculation of these indicators requires that the basic raw data be captured, which are registered in the paper forms. Nevertheless, through our analysis we identified that a majority of the raw data required for the calculation of the indicators were not currently being collected in the existing paper forms, requiring a major redesign of the forms itself, and the surrounding procedures around it which would involve the practical use of the forms to collect data routinely. Therefore, the design or redesign process would directly influence how the new system will capture the data from those forms. This further then influences the development of the GIS tool which would need to be integrated with the non-spatial data collected through these new forms.

However, for this study, the technical need for this flexibility (to allow for making changes) in the forms and what is collected through it was technically not inhibiting. The DHIS structure allows the non-spatial database to be flexible enough to handle new health data and indicators, and also being able to integrate with other systems that may be providing inputs into the database. One example of the DHIS flexibility was reflected in enabling the extraction of health data from the legacy system SISPROG and populating the DHIS database with health
data from January 1999 to March 2002, and quickly generating required reports using an extraction, transformation, and loading tool (Skobba 2003).

This technical flexibility in being able to create a central and flexible data storage through the DHIS provides the technical capability to deal with the redesign process. However, a more difficult challenge to changing this installed base concerns refocusing the existing work practices surrounding how users are currently collecting data, and the new practices that need to be incorporated with the new data elements and forms. Various researchers in the past have found that the introduction of new data elements and changing forms to be problematic. These problems arise out of various reasons, such as the lack of training to the health workers; their heavy workload in which providing care to the patients is considered higher priority than administrative tasks of filling forms; the distances which they have to travel to take the forms from one facility to another; and also the multiplicity of tasks they have to engage with (Mosse 2005). There are also technical problems relating to the redesign of the forms in SISPROG, which is a very inflexible system, and also the logistical and material problems, such as the lack of adequate availability of paper and files (Mosse 2005). The effects of these problems is reflected in the fact that changes made in form A04 in 2001 were not reflected in SISPROG, resulting in a non-standard and inconsistent database, as some districts could rectify this problem locally while others could not (Skobba 2003, Nhampossa 2004). In this paper form containing immunization data, (see Appendix C1) the value of the data element Mulheres gravidas was recorded in four different circumstances (in columns 2, 3, 4 and 5) and in the new form the same data element was aggregated into one column (appendix C2). Thus, this became problematic since there was no data element in the SISPROG to handle such new data.

The lack of flexibility to change the non-spatial database for both interconnected technical and social reasons can be conceptualized as the installed base which had a significant influence on the cultivation of the GIS application. The collection of the new data items and the calculation of the indicators, are still fundamentally dependent upon the existing work routines, systems and forms, as they would need to be done by the same health staff within the existing health context. These practices and context have rather limited flexibility to change, and are situated within a historical setting. In this way, new work practices need to be established while also
simultaneously strengthening and improving existing ones in order to collect new raw data in different paper forms and for the calculation of new indicators. Technically, our development team did not have the mandate and capacity to solve this problem, as it was a process that was being driven by the central ministry, over which we had no control, and also it required a much deeper and longer involvement that was not possible within the time and resources constraints of the project framework. In addition, since using these indicators also required a sound understanding of public health issues which we as informatics students lacked knowledge off to a large extent. As a consequence, we could only make suggestions for change, and the new infrastructure seemed to be a in a lock-in state as we could deal with the technical issues but not the interconnected organizational ones. This lock-in state prevented the evolution of the system, and made it difficult to get out of the lock in. While, as the information infrastructure theory suggests (Hanseth and Monteiro 1998), flexible technology can be an important element in order to avoid a lock-in, however, this escape is only partial and incomplete.

However, this obstacle can be addressed to a certain degree through a focus on user training in the field setting on how to collect the raw data in the new forms and later enter them into the software. In this way, the new system must be supported by training in data use and the building of a support network within the organization to enable flexibility and empowerment of the lower levels. These are related to larger level organizational changes involving also in getting the users involved in the system design process. The inclusion of new indicators in the system implies the need for user training to be carried out at multiple levels comprising the HIS, starting from the health facility level where the staff have to collect the data to the higher levels where these indicators are calculated, interpreted, and use to guide action. The integration of the GIS database with the non-spatial database and the used of its outputs thus involves the multiplicity of these levels and the associated practices.

**SIMP software:** SIMP as an installed base, carries the heritage from the prior existing systems mainly SISPROG, as it takes data from it at province level, processes it and provides reports to the national level. In turn, SISPROG carries the heritage from the existing paper forms and work practices, since it is manually populated at the province level with data from the districts.
in the paper forms. Basically, SIMP software collects data in different tables from SISPROG, and integrates it with data drawn from some other tables that are manually entered. This is problematic because of the inflexibility of SISPROG caused by the absence of the source code and relevant documentation required to upgrade and evolve the system in response to the rapidly changing needs of the organization (Nhampossa 2005). SISPROG is a legacy system running on a Microsoft-DOS operating system platform, designed in the Dbase III application, and also supporting the Windows 95 environment. SISPROG was the first software application of the Ministry of Health developed and deployed at the national and provincial health directorates in 1992-1994 (MISAU 1994, Lungo 2003, Nhampossa 2005).

SISPROG has various limitations, which makes it difficult to change. For example it is not possible even to incorporate new attribute data added in the forms or making it run on new versions of Windows platforms (Skobba 2003). These limitations of SISPROG are directly transmitted to the SIMP software which is dependent on it for effective report generation as the data is extracted from SISPROG. As now the needs are quite different from the point when SISPROG was introduced (1994), there are many new forms that have been developed which are not currently included in SISPROG and thus have to be manually entered into SIMP. In this way, the SIMP application is strongly influenced by this installed base, comprising of the existing parallel systems, and the existing work practices such as the manner in which the health staff are used to collect forms in formats that are replicated in the SISPROG user interface.

SIMP was developed locally as a temporary solution in 2001 as an integration and planning tool, for the purpose of integrating the different HISs, which are still in use in spite of various limitations. For example, SIMP is not flexible enough to incorporate new data items and indicators without changing the source code. However, the control of the source code by its developer makes it very difficult for the provincial and district levels staff to make local level changes. The inflexibility of the existing installed base (for example the “lock” on SISPROG), further magnifies by the technical limitations of SIMP (which arises due to its lack of database capabilities, as it is based on a system of spreadsheets). These conditions contribute to make SIMP as a very deeply rigid system, and difficult to link with the new infrastructure.
The examples described above outline the challenges of the installed base and the inertial influences it produces on creating the non-spatial database. In addition, the creation of the spatial database comes with its own complexities and installed base, especially in relation to gaining access to digital maps. Taken together, they constitute a significant installed base that constrains the development of the GIS application.

The importance of spatial data in the health sector is evident, and over ninety percent of health data have been described to contain spatial attributes (White 2002). GIS system development and implementation is constrained by many factors, including political, socio-cultural, organizational, and so on. In our study, these constraining conditions were produced due to reasons of economics (high cost of acquiring maps), awareness (lack of understanding of the use of maps), politics (inertia in disbanding legacy systems) and organizational procedures (such as the lock into forms that were replicated in SISPROG). For example, one of the reasons for not purchasing updated maps at the initial stage of the project was due to its high costs, and this purchase also could not be done because of the political situation of the country at that time due to the forthcoming elections, therefore such decisions were put on hold.

Another problem faced in the development and implementation phases was due to the poor culture of sharing spatial data between institutions, requiring extensive negotiations between the project team and the institutions owning the maps. Spatial data in the Mozambican context currently does not share infrastructural characteristics of a shared resource, and also the complexity of the technology itself imparts a degree of inflexibility in the possibility of changing spatial data by either adding or deleting attributes, and their linking with the non-spatial database.

After discussing some of the challenges in the development and implement of the GIS tool through the concept of the installed base, in the next section, through the notion of cultivation drawn also from information infrastructure theory, I discuss how we tried to address these challenges. While the above discussion helps to answer the first research question posed in this thesis (the challenges to development and introduction of a GIS application), the next section deals with the second question of potential strategies to deal with these challenges.
6.2 Cultivating the installed base

The existence of the installed base discussed in the previous section emphasizes the complexities that surrounds the design and development of the GIS tool for health support. An understanding of this complexity was especially for the development team to get sensitized to the limits of a technical approach and to consider the changes required with respect to organizational work practices. The cultivation approach helps to focus on the limits of human control, and to take a more organic view of the socio-technical infrastructure, and the need for it to be gradually and incrementally extended and evolved over time. Braa and Hedberg (2002) describes some characteristics of the cultivation approach as has been employed by the HISP approach to health infrastructure development in the context of South Africa as follows:

By cultivation, we mean a slow, incremental, bottom-up process of aligning actors by enabling translation of their interests and gradually transforming social structures and information infrastructures where the resources already available form the base. The precise outcome of the design process is not given, but is negotiated within a broader set of goals.

(Braa and Hedberg 2002:116)

In our case, cultivation involved the process of software customization from the Indian context to the Mozambican situation. This involved the establishment of a collaborative research development team including the CHD managers and to help undertake specific tasks relating to non-spatial and spatial database building, and its linkage. Thus, the cultivation approach was carried out over the following incremental steps.

1. **Building the non-spatial database**: As referred to also in chapter five, the use of data coming from SIMP software was mandatory to gain the acceptance of the research and its support from the CHD, as the managers there only wanted to deal with official data which they argued was provided by SIMP. However, the research team aimed to use DHIS database as it was their responsibility to implement it in Mozambique under the HISP initiative. Furthermore, the GIS application for the first prototype in India was linked to DHIS, and since we planned to customize this prototype to the Mozambique context, we were thus in a way locked into DHIS. These alternative preferences (SIMP by CHD and DHIS by us) created a diversity of interests which needed to be reconciled for the project to proceed. There was thus the important need to translate (Monteiro 2000) the interests of the CHD managers to our own,
and also with the proposed technological solution. Possible alternative solutions could have been to introduce changes in the existing work practices at CHD and reconfiguring the SIMP software so as to link it directly to the GIS system. However, the pressure of making such changes needs to be balanced against the conservative influence of the existing installed base (Hanseth and Monteiro 1998). The SIMP software was difficult to change as discussed above for both technical and social reasons, which made us, reject this alternative.

We thus needed to engage in a cultivation process involving extensive field level negotiations in which we tried to show the CHD managers the advantages of GIS in the field level. These negotiations led to the decision to create the non-spatial database based on Microsoft Access under the DHIS structure. The database would then have to be populated with PAV and SMI data from SIMP together with population data from national census 1997. There was then the process of acquiring data which involved searching for the data from CHD, which was provided by the Department of Planning in a spreadsheet format. Afterwards, we adapted the DHIS database to handle the CHD data. The new database was gradually aligned to the existing actor-network.

Following the cultivation strategy, the new database could be seen to serve as a gateway between SIMP and DHIS thus providing a linkage between the two actor-networks. According to Hanseth (2002), when larger networks are already in place, linking them through gateways may be easier than trying to build new one. In this specific case, two larger infrastructures of SIMP (linked with existing legacy systems and the surrounding work practices) and the DHIS (linked to the existing application and our interests) were linked through a gateway which was easier than incorporating all the required GIS functionality into SIMP software. The non-spatial database provided a common storage and understandable source of data, and a platform whereby SIMP and DHIS could be cultivated through a process of extension and improvement to create a common “new” infrastructure. In Figure 6.1, I illustrate how the non-spatial database serves as a gateway between the SIMP and DHIS software. The database built under the DHIS structure contains data from SIMP software.
Chapter 6: Analysis and Discussions

Figure 6.1: shows the linkage between the SIMP and DHIS software

The gateway building process was done progressively through the adaptation of the DHIS software to the non-spatial database. The adaptation process involved a mutual development that resulted in the customization of the DHIS software using SIMP data in order to decrease the distance between the two. The adaptation process consisted on first “cleaning” the database making it able to handle data from SIMP and then manually populating it.

During this process, the team followed the standards (such as the codes to identify health units and districts, their names and categories) stipulated by MISAU and translated them into the non-spatial database. Thus, similar standards were used as in SIMP to support the development of a common understanding between CHD and us, and also helped to reduce the incompatibilities arising from the use of data from different sources. Due to the non-existence of the health facility data in the SIMP software, a dummy level was created. This, because, the hierarchical structure of the non-spatial database comprises of five levels inherited from the DHIS software, which can be treated as a complex installed base itself for this project. The DHIS software is currently locked to the hierarchy structure consisting of five levels: (national, provincial, district, health facility and dummy), as the Mozambique health organizational structure is comprised of four levels (see chapter three). Thus, to solve this problem a ‘dummy’ district level was introduced, see figure 6.2.
However, this strategy employed by us might lead to a future lock in situation when data from the facility level may become available and needs to be incorporated into the application. This complexity can be reduced through training where users are educated on how to change the organizational structure, add, modify or remove health indicators and *data elements* in the database. The possibility of the users to change the structure of the database requires the translations of their interests to those inscribed in the software.

The non-spatial database was built through *extensions* and improvements of the existing installed base (around SIMP) and linked with the database under the structure and functionalities of the DHIS. The *extension* would need to be further extended in the future by redefining the work practices of users in a way that promotes a culture of using data for local analyses and action, instead of for merely reporting. Also, this extension process was also not merely a technical one of exporting data to the new non-spatial database, but since this

![Diagram of Mozambique health organizational structure adapted to CHD context](image-url)
database is embedded in the DHIS software, it implies that the DHIS functionalities replace the existing ones. This involves further training on using the DHIS software, including on the tasks of data entry, database maintenance, calculation of indicators and their addition and definition, and also report generation. However, as the concept of installed base has helped to highlight, making such changes are difficult to do for various historical and institutional reasons, especially relating to work practices.

2. **Building the spatial database**: the cultivation approach in developing the spatial database was initiated through the process of obtaining, preparing and cleaning maps. Although they are currently some signs of change, the culture of using maps on an institutional basis is virtually non-existent in the Mozambique context, particularly within the health sector. Thus, efforts and negotiations were needed with individual institutions to access and use maps. The difficulties experienced influenced the system development process, such as the inherent delays. The lack of standards for spatial data storage meant that there was also the absence of gateways between institutions to enable data sharing, which consequently also affected the system development process. For example, the spatial data obtained from the National Institute of Statistics and from MISAU lacked standards, and so did not communicate with each other, and required their cultivation by the preparation of derived maps that could map out the required relationships between the different entities. This required the establishment of gateways that enabled communication between the spatial and the non-spatial database. This was done through the creation of *layers* and attributing the same *ID* to the same *data element*. Thus, the spatial data was linked to the non-spatial database by creating a common organizational field. Map cleaning and conversion to the common file format also played a crucial and necessary role in the preparation of maps. The development of spatial database was thus done through a small incremental process where the existing digitalized maps were improved during the process and linked to the existing non-spatial database.
3. Customizing the GIS tool and linking it to the spatial and non-spatial database

The first prototype of the GIS tool was developed based on the Indian context, and so its introduction to the Mozambican context required a customization and adaptation process. The challenge then was to examine on how the flexible GIS software was to enable this adaptation process and be further extended to include the functionalities required by the Mozambique health system. Some of the challenges arose from the difference of languages (English in India and Portuguese in Mozambique), and variations in the health structure (different number of levels – 5 in India and 4 in Mozambique) for the reporting system, which was increased by the non-availability of health facility data from the SIMP software. The customization process was thus constrained by many factors including data requirements and the institutional context, which can be described as the inertial influences of the installed base.

To deal with these inertial influences, the customization process, which can be described as one of cultivation, first involved the task of language translation from English to Portuguese, then the user screen adaptation, and subsequently enhancing the functionalities. The GIS tool was localized to reflect the CHD requirements by changing the login screen, which created the linking between the spatial and non-spatial databases. This process was done through an incremental process where strings were being translated, modified and incorporated to enable the system development process. This process was keenly promoted by the CHD Director. Some of the modifications carried out in the other screens and of some basic functionalities such as “add or remove layers.” Through this, the users are allowed to add or remove different layers in the linked map with the non-spatial database; the “Query feature”- by which the user can define queries from the non-spatial database and link it with the map; the “Label feature”- by which the user can label the polygons according to the attributes provided by the map and the non-spatial database.

This customization process was aided by the degree of flexibility offered by the DHIS software as it enabled making changes in the organizational structure (dummy level creation). This provided the localization of the level of analysis in the query feature of GIS application, so that it could be used for analysis at different levels of the organizational hierarchy (national, provincial and district). Thus, in the login screen, the user selection of the maps and database
was automated so that user can choose the level of analysis directly. Thus providing flexibility in dealing with user requirements during the system development was important. For example, during the customization process, an additional spatial functionality was added according to the CHD requirements, which enabled the grading of health performance of districts or provinces with respect to the population coverage by the health facilities. Thus the GIS system could be treated as evolving over time and being adapted from one context to another.

The non-spatial database can contain information that is used in diverse areas of health programs for different purposes. Different interpretations may arise of the data being used by different users. Thus, the infrastructure characteristics of the DHIS software like sharable, flexible and evolving is transmitted to the GIS system as a socio-technical tool. However a multilingual facility from DHIS software was not incorporated to the GIS tool, making the translation process to be done manually. Translation of the basic strings to Portuguese helped to increase the degree of system acceptance in health sector, and also the prior experience of the Indian team member in system development (DHIS) and implementation in health played an important supporting role.

When looking at the GIS application in an II perspective, we can describe it as a larger infrastructure that evolves over time linking with multiple actors-networks. Therefore, the GIS for health support tool can be conceptualized as a socio-technical network consisting of both technical and non-technical components. It comprises heterogeneous networks of actors, knowledge, procedures and routines. Standards had been adopted in order to make the GIS application serve as a “bridge” that supports communication between heterogeneous actor-networks. For example the different ways of categorizing the health facility (referred in chapter five, section 5.4.2) between the MISAU and National Institute of Statistic brought to focus the issue of lack of standards between them. Even though the two actors have similar interests of categorizing health facilities according to their services provisions, they lacked standards that were needed to be built during the process of databases creation. MISAU categorized the health facilities for their monitoring and planning activities and the Institute categorizes the health facilities for the purpose of mapping them. The different interests were aligned in the project through providing communication channels between the two databases
by the addition of the common fields. The establishment of standards around GIS use is needed to strengthen communication between the different institutions involved, and share data without much effort even though the different institutions might have different data requirements. This poses a challenge in Mozambique, where the institutes tend not to engage in data sharing.

6.3 Synthesis of the empirical analyses
The cultivation process in developing both the spatial and non-spatial databases and customizing the GIS tool started with the effort of understanding the existing installed base and aligning different actor interests at various levels. Adaptation of the DHIS software by integrating it with the existing installed base and cultivating the development of the non-spatial database (paper forms, work practices etc) mediated the cultivation process. Integrating the GIS application (which was designed based on the existing infrastructure DHIS) with the SIMP data and slowly enhancing the functionality was a gradual and incremental process. Thus, the empirical analysis in this thesis has been elaborated using two main analytical concepts: installed base and cultivation approach from II theory. These two concepts taken together provide the conceptual basis to address the two research questions that have been posed in the thesis.

The first research question concerns understanding the existing installed base and its surrounding characteristics that could be seen to influence the development process. The basic assumption here is to emphasize the (sometimes adverse) role of history on the existing installed base which arises from different reasons (for example, the existence of legacy systems comprising health information system, the poor culture of using maps in the country, etc), and also the physical and social settings. The concept of installed base is used to emphasize the importance of sustained efforts that are required to deal with these existing constraints, so as to enable the health sector to use the new technology.

The research revealed that HIS developers in developing countries, as well as the managers of the healthcare organizations should consider the process of introducing IT solutions as a staged process which needs to be managed. This study suggests the need to consider the
organizational context when introducing new technologies to a particular setting rather than only the technical aspects. This is because the process is more complex than often visualized. In addition, most researchers focus on the challenges of creating the spatial database when implementing the GIS rather than just the non-spatial data. However, II theory has helped to emphasize the challenges of also dealing with the non-spatial data, in addition to the spatial, through the cultivation approach. The potential GIS system is fundamentally dependent on the non-spatial component, i.e. if the non-spatial data is not of good quality, the GIS system will also suffer. The issue becomes more complex in the context of developing countries due to the present social, economic, political and organizational settings, which make the acquisition and access to spatial data very complex.

Introducing new IT solutions like GIS is not only about installing the hardware, software and offering necessary training, but it involves a wider process of organizational change and political brokering. The need to identify issues in advance that may facilitate or inhibit changes, and their planning is crucial in order to reduce the gap between the technology requirements and that of reality. These may include identifying the existing staff capabilities in terms of quantity and quality in relation to the requirements of the new technology, and identifying and securing financial support. For example, in Mozambique the updated maps for the project were not purchased by the CHD in time because of the high costs, while in India maps could not be obtained because of security considerations which prevent the free availability of maps to the common public.

The second research question concerns understanding the challenges related to effective implementation of a technology that was designed in one context and introduce to another through cultivation approach. The basic assumption underlying the use of this concept is to emphasize the complexity related to the context. II theory has been used to guide IS design in the context of the developed world, and also is helpful to guide efforts of creating a GIS application in a developing country like Mozambique. As a strategy, to decrease gaps between different networks, the concept of gateways was used, and the extension took place in small and incremental steps with a focus on a particular part of a larger installed base, and its gradual extension over time. Basically, the concepts of installed base, cultivation, and their
interlinking helps to both analyze the existing challenges in developing and introducing the GIS tool and aligning it with the HIS.

In conclusion, in this chapter, I have presented the case study analysis through the concepts of installed base, cultivation, and their linkages. These concepts taken together help in answering the research questions posed in this thesis concerning the analysis of existing challenges and approaches in introducing GIS tool for health in CHD. In the next chapter, on conclusions and contributions, I discuss some key contributions arising from the thesis.
In this thesis, I have presented the theoretical framework around the concepts of information infrastructure in chapter 2, and the case study (in chapter 5) followed by its analysis in chapter 6 using some key theoretical ideas presented in chapter 2. The theoretical framework has informed the empirical analysis of our efforts to introduce a GIS tool in the health sector of a developing country context like Mozambique. While the notion of installed base helped to identify the challenges of developing and introducing such a tool, the cultivation approach guided us to focus on the challenges arising from the inertia of the installed base, and possible strategies to deal with them.

This research, I argue makes some important contributions to the research domain of HIS in developing countries more generally, and to the application of GIS technology for health care support more specifically. Most literature in the domain of HIS in developing countries has focused on non-spatial systems, and the challenges introduced with their introduction (for example, Lippeveld and Sauerborn 2000, Sauerborn and Lippeveld 2000, Lippeveld 2001, Braa et al. 2004). However, research into implementation challenges of GIS more broadly in the context of developing countries has remained scant (Sahay and Walsham 1997), and with a few exceptions (for example, Lewis 2005) remains literally non-existent in the domain of primary health care. What we find however, are numerous examples of the potential that GIS technology offers, for example to map infectious diseases (Gupta et al. 2003, Sipe and Dale 2003), to show the spatial distribution of infrastructure (Ghosh et al. 2003), or to support decision making (Hall et al. 1997) and also to support business decisions (Pun-Cheng and Chu 2004). However, what is often missing in these discussions and examples is the complexity associated with getting these systems to work in practice, i.e. what are the practical challenges associated with their design, development, introduction, and their use. In trying to highlight
and deal with these challenges, I believe my thesis makes a useful contribution to the research domain of HIS in developing countries.

Another contribution of this thesis arises from the identification of the nature of challenges that exist in implementation. Very often in GIS studies, what we find is a discussion of the challenges in obtaining spatial data, including the underlying technical (Alspach 1998, Tom 1994) and institutional (Levinson 1989) reasons for that, and how this impedes the implementation process. However, what is often not considered seriously enough in such analysis is the challenges of getting up and running the non-spatial database that would need to be linked up with the spatial database. In the domain of health care, especially, without an effective non-spatial database (for example, containing the disease statistics), the maps themselves are without value as they cannot display, in this case, the spread of diseases across geographical areas. My analysis highlights the importance of this linkage, and draws upon the notion of installed base to highlight what already exists (or not), the non-spatial data, and how this both influences, and in some cases provides some opportunities, to the implementation process.

The use of the concept of the installed base helps to make explicit another contribution, which relates to the multi-level nature of the linkages, and how one depends on another. For example, the GIS spatial database depends on the linkage with non-spatial data. However, as I have shown through the empirical analysis, the non-spatial is not one monolithic entity, but is itself comprised of multiple and interconnected layers. For example, the DHIS (the non-spatial database used in our case), depends on SIMP for the data, but however, SIMP is dependent on SISPROG and various other legacy systems, which in turn are comprised of various paper forms, and the data collecting procedures through which these forms are filled in practice. This multi-level and connected nature of the installed base thus emphasizes that to display certain indicators on a GIS map (as the CHD Director wanted), we need to address the various interconnections right down to the level of the paper forms, and the work practices. This is a complex process of change, and my analysis helps to unpack some of this understanding about the nature of the complexity.
Chapter 7: Concluding remarks and contributions

Another contribution of this thesis comes from emphasizing the socio-technical nature of the installed base. Often the discussion on installed base is confined to the technical influences of the legacy IS (for example Skobba 2003) which tends to largely ignore the various institutional and organizational interests that also are part of the influence and also influence the technical. For example, we noted how the SIMP code, although given to us technically, could not be used by us because its developer was reluctant to let us use the code. As a result, he took more than 2 months to tell us how that should be done. Similarly, with SISPROG, there were interests in MISAU who wanted that systems to continue, primarily for reasons arising from social inertia. The contribution thus arising from this analysis, is to emphasize that the nature of the installed base is socio-technical in nature, embroiled with various interests, and cultivation strategies need to not only deal with the technical legacies but also their interconnected social ones.

Another contribution of this thesis comes in trying out practically different approaches to cultivation in the process of creating the GIS tool. I identified, in our case, to describe cultivation employing a multi-stage process including the building of the non-spatial database, then the spatial, followed by its linkage. Each of these three steps had their own sub-parts and elements of cultivation were inherent in them. For example, for building the spatial database, there were various elements included such as obtaining permissions to access maps, obtaining them, their cleaning, combining, and their incorporation in the database. While this process and approach in our case concerns an application for the health sector, I argue that this can also be used not only for building systems for other domains such as education or rural development in Mozambique, but also in other developing countries more broadly.

The thesis also contributes to highlighting a strategy of GIS development based on customizing an application that has been developed in another country (India in this case). In a recent paper, Braa at al. (2004) have argued for the need to strengthen HIS in developing countries through the approach of “networks of action”. This approach lays focus on the sharing of experiences, software products and services, training material, through different nodes of the network in a south-south collaborative framework. Our research has demonstrated how such a network of action can be created within a practical setting, through
collaboration between the members from different countries (India and Mozambique), and while simultaneously developing the capacity of the local team to customize, develop, and support the application in the longer run. Again, I will argue that demonstrating the value of such an approach, and the process by which it can be realized, has broader implications both for the HISP network and also for creating south-south networks for enabling technology transfer in general.

Another contribution is related to elaborating on the mechanisms of cultivation approach in dealing with the GIS application design through the strategy of using gateways in the process of linking incompatible components. For example, designing and organizing non-spatial database, included identification and collection of non-spatial data such as Census data in digital form and routine health data. Thus, despite dealing with the same kind of data, our research illustrated the need of editing the non-spatial data attributes to help transform it into a suitable standard digital form, i.e. to make the database files compatible. Then, a one to one relationship was needed to be established between each of the non-spatial and spatial data fields. Thus, a creation and selection of key fields as a linkage item (such as the census code or ID) was required. This was done through a process of cultivation allowing the socio-technical components to extend and evolve over time. The extensions and improvements of the aligned components were conducted gradually, following spatial stepwise changes of the components at a time, which were then aligned to the existing actor-networks. Thus, the alignment was obtained through the practice of gateways, and linking networks internally and to other networks.

Basically, the extensions of II theory and its application for empirical analysis, contribute more broadly to GIS research in general. Some of the specific contributions arising from my analysis concerns the emphasis on the negotiation of the spatial data. This concerned the identification of the nature of the existing installed base in both technical (such as scales) and institutional (ownership of maps) terms. This interlinking of the technical and institutional influences the provision of the matches (in order to provide communication between the maps) and also to establish the linkage between the spatial and non-spatial data.
Like any project of new technology introduction, our project also has some limitations. For example, the limited availability and use of maps in the health sector constrains the implementation and effective use of the application. This problem is further magnified also by the poor state of the non-spatial data. Another limitation, was the unavailability of the sub-district level non-spatial data, which limited the value of the application in providing habitation level maps, such as concerning access to clinics. Such maps could be especially useful to try and develop interventions to address the maternal mortality problem.

Despite these limitations, the thesis makes a modest contribution to understand the complexities related to GIS technology introduction in a developing country like Mozambique. The biggest contribution, it can be argued, comes from developing an awareness about the potential of the technology and also about the challenges to making it work effectively in practice. I feel that our research team has helped to plant a seed that can be cultivated in the future into a full blown and useful application.


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applications in developing countries; Teefelen, V.P.; Gustavson, V.L.; Verkoren, O (ed); Utrecht, 103-109.


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Appendix A: List of Indicators provided by the Department of Community Health

<table>
<thead>
<tr>
<th>No.</th>
<th>Indicator</th>
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<tbody>
<tr>
<td>1</td>
<td>Promocao de US que prestam COEB</td>
</tr>
<tr>
<td>2</td>
<td>Promocao de US que prestam COEC</td>
</tr>
<tr>
<td>3</td>
<td>Cobertura dos partos institucionais em US de COEB e COEC</td>
</tr>
<tr>
<td>4</td>
<td>Cobertura de cesarianas</td>
</tr>
<tr>
<td>5</td>
<td>Taxa de letalidade por complicaçao obstétrica</td>
</tr>
<tr>
<td>6</td>
<td>Cobertura de Consultas Pré Natais</td>
</tr>
<tr>
<td>7</td>
<td>Nº médio de visitas por grávidas</td>
</tr>
<tr>
<td>8</td>
<td>Percentagem detectada de Alto Risco</td>
</tr>
<tr>
<td>9</td>
<td>Cobertura Anti-tetânica</td>
</tr>
<tr>
<td>10</td>
<td>Cobertura Institucional de partos por ano</td>
</tr>
<tr>
<td>11</td>
<td>Cobertura de partos na comunidade por ano</td>
</tr>
<tr>
<td>12</td>
<td>Cobertura Pós Parto no ano</td>
</tr>
<tr>
<td>13</td>
<td>Mortalidade Materna Institucional no ano</td>
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<tr>
<td>14</td>
<td>Proporção de mortes maternas directas institucionais</td>
</tr>
<tr>
<td>15</td>
<td>Nati- Mortalidade institucional por ano</td>
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<tr>
<td>16</td>
<td>Taxa de prevalência anticoncepcional</td>
</tr>
<tr>
<td>17</td>
<td>Taxa de novas utentes de Planeamento Familiar por ano</td>
</tr>
<tr>
<td>18</td>
<td>Casais protegidos ano por depo provera</td>
</tr>
<tr>
<td>19</td>
<td>Casais protegidos ano por Pilulas</td>
</tr>
<tr>
<td>20</td>
<td>Casais protegidos ano por DIU</td>
</tr>
<tr>
<td>21</td>
<td>% de US que oferecem serviços PF</td>
</tr>
<tr>
<td>22</td>
<td>% de comités de MM/PN em funcionamento</td>
</tr>
<tr>
<td>23</td>
<td>Proportion de casos devido de aborto</td>
</tr>
<tr>
<td>24</td>
<td>Seroprevalência de sífilis nas grávidas</td>
</tr>
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<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>27</strong></td>
<td>Percentagem de grávidas testadas para sífilis</td>
</tr>
<tr>
<td><strong>28</strong></td>
<td>Proporção das Maternidades com ESMI</td>
</tr>
<tr>
<td><strong>29</strong></td>
<td>Percentagem das US que oferecem serviço de aconselhamento para violência do género</td>
</tr>
</tbody>
</table>

**SAUDE ESCOLAR E DO ADOLESCENTE**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>30</strong></td>
<td>1. % de províncias com o programa multisectorial de SSRAJ/HIV/SIDA em implementação</td>
</tr>
<tr>
<td><strong>31</strong></td>
<td>2. % de US’s com serviços específicos para adolescentes e jovens.</td>
</tr>
<tr>
<td><strong>32</strong></td>
<td>3. Percentagem de técnicos de saúde formados e prestando serviços de acordo com as normas instituídas pelo programa.</td>
</tr>
<tr>
<td><strong>33</strong></td>
<td>4. Percentagem de SAAJ’s equipados de acordo com padrões nacionais</td>
</tr>
<tr>
<td><strong>34</strong></td>
<td>% de adolescentes e jovens (10-24 anos) por sexo com a 1a relação sexual protegida</td>
</tr>
<tr>
<td><strong>35</strong></td>
<td>% de adolescentes com última relação sexual protegida</td>
</tr>
<tr>
<td><strong>36</strong></td>
<td>6. % de adolescentes de 10-14 e de 15-19 anos que ficaram grávidas</td>
</tr>
<tr>
<td><strong>37</strong></td>
<td>7. Percentagem de nascimentos desejados naquele momento em adolescentes dos 10-19 anos</td>
</tr>
<tr>
<td><strong>38</strong></td>
<td>8. Percentagem de nascimentos institucionais em adolescentes dos 10-19 anos</td>
</tr>
<tr>
<td><strong>39</strong></td>
<td>9. % de abortos atendidos em adolescentes dos 10-19 anos</td>
</tr>
<tr>
<td><strong>40</strong></td>
<td>10. % de complicações de aborto em adolescentes (10-19 anos) nas US</td>
</tr>
<tr>
<td><strong>41</strong></td>
<td>11. Percentagem de novos clientes adolescentes e jovens que visitam os SAAJ’s</td>
</tr>
<tr>
<td><strong>42</strong></td>
<td>12. % de clientes adolescentes e jovens (10-24 anos) nos SAAJ’s que recebem assistência às ITS (informação, aconselhamento, tratamento) e ao HIV/SIDA</td>
</tr>
<tr>
<td><strong>43</strong></td>
<td>13. Proporção de SAAJ’s avaliados como amigos de adolescente e jovem de acordo com o padrão de SAAJ</td>
</tr>
<tr>
<td><strong>44</strong></td>
<td>14. % de adolescentes e jovens (10-24 anos) que referem satisfação com os serviços de SSRAJ/HIV/SIDA</td>
</tr>
<tr>
<td><strong>45</strong></td>
<td>15. % de escolas (EP1 e EP2) implementando o pacote básico do programa de Saúde Escolar</td>
</tr>
<tr>
<td><strong>46</strong></td>
<td>16. % de alunos e professores que têm conhecimento em SSR/HIV/SIDA</td>
</tr>
<tr>
<td><strong>47</strong></td>
<td>17. % de escolas (EP1 e EP2) visitadas no âmbito do Programa de Saúde Escolar</td>
</tr>
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</table>

**SAUDE MENTAL**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>48</strong></td>
<td>Morbidade por TMC (Transtornos Mentais e de Comportamento) no atendimento externo</td>
</tr>
<tr>
<td><strong>49</strong></td>
<td>Morbidade Hospitalar por TMC</td>
</tr>
<tr>
<td><strong>50</strong></td>
<td>Distribuição dos principais TMC por grupo etário e sexo</td>
</tr>
<tr>
<td><strong>51</strong></td>
<td>Distribuição de tentativas de suicídio por grupo etário e sexo</td>
</tr>
<tr>
<td><strong>52</strong></td>
<td>Distribuição de Suicídios por grupo etário e sexo</td>
</tr>
<tr>
<td><strong>53</strong></td>
<td>Prevalência de consumidores abusivos de tabaco, álcool e outras drogas por idade e sexo</td>
</tr>
</tbody>
</table>

**SAUDE INFANTIL**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tr>
<td><strong>54</strong></td>
<td>Consulta 0-11 meses para consulta da criança sábia</td>
</tr>
<tr>
<td><strong>55</strong></td>
<td>Morbidade específica (ih), (pneumonia, diarreia, malária, anemia, sarampo, malnutrição e HIV/SIDA)</td>
</tr>
<tr>
<td><strong>56</strong></td>
<td>Mortalidade específica (ih), por pneumonia, diarreia, malária, anemia, sarampo, malnutrição e HIV/SIDA</td>
</tr>
<tr>
<td><strong>57</strong></td>
<td>% de US c/ Trabalhadores de Saúde treinados em AIDS</td>
</tr>
</tbody>
</table>

118
<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>58</td>
<td>Percentagem de US tipo 1-2 que tem Quinino e Cloranfenicol para tratamento de pré-referência em AIDI</td>
</tr>
<tr>
<td>59</td>
<td>Percentagem de US do tipo 1-2 que fazem Quinino e Cloranfenicol (pré-referência)</td>
</tr>
<tr>
<td>60</td>
<td>Percentagem de crianças observadas pelos três sinais de perigo (Não beber, não mamar e convulsões/ inconsciência), segundo a AIDI</td>
</tr>
<tr>
<td>61</td>
<td>Percentagem de cumprimento de avaliação integrada da criança segundo a AIDI</td>
</tr>
<tr>
<td>62</td>
<td>Percentagem de crianças observadas devido a presença de tosse, diarreia e febre</td>
</tr>
<tr>
<td>63</td>
<td>Percentagem de crianças cujo peso foi observado no Cartão de Saúde da Criança durante a consulta AIDI</td>
</tr>
<tr>
<td>64</td>
<td>Percentagem de crianças necessitadas de antibiótico e/ou um anti-malárico orais prescritos correctamente</td>
</tr>
<tr>
<td>65</td>
<td>Percentagem de crianças precisando de referência (assistência num outro nível de atendimento) que estão correctamente referidas.</td>
</tr>
<tr>
<td>66</td>
<td>Percentagem de crianças a quem foi prescrita medicação oral cujo acompanhante está informado sobre como administrar o tratamento</td>
</tr>
<tr>
<td>67</td>
<td>Taxa de Mortalidade Neonatal</td>
</tr>
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**SAUDE ORAL**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>68</td>
<td>% de extracções dentárias</td>
</tr>
<tr>
<td>69</td>
<td>% de obturações dentárias</td>
</tr>
<tr>
<td>70</td>
<td>% de doentes com Tartarectomias realizadas</td>
</tr>
<tr>
<td>71</td>
<td>% de doentes com Alveolites diagnosticadas</td>
</tr>
<tr>
<td>72</td>
<td>Prevalência de casos de Noma em crianças dos 2 a 10 anos</td>
</tr>
<tr>
<td>73</td>
<td>Prevalência de cárie dentária nos grupos etários 5-6, 12-15 e dos 35-44 anos</td>
</tr>
<tr>
<td>74</td>
<td>Prevalência de gengivites nos grupos etários 5-6, 12-15 e dos 35-44 anos</td>
</tr>
<tr>
<td>75</td>
<td>% de casos de Traumatismo maxilo- facial notificados nos Hospitais.</td>
</tr>
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</table>

**PROGRAMA DE TRANSMISSAO VERTICAL**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>76</td>
<td>% mulheres grávidas aconselhadas no GATV-PTV</td>
</tr>
<tr>
<td>77</td>
<td>% de mulheres grávidas que testadas</td>
</tr>
<tr>
<td>78</td>
<td>% de mulheres grávidas HIV +</td>
</tr>
<tr>
<td>79</td>
<td>% de mulheres grávidas SP que receberam preventivo Profilaxia da malária com Sulfadoxina-Pyrimetamina intermitente.</td>
</tr>
<tr>
<td>80</td>
<td>% de mulheres grávidas SP que receberam Mebendazol</td>
</tr>
<tr>
<td>81</td>
<td>% Mulheres SP Suplemento de multivitaminas, vitamina A.</td>
</tr>
<tr>
<td>82</td>
<td>% Mulheres grávidas SP recebendo Cotrimoxazol, (grávidas sintomáticas)</td>
</tr>
<tr>
<td>83</td>
<td>% de mulheres grávidas SP que receberam nevirapina para levar para casa</td>
</tr>
<tr>
<td>84</td>
<td>% de mulheres grávidas SP em TARV</td>
</tr>
<tr>
<td>85</td>
<td>% de mulheres grávidas SP com curso curto AZT + NVP</td>
</tr>
<tr>
<td>86</td>
<td>% de mulheres que assistem palestra em grupo</td>
</tr>
</tbody>
</table>

**PROGRAMA ALARGADO DE VACINACAO**
### Appendices

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>87</td>
<td>Taxa de cobertura de BCG</td>
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<tr>
<td>88</td>
<td>Taxa de cobertura (Sarampo)</td>
</tr>
<tr>
<td>89</td>
<td>Taxa de cobertura de (DPTHepB 3)</td>
</tr>
<tr>
<td>90</td>
<td>Taxa de cobertura de POLIO 3</td>
</tr>
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<td>91</td>
<td>TC de gravidez protegida (GP)</td>
</tr>
<tr>
<td>92</td>
<td>Lista de distritos com as taxas de cobertura agrupadas (&lt;50%, 50-79% e 80%-100% e &gt;100%)</td>
</tr>
<tr>
<td>93</td>
<td>% Crianças completamente vacinadas &lt; 1 ano idade Gestão do Prog.</td>
</tr>
<tr>
<td>94</td>
<td>% contribuição de vacinação das brigadas móveis em relação aos resultados totais</td>
</tr>
<tr>
<td>95</td>
<td>Índice de quebra vacinal</td>
</tr>
<tr>
<td>96</td>
<td>Taxa de desperdício de vacinas</td>
</tr>
<tr>
<td>97</td>
<td>% de unidades sanitárias com rotura de stocks de vacinas</td>
</tr>
<tr>
<td>98</td>
<td>% de unidades sanitárias com rotura de stock de petróleo</td>
</tr>
<tr>
<td>99</td>
<td>% de US’s com rotura de stocks de AD Seringas</td>
</tr>
<tr>
<td>100</td>
<td>% de US’s com rotura de stocks de caixas incineradoras</td>
</tr>
<tr>
<td>101</td>
<td>% de postos fixos de vacinação em geleiras a funcionar</td>
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### NUTRICAO

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<table>
<thead>
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<tbody>
<tr>
<td>102</td>
<td>1. Percentagem de Crescimento</td>
</tr>
<tr>
<td>103</td>
<td>Insuficiente (CI) nas crianças dos 0-59 meses</td>
</tr>
<tr>
<td>104</td>
<td>2. Percentagem de Baixo Peso a NASENSA (BPN)</td>
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<tr>
<td>105</td>
<td>3. Cobertura Vit A 1a dose; 2a dose (para ser incluído na nova ficha PAV)</td>
</tr>
<tr>
<td>106</td>
<td>4. Cobertura de Vit A durante o parto</td>
</tr>
<tr>
<td>107</td>
<td>5. Suplementação c/ Sulfato Ferroso &amp; Ácido Fólico (mulheres grávidas)</td>
</tr>
<tr>
<td>108</td>
<td>6. Taxa de Cobertura de suplementação com óleo iodado (em Niassa e Tete)</td>
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<tr>
<td>109</td>
<td>7. Suplementação com Sulfato Ferroso às crianças dos 6-23 meses</td>
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<tr>
<td>110</td>
<td>8. Cobertura de Consumo do Sal Iodado ao nível dos Agregados Familiares (AF).</td>
</tr>
<tr>
<td>111</td>
<td>9. Número de internamentos por malnutrição nas Enfermarias de Pediatria</td>
</tr>
<tr>
<td>112</td>
<td>10. Letalidade por malnutrição nas Enfermarias de Pediatria</td>
</tr>
<tr>
<td>113</td>
<td>11. Desnutrição Aguda/Actual: Peso/Altura (0-59 meses)</td>
</tr>
<tr>
<td>114</td>
<td>12. Desnutrição Crónica: Altura/Idade (0-59 meses)</td>
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<tr>
<td>115</td>
<td>13. Desnutrição Aguda/Actual: Peso/Idade (0-59 meses)</td>
</tr>
<tr>
<td>116</td>
<td>14. Proporção de Mulheres com Altura &lt; 145cm</td>
</tr>
<tr>
<td>117</td>
<td>15. Índice de Massa Corporal em mulheres idade fértil (15-49 anos) entrevistadas : IMC</td>
</tr>
<tr>
<td>118</td>
<td>16. Anemia/ Deficiência de ferro</td>
</tr>
<tr>
<td>119</td>
<td>(74% das crianças dos 6-59 meses são anêmicas)</td>
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<tr>
<td>120</td>
<td>17. Deficiência de Vitamina A</td>
</tr>
<tr>
<td>121</td>
<td>(68,8% das crianças dos 6-59 meses tem deficiência de Vit.A)</td>
</tr>
<tr>
<td>122</td>
<td>18. Prevalência de Cegueira Nocturna nas Mulheres grávidas</td>
</tr>
<tr>
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<tr>
<td>---</td>
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</tr>
<tr>
<td>123</td>
<td>19. Deficiência de iodo (71,0% de crianças em idade escolar sofrem de bócio, média Niassa e Tete)</td>
</tr>
<tr>
<td></td>
<td>REPARTIÇÃO PARA EDUCAÇÃO EM SAÚDE PÚBLICA</td>
</tr>
<tr>
<td>124</td>
<td>% de U.S com CLS’s em funcionamento (são considerados CLS’s funcionários que desenvolvem atividade comunitária na área de saúde)</td>
</tr>
<tr>
<td>125</td>
<td>% de escolas implementando o pacote básico do programa de saúde Escolar por Distrito</td>
</tr>
<tr>
<td>126</td>
<td>% de crianças, exclusivamente amamentadas com leite materno dos 0-4 meses de idade</td>
</tr>
<tr>
<td>127</td>
<td>Porporção de crianças que recebem alimentação suplementar, a partir dos 4 meses</td>
</tr>
</tbody>
</table>
Appendix B1: Project proposal (English version)

Developing a National Level Spatial Database for the Department of Community Health

A Project Proposal

Proposed by the

UNIVERSITY EDUARDO MONDLANE and UNIVERSITY OF OSLO
Sundeep Sahay, Esselina Macome, Zeferino Saugene, Lucia Ginger, John Lewis, Knut Staring

6th May 2004

1. Background on Geographical Information Systems in Mozambique
Efforts are made to increase control activities in Mozambique. Projects on GIS are being introduced in different fields in the country. Design and Implementation of a Geographic Information System (GIS) for Sustainable Development and Regional Planning in Beira (Mozambique). Planners and decision makers get up-to-date geospatial information from the regional GI service centre and use it for informed decision. The project contributes to sustainable development in Mozambique as an overall objective of national priority. Researches were also carried out on changing diarrhea disease endemic and epidemic in central Mozambique. Recent moves towards poverty reduction through food and livelihood security in Zambézia province, and the development of a geographic health information system to control malaria. These GIS project include themes analyzing the influence of land degradation on incidence of infectious diseases, situating human health in land-based notions of sustainable development, and communality between environmental health care and land-based poverty reduction policies.

Other initiatives includes the “Capacity Building in Geo information for Sustainable Development at CIG-UCM in Beira/Mozambique(CIG-UCM)” project which is in second phase of implementation. Based on project results achieved during a first phase (1998 – 2003), the main goal of this current project is to strengthen the role of the GIS-Center (CIG-UCM) within the Universidade Católica de Moçambique.
With the experience made during the former projects CIDDI-GIS and FLAME the Austrian Government assigned GIS team (Z_GIS) to advise CIG-UCM within their capacity building process. The core issue is to establish a well-trained and well-equipped GIS-Center within the Catholic University in Beira. One main activity is to undertake training (GIS and Remote Sensing) but also to consult the Centre within various GIS-related tasks (meta-database, Web mapping, …). Affected by natural hazards (floods, severe tropical storms, bush fires, drought) risk and disaster management is one of the main research issues of the centre. Further research is undertaken in the health sector (Malaria, AIDS) and regional development planning. Z_GIS also supports CIG-UCM in their research interests through expert advice and by establishing networks to scientific partners.

2. Project Aims

The aim of the project is to design, develop and implement a national level spatial database using Geographical Information Systems (GIS) for the Department of Community Health MISAU; Mozambique.

Some of the specific aims of this spatial database are:

1. To create a database that includes the following non-spatial items:
   a. Routine data (SMI and PAV) from the Department of Information Systems, MISAU, and the BES data from the Department of Epidemiology.
   b. Semi permanent data relating to infrastructure of health facilities, and population.
   c. Data indicators that have been identified by the Department of Community Health.
   d. Data on health indicators and poverty from Demographic Health Survey of 1997 and 2003 as and when it becomes available electronically.

2. To link this database containing this routine non-spatial data with the map database that would contain the following layers:
   a. District level boundaries
b. Location of various health facilities including district hospitals, province hospitals and health centers.

c. Road maps.

d. Population density across the districts.

e. Physical features like rivers, lakes, and mountains.

f. Any other map data that is available in digital form.

Once the spatial and non-spatial databases are linked, we will develop the following applications that can be used by the decision makers at the Department of Community Health and Epidemiologic Department to support their decision making:

1. Representation of various diseases by geographical areas.

2. Representation of various health indicators (for example, BCG coverage) by geographical areas.

3. Comparison of health indicators over time and across geographical areas.

4. Access to health facilities by combining the population data with location of health facilities.

5. Comparison of health indicators as computed from the routine data obtained from MISAU with that published by the Demographic Health Survey.

6. Any other application that is identified to be important.

3. Project team

The project team will be comprised of:

1. Zeferino Benjamim Saugene, Masters Student who is working on GIS for MISAU as his dissertation topic.

2. Lucia Joaquim Ginger, also a Masters Student who is working on the same project.

3. John Lewis, an Indian, also a Masters Student working on GIS development for his thesis. He has previously designed and developed a GIS application for the Indian Primary Health Sector.

4. One person from MISAU who can serve as the Project Administrator from the MISAU side, and be the point of contact for our project team. This will help to provide better participation in the process of GIS tool implementation from the MISAU side.
All the three students have undertaken a course on GIS for health care as a part of the Masters course at Oslo and are competent with the technical aspects of GIS. All the three students will be supervised by Sundeep Sahay and Knut Staring who have extensive experience in GIS in various countries. Supervision support will also be provided by Esselina Macome who will help in providing the local support and interpretation of documents.

4. Time Frame

The project will be implemented in the period from May 2004 to May 2005. The two Mozambican students will be based here right through this period and John will spend at least 7 months of this 12 month period in Mozambique. Sundeep and Knut will spend at least two months each during this period in Mozambique. In addition, they and also John will provide technical and other support over email when not present in Mozambique.

5. Methodology and time lines

The following steps are anticipated in the project:

<table>
<thead>
<tr>
<th>Project Steps</th>
<th>Timelines</th>
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<tbody>
<tr>
<td>1. Creation of routine database</td>
<td>May 2004</td>
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<tr>
<td>2. Assess availability of electronic maps</td>
<td></td>
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<tr>
<td>Creation of spatial database</td>
<td>By June 15</td>
</tr>
<tr>
<td>Linking of spatial and non-spatial database</td>
<td>By end of July</td>
</tr>
<tr>
<td>Development of applications – initial prototype</td>
<td>By end of August</td>
</tr>
<tr>
<td>Testing of prototype at MISAU and initial training</td>
<td>By middle September</td>
</tr>
<tr>
<td>Revision of prototype and further</td>
<td>By middle October</td>
</tr>
<tr>
<td>application development if necessary</td>
<td>Implementing of system in 2 or 3 provinces</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Ongoing support and training and revisions where necessary</td>
<td>Till May 2005</td>
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</table>

6. Support requested

1. Software: We propose to develop the system using Map Object 2.0 and Map Object Lite. This software has been tried by us in India and has worked successfully. It is also reasonably priced as compared to Arc View. The platform for development will be Windows XP and Office 2000. The requirements would be: One license for Map Object 2.0 and Map Object Lite for development and additional licenses depending on how many installations are required. For this, we can also try to approach ESRI directly for making donation of the software. We have done this in the case of India.

2. Hardware:

- Database server: Windows operating system, 1 GB RAM, 2 internal 8 GB SCSI disks, Disk array with RAID technology (or similar) and capacity 64 GB, LAN-adapters, Backup streamer station DLT, CD-ROM drive, Monitor 17”, Smart UPS
- Administration/E-mail server: MS Windows NT Server 4.0 – Pentium technology, 256 MB RAM, 4 GB Hard Disk Drive, Backup streamer station DAT, CD-ROM drive, LAN-adapters, Monitor 17”, Smart UPS
- Work stations: MS Windows NT Workstation 4.0 – Pentium technology, 256 MB RAM, 2 GB Hard Disk Drive, CD-ROM drive, LAN-adapter, Monitor 21”, Smart UPS
- Network Laser Printer, A4 format, 18 pages per minute, 600 dpi
- Scanner A0 format, full colour RGB, scanning resolution 1200 dpi
- Central LAN equipment (hubs, cables)
Appendices

- Central WAN equipment (Routers, modems, router and modem for leased lines provided by telecommunication supplier, guaranteed speed/capacity 256 kbit/s)
- Digitizer,
- GPS (2) (Specifications for digitizer and GPS will be provided)

3. Data: In addition to the hardware and software requirements, we would request the department of Community Health to provide us access to the following:
   1. Routine data from MISAU.
   2. BES data from Department of Epidemiology.
   3. Latest shape files from DINAGECA.
   4. Latest population data from the Demographic Health Survey from INE.

4. Access to staff to conduct interviews. Access to meeting various officials from the Department of Community Health to understand their needs for map based applications.

5. Sitting space. We will request for sitting space in the Department for our project team, to allow for closer interaction with the MISAU Project Coordinator on an everyday basis and also to slowly develop a better understanding of MISAU requirements.

6. Travel expenses: To cover local travel and to the province where required.
Appendix C1: Old form A04

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