UNIVERSITY OF OSLO

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Challenges and Opportunities in Using GIS for Monitoring and Management of HIV/AIDS: A Case Study from Malawi

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Dedication

I dedicate this body of work to my wife, Taonga *Nyaukandawire* Msiska and my mum, Maria *Nyagondwe* Msiska.

Abstract

This research falls within the domain of health information systems (HIS) development with particular interest in developing countries. The main objective of the research was to study HIS in order to highlight challenges and opportunities in using GIS for monitoring and management of HIV/AIDS in Malawi as well as propose strategies to address the challenges and harness the opportunities identified.

A case study was carried out in Malawi. The HIS in Malawi is mainly organized into three levels: the national level, the district level and the health facility level. For purposes of this research studies were done at the national level and district level. At the national level studies were done at the National AIDS Commission and the Ministry of Health. At the district level studies were done in Zomba and Balaka districts. Qualitative research methods were used which included interviews, document analysis and observations. A GIS prototype was constructed in order to facilitate understanding of practical issues surrounding the intended use of GIS.

The research revealed the presence of GIS technology within the Malawian health sector. However, its use has been limited to research with no specific evidence of its use in monitoring and management of HIV/AIDS. There a number of challenges working against the diffusion of GIS into other areas of application, including HIV/AIDS. In order to understand these challenges this research draws from the Information Infrastructure theory and in the process makes use of installed base, heterogeneity and standardization concepts.

The research emphasizes on the need for local capacity for sustainability and scalability of GIS projects. Thus, capacity building through context-driven training should be amongst the strategies employed in GIS endeavours. Furthermore, in recognizing the need for cost-effectiveness of GIS projects in developing countries the research advocates for setting up infrastructure and building partnerships to facilitate sharing of spatial data between institutions.

Keywords: Health Information Systems, Geographical Information Systems (GIS), Information Infrastructure, HIV, AIDS, Monitoring, Evaluation, Management, Developing Countries, Malawi.

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AIDS	Acquired Immune Deficiency Syndrome
ART	Antiretroviral Treatment/Therapy
CBO	Community Based Organisation
DAC	District AIDS Coordinator
DHIS	District Health Information System
DHO	District Health Officer
DFID	Department for International Development
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
HBC	Home Based Care
HIS	Health Information System
HISP	Health Information System Project
HIV	Human Immune Deficiency Virus
HMIS	Health Management Information System
IS	Information System
MOH	Ministry of Health
NAC	National AIDS Commission
NGO	Non Governmental Organisation
OPC	Office of the President and Cabinet
PDA	Portable Digital Assistant
PMTCT	Prevention of Mother to Child Transmission
TB	Tuberculosis
UN	United Nations
USAID	United States Agency for International Development
WHO	World Health Organization

1.0
Introduction

The thesis is generally concerned with the challenges and opportunities in using of Geographical Information Systems (GIS) for monitoring and management of HIV/AIDS programmes in the context of developing countries, with specific interest on the case of Malawi. It is based on a case study carried out in Malawi.

1.1 Background

HIV/AIDS is global health crisis that countries worldwide are currently battling. Nowhere in the world is the crisis as severe as in the Sub Saharan Africa region. Malawi, a small country in this region, is ranked 8th amongst the countries with the highest HIV prevalence (DFID 2005). AIDS accounts for the majority of deaths amongst Malawian adults with more than 80,000 deaths annually which has translated into a heavy burden of orphans with approximately 400,000 children loosing their parents to AIDS (NAC 2003).

The Malawi Government has responded by mobilizing a multi-sectoral national response to the HIV/AIDS crisis. In 2001, with cooperation from key stakeholders, the Government of Malawi established the *National AIDS Commission* (NAC) to coordinate the national response (USAID, 2005). While progress has been made in HIV testing and counseling, provision of anti-retroviral treatment, prevention of mother to child transmission and other HIV/AIDS intervention programmes there is still a need to strengthen monitoring and evaluation (OPC 2007). One way monitoring and management of HIV/AIDS can be strengthen is by making use of Geographical Information Systems (Hugo 2000; Vanmeulebrouk et al. 2008).

Health is largely determined by environmental factors (including socio-cultural and physical environment) which vary greatly in space; making the spatial dimension important in addressing health issues (Tanser & Sueur 2002). Thus, HIV/AIDS as a health issue has a spatial dimension that ought to be considered. Important questions like

whether HIV/AIDS intervention programmes reach the populations in need cannot be adequately addressed without considering the spatial dimension. Furthermore, under resource constrained conditions the spatial dimension becomes very important when it comes to deployment of already scarce resources in order to ensure their effectiveness (Hugo, 2000). It is in this regard that GIS can strengthen monitoring and management of HIV/AIDS.

However, health information systems (HIS) in Africa have often overlooked the spatial dimension when dealing with the HIV/AIDS epidemic and other important health issues (Tanser & Sueur 2002). While it is possible to work without taking into account this geographical component; using spreadsheets or databases, for example, this is effectively throwing away potentially important and valuable information (Saugene 2005). This inadequacy resulting from failure to adequately address the spatial dimension means that decision makers are hampered from making well-informed and more directed decisions on preventative and intervention programmes. With the decision making process hampered in such a way, the success of preventative and intervention programmes is limited and that gives room for further spread of HIV/AIDS.

Although this is the case, GIS has been shown to have potential to assist in the fight against HIV/AIDS by providing excellent means for presenting, visualizing and analyzing disease data (Hugo 2000). As suggested by Tanser & Sueur (2002), the spatial modeling capacity offered by GIS is directly applicable to understanding the spatial variation of the disease, and its relationship to environmental factors and the health care system. GIS projects in developing countries like Malawi face unique challenges mainly due to infrastructural and cost constraints (Hall et al. 1997; Dunn et al. 1997; Tanser & Sueur 2002). Thus, this research sought to explore HIS in Malawi in order to see how GIS can used in the monitoring and management of HIV/AIDS and understand the challenges and opportunities that exist in that regard.

1.2 Research Objectives

With the background given above, the main aim of this research was to explore the HIS in Malawi in order to find out how GIS can used to strengthen monitoring and management of HIV/AIDS and understand the challenges and opportunities that exist in that regard.

To achieve this aim the study addressed the following research questions:

1. What challenges and opportunities exist for sustainable use of GIS in monitoring and management of HIV/AIDS in Malawi?

2. What strategies can be used to address the challenges and harness the opportunities identified in order to have sustainable GIS usage?

To answer these questions the study specifically aimed to:

1. Assess the monitoring and management systems and/or routines for HIV/AIDS currently in use in Malawi.

2. Identify gaps (or challenges) in monitoring and management of HIV/AIDS that can be addressed using GIS.

3. Assess how GIS can (or is being) used to address the challenges identified.

4. Develop a GIS prototype to facilitate empirical data collection on practical issues surrounding the using GIS for monitoring and management of HIV/AIDS.

1.3 Research Setting and Methods

The study falls within the domain of health information systems (HIS). Drawing from Walsham et al. (1988) this study adopts the view of HIS are social-technical systems. According to (Silverman 2001), qualitative research provides a deeper understanding of social phenomena than would be obtained from purely quantitative data. Therefore a

qualitative research approach was adopted for this study and made use of the case study research method. The case study focused on two levels; the national level and the district level. At the national level studies were conducted at the National AIDS Commission and the Ministry of Health. At the district level studies were conducted at District Health Offices in two districts in the southern region of Malawi; Zomba and Balaka.

Empirical data collection was largely collected through semi-structured interviews with various personnel at the national and district level. Apart from that data was also collected using document analysis and to a lesser extent observation. Data was also realized through the GIS prototype that was constructed.

1.4 Research Motivation

To start with, this research falls under the umbrella of the Health Information Systems Programme (HISP), an ongoing action research involving developing countries such as South Africa, Ethiopia, Vietnam, India, Botswana, Tanzania Mainland, Malawi and Nigeria. Amongst the aims of this programme is strengthening and sustaining of health information systems in the countries involved. The potential that GIS has to strengthen monitoring and management of HIV/AIDS and HIS in general has been one of the motivating factor for this research as it ties in well with the aims of HISP.

As stated in the background given above, AIDS accounts for the majority of deaths amongst Malawian adults with more than 80,000 deaths annually (NAC, 2003). Since there is no cure for HIV/AIDS, success in the fight against the epidemic largely depends on the effectiveness of planning and monitoring activities as well as the management decisions on preventative and intervention programmes. GIS has potential to assist in the fight against HIV/AIDS by providing excellent means for presenting, visualizing and analyzing disease data (Hugo, 2000). Therefore, part of the motivation of this research lies in the quest to contribute to the fight against HIV/AIDS in Malawi by strengthening monitoring and management of the disease using GIS.

In addition, literature has shown that there is little published work on the application of GIS in the fight against HIV/AIDS in the Sub Saharan Africa (Tanser & Sueur 2002;

Montana et al. 2006). Tanser & Sueur (2002) found out that most health related applications of GIS were done in South Africa thereby raising questions on the level of its application in other Sub Saharan Africa nations. Therefore, another motivating factor for this research is the quest to contribute to literature about GIS in Malawi and hence the Sub Saharan Africa region.

1.5 Theoretical Overview

Theoretically this study is guided by concepts under the information infrastructure (II) theory coupled with the perception of Information Systems and therefore HIS as Social-Technical Systems.

1.5.1 HIS as Social-Technical Systems

As argued by Walsham et al. (1988) computer-based information systems ought to be treated as social technical systems in which technology is one of the elements. That is, information systems are not technical systems but rather social systems that rely on information technology in provision and support of their functions. Turning our focus to HIS, it is obvious that an HIS constitutes several interrelated elements including tools (technology) for data collection, storage, processing and dissemination; personnel involved in the collection through to its dissemination; standards and procedures that regulate the operations of the HIS; stake-holder community and so on. Drawing from the argument in Walsham et al. (1988) this study adopts the social-technical perception of HIS.

1.5.2 Information Infrastructure (II)

According to Hanseth (2002), contemporary information systems that are characterized by integration of systems across organizational and geographical borders are significantly different from traditional information systems and such systems should be perceived as "*information infrastructures*" rather than not systems. Information infrastructures are considered to already exist and are never created from scratch but are designed through continuous evolution of the old into the new (Hanseth & Monteiro 1998). The already

existing infrastructure is what is called the *installed base*. Thus, Hanseth (2002) defines an II as a *shared, evolving, open, standardized, and heterogeneous installed base.*

Many characteristics of HIS, as a socio-technical system, support conceptualizing it as an II as compared to being an IS. First, by its nature an HIS is a *shared* resource which can be expected to *evolve overtime* as the health sector responds to different challenges in different times. HIS can also be seen as being part of a large *heterogeneous* network comprising, technological as well as non-technological components. Furthermore, HIS are characterized by an *installed base* which ought to be taken into consideration every time extensions and improvements are undertaken. These characteristics support the conceptualizing of an HIS as an Information Infrastructure. Thus, Information Infrastructure (II) theory can help in attempts to understand, extend or improve upon HIS.

1.6 Expected Contributions

This study concerns the use of GIS in the monitoring and management of HIV/AIDS particularly in the case of Malawi. As pointed out under research motivations, literature has shown that there is little published work on the application of GIS in the fight against HIV/AIDS in the Sub Saharan Africa (Montana et al. 2006; Tanser & Sueur 2002). Therefore, one of the immediate contributions of this study is to the body of published material on the application of GIS in the fight against HIV/AIDS in Sub Saharan Africa.

Hall et al (1997) outlined a number of challenges developing countries, particularly those in Africa, face in the adoption of GIS technology. Therefore by investigating challenges and opportunities that exist in Malawi and making recommendations this study provides practical contributions on using GIS for monitoring and management of HIV/AIDS under such challenges. In addition, the similarities in the challenges faced by these countries offer an opportunity to transfer experience from one country to another. Thus, recommendations and strategies devised for Malawi can be adopted in another developing country facing similar challenges.

Furthermore, since there is no cure for HIV/AIDS, success in the fight against the epidemic largely depends on the effectiveness of planning and monitoring activities as

well as the management decisions on preventative and intervention programmes. The effectiveness of the planning and monitoring as well as management decisions all depend on the quality, detail and format of information available. As compared to traditional reporting systems, GIS is found to have excellent visual and analytical facilities that enable discovery of trends, dependencies and interrelationships that are otherwise difficult to obtain (Johnson and Johnson, 2001). Therefore through this study I expect to practically contribute to the enhancing of HIS in Malawi towards the fight against HIV/AIDS.

Finally, in trying to understand and make sense of the information collected in the study some theories have been selected to constitute a theoretical framework. I view that as a contribution in itself with respect to the chosen theories in terms of their applicability into the area of my study.

1.7 Thesis Organisation

The thesis has been organized as follows: chapter 2 follows this introductory chapter and presents the literature review and theoretical framework. This discusses relevant literature on GIS with particular interest on developing countries and health. In addition, it discusses theoretical framework derived information infrastructure theory and perceiving an HIS as a socio-technical systems. Chapter 3 presents the research setting starting with the general country profile of Malawi and ending with the country's AIDS profile. Chapter 4 presents the research methodology and basically discusses how the research was carried out.

Moving further, Chapter 5 discusses in detail the prototyping process that was carried out as part of the research (*see section 1.2*). Chapter 6 presents the empirical findings of the research while chapter 7 discusses these findings guided by the literature reviewed and the theoretical framework set.

The thesis ends with a summary of the findings and conclusions drawn from the study; presented in chapter 8. This chapter also presents the theoretical and practical contributions made by this study as well as possible area for further research.

2.0
Literature Review and Theoretical Framework

This chapter discusses literature about Geographical Information Systems with particular interest in their application in the health sector narrowing down to HIV/AIDS. In addition the chapter discusses theories that form a theoretical framework for discussing findings of this study.

2.1 Geographical Information Systems

Geographical Information Systems (GIS) have been described in different ways by different authors.

> "*GIS is an information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-referenced data, as well as a set of operations for working with the data.*" (Pick 2005, p.10)

> "*The term GIS describes computerized information storage, processing and retrieval systems that are specifically designed to cope with geographically-referenced spatial data and the corresponding attribute information.*" (Saugene, 2005, p.39)

> "*GIS as the branch of information technology which adopts rapidly developing computer based technologies and methodologies to collect, store, interrogate, analyse, model, interpret and visualize spatially referenced information.*" (Hugo 2000, p.2)

Such is the proliferation of GIS definitions and descriptions that there is no common definition for GIS. Everyone has their own favourite definition of a GIS and there are many to choose from (Longley et al. 2005). What is common amongst these definitions and descriptions is the term *spatially (or geographically) referenced data*. According to

Hugo (2000), spatially referenced information refers to information which has (or is associated with) a specific location on the earth's surface, a latitude and a longitude.

With such spatially referenced data comes the ability to analyse, monitor and manage phenomena with respect to their occurrence in space. "*Almost everything that happens, happens somewhere. Knowing where something happens can be critically important*" (Longley et al. 2005, p.4). That is the potential that GIS offers to a wide range of application areas including business, education, development and health.

2.1.1 Components of a GIS

The anatomy of GIS consists of six components: the network, people, hardware, software, data and procedures (Longley et al. 2005).

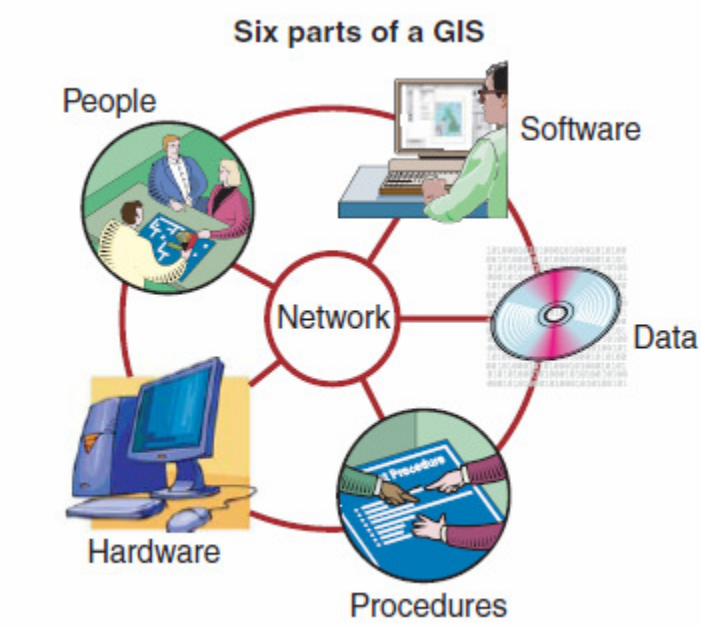


Figure 2.1: The six component parts of a GIS

(Source: Longley et al. 2005 p.24)

Today's GIS applications rely on the presence of a computer *network*: an intranet or the internet itself. The internet is increasingly integrated into many aspects of GIS use, and the days of standalone GIS are virtually over (Longley et al. 2005). The second piece of

the GIS anatomy is the user's *hardware*: the device that the user interacts with directly in carrying out GIS operations. The third component is the *software* that runs on the user's device. It might be as simple as a web browser or most likely a GIS package acquired from one of the GIS software vendors (*ibid*). To carry out GIS operations *data* is required, particularly spatial data consisting digital representations of selected aspects of some specific area on the earth's surface (Longley et al. 2005). This could be a country, a province, a district and so on.

GIS requires management. An organization must establish *procedures* and other mechanisms that ensure that its GIS activities stay within budget, maintain high quality and meets its needs (Longley et al. 2005). The last component of a GIS is *people*. GIS is useless without the people who design, program, and maintain it, supply it with data and interpret its results (*ibid*). The people can have various skills depending on the roles they perform.

2.1.2 History of GIS and Future Trends

The origins of GIS traces back to the days when human beings use to rely on mental maps to exchange directions or to explain the locality of a phenomena in question (Berry 2007). Spatial information involves two descriptors – *Where* is *What*. For thousands of years the link between the two descriptors has been the traditional, manually drafted map involving pens, rub-on shading, rulers, planimeters, dot grids, and acetate sheets (*ibid*). Its historical use was for navigation through unfamiliar terrain and seas, emphasizing the accurate location of physical features.

The first GIS was the Canada Geographical Information System, developed in the mid-1960s as a computerized map measuring system (Longley et al. 2005). On the other hand, the first commercial GIS software, *ArcInfo*, came out in the late 1970s from the labs of Environmental Systems Research Institute (ESRI). GIS became widespread in the 1980s following a sharp drop in the cost of sufficiently powerful computers.

In the early years, GIS was considered the domain of a relatively few cloistered techno-geeks but today, it is potentially on everyone's desk, PDA and even cell phone (Berry

2007). In just three decades GIS has evolved from an emerging science to a fabric of society that depends on its products from getting driving directions to sharing interactive maps of the family vacation (*ibid*). Global Positioning System (GPS) and digital maps are increasingly becoming defacto features of mobile devices, PDAs and mobile phone, bringing GIS to the palm of your hand (*ibid*).

These portable devices have given rise a broad range of new GIS applications, *Location Based Applications* (LBA), that dynamically obtain information that is relevant to their current location (Premasudha et al. 2007). Thus, one path in the future of GIS lays in portable GIS applications that are accessed on PDA, mobile phones and Mobile Internet Devices (MIDS) as compared to traditional stationary GIS applications on desktop computer. Furthermore, as GIS makes inroads into the general society new map forms are emerging to support needs of the regular user (Berry 2007). Photographs and video are some content forms that are being integrated into GIS systems as GIS becomes more consumer-oriented. This has given rise to a new arm in the future development of GIS: *multimedia mapping* (ibid).

2.2 GIS and Health

A number of researchers have written about GIS and its application in health. It has been observed that the nature of health itself makes GIS more ideal as a tool for research, monitoring and management in the health sector. Tanser & Sueur (2002) observed that health is largely determined by environmental factors that vary greatly in space and therefore has an important environmental and spatial dimension. The spatial modelling capacities that GIS has can therefore help understand the spatial distribution of diseases and its relationships to environmental factors (*ibid*).

GIS can prove very effective in answering many questions that we are faced with in health planning and health in general. Since much of the data used and generated by health and social service agencies has a spatial dimension, geographic information system (GIS) is particularly useful to health professionals and administrators in planning and day-to-day management (C. Johnson & J. Johnson 2001). For example, questions on the

location of health care centers and the kind of services to provide at specific health care centers are some of the problems that GIS can help address.

The inherent ability of GIS to generate dynamic maps with respect to space and time means that GIS can also be used as a monitoring and evaluation tool for health programmes, intervention and services. Monitoring and evaluation are essential activities in health programmes and GIS with its ability to show spatial distribution of diseases in space and time can greatly enhance the monitoring and appraisal of health programmes (C. Johnson & J. Johnson 2001).

2.2.1 GIS and Epidemiology

Epidemiology can be defined as "*the study of the distribution and determinants of health-related states and events in populations, and the application of this study to control health problems*" (Balaji 2000). Inherent in this definition is the measurement of frequency, distributions and determinants of diseases (ibid). In order to understand, interpret and take action on any of these factors the spatial dimension is very important. The question of location (where?) is important to these three factors. Thus, GIS is can be seen to be well suited for application as a tool for monitoring and management of epidemics, a major concern of epidemiology.

"GIS provides excellent means for visualizing and analyzing epidemiological data, revealing trends, dependencies and inter-relationships that would be more difficult to discover in tabular formats" (Johnson and Johnson, 2001). Epidemiological analysis involves the study of relationships and dependencies between several factors and trends associated with a particular disease in order to allow predictive insights that can help monitor and control the disease. Such a task is difficult to undertake with traditional reporting systems that are characterized by presentation of data in tabular forms. Making sense of information across two or more tables can prove difficult, tedious, time consuming and slow. Unfortunately, when dealing with epidemics one does not have the luxury of time. GIS with its excellent visualizing and analyzing abilities is therefore well

suited to epidemiology as it is capable of strengthening the whole process of epidemiological information management and analysis.

GIS is also characterized by speed (Hugo, 2005). GIS aids faster and better health mapping and analysis than conventional methods. It allows for quick and easy insights from large volumes of health data. Such speed can greatly enhance decision making processes when dealing with health emergencies.

2.2.2 GIS and HIV/AIDS

HIV/AIDS, like tuberculosis and malaria, is an 'environmental' disease (Tanser & Sueur 2002). The distribution and incidence levels of such diseases are considerably dependent on environmental or spatial factors. It is for these so called 'environmental' diseases that GIS is seen to be well-suited and highly applicable in terms of research, monitoring and management (*ibid*). Therefore, the potential of GIS as discussed earlier is highly applicable in research, monitoring and management of HIV/AIDS. Furthermore, in providing treatment to those already infected with the disease the spatial dimension is very important when it comes to deployment of already scarce resources in order to ensure effectiveness (Hugo, 2000) which can easily be resolved using GIS.

There are several ways in which GIS can help in the fight against HIV/AIDS. Literature points at five major ways in which GIS can help in the fight against the HIV/AIDS epidemic.

1. **Visualisation Capabilities**

   Modern GIS have the capacity to analyse huge amounts of spatially referenced information and present it in the form of maps extremely quickly (Hugo, 2000). With such speed information can be made available in good time to policy makers and planners in a form which allows patterns and trends to be readily identified. As a result action can be planned and taken immediately and hence enhance the chances of it being effective.

Furthermore, GIS allows overlaying of a number of layers of information (Johnson and Johnson, 2001). With respect to HIV/AIDS, the layers of information can include distributions of all the elements thought to influence the spread of the disease. For example, location of roads, location of health centres, cultural attributes of the population, migration patterns, incidence of prostitution, population density and drug use.

The simplest use of the visualisation capabilities of GIS is the production of maps of the incidence/prevalence of HIV/AIDS (Hugo, 2000), for example, of the distribution of HIV/AIDS in Malawi. In addition, GIS has the ability to 'zoom in' to very local or regional scales of visualization, for example district level. It is obvious that such maps can go a long way in assisting in planning interventions.

2. Deployment of Resources

With GIS it is possible to have a map and a model that can be used to determine the optimal allocation of resources across different areas (Hugo, 2000). In the case of HIV/AIDS it could be used to decide where to locate counselling and testing services, condom distribution programs and so on.

3. Evaluation and Monitoring

Furthermore, GIS also enables evaluation of the effectiveness of services and resource allocations after they have been made (Hugo 2000; C. Johnson & J. Johnson 2001). If services and the allocation of resources are effective then they should reduce the extent of the disease, over time, in the areas where they have been deployed. GIS with its ability to show spatial distribution of diseases in space and time can assist in monitoring changes in the areas where such resources, services and intervention programmes have been deployed in the fight against HIV/AIDS.

4. Web-based GIS

Web GIS (or web-based GIS) is a recent development that allows users to connect to a central GIS server through the internet or intranet (Johnson and Johnson, 2001).

This opens up GIS across the entire stakeholder community in the fight against HIV/AIDS allowing operatives in the field to access and manipulate data sets with respect to their planning and operational activities (Hugo, 2000). Furthermore, central decision making is better informed by local knowledge leading to better decisions (*ibid*).

Although GIS is seen to hold this potential to assist in the fight against HIV/AIDS, Health information systems (HIS) in Africa and corresponding research have often overlooked the spatial dimension when dealing with the HIV/AIDS epidemic and other important health issues (Tanser & Sueur 2002). Tanser & Sueur (2002) discovered that most research on HIV/AIDS in Africa concentrated more on temporal analysis other than the spatial dimension. Recent studies do not indicate a major shift from that. There is little current research on HIV prevalence in Africa that has utilized Geographic Information Systems (GIS) technology to its full potential (Montana et al, 2006). A majority of published studies on application of GIS in health-related issues are undertaken in South Africa. This raises questions on what is being done concerning the application of GIS in dealing with HIV/AIDS in other Sub Saharan Africa countries, including Malawi.

2.3 GIS and Developing Countries

There have been questions raised on the appropriateness of GIS for poor developing nations, particularly in Africa. Can a technology initiated and concentrated in industrialized countries be valuable where fewer resources are available? (Dunn et al. 1997) Furthermore, is the concentration of GIS in the north because it is inappropriate in the south? (*ibid*) Developing countries, particularly in Africa, face a myriad of challenges with respect to GIS projects ranging from the cost of acquiring GIS technology, lack of local knowledge and expertise in GIS technology, availability of usable geo-referenced data (Hall et al, 1997).

Despite these challenges Dunn et al (1997) argue that GIS is still applicable in developing countries. The key lies in avoiding a quick fix approach (*ibid*). It is important to realize

that a lack of appreciation of GIS' potential exists in most developing countries. Simply providing a GIS solution does not help at all if the people to use it do not know how it helps them. Both Dunn et al (1997) and Hall et al (1997) argue for training and building of local capacity as one of the strategies for sustainable GIS projects in Africa and other developing countries.

Tanser (2000) argues against the issue of cost of GIS by observing that hardware has become increasingly cheaper and powerful. As a result of these trends complex analysis of spatial data can be done with a desktop computer. At the same time while in the past decade GIS software was to a larger extent commercially available this decade has seen an increasing amount of free GIS software (*ibid*) which developing nations can take advantage of.

2.4 HIS as Socio-Technical Systems

It has been argued by researchers that information systems and subsequently Health Information Systems (HIS) should not be perceived as technical systems but rather as social systems of which technology is just one of the components. Traditionally, computer-based information systems have been taken to be technical systems as such behavioral and organizational issues have been relegated to a secondary role or are not considered at all (Walsham et al, 1988). However, information systems constitute a lot more than information technology because they to a greater extent involve people and actions that are subject to the organizational setting in which they are found (Heeks 1998). Therefore, as argued by Walsham et al. (1988) computer-based information systems ought to be treated as social systems in which technology is one of the elements. That is, information systems are not technical systems but rather social systems that rely on information technology in provision and support of their functions (*ibid*).

Turning our focus to HIS, it is obvious that an HIS constitutes several interrelated elements including tools (technology) for data collection, storage, processing and dissemination; personnel involved in the collection through to its dissemination; standards and procedures that regulate the operations of the HIS; stake-holder community

and so on. As a result it is subject to influence by social, cultural and other factors which can easily determine its success or failure. The success of HIS depends not only on technical improvements but also on in-depth understanding of political, socio-cultural, and administrative factors (Lippeveld & Sauerborn 2000). Conceptualizing HIS as socio-technical system, embraces the need to consider social, cultural, and other non-technical factors in the development and attempts to understand HIS. These factors have a greater influence on HIV/AIDS matters and subsequently in associated HIS; as a result they need to be given proper attention.

2.5 Information Infrastructure

According to Hanseth (2002), contemporary information systems that are characterized by integration of systems across organizational and geographical borders are significantly different from traditional information systems. Successful establishment of such information systems hinges on perceiving such systems as "information infrastructures" – not systems (ibid).

Of importance is the difference between II and traditional information systems. Unlike traditional information systems II are considered as already existing; they are not developed from scratch (Hanseth and Monteiro, 1998). "*New infrastructures are designed as extensions and improvements of existing ones – not from scratch. The new or improved elements have to fit into the old*" (Hanseth, 2002, p.1). The key to understanding this point lies in the II concept of *installed base* described later in this section. On the other hand, the manner in which traditional information systems are developed follows the general assumption that systems can be developed or should be developed from scratch (*ibid*). Furthermore, an information infrastructure evolves over a longtime. That is, its state at each given point in time is determined by a series of continuous extensions and improvements it has undergone. Where as the in traditional systems "the design project is assumed to have a well defined start and ending times – it is an event not an ongoing process" (Orlikowski 1996 cited in Hanseth 2002). In other words, traditional design methodologies aim at developing a closed system by a closed

project organization for a closed customer organization within a closed time frame (Hanseth, 2002).

The idea is that the IS concept is sometimes inadequate when dealing with some contemporary information systems characterized by among other things integration of systems across organizations and geographical areas. The concept of II is therefore put across not to replace that of IS but rather to complement it (Hanseth, 2002). Information systems should therefore be seen as part of larger information infrastructures and be developed within the context of strategies for developing infrastructures they are to become part of (ibid).

There are six underlining characteristics for an information infrastructure worthy of mention: *shared*, *evolving*, *open*, *standardized*, *heterogeneous* and having an *installed base*. This leads to the summary "*an infrastructure is a shared, evolving, open, standardized, and heterogeneous installed base*" (Hanseth 2002, p.7).

2.5.1 Heterogeneous

Despite being standardized, II are also heterogeneous in the sense that they include components of different kinds both technological and non-technological (human, social, organizational and so on) (Hanseth, 2002). Therefore, with such heterogeneity II can be thought of as being more of socio-technical in nature than more technical.

2.5.2 Installed Base

Of critical importance to the concept of II is the notion of an *installed base*. As earlier noted, II are considered to already exist and are never created from scratch but are designed through continuous evolution of the old into the new (Hanseth, 2002). The already existing infrastructure is what is called the installed base.

As the infrastructure is being modified, each new feature or each new version of a component replacing an existing one must fit with the existing infrastructure. This requirement means the installed base heavily limits and influences how the new infrastructure is designed (Hanseth, 2002). Therefore the installed base can be thought of

as some sort of "designer" having a role to play in the development of the II (*ibid*). This means an II (installed base) should not be thought of as a passive material that can be modified anyhow but an active "living organisms" that is able to determine its own existence. Such a nature of the II means traditional strategies and methodologies of system design would not suffice in the development of II. This leads to the design strategy called *cultivation* described below.

2.5.3 Cultivation

As already outlined the installed base should be thought of as a "living organism" able to determine its own growth and direction and hence beyond the control of the project manager, system designer, and so on. Therefore the development of II therefore has to embrace the fact that the various technological and organizational changes to be made during this ongoing process (evolution) cannot, by definition, all be anticipated ahead of time (Hanseth, 2002). Cultivation therefore emphasizes the role of existing installed base as an actor in the development process and the limits it poses on rational, human control (ibid). This is in sharp contrast to traditional systems design methodologies where the project manager assumes control over the design process with the general assumption that it is possible to design exact solution to exact needs of the user community (Hanseth and Monteiro, 2000).

2.6 HIS as Information Infrastructure

Many characteristics of HIS, as a socio-technical system, support conceptualizing it as an II as compared to being an IS. First, by its nature an HIS is a *shared* resource which can be expected to *evolve overtime* as the health sector responds to different challenges in different times. HIS can also be seen as being part of a large *heterogeneous* network comprising, technological as well as non-technological components. Furthermore, HIS are characterized by an *installed base* comprising of procedures, ethics, personnel, tools, resources, an so on. These characteristics support the conceptualizing of an HIS as an Information Infrastructure. Thus, studies and attempts to understand, extend or improve upon HIS can benefit from concepts under the umbrella of Information Infrastructure (II) theory.

This study to a larger extent focused on the extension of existing HIS, particularly with respect to HIV/AIDS, by adopting GIS technology. According to Hanseth (2002), any new or improved elements have to fit with the old. Thus, such extension cannot be carried out without respecting what already exists – the *installed base*. The installed base as one of the actors in II development has some influencing and limiting powers which can help explain some challenges and opportunities encountered in the process. Therefore, the II theory will be helpful in understanding the characteristics of the HIS surrounding HIV/AIDS programmes, explaining challenges and opportunities in using GIS as intended in this study and provide a framework for developing a strategy for extending such HIS with GIS technology. Thus, apart from talking of health information systems we can also talk of health information infrastructures (HII).

2.7 GIS as Information Infrastructure

Furthermore, GIS itself exhibits characteristics of an Information Infrastructure. Firstly, GIS like most infrastructure has evolved and continues to evolve over time. GIS has been described as *enabling* technology readily applicable in the health sector (Tanser & Sueur 2002). GIS applications are *shared* between individuals and often between organizations as well. GIS is *open* as it offers possibility of being linked to other information resources like relational databases and other information systems. Looking at the six components of a GIS mentioned earlier, it can be seen that GIS is *heterogeneous* in terms of stakeholders, tools and other artefacts involved, procedures and so on. Therefore, if GIS is an II it only makes sense that it should be treated and studied like one.

Just like information systems can be decomposed into sub-systems, information infrastructures can be decomposed into sub-infrastructures (Hanseth 2002). This allows us to perceive a GIS system under the context of a given health information infrastructure as a sub-infrastructure of that II. To this end studies on GIS can as well benefit from perceiving GIS system as infrastructures, Geographical Information Infrastructures (GII). Consequently, the II theory, particularly, the concept of cultivation can be relevant in devising strategies for sustainable GIS projects in developing countries, including Malawi.

2.8 Prototyping

In software development, a prototype is a rudimentary working model of a product or information system, usually built for demonstration purposes or as part of the development process (Sommerville 2004). The development of prototypes, called prototyping, is a rapid process. Prototyping can be done for various reasons including eliciting system requirements from users, trying out design options and demonstration purposes. Prototype is suitable for systems that involve interaction with the user but not non-interactive systems like batch-processing systems (*ibid*).

In the past prototypes were considered inferior to the required system and further development was required. However, with various prototyping approaches available the boundary between prototyping and normal software development has become blurred and many systems are now developed using an evolutionary approach (*ibid*). Generally, prototyping approaches can be categorized into two: throw-away prototyping and evolutionary prototyping.

2.8.1 Throw-away Prototyping

Throw-away prototyping involves developing a prototype to meet a specific objective related to the required system and then discarded once that objective has been met (Sommerville 2004). The reason for this kind of prototyping might be to elicit requirements for the required system, demonstrate the feasibility of the system, and try out design options. In order to save time not all software development principles such as commenting of code are adhered to in this prototyping approach (*ibid*). The prototype goes through circles of build and evaluate until the objective has been met.

2.8.2 Evolutionary Prototyping

Unlike throw-away prototyping, evolutionary prototyping aims to deliver a working system to the users (Sommerville 2004). The development process starts with those requirements that are best understood and continues incrementally as other requirements are discovered and refined until an adequate system has been achieved.

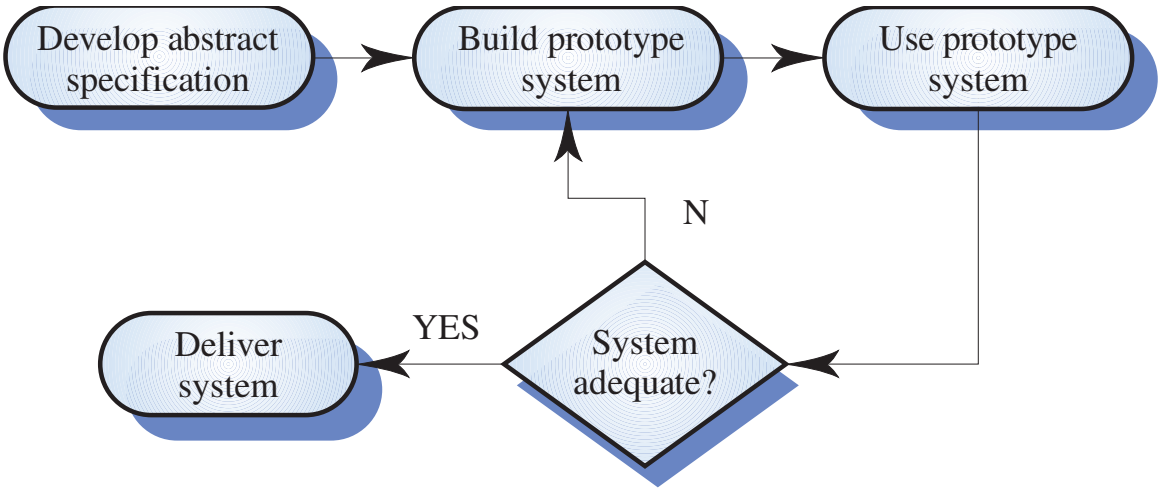


Figure 2.2: Evolutionary Prototyping

Because an evolutionary prototype becomes the final system its construction must adhere to software development principles. Without that the quality of the resulting system is compromised and its maintenance becomes difficult (Sommerville 2004).

3.0
Research Setting

This chapter presents the context in which this research was carried out. The research was carried out in Malawi, one of the Sub-Saharan Africa countries. The chapter presents the general profile of Malawi as a country, Malawi's HIV/AIDS profile followed by details of the two districts that were visited during this study: Zomba and Balaka.

3.1 Geographical Profile

Malawi is a country in the Sub-Saharan Africa. It is bordered to the north and northeast by Tanzania; to the East, South and South West by Mozambique and to the West by Zambia (*see Figure 3.1 below*). The country covers 118,484 square kilometers. The country has four fresh water lakes, the largest of which is Lake Malawi, which covers about 23600 square kilometers.

The country is divided into three regions (provinces): *Northern Region*, *Central Region* and *Southern Region*. Each region is further divided into districts: five in the Northern Region, eight in the Central Region and 15 in the Southern Region, giving a total of 28 districts altogether. The capital city of Malawi, *Lilongwe*, is in Lilongwe District in the Central Region. Apart from Lilongwe, there are two other major cities in Malawi, *Blantyre* in the Southern Region and *Mzuzu* City in the Northern Region. The two districts I visited during this case study, *Zomba* and *Balaka*, are both located in the Southern Region.

Malawi is a densely populated country with an estimated population of 13.1 Million and an annual population growth rate of 2.8 percent per annum (NSO 2008). Out of this, 6.4 million (49 percent) are males and 6.7 million (51 percent) are females. At regional level, the Southern Region has the highest population of 5,876,784 (45 percent), Central Region, 5,491,034 (42 percent) and Northern Region, 1,698,502 (13 percent).

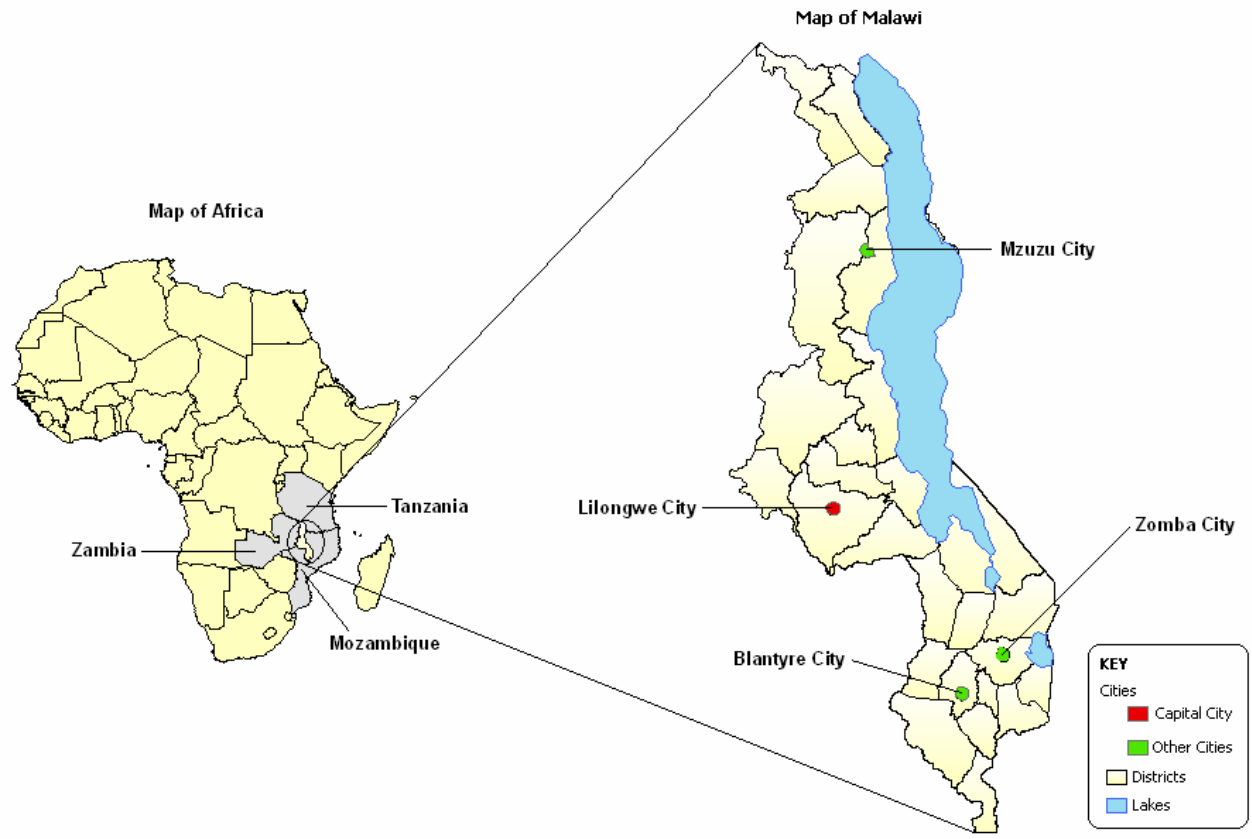


Figure 3.1: Map of Malawi, Cities and Neighbouring Countries

3.2 Country Political Profile

Malawi is democratic country with an infant democracy running just over a decade. Malawi was a British protectorate for 73 years and gained its independence in 1964 and became a republic on 6th July, 1965 (EISA 2004). Dr. Hastings Kamuzu Banda became the country's first prime minister. A constitutional review of 1966 led to the abolition of multiparty democracy and ushered in a one party regime under the Malawi Congress Party (*ibid*). From then on all constitutional powers virtually lay in the hands of the state president, a position Dr. Hastings Kamuzu Banda held from 1971 to 1992.

Due to pressure from within the country and international institutions coupled with ailing health Dr. Banda agreed to a referendum on the re-introduction of a multiparty political system (EISA 2004). The referendum of June 1993 confirmed an overwhelming victory

for multiparty democracy and set the stage for the first multiparty elections in three decades. In May 1995, a new constitution providing for protection and promotion of basic rights and freedoms; ensuring the holding of periodic competitive elections and sharing of powers between the executive, legislative and judicial branches of the government was passed (*ibid*).

Under the new constitution, the President is directly elected by the people for a term of five years, renewable for another term by popular election. The President wields considerable power. He is the Head of State, Head of Government and Commander- in-Chief of the Armed Forces; he appoints and dismisses Ministers, senior civil servants and diplomats abroad. Although the concept of separation of powers is enshrined in the country's Constitution, the President is allowed to select his cabinet from both within and outside the Parliament and thus it has been a tendency amongst Presidents to appoint ministers from amongst Members of Parliament in order to muster support within Parliament (EISA 2004).

The most recent general elections took place in May 2004 and ushered in a government led by the current president, Dr. Bingu wa Mutharika. Next general elections are scheduled to take place in May 2009.

3.3 Country Health System

The health sector in Malawi is characterized by multiple stakeholders from service providers through to regulators. Leading the pack of stakeholders is the Ministry of Health and Population Services or simply the Ministry of Health (MOH). The Ministry of Health has the responsibility of developing policies, planning strategies and programmes, and ensuring that the general population has access to good quality health services by ensuring that all providers follow set national policies and standards.

3.3.1 Health Service Providers

There are three major kinds of health service providers: government (public) providers, religious or non-profit providers and private (profit-based) providers. Apart from these, at

the community level limited health services are provided by Traditional Birth Attendants (TBA), Home-Based Care (HBC) volunteers and some community based organizations (CBO).

Public providers account for about 60 percent of total health services (Galimoto 2007). These include hospitals, clinics, dispensaries and health centres under the Ministry of Health. In addition to these, there are clinics owned under the Ministry of Local Government, the Ministry of Agriculture and some government institutions such as the police and the army which provide services to their staff as well as the general public.

The majority of the health facilities in the non-profit sector belongs to religious institutions and fall under the umbrella of the Christian Health Association of Malawi (CHAM). Unlike government facilities CHAM facilities charge a subsidized fee, agreed with Government, for their services. Services at CHAM facilities are considered better than those at government facilities (Galimoto 2007).

On the other hand, there are private pharmacies, clinics and hospitals especially in the urban areas which provide health services at a commercial fee.

3.3.2 Health Management

At the top of health management is the Ministry of Health. The ministry has the responsibility of developing policies, planning strategies and programmes, and ensuring that the general population has access to good quality health services by ensuring that all providers follow set national policies and standards. Malawi has 28 districts and each district has a District Health Officer (DHO) who is responsible for the dissemination of national policies, overall coordination of health services and programs, and provision of services at district level. The District Health Office is in most cases housed at the Ministry of Health District Hospital, and manages and supervises health institutions within the district that fall under the jurisdiction of the Ministry of Health.

3.3.3 Country Health Information System

Malawi through the Ministry of Health has since 2002 implemented an integrated Health Management Information System (HMIS) covering all districts in country. This system has been built around a limited set (essential set) of indicators that serve to inform health programme managers at district and national level on their programmes and alert them where intervention is required. Complete integration has not been feasible and the HMIS exists as a group of interdependent subsystems (Galimoto 2007). Altogether there are five main subsystems: (a) the financial management information system (FMIS), (b) human resources management information system (HRMIS), (c) logistic and supply management information system (LMIS), (d) physical assets management information system (PAMIS), and the integrated health services management information system (HSMIS). Figure 3.2 adopted from one in Galimoto (2007) shows an overview of HMIS in Malawi.

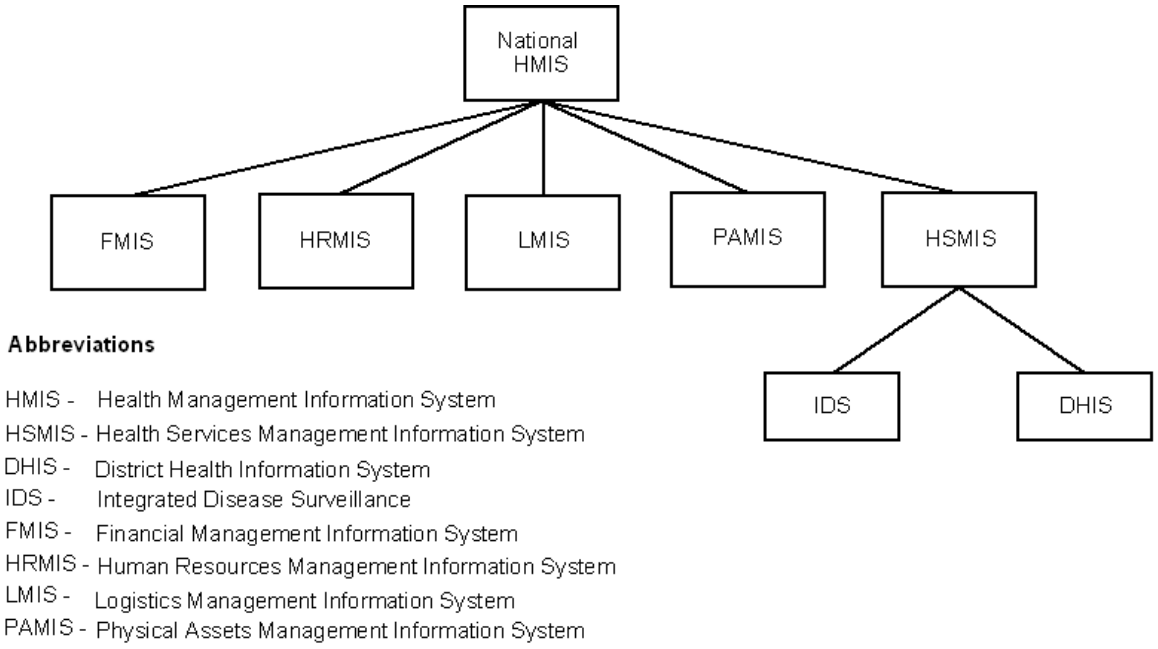


Figure 3.2: Overview of HMIS

Routine and non-routine health data is handled by the HSMIS component of the HMIS. HSMIS makes use of *District Health Information System* (DHIS) developed in South Africa under the Health Information Systems Programme, an ongoing information systems action research in which Malawi is one of the participants.

3.4 Malawi AIDS Profile

3.4.1 History of AIDS in Malawi

The first HIV case in Malawi was reported in 1985 (NAC 2003; USAID 2005). In response, the Malawi Government implemented a short-term AIDS strategy that included blood screening and HIV education programmes. In 1988, the National AIDS Control Programme (NACP) was established to coordinate the country's AIDS education and HIV prevention efforts. However, it was not until 1989 when a five-year AIDS plan was announced, that the Government began to show any real commitment towards tackling the problem (AVERT 2009).

At this time Malawi was under the one party regime where public discussion of sexual matters was generally banned or censored, and HIV and AIDS were considered taboo subjects. Subsequently, between 1985 and 1993, HIV prevalence amongst women tested at urban antenatal clinics increased from 2% to 30% (AVERT 2009). In 1994, following protests and international condemnation, Malawi became a multi-party democracy. Freedom of speech was re-established, creating a more liberal climate in which AIDS education could be carried out without fear of persecution.

The year 2000 saw the establishment of a five-year National Strategic Framework to combat AIDS. However, the policy was slow to take effect due to financial and organizational difficulties within the NACP (AVERT 2009). There was a need for a more structured body to co-ordinate Malawi's response to HIV and AIDS. In 2001, together with its cooperating partners, the Malawi Government established the National AIDS Commission (NAC) under the Office of the President and Cabinet (OPC) to coordinate a national multi-sectoral response to the HIV/AIDS crisis (USAID 2005).

Malawi's response to AIDS was further strengthened in 2004 with the election of new President Bingu Wa Mutharika, who launched Malawi's first National AIDS Policy (AVERT 2009). The policy sets the goal of improving the provision of prevention, treatment, care and support services, and calls for a multi-sectoral response to the

epidemic. A Principal Secretary for HIV and AIDS was appointed within the Government, and treatment and prevention programmes have been scaled up.

3.4.2 Situation Analysis of HIV/AIDS in Malawi

Malawi is one of the poorest nations in the world and one of the 10 countries most affected by AIDS worldwide (USAID 2005). Malawi's HIV prevalence is ranked 8th highest worldwide (DFID 2005). The adult HIV prevalence in Malawi is estimated to be 14.1% and approximately 70,000 new HIV/AIDS cases are reported each year and there are approximately 110,000 new HIV infections each year (USAID 2005). AIDS is one of the leading causes of death among Malawian adults. In fact, AIDS accounts for the majority of deaths amongst Malawian Adults; with more than 80,000 deaths annually attributed to it (NAC 2003; USAID 2005).

The impact is not limited to the adult population only; the children are affected by either contracting the disease from their mothers at birth or by losing a parent or both to the disease. At the end of 2005, an estimated 91,000 children in Malawi were living with HIV and more than half a million had been orphaned by AIDS (USAID 2008). This has given rise to child-headed homes as the traditional extended family system has been overwhelmed by the situation and the children have no extended family to rely on following the death of their parents (*ibid*).

The HIV/AIDS epidemic in Malawi is having a devastating impact on the country's productivity. In 2002, Malawi suffered its worst food crisis for over fifty years, with HIV recognised as one of the factors that contributed most significantly to the famine (AVERT 2009). This is because farmers could not provide food, children could not attend school and workers could not support their families, either because they were infected with HIV or because they were caring for someone who was (*ibid*).

Furthermore, Malawi faces a critical shortage of public health workers, health care providers, facilities, equipment, and medicines; and the active labor force is becoming too small to support the needs of the young, the old, and the chronically ill. Patients with HIV/AIDS-related conditions currently occupy over 70% of hospital beds (USAID

2005). The spread of HIV has resulted in an increase in the number of tuberculosis (TB) cases. A 1999 survey showed an HIV seroprevalence of 77% among TB patients (DFID 2005; USAID 2005).

There are significant geographical differences with respect to HIV prevalence in Malawi. HIV prevalence is significantly higher in urban areas compared to rural areas where about 80% of the population lives (USAID 2008). In the southern region, where roughly half of the country's population lives, HIV rates for both urban and rural areas are much higher than in other regions.

Malawi's AIDS epidemic is feminized; around 60% of adults living with HIV in Malawi are female (AVERT 2009). The 2004 Demographic and Health Survey (DHS) demonstrated that HIV prevalence was higher for women than men, at 13 percent and 10 percent respectively (USAID 2008). Furthermore, HIV prevalence among young women, 15 to 24 years old, in Malawi is much higher than among men of similar age: 9 percent compared with 2 percent overall, and, in urban areas, 13 percent compared with less than 1 percent (*ibid*).

HIV/AIDS is still stigmatized in Malawi, hindering the flow of information to communities, hampering prevention efforts, and reducing use of HIV/AIDS services (AVERT 2009; USAID 2008). As a result, few people living with HIV make their status known, many have difficulty discussing the subject with their families, and some support groups do not meet openly (AVERT 2009). Other barriers to prevention, treatment, and care and support include the limited coverage of behavioral change communications, inadequate empowerment of women, limited access to services, insufficient focus on pediatric cases, inadequate laboratory services, lack of trained staff, and limited capacity for home-based care.

3.4.3 HIV/AIDS Prevention and Treatment

There are three major HIV/AIDS prevention and treatment programmes in Malawi: HIV Counselling and Testing, Prevention of Mother to Child Transmission of HIV and Anti Retroviral Treatment.

HIV Counselling and Testing

HIV Counselling and Testing (HTC) - widely referred to as VCT for Voluntary Counselling and Testing - combines HIV testing with counselling, information and support. HTC services were introduced in Malawi in 1992 (AVERT 2009). HTC services are offered by Government and CHAM health facilities as well as Malawi AIDS Counselling Resource Organisation (MACRO), an NGO with the aim of strengthening and developing VCT initiatives. Over the years, there has been a significant increase in the number of health facilities providing HTC services across all regions. Between 2001 and 2006 the number of health facilities offering HTC services grew from 2.2 percent to 55 percent (OPC 2007).

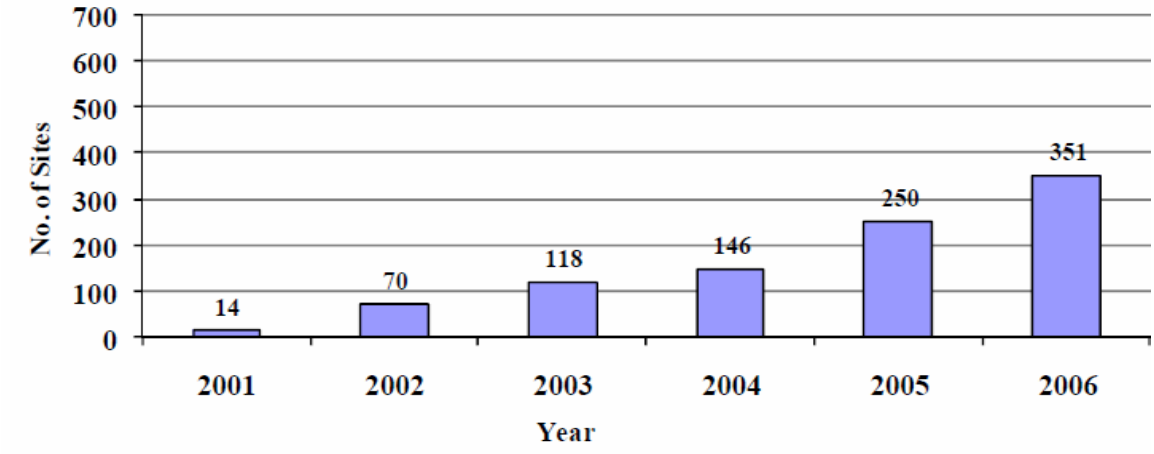


Figure 3.3: Number of Sites Offering HTC Services 2001 – 2006

(Source: OPC, 2007 p. 42)

Through the collaboration of the Ministry of Health, NAC, District Assemblies, development partners, Non Government Organisations and the private sector a National HIV Testing and Counselling week was introduced in 1996 (NAC 2007b). The aims of the HTC week, which comes once a year, are to: give people an opportunity to know their HIV sero-status, facilitate changes in risky behaviours, increase the visibility of HTC sites so that there is continued patronage of the services within existing facilities and to widely disseminate key HIV and AIDS prevention and care messages to the general public.

Prevention of Mother to Child Transmission of HIV

The PMTCT programme started in 2002 (OPC 2007). In 2003 a national strategy was launched to prevent mother to child transmission of HIV (AVERT 2009).Under this strategy and the Government's five-year AIDS treatment plan, access to the drug nevirapine (which significantly reduces the chances of a pregnant woman passing HIV on to her child) has been scaled up in Malawi. HIV testing is routinely offered to pregnant women at all antenatal clinics and at many hospitals, but there has been concern about the low numbers of women who choose to be tested (WHO 2005). The number of ANC facilities offering PMTCT has been steadily increasing over the years (*see fig 3.3 below*).

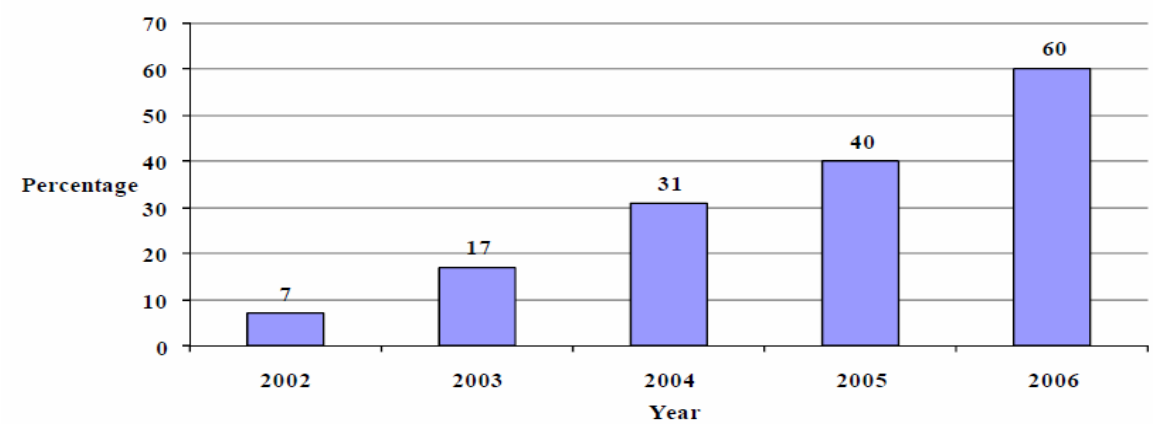


Figure 3.4: Number of ANC facilities providing PMTCT services 2002-2006

(Source: OPC, 2007 p. 45)

Anti Retroviral Treatment

Antiretroviral drugs (ARVs), which effectively delay the onset of AIDS in people living with HIV, were first made available to the public sector in Malawi in 2003. In 2004, following a grant from the Global Fund to Fight AIDS, TB and Malaria, the Government announced a five-year plan to make ARVs widely available in the public sector and began to distribute them to hospitals and clinics around the country. The government has maintained a strong commitment to providing AIDS treatment, and substantial progress has been made in recent years (*see Table 3.1 below*).

Table 3.1: Number of persons on ART Treatment

	2003	2004	2005	2006	2007[51]	Baseline	UA target 2010
National	3000	13183	37840	85200	130488	13183	208000
Male		5274	14819	33238	50890		
Female		7909	23021	51972	79598		

(Source: OPC, 2007 p. 48)

While the situation has improved significantly, there are still an estimated 189,000 people who are in need of ARVs, but have no access to treatment. Alongside financial constraints, the distribution of ARVs in Malawi is hindered by the low number of health care workers available to administer the drugs (AVERT 2009). In order to address the shortage of human resources the Government has been actively training medical personnel on administering ART. Altogether, 2,367 health workers have been trained in ART, 318 health workers have been trained in PMTCT, 1,513 have been trained in HTC and 9,989 have been trained in HBC (OPC 2007).

3.5 National AIDS Commission

National AIDS Commission (NAC) is a coordinating body for all HIV/AIDS activities in Malawi with a mandate to providing leadership in planning, organizing, coordinating and setting standards and guidelines for the prevention and control of HIV/AIDS in Malawi. Activities implemented by the Commission follow the National HIV/AIDS Strategic Framework, which contributes to the national health plan and is part of the Government strategy of poverty reduction.

NAC was established as a public Trust, under the *Office of the President and Cabinet* (OPC), in July 2001 to replace National AIDS Control Programme, which was in operation from 1987 to 2001. The Commission came into being after realizing that the response to the HIV/AIDS pandemic required a multisectoral approach because of the interaction between HIV/AIDS and broader issues of population, economic development,

human resources development and management, social service provision, culture, community development and gender.

The role of the NAC is to coordinate and facilitate the national response to the HIV/AIDS pandemic. Its specific objectives of the NAC are to:

- Manage and coordinate the implementation of Government policies on HIV/AIDS;
- Liaise with relevant Ministries as appropriate on all matters relating to HIV/AIDS in order to ensure that there are no legal, medical or regulatory barriers to information on HIV/AIDS;
- Ensure through advocacy, that all political, community and traditional leaders play a strong, sustained and visible role in the prevention of HIV/AIDS;
- Develop and maintain an up-to-date information system and establish suitable mechanisms of disseminating and utilizing such information;
- Supervise, monitor and evaluate progress and impact of HIV/AIDS prevention, care and mitigation programmes;
- Develop and institute guidelines for cooperation among the Commission, Government and other organizations and agencies in Malawi.

NAC with the help of the Ministry of Health HIV/AIDS unit coordinates surveillance, monitoring and evaluation of HIV/AIDS programmes. Other key institutions in the monitoring process include teaching hospitals: Zomba Central Hospital; Kamuzu Central Hospital and Queen Elizabeth Central Hospital, and the College of Medicine (WHO 2005). On the other hand, WHO, UNAIDS and the United States Centers for Disease Control and Prevention provide technical assistance (*ibid*).

3.6 District Profiles

3.6.1 Zomba District

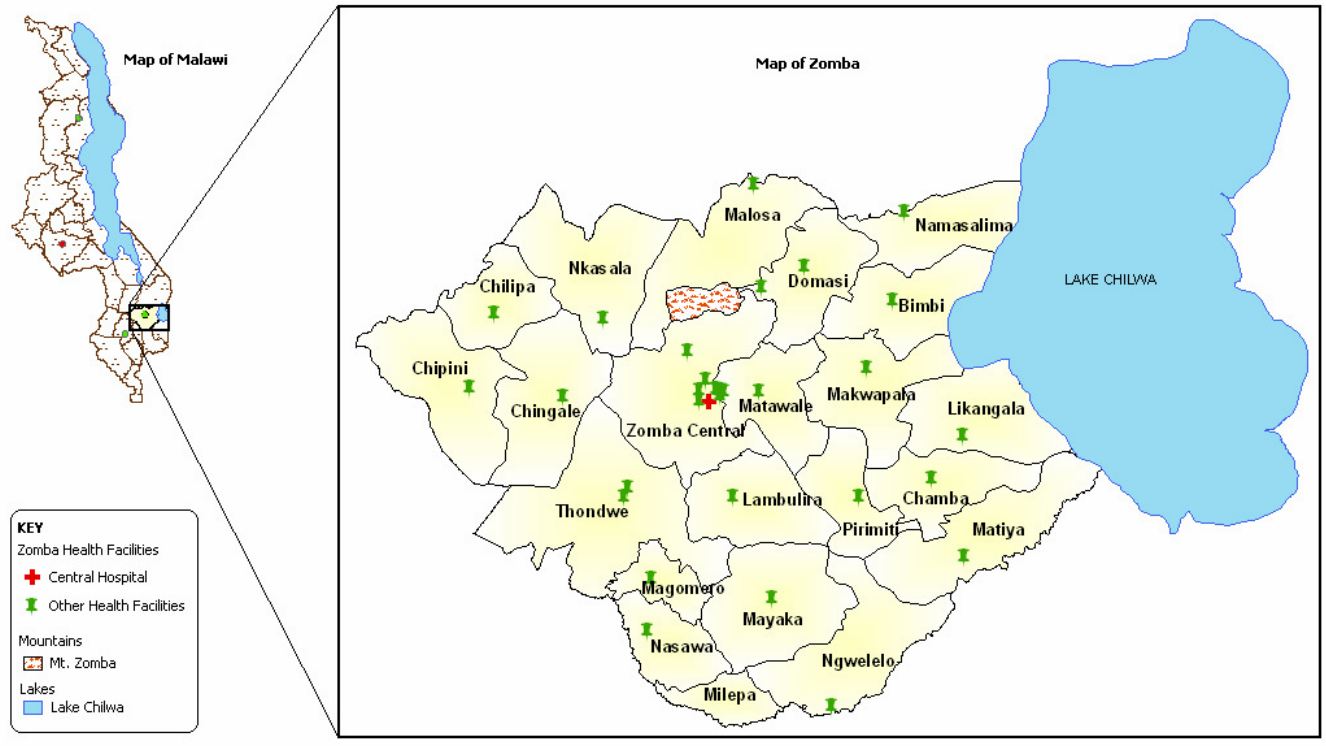


Figure 3.5: Map of Zomba District

Zomba is a district in the southern region of Malawi (*see figure 3.5*). It used to be the capital of Malawi in the colonial days. It covers an area of about 3,241 square kilometers. Zomba is one of the districts where HIV rates are high (NAC 2007b). It has an estimated population of 670,533 people the majority of which, about 583,167 lives in the rural (NSO 2008). The district is served by Zomba Central Hospital plus 30 other health facilities and a mental hospital. 15 of the health facilities are run by the MOH, 11 are run by CHAM, 1 by the local government, 1 by the Malawi Defence Force, 1 by the Malawi Police, 1 by the Malawi Prison Service, 1 by the Department of Forestry and 1 by Banja La Mtsogolo. The district is divided into 22 health zones (or catchment areas).

3.6.2 Balaka District

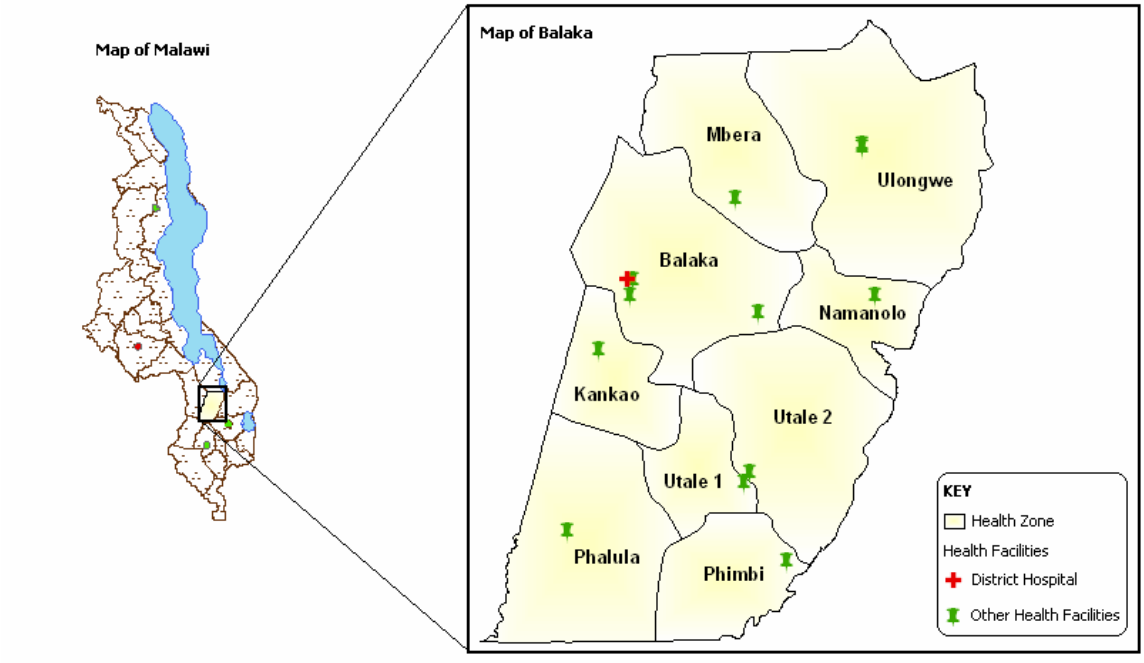


Figure 3.6: Map of Balaka District

Balaka, just like Zomba, is a district in the southern region of Malawi. Until 2000, it used to be part of Machinga district. It is located on the north west of Zomba (*see figure 3.6*). It covers an area of about 2,136 square kilometers. Balaka is one of the districts in Malawi that have mid-range HIV rates (NAC 2007b). According to (NSO 2008), Balaka has an estimated population of 316, 748 people. There are 14 health facilities altogether in the district, of which one is a district hospital. Seven of the health facilities are run by the MOH, six are run by CHAM and one by BLM. The district is divided into 9 health zones.

4.0
Research Methodology

This focus of this study was on exploring HIS in Malawi in order to understand challenges and opportunities that exist in the adoption of GIS for monitoring and management of HIV/AIDS programmes in the country.

This chapter presents how the research was conducted in order to meet the research objectives at hand.

4.1 Research Approach

Research approaches can generally be classified into two groups, qualitative and quantitative. The choice of a research approach to be used is solely determined by what the research seeks to find out (Myers 1997). Traditionally, the quantitative approach is associated with natural sciences such as biology, chemistry, physics, etc where studies are concerned with investigating things that we could observe and measure in some way (Myers 1997). To put it in another way, quantitative research is concerned with quantifying things. It is concerned with how much, how many, how often and so on. Myers (1997) mentions surveys, laboratory experiments, formal methods (such as econometrics) and numerical methods such as mathematical modelling as some good examples of quantitative methods.

On the other hand, qualitative research has its roots in the social sciences where the focus is on understanding of why things are the way they are in our social world and why people act the ways they do (Myers 1997). This is difficult to achieve with quantitative methods because the ability to understand a phenomenon from its institutional (social) context is lost when data is quantified (*ibid*). According to Silverman (2001) qualitative methods provide a deeper understanding of social phenomena than would be obtained from purely quantitative data.

As argued earlier HIS are social-technical systems (Walsham et al. 1988). Therefore any studies on HIS ought to respect and understand the social context in which such systems

operate. That makes qualitative research more suitable for studying HIS. This study involves HIS in Malawi and aims at understanding the challenges and opportunities that exist in the adoption of GIS for the monitoring and management of HIV/AIDS programmes. In order to understand these challenges and opportunities there is a need to understand people and institutional behaviors and practices involved. All this makes the qualitative research approach an ideal option for this study.

4.2 Research Method

There are several research methods that are associated with qualitative research. With respect to IS research, qualitative research methods often used include case study, action research and ethnography. While all these methods are applicable to IS research, Myers (1997) argues that the case study research method is particularly well suited to IS research, since discipline involves studying of information systems in organizations, which shifts the interest from purely technical issues to organizational issues. According to Yin (2003), a case study is "*an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*". Furthermore, Braa & Hedberg (2002) argue that information systems are part of their social context of use and so the health care information systems are deeply embedded in social work practices and are barely separable from the social context of which they are part.

Consequently, this study adopted a case study approach to help explore the HIS in Malawi with respect to the objectives of this research. The case study was done at two levels, the national level and the district level. At the national level, the study focused on the Ministry of Health and National AIDS Commission who are the dominant bodies in the monitoring and management of HIV/AIDS programmes. At the district level, the District Health Office is key coordination point for HIV/AIDS programmes. In this study, two districts, Zomba and Balaka, were visited.

4.3 Data Collection

Data collection was predominantly conducted using interviews, as interviews are the primary data collection technique in case studies (Myers 1997). This was supported by document review and to a lesser extent observation where possible. In addition to these, prototyping was also used to collect data of practical relevance and to gain a practical understanding of opportunities and challenges that exist with regard to the objectives of this study.

To facilitate the data collection process an approval was sought from the Ministry of Health, National Health Sciences Research Committee. The approval was granted on 8th October 2008 (*see Appendix A*). Data collection, therefore, started on Monday, 13th October, 2008. However, spatial data collection for purposes of prototyping started earlier. The time frame of the data collection effort for the study is given in *Table 4.1* below.

Table 4.1: Data Collection Time Frame

Period	Activity	Location
Aug – Oct 2008	Processing Approval for Research at MOH Training in Arc view GIS Collecting Spatial Data	MOH Blantyre, Polytechnic MOH and SAHIMS website
13th Oct – 16th Oct 2008	Data Collection/Interviews	Zomba DHO
21st Oct – 23rd Oct 2008	Data Collection/Interviews	NAC/MOH
23rd Oct – 31st Oct 2008	Data Collection/Interviews	Balaka/Zomba DHO
13th Nov – 14th Nov 2008	Observation: HTC Week	Police Clinic, Zomba
26th Nov – 4th Dec 2008	Data Collection/Interviews	NAC/MOH
8th Dec 08 – 5th Jan 2009	Prototype Demonstration /Evaluation	Zomba DHO

4.3.1 Interviews

As stated earlier, data collection was done at national level and at district level. Altogether, interviews were conducted over a period of two months, from 13th October, 2008 to 12th December, 2008. In total, 14 respondents were interviewed, eight at national level and six at district level. At the national level, there were five interviewees at NAC and three interviewees at MOH. At the district level, three respondents were interviewed per district.

Interviews can be of three kinds: structured, semi-structured and unstructured. Structured interviews are rigidly organized in that the respondents are asked the same questions in the same manner as much as possible. Semi-structured interviews, on the other hand, draw from an interview guide, which suggests the questions to be asked in the interview or data to be collected but offers freedom to the interviewer and interviewee to discuss some topics in more detail. Unstructured interviews have little or no structure at all; questions tend to depend on the responses from the interviewee. This study employed the semi-structured style of interviews because of the freedom it gives to the interviewer and interviewee to explore topics in greater detail (Silverman 2001). Furthermore, semi structured interviews allow some level of control on the side of the interviewer without stifling expression on the side of the interviewee.

At the national level, interviews were conducted at NAC, the government body established to coordinate a multisectoral national response to HIV/AIDS and MOH. At NAC I visited the Monitoring and Evaluation (M & E) department. I interviewed the head of the department and two other M & E officers. In addition, I also interviewed the IT officer and the librarian who is responsible for NAC's and other national publications on HIV/AIDS that NAC holds. At the Ministry of Health, interviews were conducted with a Senior Statistician responsible for GIS technology, the Chief Statistician and the Head of the HIV/AIDS Unit.

Further interviews were conducted at the district level, at the DHO. This was done in order to understand the monitoring and management routines of HIV/AIDS programmes

at this level, the level of usage or non use of GIS technology and the opportunities and challenges that exist at this level with respect to adopting GIS technology for monitoring and management of HIV/AIDS programmes. This was important because as a result of decentralization the district assembly through the DHO, with support from MOH, is responsible for the management of health services and programmes within its own district. At this level, interviews were mainly conducted with the District AIDS Coordinator (DAC), the District Statistician and to a lesser extent the District Health Officer (DHO) who is the overseer of health issues in a district. As mentioned earlier, two districts – Zomba and Balaka - were visited bringing the number of respondents at this level to six.

4.3.2 Document Review

While much of the information was collected through interviews, supporting information was collected through analysis of documents and various publications both at a national and district level. Document analysis is very useful in understanding underlying policies, strategies and procedures that affect how things are done. In this study, document analysis covered data collection forms, monitoring and evaluation forms particularly for VCT, report and publications by NAC, Government and other stakeholders on HIV/AIDS in Malawi.

Specifically, national documents that were studied include: *The Malawi National HIV/AIDS Policy* by the Malawi Government, *2007 Malawi HIV and AIDS Monitoring and Evaluation Report* and *2005 Malawi HIV and AIDS Monitoring and Evaluation Report* by the OPC, *2007 National HIV Testing and Counselling Week: Technical Report* and *The NAC Activity Reporting System for HIV Interventions: A guideline for Implementers of HIV interventions* by the National AIDS Commission, just to mention a few.

While providing an understanding of how the national response to HIV/AIDS is coordinated and the monitoring and evaluation routines that have been put in place, some

of these documents also provided background data which was used in the GIS prototype built during the study.

4.3.3 Observation

There are two types of observation techniques that can be deployed in research: passive (uninvolved) observation and participatory observation. During this study, passive observation was carried out during the 2008 HTC week which took place between November 10 and November 16, 2008 at Police Clinic which served as one of the HTC sites. This was done to appreciate the data collection and data quality assurance procedures in practice. Furthermore, since data reporting to the Ministry is done on quarterly basis I was able to observe the compiling and reporting activities that are undertaken by the district statistician at Zomba district.

These observations were carried out in order to understand the processes that generate the data that ends up being used for monitoring and evaluation and planning purposes. This is important because it is the very same data that would be used in a GIS system where one exists.

4.3.4 Prototyping

In software development, a prototype is a rudimentary working model of a product or information system, usually built for demonstration purposes or as part of the development process (Sommerville 2004). The development of prototypes, called prototyping, is a rapid process. Prototyping can be done for various reasons including eliciting system requirements from users, trying out design options and demonstration purposes (*ibid*).

One of the things that were found out during the interviews was that there was little or no knowledge, at the district level, of GIS technology and its abilities and relevance to health. Consequently, one of the reasons why prototyping was carried out in this study was to demonstrate the potential that GIS has with respect to enhance monitoring and evaluation of HIV/AIDS interventions as well us its presentation abilities. However, the

major reason for the prototyping was to facilitate empirical data collection on practical issues surrounding the use of GIS for monitoring and management of HIV/AIDS. In this regard, prototyping would facilitate understanding from the practical point of view the opportunities and challenges involved. Furthermore, prototyping afforded the study an opportunity to assess the availability and quality of both spatial and attribute data required for such a system.

The prototype was built using ArcGIS 9.1 and Microsoft Access 2003 as the underlying Database Management System (DBMS). The Microsoft Access database was used to store attribute data, representing some HIV/AIDS statistics at the district level. The database was linked to ArcGIS 9.1 through the OLE DB connection feature in order to make the attribute data dynamically available to the GIS system (*see Figure 5.3*).

4.4 Empirical Data Analysis

Data analysis as a process involves getting meaning or understanding out of the data collected. In a typical qualitative research study, a clear separation of data collection and data analysis is difficult (Myers 1997). Furthermore, data analysis is a cyclical process; data is collected and analysed, follow ups are made on areas that do not make sense by collecting more data which is further analysed and so on (Agar 1980 cited in Saugene 2005). In a similar way, during this study data analysis started during the data collection.

During data collection, analysis started with transcribing, expanding and organizing of data collected from fieldwork into a memo. This was done immediately after the fieldwork – interviews, document analysis and so on – in order to ensure that important details were not forgotten. The outcome of this process was further analysed in order to draw meanings, inferences and identify gaps. Analytical notes were made from this analysis. Gaps needing further clarification were subsequently followed up by collecting more data thereby increasing the validity and the reliability of the data collected. This kind of analysis also provided background information which was crucial in the planning subsequent data collection efforts.

The data analysis, done at this stage, mainly employed triangulation and content analysis techniques. By triangulating data sources and data collecting techniques inconsistent and contradictory data was identified and due clarification was sought where necessary. This enhanced the reliability and validity of the data collected.

Further data analysis, after data collection, involved making use of the established conceptual framework to draw meaning, understanding and explanations to the research findings.

4.5 Validity and Reliability of Data

In order to ensure the validity and reliability of data obtained during this study, a number of techniques were used. First of all, the study employed what can be called *analyse and follow up* routine whereby data was analysed immediately after collection, as explained in *section 4.4* above, in order to identify gaps that needed clarifications. These gaps were subsequently followed up by collection more data and seeking clarifications where necessary.

Furthermore, the study employed triangulation of data sources and data collection methods. This afforded the study the ability to confirm the data collected using one method with another. This helped to ensure that the reality of the ground was accurately captured. In addition, by triangulating data sources inconsistencies and contradictions could be identified and addressed appropriately.

4.6 Ethical Considerations

This study took into account ethical issues relevant to the research. Ethical clearance/approval was sought from the National Health Sciences Research Committee which was granted on 8th October, 2008. In addition to that, an informed consent form was developed which all interviewees signed upon being informed about the research and having agreed to take part.

Issues of confidentiality and anonymity were taken into account. Consequently, no names of any of the participants/respondents in this study have been disclosed in this body of work and any associated documents.

The issue of HIV/AIDS is a sensitive one world wide, particularly in those countries highly affected by the phenomena. No HIV/AIDS related document, forms and the like, that was made available to this study have been used without prior authority to use them. In most cases, documents were just studied and no copies were made.

4.7 Limitations of the Study

The study faced a number of constraints. First and far most, the study was time constrained due to the delay in the approval from the National Health Sciences Research Committee. The delay limited the period of fieldwork for the study to just two months.

Apart from that, the sensitivity attached to HIV/AIDS means that some of the documents that would have assisted this body of work to provide a good picture in support of observations made are either not available or no consent was granted to use them. This is particularly the case regarding completed data collection forms.

Furthermore, as a result of the delay in granting approval to the research, input from other stakeholders including the private sector, NGOs, cooperating partners/donor agencies and UN bodies has not been sought. Input from these entities would have been valuable as they are directly or indirectly involved in the national monitoring and evaluation system coordinated by NAC.

5.0
Prototype

In order to appreciate practical issues surrounding the use of GIS for monitoring and management of HIV/AIDS in Malawi as well as to demonstrate its capability in that aspect a prototype was developed as part of this study. The prototype was developed using ESRI ArcGIS with Microsoft Access 2003 as the underlying database management system. This chapter describes the prototyping process and the outcome thereof.

5.1 Prototype Scope

The prototype focused on the possible uses of GIS at national level and district level. At the national level data was sourced from the National AIDS Commission while at the district level data was sourced from Zomba District. Balaka district was excluded from the prototyping process due to problems with available spatial data and because of the time available for the study. The prototyping and subsequent demonstration and evaluation were largely carried out at the Zomba District Health Office

5.2 Establishing Requirements for the Prototype

The first step in the prototyping process involved establishing initial requirements of the GIS prototype to be developed. The establishment of requirements was a consultative process that mainly involved the District AIDS Coordinator and the District Statistician at Zomba District Health Office. The process of establishment of initial requirements was based on the prototyping principle of a starting with a small set of requirements that sets the foundation for building a desired system. Since prototyping is an iterative process further requirements can be accommodated as they come to light.

The process was informed by the existing monitoring and evaluation system in terms of indicators (*see Appendix D*). HIV prevalence and incidence levels are outcome indicators that are used to determine effects intervention programmes – that is if the programmes are yielding the desired result, reducing the spread of HIV. In Malawi it is largely prevalence rates that are computed other than incidence rates. Thus, the first and most

important requirement of the prototype was to map prevalence rates at a district level and at the national level. At the national level, the mapping was to be done according to districts as well as regions. In addition to mapping HIV prevalence there was also a requirement to show the trend in prevalence over a number of years – whether decreasing or increasing.

Another requirement that came up was to map the distribution of services across health facilities. As stated earlier in the research setting chapter there are three main HIV services or intervention programmes in Malawi: HIV Testing and Counselling (HTC), Antiretroviral Treatment (ART) and Prevention of Mother to Child Transmission (PMTCT). Thus, there was a need to show what programmes are running at each of the health facilities within the district.

For intervention programmes performance indicators are computed. For example, for HTC the *number of people counselled and tested* and *the number of people tested that actually received* their results are some of performance (output) indicators. Thus, another requirement for the prototype was to map performance indicators for intervention programmes such as HTC.

In summary the established initial requirements for the GIS prototype were as listed below:

1. Map HIV prevalence and prevalence trends at district and national level.

2. Map the distribution of HIV services across health facilities within a district.

3. Map performance indicators for HIV intervention programmes such as HTC.

These requirements provided the foundation for construction the GIS prototype for HIV/AIDS.

5.3 Prototype Development

The prototype was developed using ESRI ArcGIS 9.1 alongside Microsoft Access 2003 as the underlying database management system. A database was created in Microsoft Access for storage and manipulation of non-spatial data. A corresponding GIS project was created in ArcGIS and linked with the Microsoft Access database through the *OLE DB connection* feature in order to make the attribute data dynamically available to the GIS system.

5.3.1 Getting Required Data

The requirements established described above resulted in some data needs, spatial and non-spatial, that had to be met in order to fulfill those requirements. The spatial data required included shape files for districts, regions, healthy facilities and the country as a whole. On the other hand, non-spatial data required included HIV prevalence data at the national and district level, service distribution data within the district as well as performance data for intervention programmes at the district level.

Spatial data was largely obtained from the Ministry of Health except for data for features like roads, rivers and lakes which was obtained from Southern African Human-development Information Management System (SAHIMS) GIS Data Server. Table 5.1 below shows a summary of shape files used in the prototype and their sources.

Table 5.1: Spatial data used and its sources

Shape File	Type	Source
Malawi Map showing Regions	Polygon	Ministry of Health
Malawi Map showing Districts	Polygon	Ministry of Health
Health Facilities in Malawi	Point	Ministry of Health
Zomba District showing Catchment Areas for Health Facilities	Polygon	Ministry of Health
Health Facilities in Zomba	Point	Ministry of Health
Cities and towns in Malawi	Point	SAHIMS
Lakes	Polygon	SAHIMS
Rivers	Line	SAHIMS
Roads	Line	SAHIMS

Non-spatial data was obtained was three sources. HIV prevalence data at national level came from the National AIDS Commission. At the district level HIV prevalence, service distribution and programme performance data was obtained from Zomba district health office. However, for HIV prevalence data was not readily available and had to be estimated from 2007 HIV Testing and Counselling week. In addition, census data was obtained from the National Statistics Office. The census data came from the 2008 population and housing census.

5.3.2 Creating Non-Spatial Data Database

With non-spatial data coming from different sources it became necessary to create a separate database to hold this data. Furthermore, creating a separate database meant that the prototype was only going to handle the data that it needed and therefore would lighter. The first step in creating the database was an entity analysis using ER diagramming in order to visualize on what objects was data supposed to be kept and therefore the scope of the database (*see figure 5.1*).

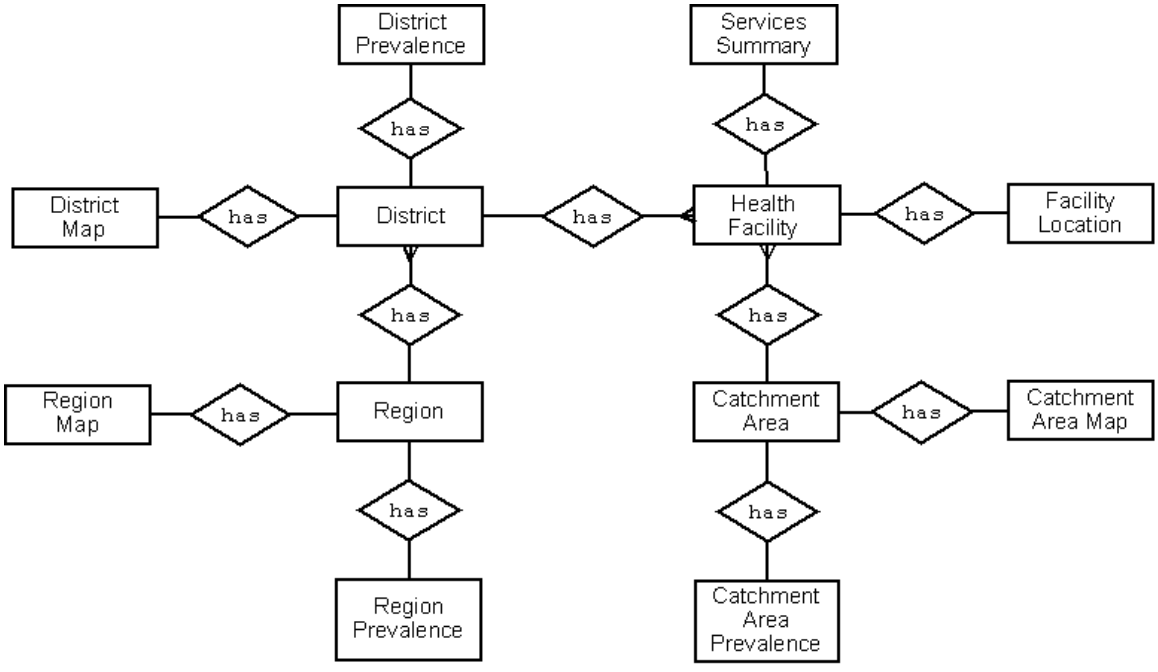


Figure 5.1: ER Diagram for Non-Spatial Data

In order to facilitate linking of spatial data to non-spatial data the ER diagram also includes spatial elements: district map, region map, catchment area map and facility position. Thus, while transforming the ER diagram to a database the identifying field for spatial data which in most cases was named ID was imported as a *foreign key* or *primary key* into corresponding tables in the non-spatial data databases in order to facilitate links between two. A partial schema of the resulting database is shown in *figure 5.2* below.

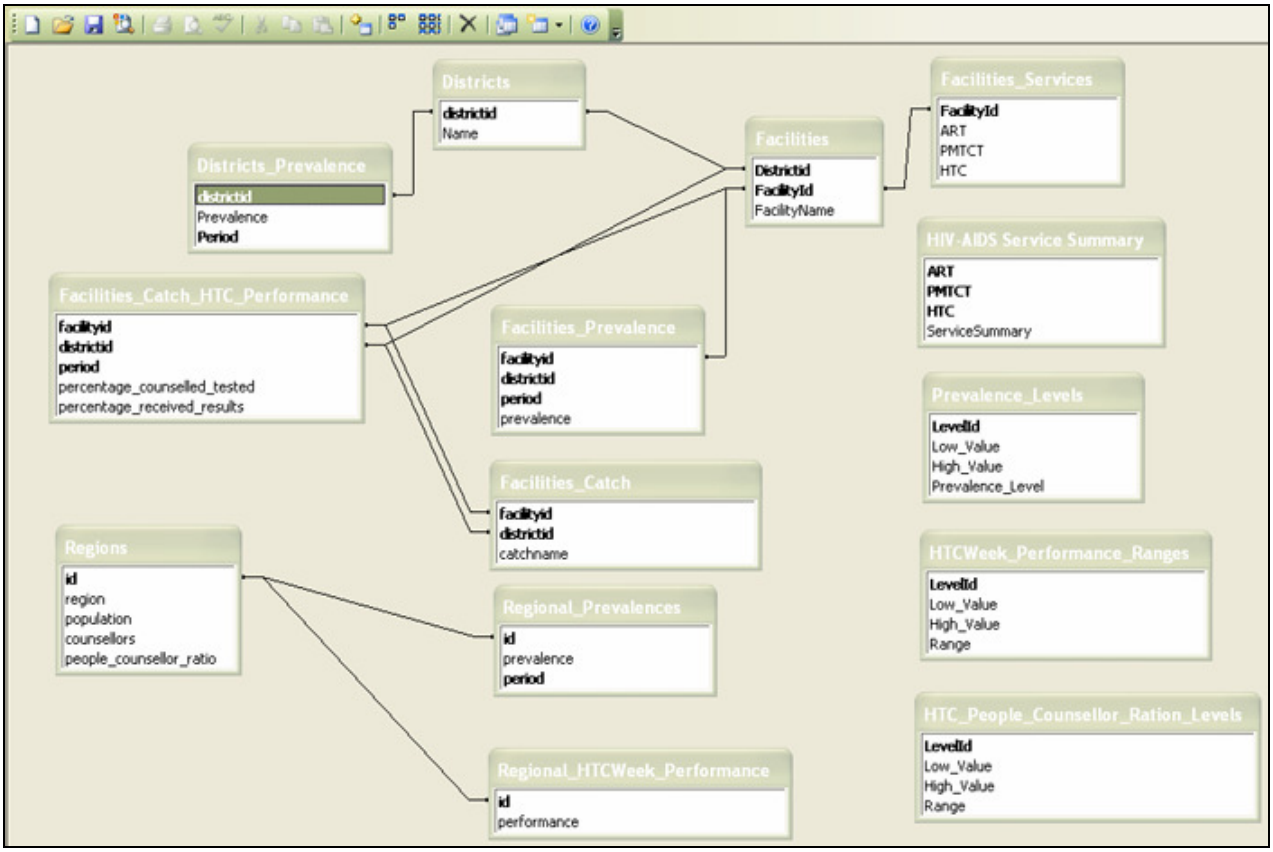


Figure 5.2: Partial Schema for the Non-Spatial Database

The non-spatial database was then populated with the corresponding data collected from the sources mentioned.

5.3.3 Creating the GIS Prototype

Having created the non-spatial database in Microsoft Access the next step was building the GIS system using ArcGIS 9.1. The GIS system was linked with the non-spatial database through the ArcGIS's *OLE DB Connection* feature in order to make the attribute

data dynamically available to the GIS system. Using this feature SQL queries to retrieve data from the non-spatial database and make it available to ArcGIS were specified. The queries are executed automatically every time the GIS prototype is run retrieving the required data. This means that any changes that would have been made on the data in the non-spatial database are automatically reflected in the maps produced. *Figure 5.2* shows a diagrammatic representation of the structure of the GIS prototype.

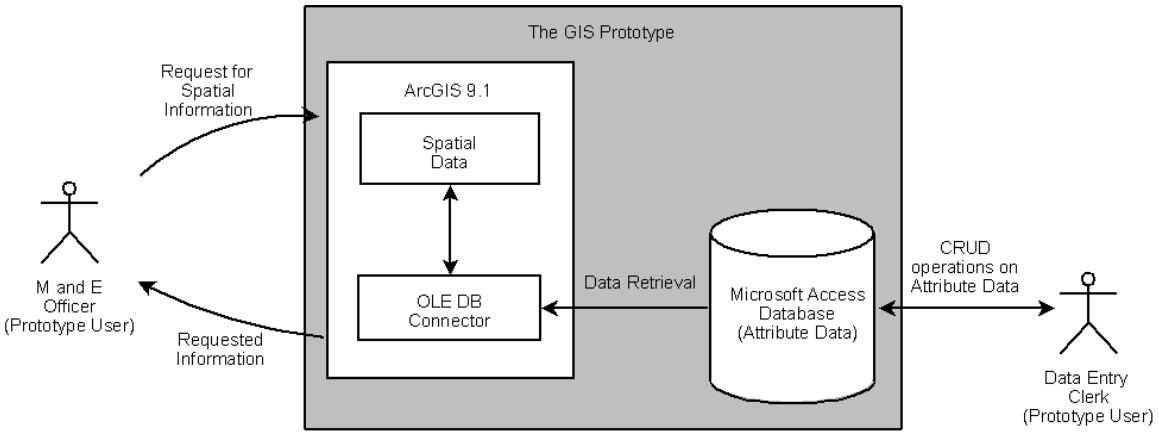


Figure 5.3: Overview of the Prototype

The GIS prototype was developed incrementally following an *evolutionary prototyping* approach (*see figure 5.4*). The aim was to deliver a limited but usable prototype. Thus, evolutionary prototyping was chosen over *throw-away prototyping*. Using this strategy the first requirement of mapping HIV prevalence and prevalence trends was implemented first. Upon satisfaction with implementation the next requirement was implemented and so on; until all requirements set for the prototype were met.

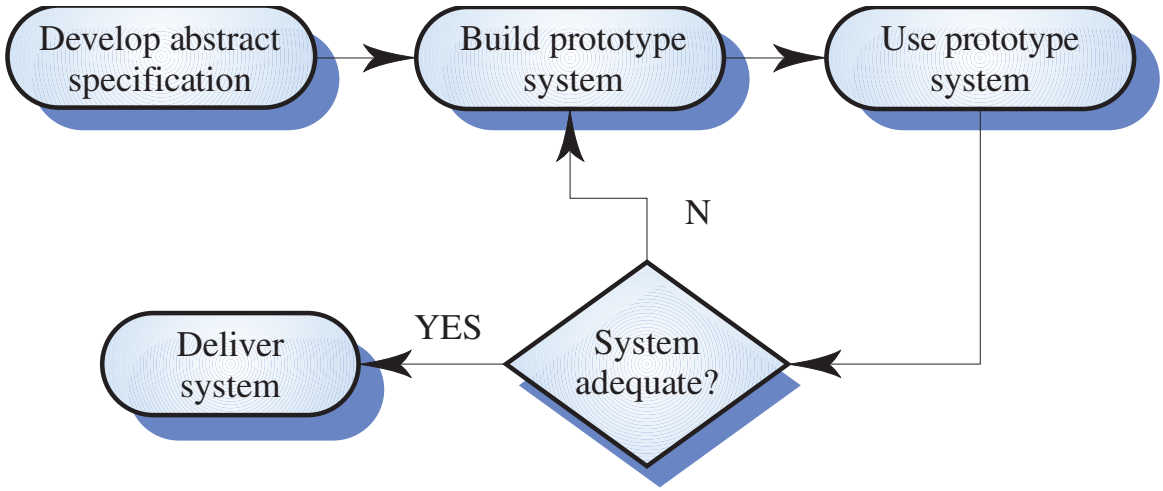


Figure 5.4: Overview of Evolutionary Prototyping

The end result of this incremental development process was a GIS prototype that satisfied the initial set of requirements. *Figure 5.5* shows a screenshot of the GIS prototype in ArcGIS.

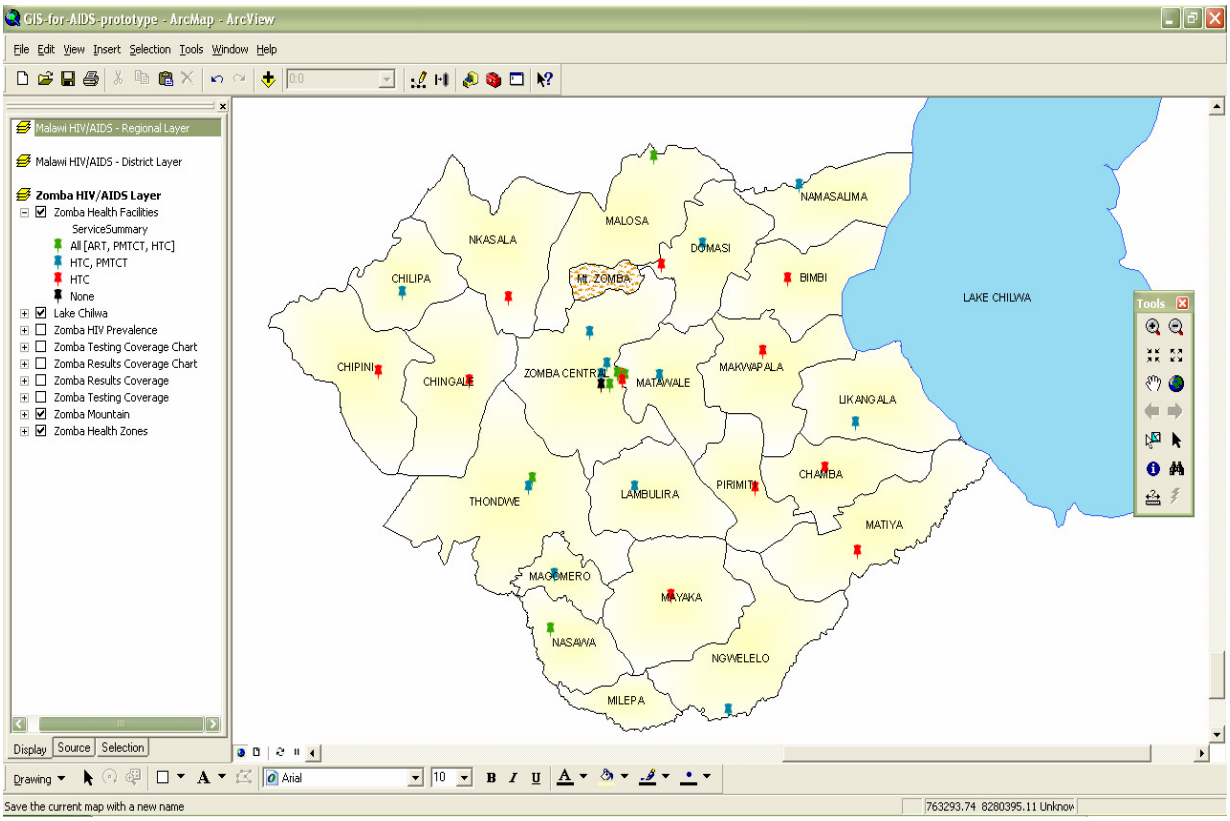


Figure 5.5: Screenshot of the GIS Prototype in ArcGIS

5.4 Outcome

5.4.1 Mapping HIV Prevalence

The first requirement that had been set for the prototype was to map HIV prevalence at the national level and at the district level. At the district level, as mentioned before, HIV prevalence data was not readily available and estimates from the data collected during the 2007 HIV Testing and Counselling week were used instead. First, the HIV prevalence levels were classified (categorized) into three groups: high, medium and low. With that classification the prototype was able to map districts with high, medium or low HIV prevalence at the national level and health zones (catchment areas) at the district level (*see figure 5.6 and figure 5.7*).

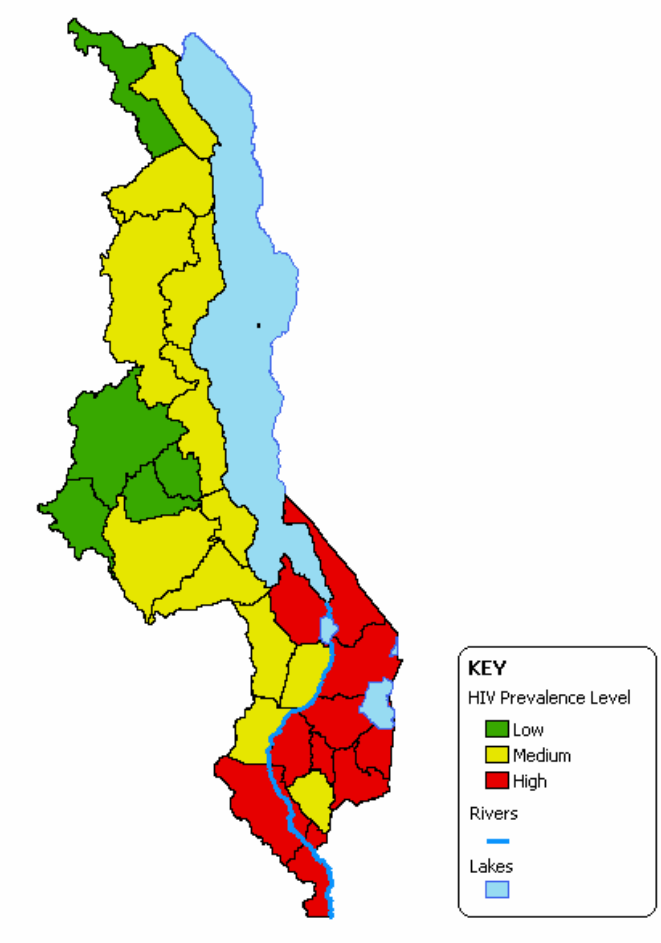


Figure 5.6: HIV Prevalence According To District – 2007

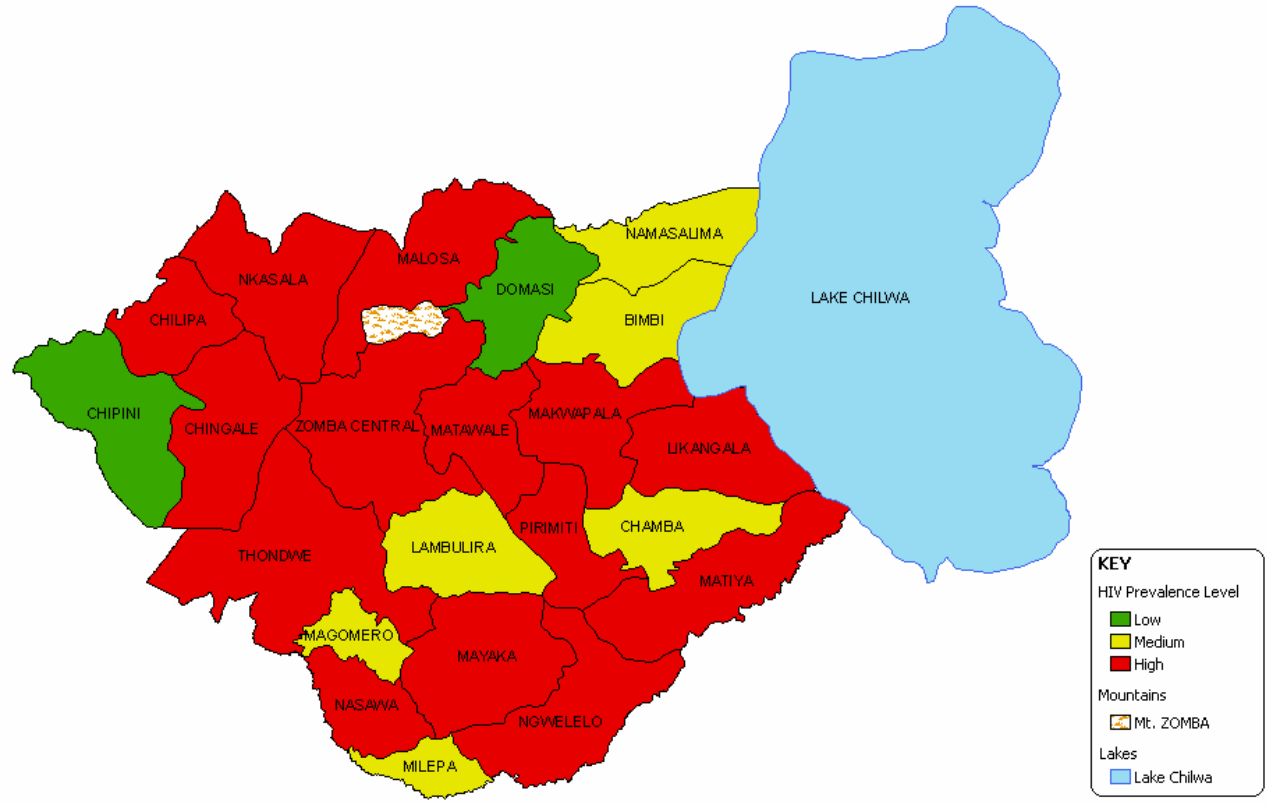


Figure 5.7: Estimated HIV Prevalence Levels for Zomba - 2007

5.4.2 Mapping HIV Prevalence Trends

The ability to monitor HIV prevalence trends is crucial to monitoring and management of the epidemic in general. By looking at the trends – decreasing or increasing – managers can determine if intervention programmes are having the desired impact or not. Thus, apart from simply mapping the HIV prevalence the prototype also set out to depict HIV prevalence trends.

To map HIV prevalence trends there is a need to have prevalence data for at least two years. However, at the district level there was data for 2007 only. On the other hand, at the national level prevalence data according to regions was available for years 2001, 2003, 2005 and 2007. As the result of the unavailability of data at the district level the prototype could only map HIV prevalence trends for the national level. This was done using data for three years 2001, 2003, 2005 and 2007 (*see figure 5.8 and figure 5.9 below*).

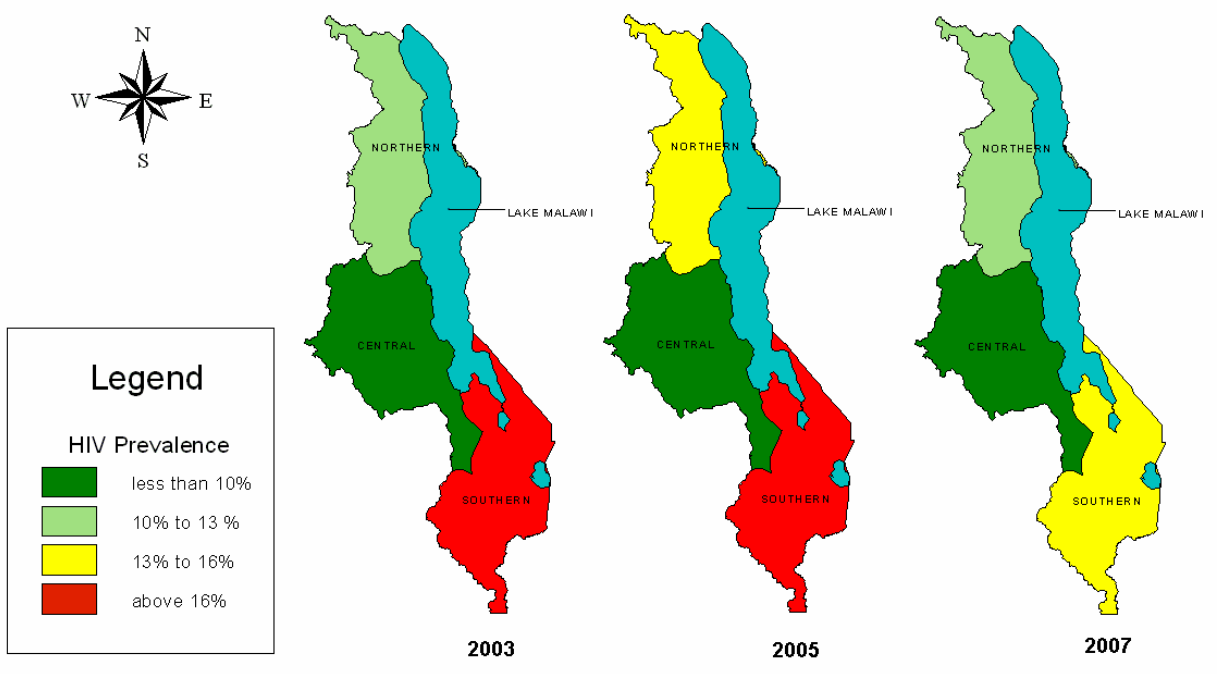


Figure 5.8: Regional HIV Prevalence Trends 2003 - 2007

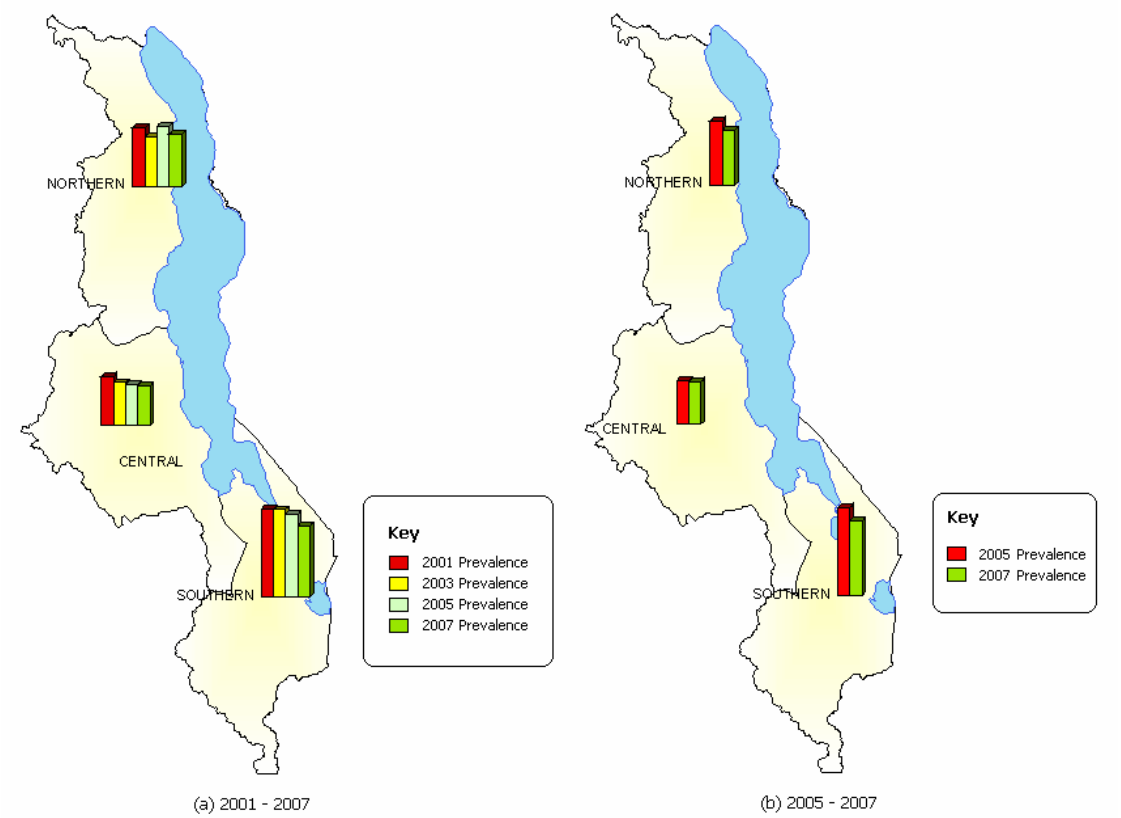


Figure 5.9: Regional HIV Prevalence Trends 2001 - 2007

The general trend is that HIV prevalence in Malawi has been decreasing with the exception of the period between 2003 and 2005 when the Northern Region recorded an increase in prevalence from 11.3% to 13.5%. However, the trend resumed for period 2005 to 2007 which shows a drop in prevalence for all three regions. This is better visualized in *figure 5.9* above.

5.4.3 Mapping HIV/AIDS Service Distribution

Another requirement the prototype was set out to meet was to map the distribution of HIV/AIDS services within a district, in this case Zomba. There are three main HIV/AIDS services ART, PMTCT and HTC. In the case of Zomba, HTC is provided by all health facilities except the mental hospital. Having mapped the service distribution it is possible to visualize where services are offered and how accessible they are to certain communities. *Figure 5.10* shows a map of service distribution for Zomba produced by the prototype.

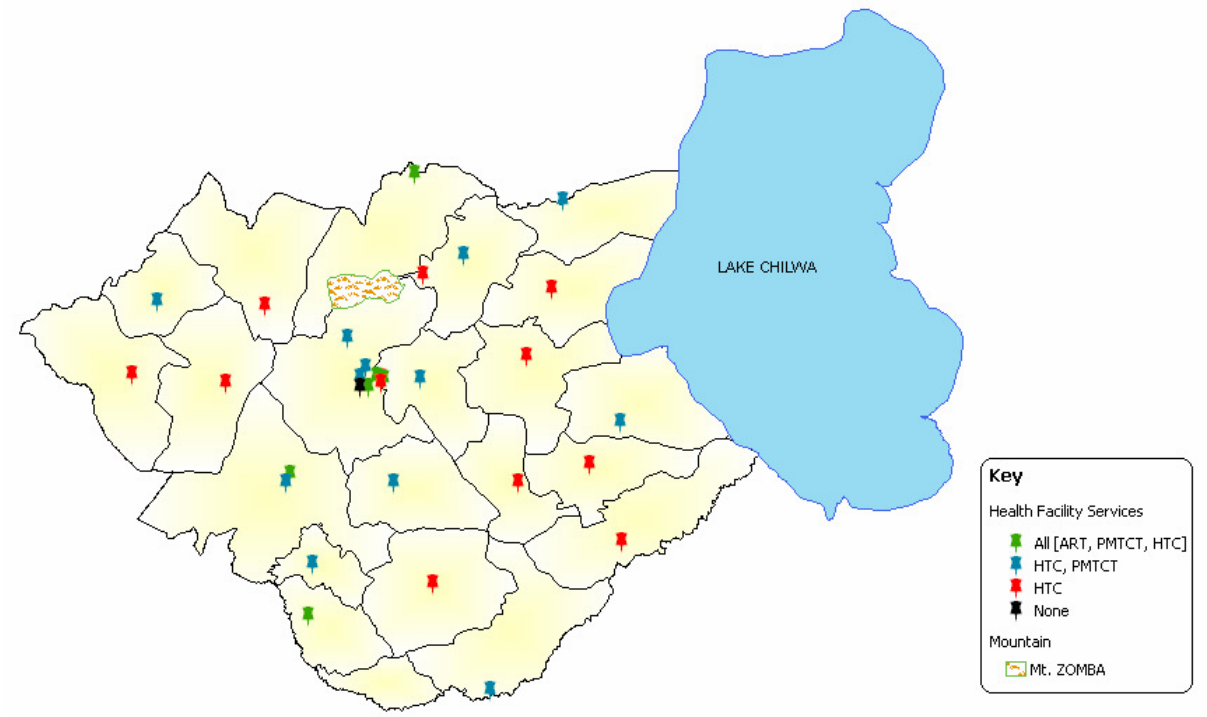


Figure 5.10: Distribution of HIV/AIDS Services in Zomba

5.4.4 Mapping Performance Indicators for HIV/AIDS Services

There are a number of performance (output) indicators that are computed for various HIV/AIDS programmes. For purposes of the prototype, the HTC programme was chosen. With the time available for the study it was not possible to consider each and every programme or service. Thus, the mapping in this case was limited to HTC indicators.

For HTC, there are basically two main performance indicators: (a) *testing coverage* (the percentage of the number of people expected to be tested in a period that have actually been tested) and (b) *results-delivery coverage* (the percentage of people tested that actually receive their results). *Figure 5.11* and *figure 5.12* are maps of testing coverage and results-delivery coverage for 2007 in Zomba produced by the prototype.

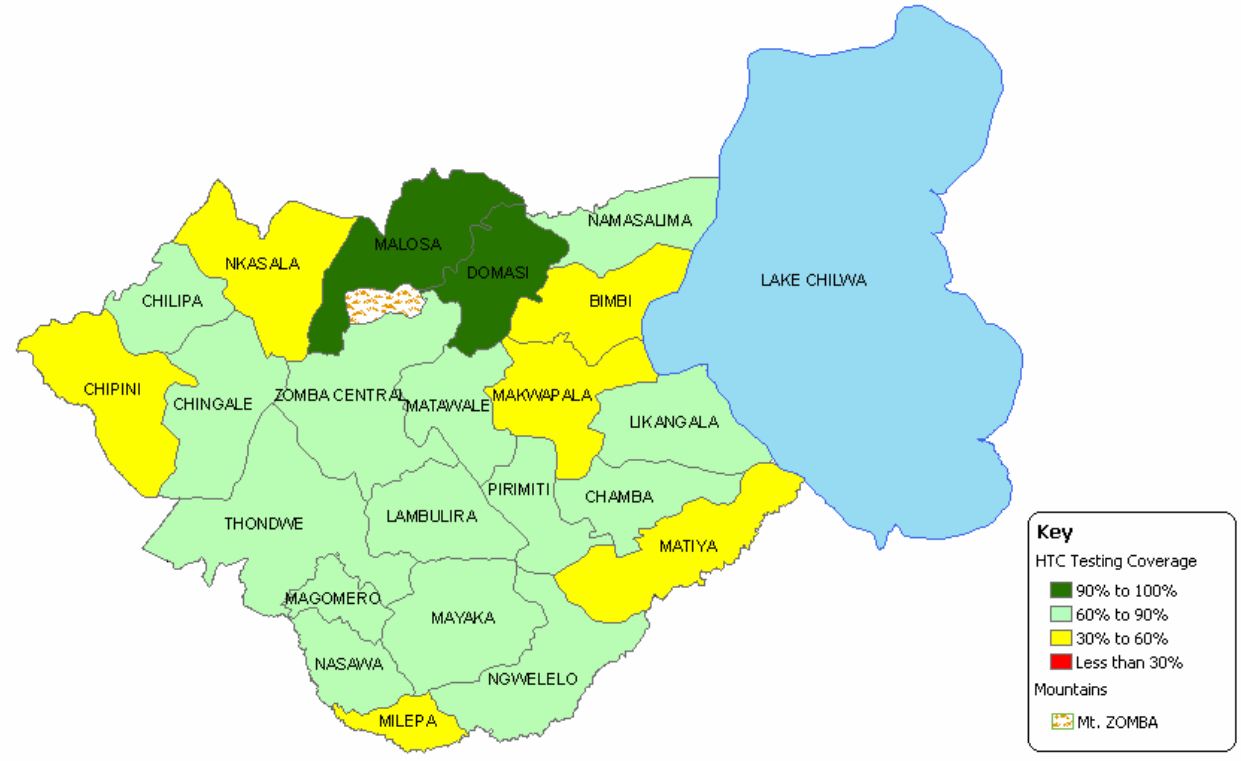


Figure 5.11: Zomba HIV Testing Coverage 2007

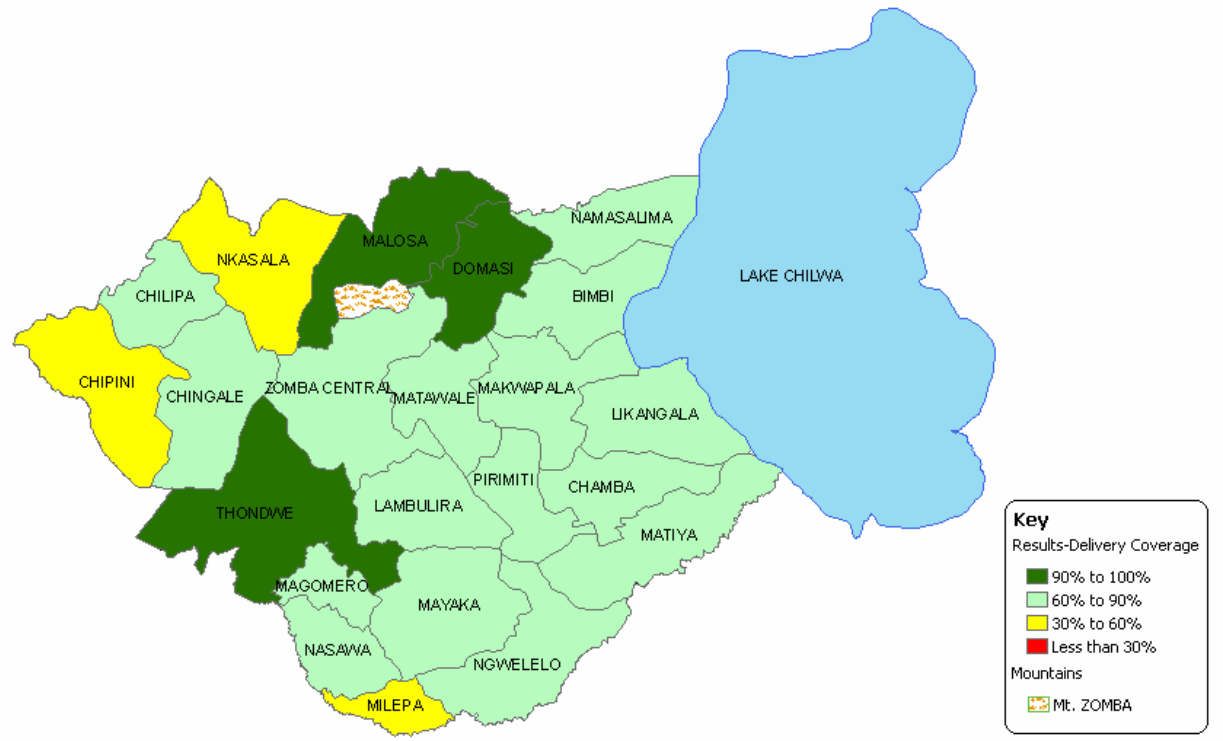


Figure 5.12: Zomba Results-Delivery Coverage 2007

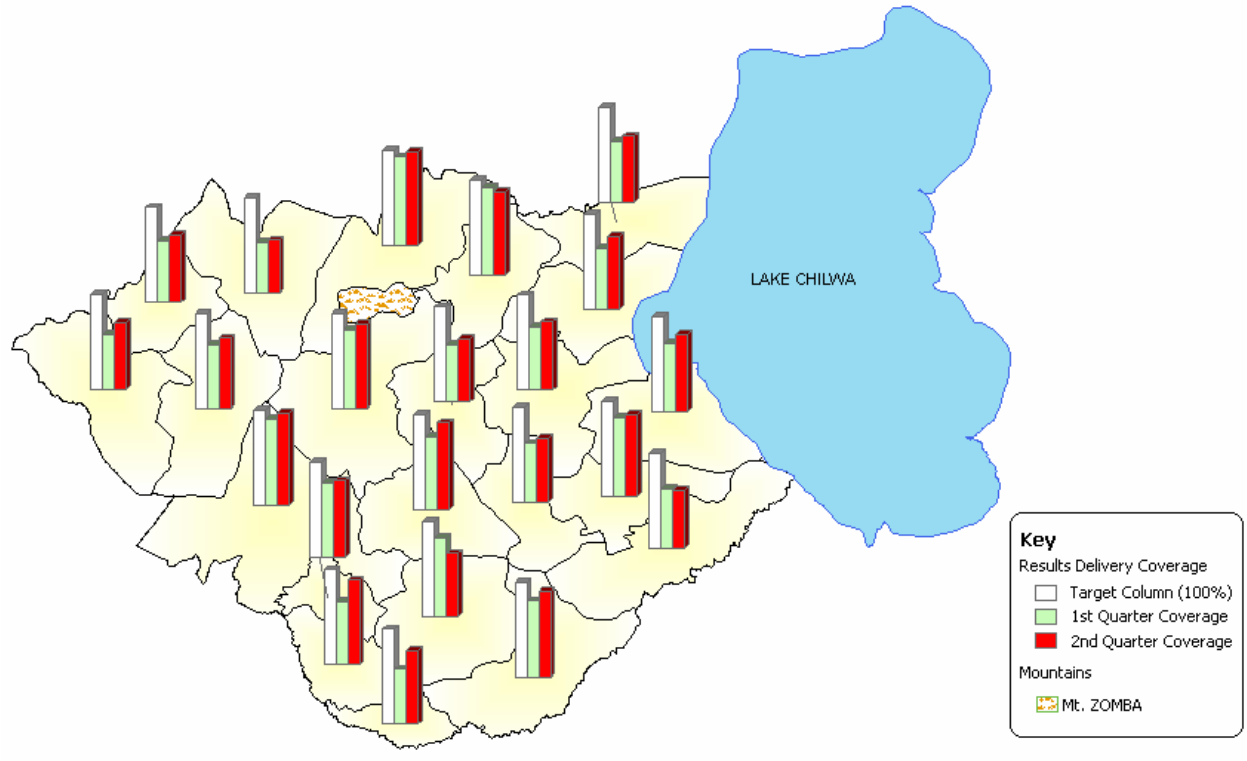


Figure 5.13: Zomba Results-Delivery Chart-Map 2007

Furthermore, as *figure 5.13* above shows, the prototype enabled comparison of performance indicator values between two or more periods. In this figure 1st Quarter result-delivery coverage is being compared with 2nd Quarter result-delivery coverage for 2007 within health zones (catchment areas). The *target column* parameter was introduced to circumvent a limitation in the charting feature in ArcGIS. It basically indicates where 100% coverage would be. That is if result-delivery coverage for a given quarter in a given health zone is 100% then the corresponding bar in the chart will be of equal height to that of Target Column.

5.4.5 Mapping and Assessing Resource Allocation

On aspect of management of HIV/AIDS involves managing resources which could be human resources, equipment, medical supplies and so on. Input indicators are used to measure the amount of resources required, allocated or used. One of the factors crucial to fair allocating resources is population. For purposes of the prototype an assessment of HTC counsellors allocation was made to see if they had been fairly distributed across the three regions. The population and number of counsellors allocated to each region are shown in table

Table 5.2: Regional Populations and Number of Counsellors

Region	Population	No. of Counsellors
Southern	5,876,784	1049
Central	5,491,034	612
Northern	1,698,502	429

To assess whether the distribution of counsellors was fair the number of counsellors allocated was compared with the expected number of counsellors computed as follows:

$$Ec = \frac{Population}{\sum Population} \times \sum Counsellors$$

where *Ec* is *expected number of counsellors*. That is, the *population of the region* divided by the *total population of the country*, multiplied by the *total number counsellors in the country*. This formula was input into the GIS system to enable it compute *Ec* given

populations and number of counsellors in each region. The result of that computation is shown *figure 5.14* below.

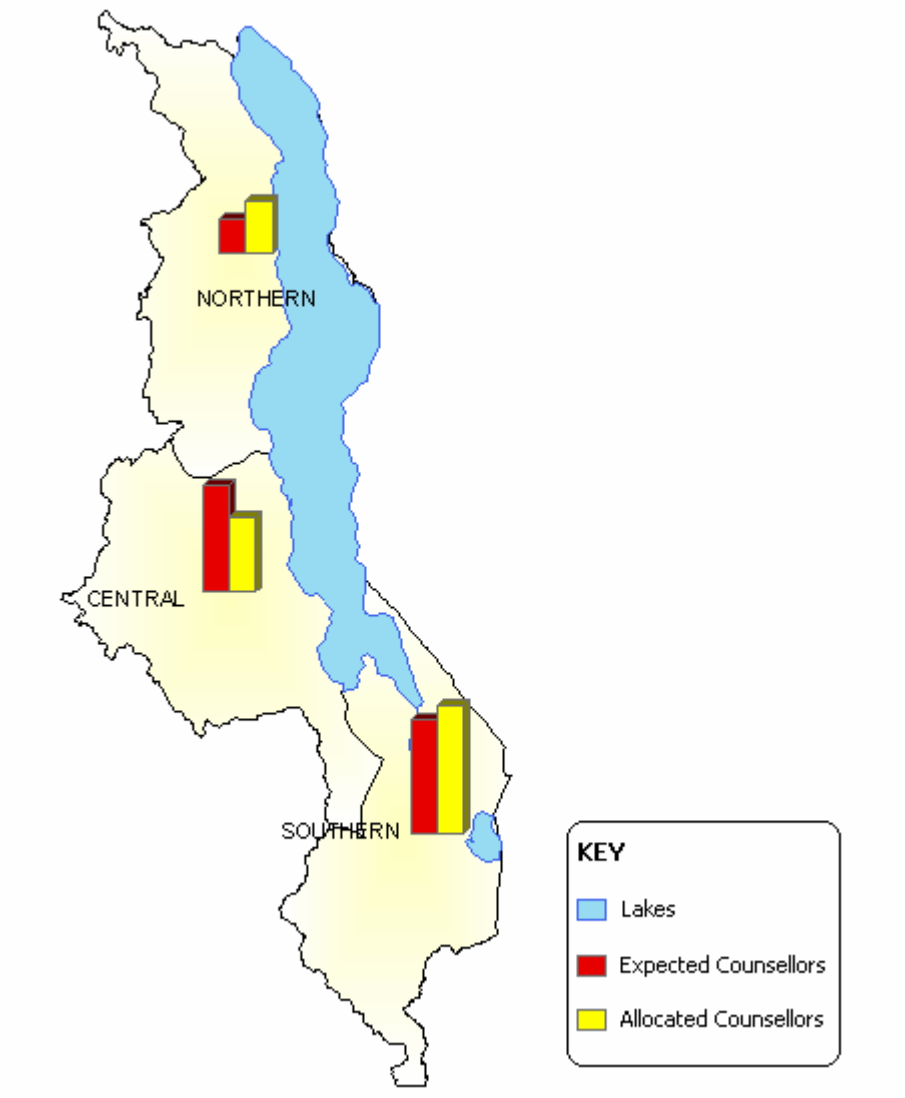


Figure 5.14: Comparing Expected and Allocated Number of Counsellors

As can be seen, the number of allocated counsellors for the Southern Region and Northern Region exceed their corresponding expected values where as in the central region the number of allocated counsellors is less than the expected number of counsellors. While on face value (*see table 5.2*) the Central Region seems to be better off in number of counsellors than the Northern Region the GIS system by factoring in

population data shows that it is in fact the Northern Region which is better off. Thus, the GIS prototype allows evaluation of resource allocation and vice versa.

5.5 Comments on the Prototype

The prototype drew interesting comments from the few that had the opportunity to explore it and work with it. The following is a summary of comments received:

1. **Easy, Accurate and Quick Mapping**

   The first comment was that it made mapping quicker, easier and accurate compared to maps drawn by hand which were tedious, time consuming and prone to errors. One participant explained:

   > "*This is how it should be. It is quick and easier. I don't have to start allover again with each map I want. I just update the data*."

2. **Enhanced Presentation of HIV/AIDS Information**

   The participants also commented that it can strengthen the presentation of HIV/AIDS information. They explained that because of the effort required in creating hand drawn maps, maps are not widely used in presenting district HIV/AIDS information. Graphs and tables are used because software tools that facilitate their creation are available. One participant explained as follows:

   > "*There are situations where a map would be better than a table or a graph and vice versa. But because we don't have mapping tools like this we are forced to either use table and graphs. Otherwise, we have to draw maps manually which is time consuming*".

3. **Need for Proactive Data Collection**

   Participants also noted that there was a need to be proactive in the data collection and data processing if such a system could be of good use. This was mentioned in

reference to failure to map HIV prevalence trends at the district level due to lack of prevalence data for years before 2007. One of the participants said:

> "*… Maps alone are not enough. It is the information on the map that is important. It is the data that we have that determines the information we can present on the maps. If we don't have data we have an empty map*…"

Generally, participants were in agreement with the view that GIS technology can enhance monitoring and management of HIV/AIDS programmes. Furthermore, the tone of surprise in the comments received only serve to confirm an observation of there being little or no knowledge of GIS and its capabilities within the Malawian health sector, especially at district levels and below.

5.6 Constraints

There were a few constraints that the prototyping process faced:

1. **Time**

   Time was the major constraint the prototyping process and this study in general faced. The initial intention was to build a prototype that could be used beyond the study period. For this reason evolutionary prototyping was used over throw away prototyping. However, because of the time available it was not possible to consider all indicators worthy mapping thereby limiting the subsequent usage of the prototype.

2. **Data Availability**

   Some data required to satisfy the requirements of the prototype, especially at the district level, was not available. Like already mentioned to map HIV prevalence trends there was need for data for at least two periods. HIV prevalence data available at the district level was for one year only, 2007. Where as at the national level there was data for 2001, 2003, 2005 and 2007.

3. Manual Aggregation of Health Zone Data

At the district health office data received from health facilities is aggregated according to district. Getting corresponding data for health zones (catchment areas) entails manually aggregating data from health facilities. While it was easier to do for most health zones that have only one health facility the same was time consuming for other health zones with more than one health facility such as *Zomba Central*.

6.0
Research Findings

This chapter presents empirical findings of the research obtained during the field work carried out as outlined in the chapter 4. Furthermore, the chapter presents findings emanating from the prototyping process described in the previous chapter.

6.1 Monitoring and Evaluation of HIV/AIDS Interventions

In order to establish the challenges and opportunities that exist in the adoption of GIS technology for monitoring and management of HIV/AIDS programmes it is important to first of all understand the existing monitoring and evaluation routines. Such an understanding helps in establishing the gaps and challenges that exist in the monitoring and evaluation of HIV/AIDS interventions, some of which GIS may help to address.

To this end the study found that a monitoring and evaluation system for HIV/AIDS, the *National HIV/AIDS M & E System* exists under the jurisdiction of the National AIDS Commission. The main aim of the M & E system is track progress towards achieving goals of the national response; *reducing HIV incidence* and *improving the quality of life for the infected and affected.* There is a complete monitoring and evaluation department at the AIDS Commission which is responsible for the M & E system. Through the system the AIDS commission is linked to HIV/AIDS intervention programme implementers who act as data sources on HIV/AIDS programmes and stakeholders who either provide funding or technical support towards HIV interventions (*see figure 6.1*).

6.1.1 HIV/AIDS Data Reporting

Associated with the M & E system is the National HIV/AIDS Monitoring and Evaluation policy. Under this policy all implementers of HIV/AIDS intervention programmes (organizations or groups in the public or private sector and civil society that are implementing HIV-related interventions) in Malawi are under obligation to report their data to the National AIDS Commission. This enables the AIDS commission to keep track of collective progress towards achieving goals of the national response.

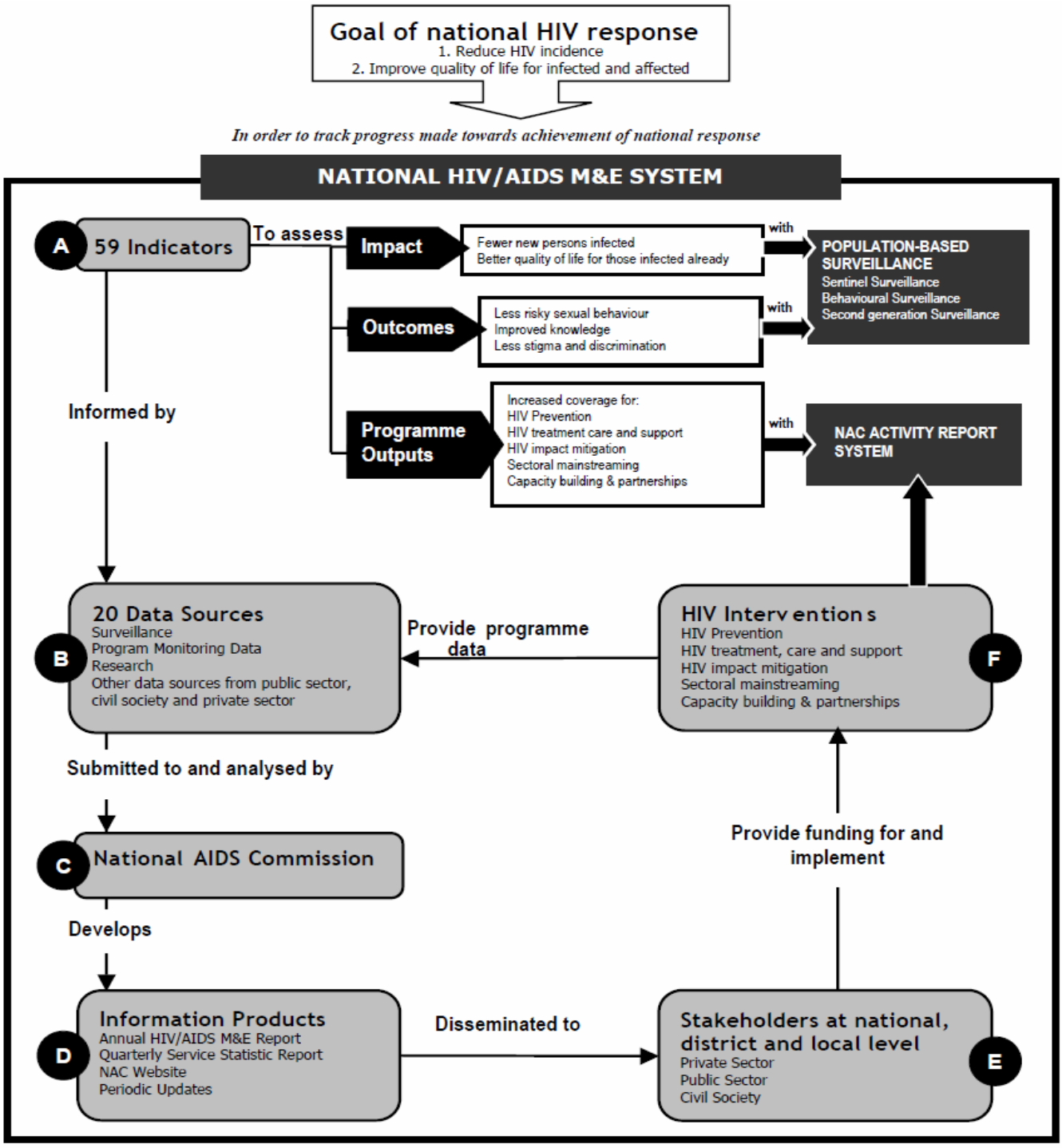


Figure 6.1: Overview of the National HIV/AIDS M & E System

(Source: (NAC 2007a, p.2) **)**

One way of categorizing implementers of HIV/AIDS interventions is into public sector implementers who fall under the management of Ministry of Health and non-public sector implementers who are not directly managed by the Ministry of Health. In the public sector, data on HIV/AIDS interventions from health facilities goes to the district health office where it is captured into HMIS by the district statistician and is also made available to the district programme coordinators for VCT, PMTCT and ART. Programme coordinators or the District AIDS Coordinator (DAC) report the data to NAC and the HIV/AIDS Unit at MOH. On the other hand, all data captured into the HMIS, including HIV/AIDS data, is aggregated on a quarterly basis and sent to MOH.

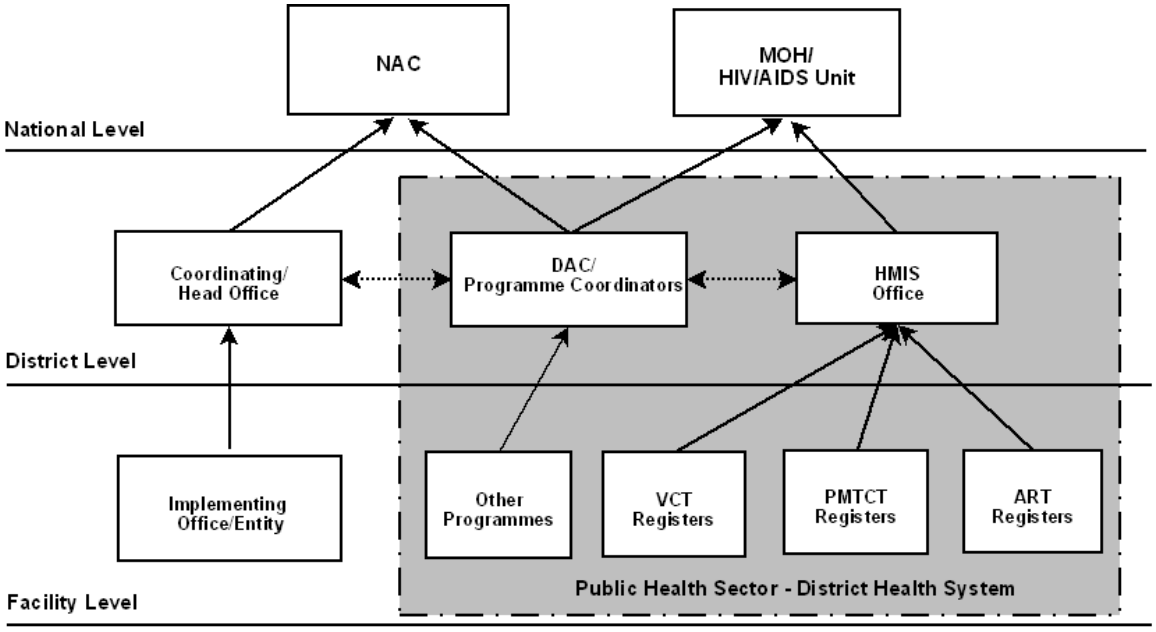


Figure 6.2: Data Flow in the HIV/AIDS M & E System

For other implementers, such as Community Based Organisations (CBO), NGOs and so on, their activity data move from implementing offices to their head quarters or umbrella bodies and from there it is reported to NAC. Apart from reporting to NAC, implementers are also obligated to report their activity data to the District AIDS Coordinator for entry into HMIS at the district level. Following decentralization, the DAC is responsible for coordination and management of HIV/AIDS interventions within the district in question. The general data flow in the National HIV/AIDS M & E System is thus as summarised in *figure 6.2* above.

However, the study found that the actual data flow is not as expected and as depicted in the figure 6.2 above. The distortion in the expected data flow comes in mostly due to non-public sector implementers. Some implementers feel more obligated to report their data to the AIDS commission and not to the local District Health Office under whose jurisdiction they operate. One of the interviewees at one of the districts visited explained this as follows:

> "*We do not always get reports from implementers possibly because they feel more obligated to report data to NAC than to us because of the funding most of them get from the commission and only required support from us.*" (Respondent, District Health Office).

Implementers that do not get any support from the district health office whether materially or technically are less keen to report data to the District AIDS Coordinator. Comparatively, there is more compliance from those implementers that get some support from the district health office. This lack of compliance by some implementers effectively means that some data available to the National AIDS Commission is not available to the District AIDS Coordinator. This in turn means that there are bound to be difference from statistics at the District Health Office and those at the AIDS Commission about the very same district.

6.1.2 HIV/AIDS Data Collection

The M & E policy, mentioned earlier, categorises HIV/AIDS intervention programmes into four broad categories: Workplace Programmes, HIV Prevention, HIV/AIDS Impact Mitigation, and HIV/AIDS Treatment, Care and Support (*see table 6.1 below*). The kind of intervention programmes that implementers are involved in vary greatly amongst implementers. Thus, the kinds of data to be reported by the implementers vary as well. This variation creates room for guess work on what data has to be reported. In order to circumvent that problem the M & E policy puts across a standardized form for reporting data on all HIV/AIDS intervention in Malawi, the ***National Activity Report Form*** *(see Appendix C)*.

Table 6.1: HIV/AIDS Intervention Areas

	HIV Intervention Category	HIV Programme Area	Examples
1.	HIV Prevention	Information, Education and Communication	Conducting a talk show about HIV/AIDS on the radio
		Promotion of Safe Sex Practices (ABCs)	Having a peer education session
		Prevention of Mother-To-Child Transmission (PMTCT)	Counseling HIV positive pregnant women on ways in which to minimise the chances of their babies being born HIV positive
		Voluntary Counselling an Testing (VCT)	Operating a site that offers voluntary counselling and testing for persons who want to know their HIV status
2.	HIV/AIDS Treatment, Care and Support	Clinical Care including OI treatment and ARVs	Treatment of HIV positive TB patients
		Home-Based Care and Support	Running a project that provides volunteers to go to chronically ill patients' homes every week
3.	HIV/AIDS Impact Mitigation	Support for Orphans and Other Vulnerable Children	Providing school fees to orphans
4.	Workplace Programmes	Any activity as defined in the organisation's HIV workplace programme	Running an HIV testing clinic for employees

The National Activity Report form is composite form that defines how routine programme data for various HIV/AIDS interventions is to be recorded and eventually reported. For each possible intervention programme the form defines what data is to be collected and reported. Thus, it prescribes two form elements for each kind of programme, one for data collection (recording) and another for aggregating that data and reporting it to the next level up. *Figure 6.3* and *6.4* are form elements for collection and reporting of VCT data, respectively, extracted from the Activity Report form.

Date	Sex	Age	Counselled? (yes/no)	HIV test (yes/no)	HIV result	Results Received?	Referred for care & support?

Figure 6.3: VCT Data Collection Form Element

e) Voluntary Counselling and Testing (VCT)		0 – 12 years		12+ to 24 years		Older than 24 years		TOTAL
		Male	Female	Male	Female	Male	Female	
VCT1	# clients who receive pre test counselling							
VCT2	# clients counselled and tested this month							
VCT3	# VCT clients receiving their test results this month							
VCT4	# VCT clients who are HIV positive							
VCT5	# HIV positive VCT clients referred to care & support services							
VCT6	# standalone VCT sites supported							

Figure 6.4: VCT Data Reporting Form Element

6.1.3 HIV/AIDS Data Processing

Processing of HIV/AIDS data starts at the point of collection by the implementing agent involved. This mostly involves manual aggregation of data from the activity register comprising of form elements like that in *figure 6.3* and transferring it onto a data reporting form comprising of form elements like one in *figure 6.4*. At this level the aggregation is usually manual (paper-based).

Once the data has been aggregated at the implementing level it is transmitted to the district level. This in most cases involves a representative from the implementing agent, for example a health facility, travelling with the aggregated data to the responsible office on the next level, for example the district health office. Once the data is received further aggregation takes place and the data is then entered into HMIS database. At the district level there are computers at the disposal of programme coordinators which means some of the processing is automated.

Data resulting from aggregation at the district level is further transmitted to the National AIDS Commission and the HIV/AIDS Unit in the Ministry of Health. The way data is transmitted varies depending on communication facilities available at the district health office. District offices that have access to the internet send their data directly unless there is a problem with the internet connection. While those offices that do not have internet access send a representative with the aggregated data on a flash disk or other secondary storage media to deliver the data to the responsible offices at the national level.

However, from the interviews conducted the study established that data is mostly delivered by other means other than the internet. This happens either because of disconnection of internet services due to non payment of bills, slow and unreliable connection and lastly because of financial gains attached to travelling to deliver data. One of the respondents at the national level put this across in the following way:

> "*When public servants travel they get a subsistence allowance. Therefore it becomes tempting for them to deliver data in person than using the internet even if it is working. Because using the internet means foregoing that allowance.*" (Respondent, national level, Malawi Health Sector).

The problem with this is that with the staffing constraints in the Malawian health sector when one travels off their base there is usually no one else to attend to their duties.

6.1.4 HIV/AIDS Data Analysis

Analysis of data happens at the district level and the national level. The analysis involves computation of indicators. The indicators computed for HIV/AIDS largely belong to three groups: *input indicators* that measure resources allocated or required in a given area, facility or programme; *performance or output indicators* that measure how well a programme has been done in a given period or area; and *outcome indicators* that measure long term effects of HIV/AIDS intervention programmes. The study found out that at the district level mainly input and performance indicators are computed. Input indicators are computed as part of budgeting activities for intervention programmes and performance indicators as means to evaluate those programmes. With respect to outcome indicators there are two main indicators; prevalence and incidence levels, which are computed at the national level by the National AIDS Commission.

The national level is responsible for computation of most HIV/AIDS indicators. Analysis is done on quarterly basis. Following this analysis the AIDS Commission releases the Quarterly Service Coverage Report (QSCR) which is made available to all stake holders and implementers to feed into their planning routines. At the end of a period of two years, the commission through the Office of the President Cabinet releases the *National HIV*

and AIDS Monitoring and Evaluation Report which summarises the progress that Malawi has made the national response to HIV and AIDS.

6.1.5 HIV/AIDS Information Presentation

Once the data has been analysed the data is presented in form of graphs, charts and tables. These are made available through various reports that are produced at the district and national level, such as those mentioned in section 6.1.4 above. Below are snapshots of some of graphs and tables in for some HIV/AIDS intervention programmes (*see figure 6.5, 6.6 and 6.7*).

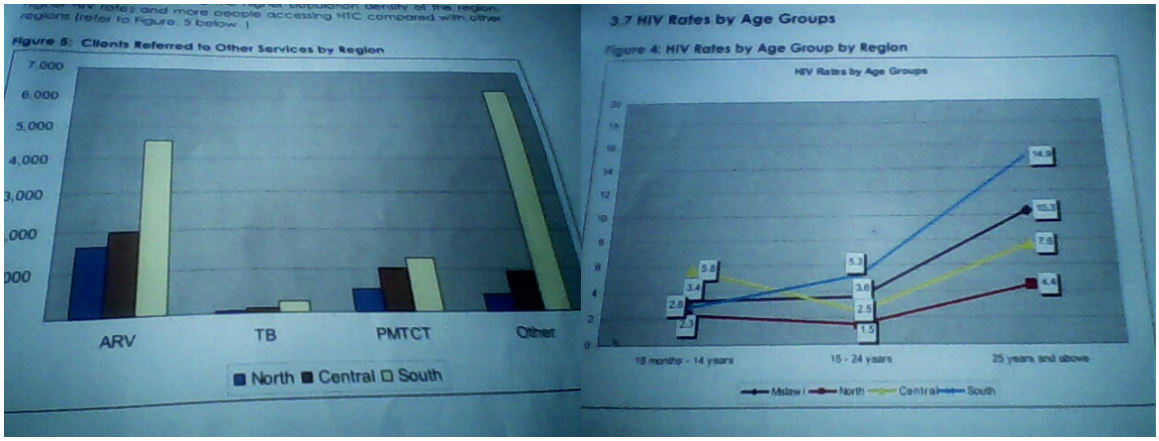


Figure 6.5: Sample Graphs and Charts

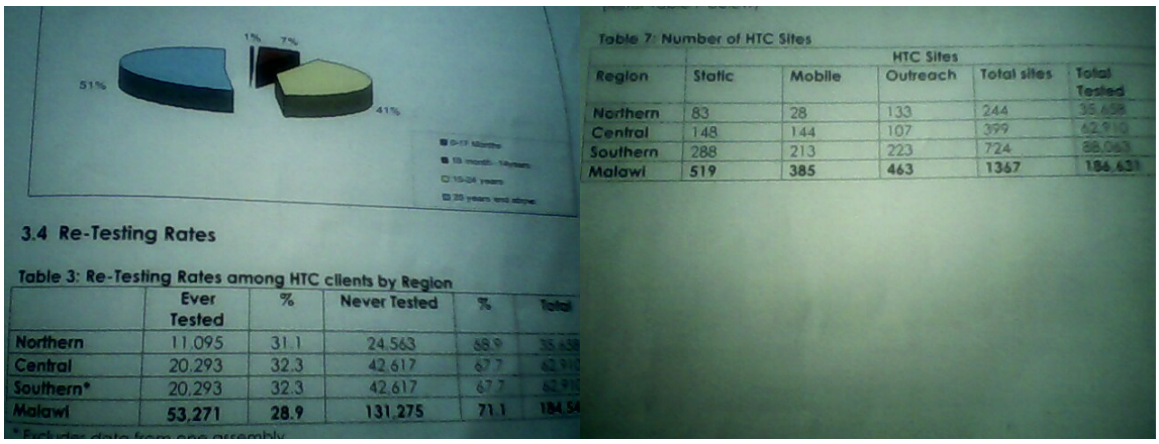


Figure 6.6: Snapshot of Sample Tables

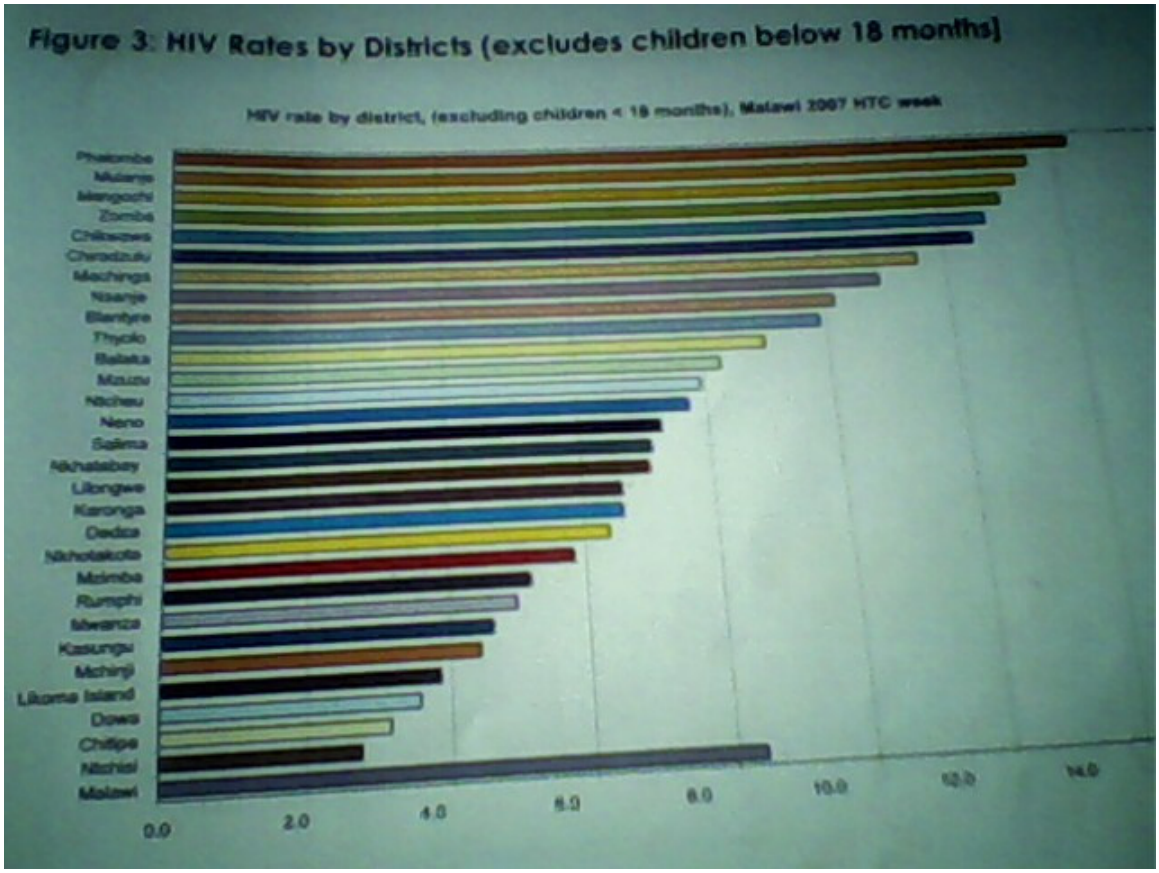


Figure 6.7: Snapshot of HIV Rates Chart for 2007 HTC Week

6.2 GIS Usage

In a nutshell, the study found out that GIS is not being used in any way as far as monitoring and evaluation of HIV/AIDS programmes is concerned, both at national and district level. However, the study also found out that of GIS technology has been available at the Ministry of Health for almost a decade but its usage has mostly been limited to research. Furthermore, the study found out that National AIDS Commission is currently in the process of acquiring a GIS system for monitoring and evaluation of HIV/AIDS programmes but has been faced with delays due to problems on the side of the consultant engaged to carry out the development work.

6.2.1 GIS Usage at the Ministry

The Ministry of Health has had GIS technology since 2002 through a joint project with the Japan International Cooperation Agency (JICA) whose objective was to map all

health facilities in Malawi. A Japanese consultant was hired to build a GIS system to meet the projects objective. The project was completed in the year 2003 and the system was handed over to Ministry of Health. The system consists mainly of spatial data in form of shape files loaded in *ArcView 3.1*. Since then the system has generally been used for research purposes and to address mapping needs of the ministry. There are no specific cases of use of the technology with respect to HIV/AIDS at the ministry level. The usage pattern suggests a shared view (misconception) of GIS as a research tool with little application in other health related areas. The statistician in charge of the GIS system explained:

> "*The system is used on an adhoc* [according to need] *basis. I deal with requests as they come. Generally, the system has been used for research purposes. For example, if one person comes with a request for a map of health facilities in the southern region I produce it...*"

One of the obstacles to wide usage of GIS at MOH has been the lack of staff training in the technology. There was no training component during and after the joint project with JICA such that it was even difficult for staff to use the system. According to the respondent, apart from training in using the technology there is a need for training in spatial data collection standards. He explained that:

> "*There are information sharing opportunities especially with the department of surveys which is active in collecting national spatial data. However, without following proper standards it is difficult to take advantage of such an opportunity.*"

Secondly, a major problem has been the lack of updates to the health facility spatial register. The spatial data on health facilities and other health service providers is rarely updated. According to the respondent:

> "*The current geo-register of health facilities dates back to 2003 when the JICA consultant was around*"

This is attributed partly to the lack of training as GPS units have been distributed to all DHOs but no training has taken place on using them and on standards to follow when collecting data. As a result the GPS units are not being used. Some have become items of prestige for district statisticians and others have gotten lost.

6.2.2 GIS Usage at National AIDS Commission

Currently the National AIDS Commission is not using GIS technology in its activities. However, it was established during the study that the commission engaged a consultant, in the second half of 2007, to develop a GIS system to be used for monitoring and evaluation of HIV/AIDS interventions. However, the developers are yet to deliver a system that meets the commission's requirements. When asked about the level of use or none use of GIS technology in M & E activities at the Commission one of the monitoring and evaluation officers responded:

> "*To say that we are using GIS right now would be a lie. We engaged a consultant to build a GIS system for our M & E activities but up to now they are yet to deliver a system that works to our requirements*".

The problem was that the system initially delivered comprised of two separate modules that could not communicate with each other; the database holding non-spatial data and the GIS module. While the initial set of non-spatial data provided to the developer was already captured into the GIS system (hard coded into shape files), new data added onto the database was not immediately available to the GIS module. This meant that changes to the non-spatial data in the database were not immediately reflected in the GIS module without further modification of the data embedded in shape files. In the words of one of the respondents at NAC:

> "*The problem really is the capacity on the side of the consultant. They just hired a GIS expert and a database expert who* [seemingly] *did not communicate and the result is a GIS system which cannot communicate with its database. What we want is a simple GIS system that does what we want.*"

Subsequently, the system was returned and a new delivery date was agreed upon by the commission and the consultant. By the time fieldwork for this study was coming to an end, in January 2009, the system had still not been delivered.

6.2.3 GIS Usage at District Level

At the district level, both districts visited indicated no GIS usage in any way no to mention, in HIV/AIDS programmes. In addition, the study found that there is little or no knowledge of GIS and its possible applications in the health sector at the district level. Only one respondent, the statistician at one of the districts, went through his first interview without requiring an explanation about GIS and its basic concepts and use. When asked how he came know about GIS, he explained:

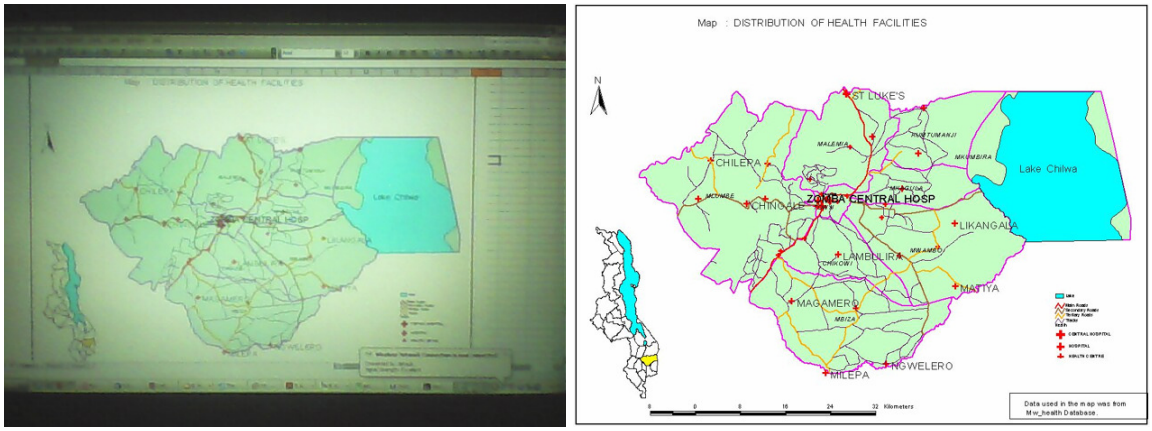
> "*I worked at NSO* [National Statistics Office] *for many years before being transferred here, last year. Through the projects at NSO I came to know about GIS but have not explored the technology*."

However, as was mentioned at the Ministry of Health it was found that the districts had received GPS units, one per district (*see figure 6.8*). Respondents further indicated that the units have rarely been put to use.

Figure 6.8: GPS Units issued out to Districts

In addition, at the Zomba District Health Office a digital map produced at the Ministry of Health showing health facilities was found embedded in an MS Excel sheet containing a

list of HTC sites (*see figure 6.9a and 6.9b below*). This to some extent indicates a need for mapping tools at the district level.



(a) Digital Map in an Excel Sheet **(b) The Map Extracted from the Sheet**

Figure 6.9: Digital Map of Zomba District in an MS Excel Sheet

6.3 Need for GIS in HIV/AIDS Monitoring and Evaluation

As indicated earlier, the National AIDS Commission is in the process of acquiring a GIS system to be used in monitoring and evaluation of HIV/AIDS programmes and services. According to commission representatives interviewed, GIS is needed in several aspects of the monitoring and evaluation process. The GIS system being developed is expected to address most of these needs. However, since they cannot address all needs at once they have adopted a strategy where they start small and continually address the needs in an incremental way.

6.3.1 Resource Tracking

One way the commission wants to use GIS is in resource tracking. The commission is responsible for distribution of grants under the Global Fund to Fight AIDS, TB and Malaria. It is also responsible for mobilizing resources for the HIV Testing and Counselling Week and similar activities. According to one of the monitoring and evaluation officer, with such a responsibility comes the need to know where resources and funds have been allocated and how much. Therefore, by using GIS, the commission will able to track allocated resources in a more convenient way. He explained as follows:

"*The GIS system will help the commission in what we have called Resource Tracking. We want to know where our resources have been allocated and how much. This is difficult when you just know some of the beneficiaries by name and not exactly where they are located*. *GIS is going to help us in that regard.*"

6.3.2 Impact Assessment of Services and Programmes

Having allocated resources or introduced programmes and services to certain areas the commission is interested to know the subsequent impact the resources, services or programmes are making in those areas. The monitoring officer explained:

"*By using GIS we will be able to depict situational characteristics before and after the introduction of the services, which will make it easier to visualize the impact our resources and services in the areas allocated*."

The impact assessment is important for planning purposes. According to the officer, if an impact assessment of a given programme shows positive results the commission can decide to scale it up by introducing it in many areas. On the other hand, if a programme is having a negative impact it can be phased out after considering other factors that could have led to failure.

6.3.3 Service Distribution

One of the challenges the commission faces is to ensure a fair distribution of HIV/AIDS services and service providers across then nation and within the districts. The aim is to provide easy access to services to all people in different areas. To this end the monitoring officer explained:

"*We get reports of new facilities or new community based organizations but mostly all we know about them is the name of the facility and the district in which it has been introduced. We would prefer to have these new facilities in areas where there use to be none. We don't want a situation where services are concentrated in one area while other areas are suffering. GIS can therefore help us in deciding where these new services and facilities should be.*"

According to the respondent, the closer the facilities are to the people the better. GIS will help the commission in analyzing accessibility of both old and new HIV/AIDS facilities and services.

6.3.4 HIV/AIDS Rates

One other way the commission intends to put GIS to use is showing the distribution of the disease, in terms of prevalence levels, at the district level. The idea, according to the respondents, is to eventually map prevalence levels down to group village headman level. Currently, that is difficult because boundaries of group village headmen territories are not well established and mapped.

6.3.5 Communication and Presentation

Finally, the commission believes that certain information is readily appreciated on maps as compared to having the same information in a table and/or a long narrative speech or piece of text. According to one of the monitoring officers, a map has the power of persuasion and captures people attention. He explained:

> "*We believe some of the information we might want to present can be readily appreciated on maps than using tables and other forms of presentation. Maps readily capture people's attention and can be persuasive. Therefore, GIS can help us tap into this communicative potential that maps have*".

6.4 Findings from Prototyping

As the result of the prototyping process described in the previous chapter a number of things came to light and are presented below.

6.4.1 Lack of Prevalence Data at District Level

HIV prevalence is one of the indicators used to measure the severity of the HIV/AIDS epidemic in a given area. While at the national level HIV prevalence values for each region and district was known at the district level HIV prevalence data for health zones

(or catchment areas) was not readily available. As a result for purposes of the prototype estimates from the 2007 HIV Counselling and Testing week were used for the district.

There were a couple of reasons given for the unavailability of the prevalence values. First, officials at the district health offices explained that we are coming from a period when governments were very protective of HIV/AIDS prevalence and incidence data because high prevalence levels were initially perceived as a thing of ridicule or shame. In order to guard against unnecessary release of prevalence data the process of calculating and releasing prevalence data was centralized. Hence, at the moment districts do not have the mandate to calculate prevalence levels. This was explained as follows by one of the officials:

> "*At the district level we don't have the mandate or a standard formula for computation of prevalence rates. They can only be computed at the National level where such mandate exists. On the other hand, it would also be difficult to compute realistic figures because some health facilities do not report their data to us. Therefore, official figures on prevalence rates can only come from the ministry.*" (Official, District Health Office).

Secondly, there is a problem with calculating prevalence data for health zone because it requires manual aggregation of requisite data. For example, population data coming from population census recognizes the districts but the same data does not recognize the health zones. Thus, while the district population is reported in census reports the population values for health zones are not readily available. In order to get this information, populations of communities that fall within the health zone must be aggregated. Furthermore, even in the health sector data is normally aggregated according to districts, then regions and lastly at the country level but not health zones. Thus, calculating prevalence levels for health zones can be challenging.

6.4.2 Data Continuity and Availability

Related to the earlier finding, the study in the course of the prototyping process found out that most HIV/AIDS related statistics are mostly computed at the national level and

aggregated according to regions. Corresponding statistics at the district level were in most cases not available. The districts mainly calculate performance indicators that seek to assess how intervention programmes have faired against set targets. A good example can be comparing *the number of people that have been tested for HIV* against *the target number of people to be tested* in a given period.

Furthermore, there are cases of lack of data continuity particularly for data aggregated according to districts and according to district health zones. That is, there is no data for some periods, months or years. While data aggregated according regions goes back to 2003 the same is not the case for districts and district health zones. Only data for 2007 was available in most cases. For example, HIV prevalence data according to regions was available from 2001 through to 2007. Where as the same kind of data aggregated according to districts was only available for 2007 and as earlier mentioned estimates from the 2007 HTC Week were used for prevalence values in health zones. Thus, the prototype could only map prevalence trends according to regions (*see figure 5.8 and 5.9*).

6.4.3 Spatial Data Quality and Usability

Thirdly, there are quality and usability concerns with respect to some of the spatial data available. As indicated earlier the geospatial health register has rarely been updated since 2003 which implies that a number of new health facilities have not been captured. Notwithstanding this problem there are other spatial data concerns as explained below.

First, some spatial data files were incompatible because of differences in scales. This was particularly the case with data sourced from the SAHIMS GIS Data server. Tracing the sources of the data files obtained SAHIMS showed that the data was randomly collected from different GIS related projects in Malawi. This explained the presence of the different scales in the spatial data and the resulting incompatibility. As a result the data had to be filtered in order to have compatible data files only.

Secondly, some features were wrongly captured or represented on some of the spatial data files. Cases of health facilities overlap across district boundaries were found. For example, some health facilities in Balaka districts cross over into Ntcheu district (*see figure 6.10*).

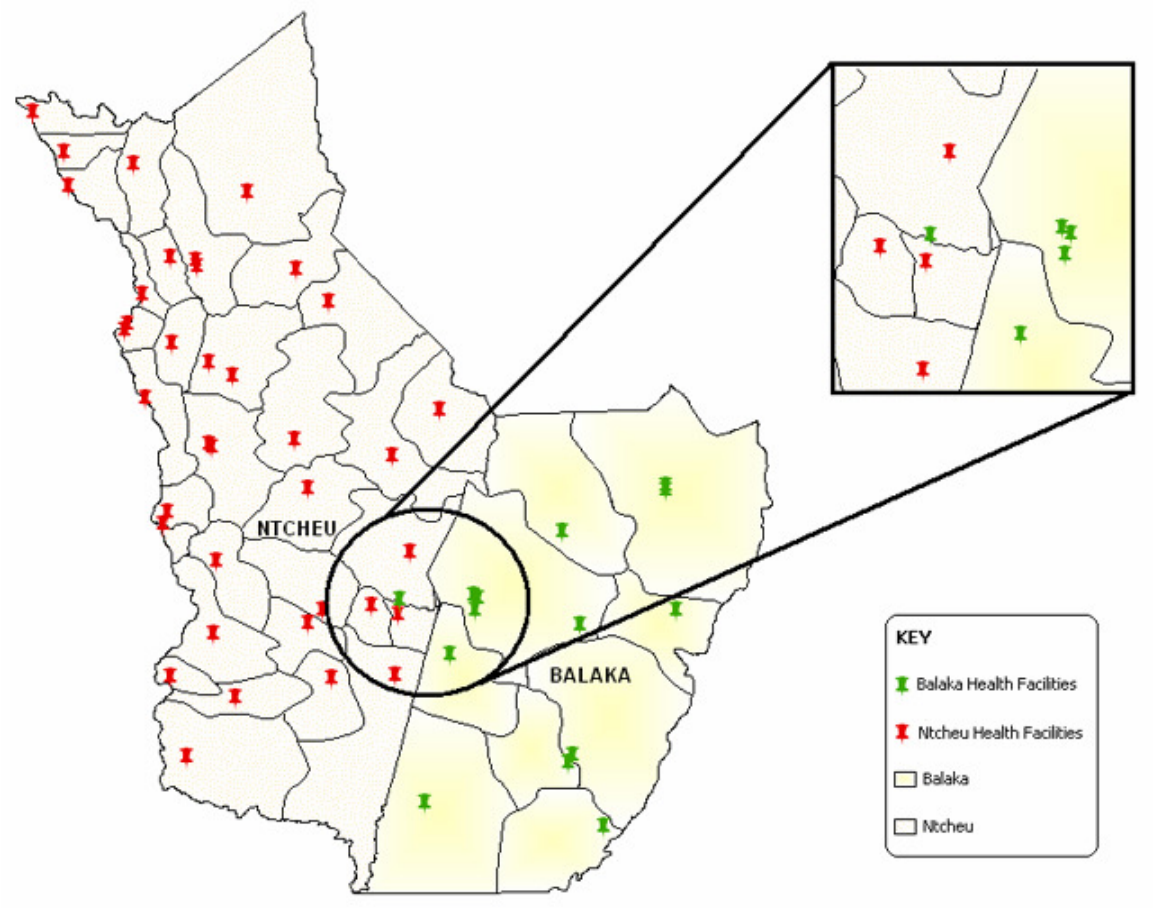


Figure 6.10: Balaka Health Facility within Ntcheu Boundary

Another example concerns the spatial data for Zomba district. The area covered by Lake Chilwa is mapped like any other health zone. Thus, if the district is mapped without the overlaying it with the map of Lake Chilwa one sees a large area that has no health facilities (*see figure 6.11 below*).

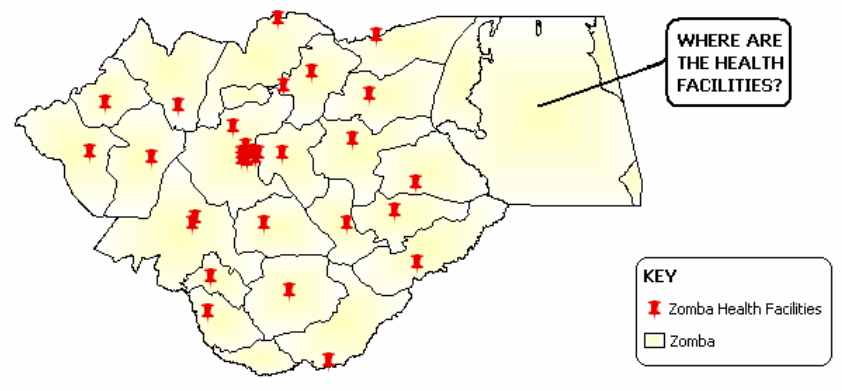


Figure 6.11: Zomba District Map without Lake Chilwa

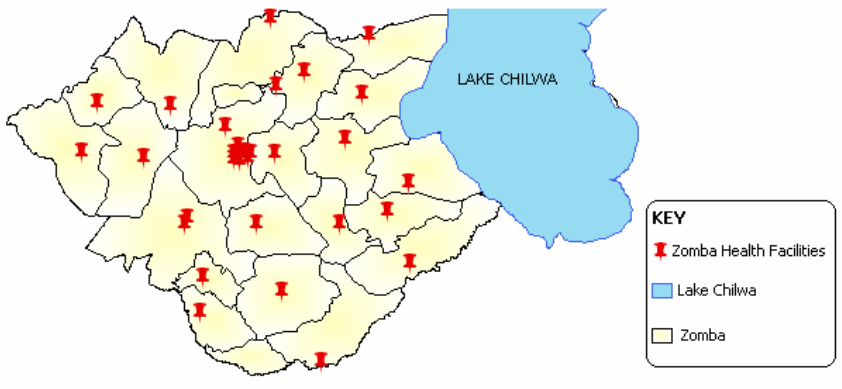


Figure 6.12: Zomba District with Lake Chilwa

Despite the quality concerns on some of the spatial data, basic data required to build a GIS system for monitoring and management of HIV/AIDS programme was found to be available. Moreover, some of the issues mentioned could be circumvented by minor editing of the spatial data files. The Ministry of Health through the joint project with JICA has some spatial data available which provides a good starting point. The department of surveys in the Ministry of Works is very active in collecting spatial data about Malawi which is available, for free, to those in need of it. Apart from that, regional spatial databases like Southern African Human-development Information Management System (SAHIMS) GIS Data Server also have some spatial data on Malawi, also available for free.

7.0
Analysis and Discussion

This chapter analyses and discusses the findings of this study. This discussion and analysis draws upon the Information Infrastructure (II) theory and makes use of the concepts of installed base, heterogeneity, cultivation and the shared and open characteristics of an information infrastructure to formulate a view that helps understand the challenges and opportunities that exist in using GIS for monitoring and evaluation of HIV/AIDS programmes.

The discussion largely dwells and relates to the research questions posed by this study:

1. What challenges and opportunities exist for sustainable use of GIS in monitoring and management of HIV/AIDS in Malawi?

2. What strategies can be used to address the challenges and harness the opportunities identified in order to have sustainable GIS usage?

To answer these questions the study specifically aimed to:

1. Assess the monitoring and management systems and/or routines for HIV/AIDS currently in use in Malawi.

2. Identify gaps (or challenges) in monitoring and management of HIV/AIDS that can be addressed using GIS.

3. Assess how GIS can (or is being) used to address the challenges identified.

4. Develop a GIS prototype to facilitate empirical data collection on practical issues surrounding the using GIS for monitoring and management of HIV/AIDS.

The chapter first puts into perspective the health information infrastructure under which HIV/AIDS programmes operates. This then leads to a general discussion of challenges of

monitoring and management of HIV/AIDS programmes in Malawi. This is followed by looking at the challenges and opportunities in using GIS for monitoring and evaluation of HIV/AIDS programmes and finally how these challenges can be addressed.

7.1 The Information Infrastructure Surrounding HIV/AIDS Programmes

The national response to HIV/AIDS in Malawi has taken a multi-sectoral approach, as explained in Chapter 4. This entails a presence of a heterogeneous crop of stake holders involved in various HIV/AIDS programmes. As would be expected, the underlying monitoring and evaluation (M & E) system for such programmes cuts across organizational borders (*see figure 7.1*).

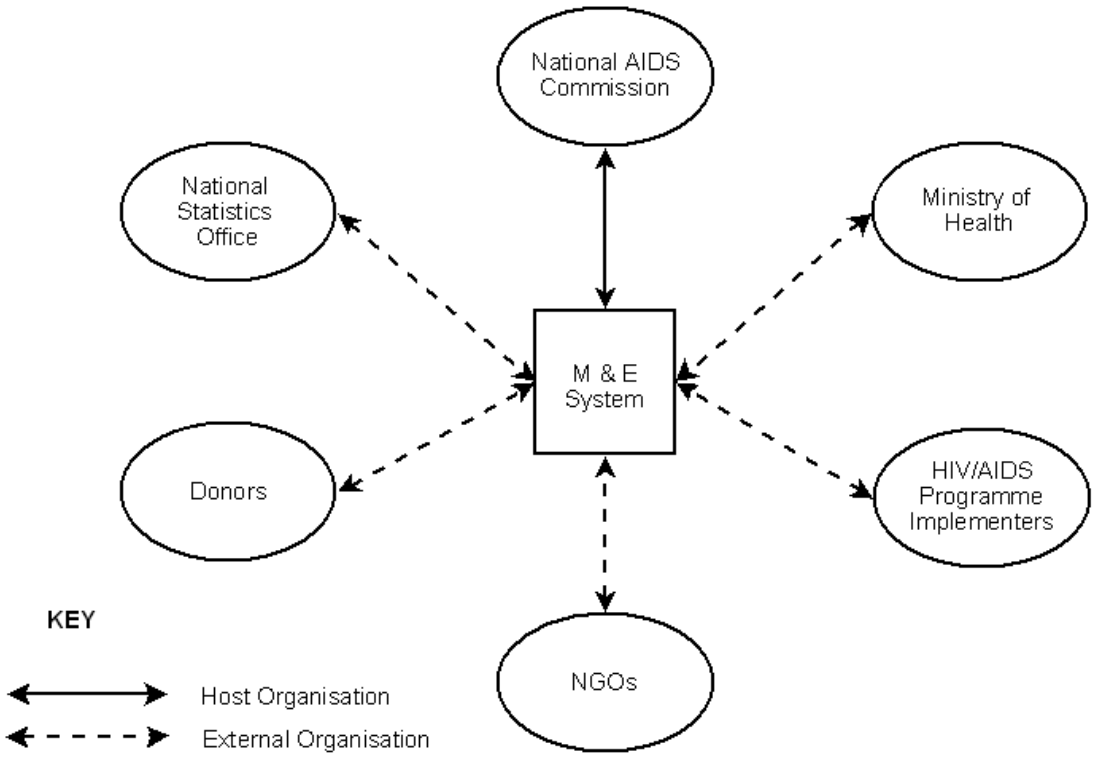


Figure 7.1: Overview Data Flow Diagram of the M & E System

While the national HIV/AIDS M & E system falls under the National AIDS Commission, as figure 7.1 shows there are several external entities that interact with it directly or indirectly. These external entities often have their own systems dealing with a particular

aspect of HIV/AIDS that is of interest to them. The M & E system, which falls under the scope of HIS in Malawi, therefore can be viewed as an attempt to integrate smaller systems in different organizations and departments from which HIV/AIDS data is obtained.

As put across by Hanseth (2002), contemporary information systems that are characterized by integration of systems across organizational and geographical borders are significantly different from traditional informational systems and successful establishment of such systems hinges on perceiving such systems as information infrastructures. As earlier explained under literature review, an information infrastructure has six underlying characteristics: *shared*, *evolving*, *open*, *standardized*, *heterogeneous,* and having an *installed base*. Both the M & E system and the HIS in Malawi at large exhibit infrastructural characteristics. For purposes of this study, discussion and analyses, the information infrastructure was therefore adopted in dealing with the National HIV/AIDS M & E system and the HIS at large.

It is important to note, as explained under literature review, that information infrastructures are considered already existing and are not developed from scratch. "*New infrastructures are designed as extensions and improvements of existing ones – not from scratch. The new or improved elements have to fit into the old*" (Hanseth 2002, p.1). The already existing part of the information infrastructure is what has been called the *installed base*. The installed base is considered as some sort of 'designer' playing a role in the development (*or evolution*) of an information infrastructure. It limits and influences how the new infrastructure is designed. Therefore in looking at the adoption of GIS for monitoring and management of HIV/AIDS one cannot ignore the existing installed base within the scope of the national M & E system as well as the HIS in general. A thorough understanding of the installed base is therefore critical to understanding challenges and opportunities that exist in using GIS in the monitoring and management of HIV/AIDS programmes.

7.1.1 The Role of the Installed Base

Infrastructures develop through extending and improving the installed base. The installed base is viewed as an actor taking part in every development activity on the information infrastructure it belongs to (Hanseth & Monteiro 1998). The installed base in the National HIV/AIDS M & E system therefore has a greater influence on what can and cannot be done with GIS within the scope of monitoring and management of HIV/AIDS programmes.

The National HIV/AIDS M & E System as outlined in chapter 6 is a cross-organisational reporting system whose main aim is to track progress towards achieving the goals of the national response to HIV/AIDS: *reduce HIV incidence* and *improve quality of life for the infected and affected*. It involves implementers of intervention programmes in the civil society, private sector and public sector, the National AIDS Commission, the Ministry of Health and other stakeholders. Within these organizations are different data collection, processing and storage procedures. Generally, data moves vertically from the implementation level towards the National AIDS Commission. There are varying degrees of data availability, both spatial and non-spatial, at different levels of the system.

The prototyping, discussed in chapter 5, was subject to influence from the installed base. The data, both spatial and non-spatial, from the Ministry of Health, National AIDS Commission and Zomba district was used to build the prototype. Data, both spatial and non-spatial, in this case is part of the installed base of the M & E system. The scope of the prototype was largely determined by the data, particularly the non-spatial data that was readily available. For example, at the district level prevalence data was only available for the year 2007 where as at the regional level there was data for 2001, 2003, 2005 and 2007. It was therefore possible to map prevalence trends at regional level (*see figure 5.9*) but the same was not possible at district level. Here we can, therefore, see the *enabling* (limiting) role of the installed base. Furthermore, this brings to light the dependent nature of GIS in that the level of exploitation of it capabilities depends on what already exists; the installed base.

In addition, procedures and regulations as part of the installed base can be a limiting factor in attempts to exploit GIS at different levels of implementation. In Malawi, certain HIV/AIDS statistics can only be computed and reported at the national level, by the National AIDS Commission. For example, incidence and prevalence rates of HIV/AIDS are normally not computed at district level. For the purposes of the prototype, estimates at a district level were obtained using data collected during the 2007 HIV Testing and Counselling week. It is therefore evident that some procedures, practices and regulations can determine where and when data is available and hence limit or enable certain processes. It is therefore important to note that while information technology, including GIS, is important in process innovation it is not the only place to start (Boddy et al. 2005). Critical evaluation of business practices can also lead to process innovation. Therefore, depending on what GIS is to be used to achieve in monitoring and management of HIV/AIDS programmes and the level at which it is being implemented some practices might have to be reviewed in order to ensure the availability of required data.

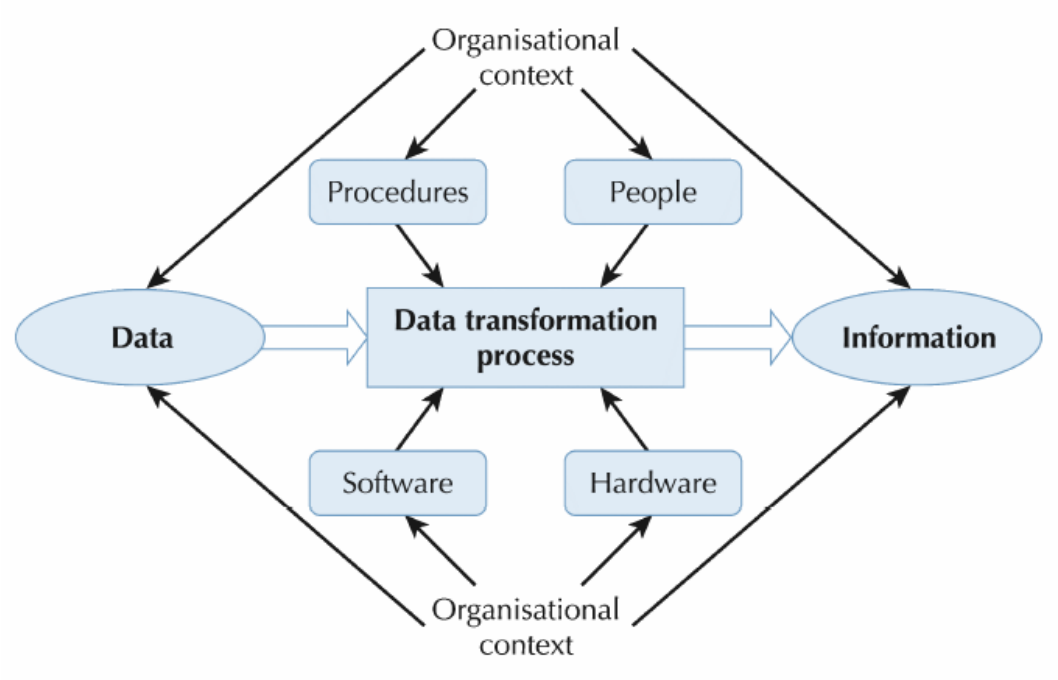


Figure 7.2: The elements and contexts of a computer-based IS

(Source: Boddy et. al 2005, p. 11)

Taking GIS as a data transformation process, *figure 7.2* shows the dependency that it has on the installed base comprising of among other things people, technical skills, procedures, data, hardware and software resources in order for it to produce information required. For example, the Ministry of Health is using ArcGIS 3.1. The current version of ArcGIS on the market is ArcGIS 9x. The gap in software ability is therefore enormous. Depending on circumstances under which GIS is implemented or used there is always a difference between what is possible and what is feasible (Hall et al. 1997). One factor that decides what is feasible is the range of features in the software being used. To this end, the version of ArcGIS being used by the Ministry of Health is a limiting factor in its GIS endeavors. Thus, once again we see the role of the installed base in limiting the extent of GIS exploitation.

7.1.2 Heterogeneity Implications

A direct result of the multi-sectoral national response to HIV/AIDS has been the heterogeneity in the M & E infrastructure in terms of stakeholders; stakeholder interests, roles and capacities; programmes and services; data collection, processing and reporting procedures; and so on. This heterogeneity has implications particularly on the availability and quality of data as well as information sharing. As explained earlier, GIS is a dependent technology in that the level of its exploitation depends on among other things the data that is available, both spatial and non-spatial data. The heterogeneous nature of the M & E infrastructure therefore has implications on the data that is made available to its GIS component, once in place.

First, there is the threat of fragmentation due to parallel information systems existing under different stake holders and different programmes. Complete integration of HIS is impossible due to the differences in the nature and management of diseases and services (Galimoto 2007). This is particularly the case with HIV/AIDS programmes because the nature of management of the disease and service programmes means that their required data cannot be integrated into existing tools (*ibid*). With such fragmentation comes the possibility of duplication of data especially in paper-based systems. With duplication comes the risk of inconsistencies in data formats and updates between any two given

entities. Thus, there is a likelihood of data quality being compromised. This applies to both spatial and non-spatial data. A typical example is the health geospatial register in the Ministry of Health which has gone years without any major updates. On the other hand, there is the National AIDS Commission correcting up to date spatial data on HTC and ART sites for purposes of its GIS system being put in place. There is little that GIS can do when presented with acceptable data but of poor quality, which takes us back to the old computer adage "*garbage in, garbage out*."

With systems set up around programmes, services and/or stake holders comes in the problem of information sharing and availability. There is a tendency amongst stake holders to want to keep data that they collect to themselves except where they feel strongly obligated to share that information with others. There are problems with information sharing across institutional boundaries and between staff of different programmes (Shihende 2005). In Malawi, implementers of HIV/AIDS programmes can be categorized in different ways. One scheme categorises them into those that receive funding from National AIDS Commission and those that do not receive funding from the Commission. All implementers are supposed to report their activity data to the AIDS Commission to be captured into the M & E system. However, it has been observed that implementers that get funding from the commission report their data more regularly as compared to those that do not. Furthermore, although implementers at the district level are also required to report their activity data to the District AIDS Coordinator to be captured into HMIS most only report to AIDS Commission. This in turn brings problems related to data completeness as well as timeliness.

The multi-sectoral approach means that traditionally disparate entities with traditionally disparate systems, procedures and practices have to find a way of coordinating their efforts against HIV/AIDS. The national response has brought together the public sector and the private sector; the government and non-governmental entities and so on. To attain proper coordination there is a need for proper information sharing. Aligning these actors to start sharing data is not easy because it involves shifting them from a position of competition to a position of cooperation. Aligning these entities might also involve translating between different formats involved. It is observed that public sector entities do

better in reporting data to the AIDS commission and Ministry of Health/District AIDS Coordinator as compared to the other entities. This in turn affects the availability of certain data. Thus, it is important to be aware of these issues that potentially affect the availability of data which GIS cannot resolve.

In summary, with the heterogeneity in the HIV/AIDS monitoring and evaluation comes fragmentation which leads to potential data duplication and consistency problems which in turn can affect the quality of data. With this fragmentation and structural differences between stake holders comes information sharing problems and different perception of data reporting obligations that in turn affects the availability, completeness and timeliness of certain data. When presented data in an acceptable format there is little that GIS can do about data quality or its availability. Thus, certain data issues that arise due to the heterogeneous nature of the M & E infrastructure cannot be expected to be resolved by the mere introduction of GIS.

7.1.3 Standardization

Information sharing, within an organization and eventually with other organizations and jurisdictions, offers great opportunities for improvement of efficiency in use of information (Van Loenen 2006). As explained earlier, there are several stake holders involved in the multi-sectoral HIV/AIDS response and its subsequent monitoring and evaluation. With this comes the inherent need to share information. One aspect of information sharing and integration is standardization (*ibid*). Standards facilitate common understanding and interpretation of data and eliminate the need for guesswork. Thus, they ensure meaningful and correct use of information obtained from external sources.

The health sector in general is already standardised. The data collection, processing and storage procedures are generally the same across health facilities. However, with HIV/AIDS we are not dealing with the health sector alone. Hence standardisation is required. The National AIDS Commission through the National Monitoring and Evaluation plan has standardised data processing by defining the essential set of indicators that ought to be computed. In addition, it has introduced the National Activity

Reporting form which defines what data is collected for what intervention programmes as well as how that data is to be aggregated and reported to the commission for capture into the M & E system. While this standardisation has created a conducive environment for data transfer between the M & E system and stake holders, the heterogeneity amongst stake holders with respect skills is still a deterrent to proper information sharing with some stake holders. For example, community based organizations are run and manned mostly by rural volunteers with little or no education at all. Such volunteers rarely appreciate standards and what they entail. Even with training some still do not get to adhere to standards and often perceive training as an expression of gratitude for the work they do rather than a way to improve on their services and subsequent reporting.

Geographical (spatial) information, on the other hand, is special because of the high costs associated with its acquisition and maintenance (Van Loenen 2006). Unlike non-spatial information, spatial information needs technology to be collected; it needs technology to be processed; it needs technology for storage and transfer; it needs technology for its presentation and interpretation. Thus, it comparatively requires advanced human resources and computing skills (Van Loenen 2006). Hence it is more cost efficient to share spatial information than having each stake holder acquire its own spatial information for its own purposes. This is turn demands putting in place standards for spatial data in terms of format, scaling and so on. In Malawi, the Ministry of Health, the National AIDS Commission, the National Statistics Office, the Ministry of Agriculture, the Ministry of Irrigation and Water Resources, the Ministry of Economic Planning and many others are exploring the use of GIS in their activities. It would, thus, be more cost effective to have common spatial data standards across these organizations which would facilitate sharing of the spatial resources aside from other forms of cooperation within the scope of the national response to HIV/AIDS.

7.1.4 GIS Usage

One of the things this study set out to find out was the level of use or non use of GIS in monitoring and management of HIV/AIDS programmes. While GIS technology exists at the Ministry of Health it is mostly used as a research tool and there was no evidence of

specific uses in monitoring and management of HIV/AIDS. GIS use is generally adhoc in nature and mostly according to need. On the other hand, the National AIDS Commission through its Monitoring and Evaluation department is in the process of acquiring a GIS system to support monitoring and evaluation activities. The diffusion and adoption of GIS within the health sector has been slow although it was introduced in the Ministry of Health as early as 2002.

The slow diffusion and adoption can be understood by looking at the prevailing factors at the time of introduction and after its introduction. GIS implementation in developing countries has not moved much beyond the experimental stage and current GIS activities rather than being locally sponsored and managed, are facilitated, in most instances, through contractually appointed expatriate employees or international development agencies (Hall et al. 1997). This is typical of the way GIS was introduced in the health sector in Malawi. As explained in chapter 6, GIS was introduced in the Ministry of Health in 2002 through a joint project with the Japan International Cooperation Agency (JICA) and involved a Japanese Consultant who helped set up a geo-spatial register covering all health facilities as at that time.

Although this kind of approach is important to initiate the use of GIS, its role in sustaining and expanding its use is not very clear. Evidence, however, suggests that that once an aid project that involves implementation of GIS comes to an end, so does the use of the technology as annual software maintenance fees cannot be paid, software upgrades fall increasingly behind current versions, and expatriate expertise that was available through the project is withdrawn (Hall et al. 1997). There is an agreement between this observation and the Malawian case. The Ministry of Health is still using ArcGIS version 3.1 yet the current supported version is ArcGIS 9x. In addition, the expatriate consultant has been called back a number of times after the project to assist in activities related to GIS. After all these years the Ministry only has one statistician who is conversant with GIS.

Sustainability and scalability are key important characteristics that a system ought to demonstrate if it is to be effective in the context of developing countries. Sustainability

refers to the ability of a system to work in practice within the same (local) setting overtime. On the other hand, scalability refers to ability or easiness of a working system to be introduced to other sites and be successfully adapted there (Braa et al. 2004). One way to promote sustainability and scalability is developing self-sufficient local expertise and learning processes, which entails having a training component where there is transfer of knowledge and skills to local manpower. In the Malawian case, this aspect was not addressed during and after the project and therefore there has been a severe lack of expertise within the Ministry to drive wide scale adoption and diffusion of GIS.

7.2 Challenges in Monitoring and Evaluation of HIV/AIDS

Among the objectives of this study was to find out the challenges and gaps that exist in the monitoring and management of HIV/AIDS programmes. Particularly, the interest was on those challenges that could be overcome by making use of GIS technology. As explained in section 7.1.4, *GIS Usage*, the study found no evidence of specific uses of GIS in monitoring and management of HIV/AIDS. Thus, the challenges outlined here can to some extent be perceived as challenges that might exist where monitoring and management of HIV/AIDS programmes has not incorporated GIS.

Health care management, epidemiology and geographical information systems are united by one common denominator: location. The compressed epidemiological question of *who* gets sick with *what* and *where* cannot be adequately addressed without the presence of appropriate tools to deal with the location aspect and relate it to other prevailing environmental factors. Health care management is concerned with, among other things, factors such as hospital and clinic placement, accessibility to these and other services contributing to the health of people (Vanmeulebrouk et al. 2008). Monitoring and management of HIV/AIDS embodies aspects of both epidemiology and health care management and location is equally of great importance in this regard. While it is possible to work without taking into account this geographical component; using spreadsheets or databases, for example, this is effectively throwing away potentially important and valuable information (Saugene 2005). Thus, absence of GIS usage like is

the case in Malawi can be a constraining factor with respect to what can be done under monitoring and management of HIV/AIDS programmes.

First, both the National AIDS Commission and the Ministry of Health have difficulties with location of health facilities and sites of HIV/AIDS services and intervention programmes. Service sites for ART, HTC and PMTCT are mostly known by name and districts they are located in. As you go down the hierarchy, through the district level then down to the facility level spatial information about facilities and service sites tends to increase. This information is often resident in the heads of personnel at district level or captured in tables showing estimated distances from the central facility or health management office and might be supported by hand drawn maps. However, hand drawn maps are often not up-to-date because maintenance of such maps is time consuming and tedious and often not done. Furthermore, the fact that decisions are largely made at top levels in the hierarchy means that unavailability of such spatial information can potentially affect the quality of decisions made. For example, there have been reports of cases of ghost health facilities and service sites that exist only on paper; siphoning away already scarce resources. Such cases are difficult to address without adequate spatial knowledge of the implementation level.

Secondly, planning and regulating distribution of services and service sites is a challenge without adequate spatial information. The ultimate goal is to achieve equitable distribution of services. In order to improve accessibility of services new service sites must be introduced in areas where there use to be none and not where services already exist. However, in a situation where sites are only known by name and district of location it becomes easier to have a higher concentration of service sites in some areas while other areas suffer. It is also important to note the role of population and other factors in this process. Therefore, there are a number of spatial factors that must be cross-referenced and considered in order to plan for and make decisions on service distribution. Without GIS this information has to be provided in other formats like tables and spreadsheets. Manual cross referencing of service distribution data provided in tabular format can be constraining and time consuming. However, GIS provides excellent means for

visualization and analysis that reveal trends, dependencies and inter-relationships that would be more difficult to discover in tabular formats (C. Johnson & J. Johnson 2001).

Thirdly, as observed by participants during the prototyping process there are situations where presenting data on map would be better than using a table or a graph and vice versa. However, because of the absence of efficient mapping tools like GIS they are forced to use table and/or graphs. The value of spatial information goes down if presented in a format that does not reflect its nature; hiding important details of potential value to eventual analysis. Saugene (2005) noted that using spreadsheets and other data formats to handle spatial information effectively throws away potentially important and valuable information. Thus, such compromises limit the scope and outcome of subsequent analysis as some dependencies and interrelationships are difficult to discover with data presented in tabular formats (C. Johnson & J. Johnson 2001).

7.3 Challenges in Using GIS for Monitoring and Management of HIV/AIDS

There are various challenges surrounding the use of GIS in the monitoring and management of HIV/AIDS programmes in Malawi. While this study is based on the Malawian scenario, shared similarities with other developing countries in the sub Saharan Africa means that observations discussed here may also apply to these other countries.

7.3.1 Lack of Local Expertise

One of the major challenges to adoption of GIS in developing countries has been a lack of local expertise (Hall et al. 1997). GIS implementation in developing countries has mostly been driven by international development agencies through contractually appointed expatriate employees (Taylor 1991 cited in Hall et al. 1997). Such, as explained earlier, is the case with Malawi where GIS was introduced in Ministry of Health through a joint project with JICA with an expatriate consultant engaged in the process. While the project was successful in introducing GIS to the health sector the lack of local expertise has greatly affected the sustainability and the scalability of GIS usage. As at the time of this study the Ministry of Health had only one statistician who was

conversant with GIS. There is therefore limited GIS expertise at the Ministry's disposal which can be tapped into to support its routine use in various decision making processes of the Ministry, including monitoring and management of HIV/AIDS programmes.

On the other hand, pockets of GIS expertise are slowly emerging in the country through pursuits in the academic arena and departments in other ministries. Colleges and departments in the University of Malawi dealing with land studies, geography and demography have GIS components in there courses. The national statistical office and the department of surveys are some other government bodies that have some ongoing activities with GIS. Nurturing these emerging pockets of GIS expertise could be the way forward to developing local GIS expertise.

7.3.2 Limited Financial Resources

Literature seems to agree that GIS is not a cheap venture (Hall et al. 1997; Van Loenen 2006; Vanmeulebrouk et al. 2008). Right from the acquisition of the software required, the licenses that go with it, required hardware like GPS units, the human resources with requisite skills and their maintenance, and getting spatial and non-spatial data, GIS can be an expensive venture. There are especially high costs associated with acquisition and maintenance geographical data (Van Loenen 2006). Therefore, GIS can be expensive to acquire and equally expensive to maintain. For developing countries like Malawi the financial demands that go with the technology like GIS can easily become an impediment.

The sustainability of GIS applications initiated with aid from international development agencies has been put to question. Evidence suggests that once the projects come to an end and aid is withdrawn, so does the use of the technology as annual software maintenance fees cannot be paid and software upgrades fall increasingly behind current versions (Hall et al. 1997). Evidence from this study supports this observation. The ArcGIS version being used in the Ministry of Health is way behind the current version on the market, 3.1 and 9x respectively.

Therefore, viable GIS applications in developing countries should deliberately incorporate cost-cutting measures. Shared geospatial infrastructures that reduce duplication of effort in the collection and storage of spatial data and use of open source alternatives to commercial GIS software are some of the ways that have potential to reduce the cost of GIS applications in developing countries (Van Loenen 2006; Vanmeulebrouk et al. 2008).

7.3.3 Data Availability and Quality

In an earlier discussion GIS has been shown as dependent on the installed base which includes spatial and non-spatial data. The availability and quality of both kinds of data can easily be an impediment to using GIS in the monitoring and management of HIV/AIDS programmes. As reported by Hall et al. (1997), the major constraint in to GIS implementation and usage in African countries is the uniform absence of useable geo-referenced and up-to-date data. While that might not be entirely the case with what this study found in Malawi, there challenges with respect to both spatial and non-spatial data that ought to be considered and addressed if GIS is to be effectively used in monitoring and management of HIV/AIDS programmes.

Firstly, data continuity is important to monitoring and evaluation as often data collected from two different periods have to be compared. The study, however, did find cases where data continuity was not there, especially at the district level. Several reasons could be given for this. One is that data has historically been collected for the top level (i.e. the national level) and once it has been submitted to the upper level it was not taken to be important anymore. The shift from this kind of data collection is as a result of the decentralization programme but traces of old centralized practices can still be found. Without data continuity some of the potential uses of GIS in the monitoring and management of HIV/AIDS programmes might not be feasible. For example, showing changes or trends in the prevalence or incidence levels of HIV/AIDS can be difficult without continuous availability of prevalence and incidence data.

As indicated earlier, the heterogeneity of stakeholders in the national AIDS response means that there are varied perceptions to data reporting obligations such that some implementers of intervention programmes are not well disposed towards submitting their activity data to the AIDS commission and/or the district AIDS coordinator. This as explained creates gaps in the range of data available. Furthermore, there are delays in data submission by some implementers that further exacerbates the problem of data availability. In addition to this, community based organizations often have problems appreciating the importance of data, standards and quality and some do not go along with set standards for data collection and data reporting. This renders the data they submit either useless or difficult to understand.

On the other hand spatial data mainly suffers from lack of updates. For example, the health geo-spatial register in the Ministry of Health has rarely been updated since 2003. This means that any eventual use of the data there in does not take into account facilities that would have been put in place after 2003. While the Ministry of Health has issued out GPS units to all districts updating the register has not started due to lack of training in their use and standards to follow in their use.

7.3.4 Lack of Knowledge about GIS

Diffusion in the application of GIS is directly related to the diffusion of knowledge in the potential contribution it can make to planning human service delivery in important areas, such as health and education (Hall et al. 1997). Awareness of some technology and its potential benefits to a particular field is a driving factor in its adoption and diffusion. As people become aware of such benefits they are more likely to demand for it in order to enhance and support corresponding activities. According to Hall et al. (1997) one of the issues at the core of problems encountered in Africa is a general low level of understanding of GIS concepts and spatial analysis and lack of appreciation of its potential applications in important areas that include health and education. As this study found out there is little or no knowledge of GIS and its possible applications in the health sector, especially at the district level. As stated earlier awareness of the benefits a particular technology has in a particular field is a driving factor in its adoption. Thus, the

slow diffusion of GIS in the Malawian health sector is partially due to a lack of awareness of its benefits by a majority of health personnel.

7.4 Opportunities in Using GIS for Monitoring and Management of HIV/AIDS

While appreciating the challenges facing usage of GIS in the monitoring and management of HIV/AIDS in Malawi it is also imperative to note opportunities that exist in the same regard. These opportunities can be nurtured and/or exploited as a springboard to eventual routine usage of GIS in monitoring and management of HIV/AIDS programmes.

7.4.1 The National AIDS Commission GIS Project

As indicated in Chapter 6, the National AIDS Commission has a project currently underway whose aim is to put in place a GIS to be used for monitoring and evaluation purposes. The system will tie up with the existing National M & E system. The prospective system is initially expected to support basic monitoring and evaluation activities and envisaged to extend to more complex applications later.

This project and the prospective GIS represent one of the major opportunities for using GIS in monitoring and management of HIV/AIDS in Malawi. They provide a learning platform where GIS potential benefits can be put to test and therefore contribute to creating an awareness that will help counteract the slow diffusion that has so far been associated with GIS within the Malawian health sector. As people use information systems to improve their processes they learn what is possible which helps them to become more confident in breaking out of the old mindset (Boddy et al. 2005). Thus, once the system being built is put to practice an increase in GIS knowledge can be expected which will help make other possible applications more apparent and hence act as a catalyst to further diffusion of GIS within the scope of monitoring and management of HIV/AIDS as well as the health sector at large.

As stated earlier, procedures and regulations as part of the installed base can be a limiting factor in attempts to exploit GIS at different levels of implementation. In Malawi, certain HIV/AIDS statistics can only be computed and reported at the national level, by the National AIDS Commission. However, depending on what GIS is to be used to achieve in monitoring and management of HIV/AIDS programmes and the level at which it is being implemented some practices might have to be reviewed in order to ensure the availability of required data. Process change and information systems are mutually reinforcing (Boddy et al. 2005). As people use information systems they see new possibilities and are willing to abandon traditional ways of thinking which can block attempts at process change – which will require further new systems (*ibid*). The use of the prospective GIS creates an opportunity to identify prohibitive procedures and regulations which when reviewed can help create a conducive environment for further adoption and diffusion of GIS.

7.4.2 GIS Technology Existence

Another plus towards the use of GIS in monitoring and management of HIV/AIDS the existence of GIS technology at the ministry of health, although its usage has been limited to research only. This works in favour of any subsequent projects to extend usage of GIS to other areas of applications, including HIV/AIDS. Such projects will not have to start from scratch but will benefit from the GIS traits of installed base resulting from current usage. This includes the spatial data currently in use, established partnerships with other institutions as well as pockets of knowledge, experience and expertise in GIS.

Furthermore, it creates room for experimentation with the technology which brings to light the potential benefits of its routine usage and also has potential to steer growth in knowledge and expertise on GIS which was found to be lacking. As argued by Boddy et al (2005), the use of technology or information systems enables people to see other possibilities thus helping break old mindsets. It can thus be expected that through the use of already existing GIS, albeit limited to research only, knowledge and expertise will grow potentially leading to greater diffusion of GIS to other areas of application, including monitoring and management of HIV/AIDS programmes.

7.4.3 Sharing of Spatial Information

Literature has indicated that amongst the data used in GIS spatial data is the most expensive. Spatial data needs technology to collect; it needs technology to process and needs technology to store (Van Loenen 2006). Thus sharing of information is often advised as a cost-cutting measure. In Malawi, the Ministry of Health, the National AIDS Commission, the National Statistics Office, the Ministry of Agriculture, the Ministry of Irrigation and Water Resources, the Ministry of Economic Planning and many others are exploring the use of GIS in their activities. This creates an opportunity for sharing spatial information as the underlying spatial data these institutions would like to use is not so different. Instead of each of these institutions collecting its own of this basic and commonly usable spatial data it would be more cost efficient to simply share this data. In fact the study found evidence of spatial information sharing between the department of surveys and the Ministry of Health where raster and vector data collected by the department of surveys was being made available to the Ministry of Health. Although this sharing of spatial data has often been unidirectional it has gone a long way in minimizing the effort and the cost in collecting spatial data for the Ministry of Health.

Furthermore, it is worthy noting that the various institutions exploring GIS in Malawi are already aligned with the National AIDS Commission and Ministry of Health under the multi sectoral national response to HIV/AIDS. Thus, it should be easier for the Commission and the Ministry of Health to use these institutions as sources of spatial data to be used for purposes of monitoring and management of HIV/AIDS.

7.4.4 External Support

GIS is a technology initiated and concentrated in the developed world (Dunn et al. 1997). Thus its usage in developing countries like Malawi entails technology transfer through projects initiated or supported by international development agencies or some other representatives of the developed world. As noted by Hall et al. (1997), this is important in the early stages of GIS adoption as a way of combating the general lack of knowledge and expertise that characterize developing countries, especially in Africa. For Malawi there are offers of international support towards capacity building in GIS specifically for

HIV/AIDS monitoring, evaluation and response. A conference entitled ***GIS capacity building in Malawi to support HIV/AIDS monitoring, evaluation and response*** took place on 12th June 2008 with attendance from World Health Organisation, University of Pennsylvania in USA, University of Malawi, the National AIDS Commission and the Ministry of Health. The conference identified training as one of the major needs and ways forward towards capacity building. To this end the University of Pennsylvania offered to provide training to local personnel with support from other potential external partners such as ESRI and Loma Lynda University (WHO 2008). Building of local capacity in GIS had been neglected to the detriment of early attempts to bring GIS to important development sectors like health and education in Africa (Hall et al. 1997). Training creates local expertise which is critical to sustainability and scalability of information infrastructures/systems once external support has been withdrawn.

7.5 Strategies: Addressing Challenges and Harnessing Opportunities

As discussed above there are a number of challenges and also opportunities for using GIS in monitoring and management of HIV/AIDS programmes. Something ought to be done about the challenges in order to pave way for GIS usage. Furthermore, the opportunities ought to be harnessed. This section discusses strategies to address the challenges observed as well to harness the existing opportunities.

7.5.1 Cultivation-Driven Incremental Development

Development of an Information Infrastructure (II) differs from that of traditional information systems in that, among other things, there is no closed timeline for development and the human developer has limited control on the process (Hanseth 2002). The development of II centers on *cultivation*. The emphasis in cultivation is on starting small, taking incremental steps and building on what is working rather than starting from scratch (Hanseth & Monteiro 1998; Hanseth 2002). There are different challenges toward using GIS for monitoring and management of HIV/AIDS programmes at different levels of HIS in Malawi. It is difficult, if not impossible, to have a closed timeline within which to overcome these challenges. Neither can GIS adoption wait until all the challenges have

been overcome. Therefore, by employing the cultivation strategy, GIS should be introduced incrementally starting at a level where there are fewer, readily addressable or tolerable challenges. Thus, the first step should be to identify a level within the HIS that would be more suitable as a launch pad for using GIS in the monitoring and management of HIV/AIDS.

Looking at the findings of the study and the prior discussion of challenges the national level can be seen to be more ready for GIS than the district level. With fewer GIS expertise in the health sector it is currently difficult to have sustainable GIS usage at district level. Furthermore, as indicated earlier the health geospatial register comprising spatial data on health facilities has rarely been updated since 2003. The district level at which level catchment areas of health facilities is of more importance is more exposed to this lack of updates than the national level which is more interested in regions and districts whose spatial data is more up to date. In addition, there are problems with data continuity at the district level.

Consequently, starting at the national level exposes us to fewer, readily addressable and/or tolerable challenges. For example, at this level the bottleneck involving the available GIS expertise and the need for such expertise is reduced to a manageable level. The dilemma that would have existed if these few expertise were to be deployed to districts subsequently disappears. This is the approach the AIDS commission has taken in its GIS project. The lessons and knowledge stemming from the implementation and usage of GIS at the national level will inform subsequent incremental steps.

Apart from creating a self-reinforcing process for the growth of an II, cultivation is also concerned with managing the growth (Hanseth & Monteiro 1998; Hanseth 2002). Part of this cultivation approach has to obviously include steps addressing practices, procedures and regulations that would impede sustainable deployment of GIS at the district level. Such practices include centralized computation of some important HIV/AIDS indicators. Thus, starting at the national level does not imply complete neglect of likely challenges at the district level. However, it facilitates creation of small, simple and cheaper information infrastructure that is easy to change. A small scale GIS system makes cost-effective sense

in terms of managing the risk of failure than a large scale one. Once a working and useable system exists and its benefits are demonstrated it can help establish a case for further adoption, even down to district level.

7.5.2 Sharing Data and Resources

One of the challenges that GIS projects in developing countries, including Malawi, face is limited financial and technological resources. Thus, the cost of GIS projects becomes an important factor is their sustainability. This challenge is further exacerbated by cost of spatial data which literature indicates that is expensive to acquire and maintain (Van Loenen 2006). The way to circumvent this challenge lies in the sharing of spatial. Spatial data sharing reduces duplication of effort in the collection and storage of spatial data and has potential to reduce the cost of GIS applications in developing countries (Van Loenen 2006; Vanmeulebrouk et al. 2008).

In the prior discussion of opportunities, the possibility of spatial data sharing has been mentioned as one of the opportunities in existence in Malawi. This opportunity has come about because a number of institutions in Malawi that are currently exploring the use of GIS in their activities. Thus, sharing spatial data across these institutions can potentially reduce the cost and total effort involved in its collection. To this end, building formal spatial data sharing partnerships with the National Statistics Office, the Department of Surveys and the University of Malawi can benefit the National AIDS Commission and the Ministry of Health.

Harnessing this potential for spatial data sharing entails among other things setting up standards to be applied across institutions involved. These standards can include agreements on the scaling of spatial data, embedded content (essential metadata to include in shape files), identification (codes to identify geographical features) and nomenclature (how to name shape files and other shareable spatial data elements). Without such standardization the sharing of spatial data is adhoc and not cost effective as data exchanged often has to be converted into a format useable in the receiving

institution. There are two approaches that can be used to share spatial data: the network approach or the infrastructural approach (*see figure 7.3a and 7.3b*).

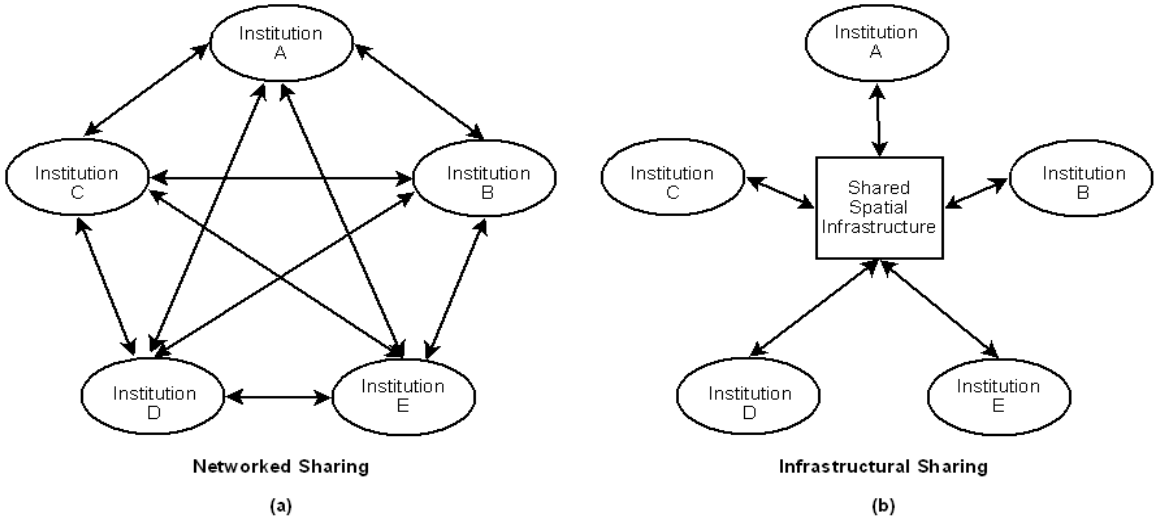


Figure 7.3: Approaches to Spatial Data Sharing

In the network approach each participating institution interacts directly with the institution that has the data it needs. There is need to know which institution has the needed data required. Unless participating institutions are using the same standards cost-efficient sharing may be difficult to attain. The more the institutions involved the more difficult it becomes to negotiate standards. This approach would thus be more applicable where there are few participating institutions and preferably a one-on-one spatial data sharing arrangement.

On the other hand, the infrastructural approach strives for a shared, open and standardized pool of spatial data that is commonly accessible to participating institutions (Van Loenen 2006). A participating institution interacts and has to align with the common infrastructure only. Thus, the institution is shielded from the dilemma of dealing with several disparate standards. As indicated earlier, the cultivation concept advocates for starting small with a few stakeholders and through incremental steps build on what is working (Hanseth 2002). That also applies in setting up this shared spatial infrastructure. From the health point of view, the initial spatial data sharing infrastructure in Malawi can bring together the National AIDS Commission, the Ministry of Health, the National

Statistics Office, the Department of Surveys and the University of Malawi (*see figure 7.4*). The infrastructure itself can take different forms; one of which is a website with standardised spatial data available for download.

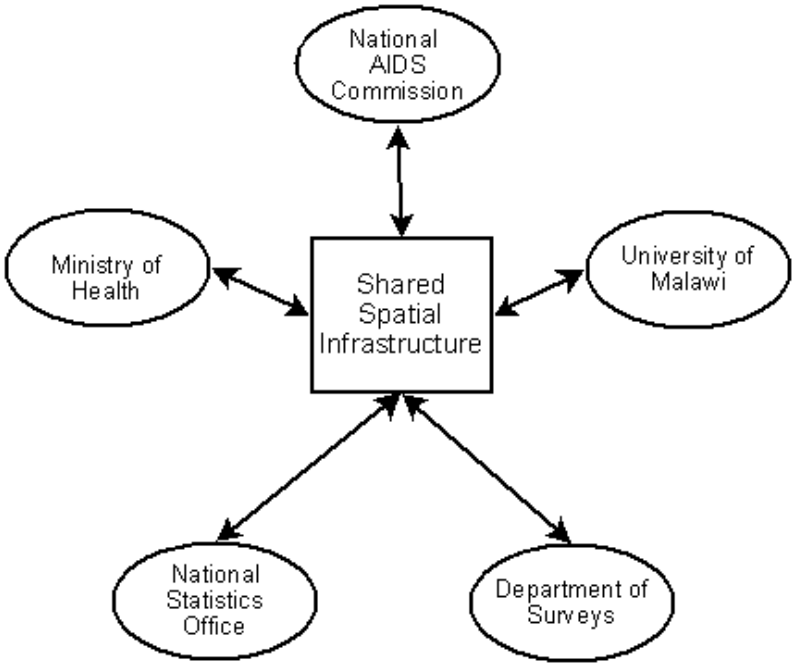


Figure 7.4: Initial Spatial Data Sharing Infrastructure

Apart from the sharing of spatial data the level of collaboration and coordination can extend to other resources. For example, institutions can pool together existing hardware such as GPS devices. The other area of collaboration is on training. Having a common training platform can also facilitate the propagation of common standards across institutions; making sharing of spatial data easier. By sharing spatial data and resources duplication of efforts is reduced, data quality can be enforced and improved and cost-effectiveness can be attained.

7.5.3 Training

Training is very important especially when sustainability and scalability is concerned. Sustainable use of GIS in monitoring and management of HIV/AIDS is dependent on having adequate local GIS expertise, which as this study found out is not the case in Malawi. This problem is not limited to Malawi alone. According to Hall et al. (1997) the

majority of developing countries face a similar problem. Circumvention of this challenge lies in training. There is a need to invest as much time and effort in strengthening and building capacity in GIS at both the Ministry of Health and the AIDS Commission by providing appropriate GIS training to staff at various levels of application depending on their roles.

Just like the introduction of GIS, GIS training has often been provided under the wings of international development agencies using expatriate tutors (Hall et al. 1997). While this is the case, it is important that the training be based as much as possible on the local context other than that of the tutor's country of origin. This removes the disjoint between training environment and the application environment thereby facilitating transfer of experience between the two. Hall et al. (1997) further suggested that participants in the training should be trained in their own setting, with their own hardware and unique operating problems. Such training enables participants to be productive under the constraints of their operating environment.

Apart from training on using GIS software and hardware such as GPS devices, training should also incorporate issues of data quality and standardisation. Data sharing opportunities will translate to nothing if the personnel involved are not aware of standards to follow. If set standards are built into the training then they are easily propagated to participants without requiring separate training altogether.

Furthermore, it might also be important that training deals with false expectations created by the manner in which GIS products are marketed. Not everything that has been written and said about GIS is feasible in developing countries. The training should therefore educate participants, particularly in developing countries where technology is often viewed with a magic wand perception, as to the difference between what is *possible* and what is *feasible* (Hall et al. 1997).

7.5.4 Explore Free Open Source Alternatives

As a result of limited financial resources developing countries have had difficulties acquiring software licenses and versions software in use have increasingly fallen behind

current versions (Hall et al. 1997). The findings of this study, in Malawi, support this observation. While this is the case free and open source alternatives are becoming increasingly available. A recent study in South Africa has shown that it is possible to use open source software to develop a GIS system for HIV/AIDS management (Vanmeulebrouk et al. 2008). Open source software was chosen in the study because of prevailing resource constraints in the study context. Similarly, Malawi and other resource constrained developing countries that are unable to keep up with software licenses can explore open source alternatives.

Since there is no license fees due for open source software the money previously spend on paying license fees outside the country can be spent on developing local skills and expertise (Vanmeulebrouk et al. 2008). In addition to this open source software gives freedom to modify the code which translates into vendor independence and has a large developer and tester base which means bugs are addressed quickly in open source software than their commercial alternatives (Krishnamurthy 2003).

According to Vanmeulebrouk et al. (2008), the study in South Africa confirms that it is possible to use open source GIS software to develop a user-friendly GIS application, containing functionality to provide local communities with spatial information. Therefore, Malawi and other resource constrained developing countries can take advantage of advances in open source GIS software and invest the money that would have been used for software licenses for capacity building.

8.0
Conclusion

This chapter draws conclusions from this study and its findings and presents recommendations, theoretical and practical contributions as well as possible further research related to this study.

8.1 Research Summary

This study was concerned with challenges and opportunities in using GIS for monitoring and management of HIV/AIDS in the case of Malawi. The study was inspired by studies by Hugo (2000) and Tanser & Sueur (2002) that pointed out potential benefits of using GIS for management of HIV/AIDS among other important health issues. Literature on GIS implementation in developing nations, particularly Africa, has pointed out some intrinsic challenges that are faced by GIS projects in such nations. To this end this study wanted to look at the challenges and opportunities that exist in using GIS for monitoring and management of HIV/AIDS and suggest strategies to overcoming those challenges and harnessing the opportunities identified.

8.1.1 Research Objectives and Methodology

In summary, the research objectives of the study were guided by two research questions that this study sought address:

1. What challenges and opportunities exist for sustainable use of GIS in monitoring and management of HIV/AIDS in Malawi?

2. What strategies can be used to address the challenges and harness the opportunities identified in order to have sustainable GIS usage?

In order to answer these questions the study specifically aimed to:

1. Assess the monitoring and management systems and/or routines for HIV/AIDS currently in use in Malawi.

2. Identify gaps (or challenges) in monitoring and management of HIV/AIDS that can be addressed using GIS.

3. Assess how GIS can (or is being) used to address the challenges identified.

4. Develop a GIS prototype to facilitate empirical data collection on practical issues surrounding the using GIS for monitoring and management of HIV/AIDS.

To meet the set objectives the study adopted a qualitative research approach and made use of the case study research method. Empirical data was collected through interviews, document analysis and to a lesser extent observations; carried out at the Ministry of Health, the National AIDS Commission, Zomba and Balaka District Health Offices. In addition, data was also realized through the prototyping of a possible GIS solution for monitoring and management of HIV/AIDS presented in chapter 5.

8.1.2 GIS Usage

The study found no evidence of specific use of GIS for monitoring and management of HIV/AIDS in Malawi. While the Ministry of Health has had GIS technology for almost a decade its usage has been limited to research only. The use pattern has been adhoc at most; with maps produced according to the prevailing need at the time. There is no evidence of GIS being used in routine management and planning activities. Going down to the district level the technology itself is nonexistent except for GPS units that have been made available to district health offices in order to facilitate collection of point (location) data on health facilities and other features of importance to the HIS.

At the National AIDS Commission there is a project currently underway whose aim is to develop a GIS system for monitoring and evaluation of HIV/AIDS programmes. The project has however been delayed by almost a year which has partly been attributed to capacity on the side of the consultant engaged to develop the system. By the time the fieldwork for this study was coming to an end, in January 2009, the system had still not been delivered.

Thus, in as far us monitoring and management of HIV/AIDS is concerned the study concludes that there is no evidence of any routine usage of GIS in the Malawian health sector. This is despite the fact that the Ministry of Health has had GIS technology for over a decade.

8.1.3 Potential Benefits of Using GIS

There are a number of potential benefits for Malawi from using GIS for monitoring and management of HIV/AIDS as can be inferred from the interviews with National AIDS Commission personnel in charge of the commission's GIS project as well as from the GIS prototype that was developed in the course of this study.

1. **Mapping HIV Prevalence**

   HIV prevalence and incidence are important indicators of the severity of HIV/AIDS in different areas which might be countries, provinces, districts and so on. Thus, the process of monitoring and management of HIV/AIDS starts with being able to know HIV prevalence in various locations of interest. Through the prototype it was possible to map HIV prevalence at regional level; district level and health zone (catchment area) level (*see figure 5.6 and figure 5.7*). With such mapping it becomes easier to see which areas are highly affected and need special attention or investigation.

2. **Mapping Trends in HIV Prevalence**

   Apart from knowing the HIV prevalence in different locations it is also important to know the changes in the prevalence through time. To know whether the battle against HIV/AIDS is being won or lost one has to look at HIV/AIDS prevalence through time. The expectation of the national response in Malawi is a reduction in the spread of HIV prevalence which implies decreasing HIV prevalence. Using the prototype, it was possible to map trends in HIV prevalence according to regions from 2001 through to 2007 (*see figure 5.8 and figure 5.9*). In addition, by overlaying charts on the maps it was easier to visualize the trends where using the map alone would be inadequate. The mapping indicated that the general trend in Malawi between 2001 and 2007 has been a decreasing HIV prevalence across all three regions.

Apart from informing the nation whether it is winning or loosing the battle against HIV/AIDS mapping trends in HIV prevalence can also facilitate evaluation/assessment of HIV/AIDS programmes meant to reduce the spread of HIV. Such programmes include Information, Education and Communication (IEC) programmes, condom distribution programmes and so on. By mapping trends in HIV prevalence in the places where such programmes have been running it should be possible to determine if they are having an impact or not. Ideally, if the programmes are successful then there must be a decreasing trend in HIV prevalence in the areas they are running.

3. Mapping Service Distribution and Accessibility

One of the goals of the National AIDS Commission is to see equitable distribution of HIV/AIDS services. That is, services must be as easily accessible to all as possible. Thus, by mapping health facilities and the kind of HIV/AIDS services they are offering it should be easier to visualize how accessible those services are. Using the prototype health facilities in Zomba district and the kind of services they were offering were mapped. The map showed a concentration of services towards Zomba Central, the hub of the district where the central hospital is also located. This implies that people from some remote health zones have to travel long distances to access certain services particularly ART and PMTCT (*see figure 5.10*).

At the district level, if given spatial data on location of villages then it should be possible to carry out a buffer analysis to see how further away villages are from the closest health facilities offering certain services. Unfortunately, at the time of developing the prototype there was no up to date data on villages in Zomba or any other district for that matter. However, that is another potential benefit of GIS that can be exploited in order to assess the accessibility of HIV/AIDS services and service centers.

4. Mapping Performance Indicators for HIV/AIDS programmes

In terms of monitoring and management of HIV/AIDS programmes it might be important to know how well a given programme performed in a particular area. Thus, mapping programme performance indicators allows a visual assessment of the performance of programmes in given areas, especially at a district level. The prototype was used in this aspect to map two performance indicators for HIV Testing and Counselling: HIV-testing coverage and test results delivery coverage (*see figures 5.11, 5.12 and 5.13*). Such mapping can help in determining where programmes are not doing well in order to ensure that programmes are performing according to expectations in all areas.

5. Resource Allocation Planning and Assessment

One aspect of HIV/AIDS management involves managing resources which could be human resources, equipment, medical supplies and so on. With GIS it is possible to have a map and a model that can be used to determine the optimal allocation of resources across different areas (Hugo, 2000). Input indicators are use to measure resources required or to be allocated to a programme or an area. They may also be used to assess or evaluate allocations made. In this aspect, the prototype was used to evaluate the distribution of counsellors across the three regions of Malawi by computing the expected number of counsellors and comparing it with the actual number of counsellors allocated (*see figure 5.14*).

On paper, the Central Region with 612 counsellors seemed better off than the Northern Region which had 429 counsellors. However, by computing the expected number of counsellors, an indicator that factors in population and total number of counsellors in the country, the GIS prototype showed that it was in fact the Northern Region that was better off. Likewise, the same strategy can be applied when planning distribution of counsellors and other HIV/AIDS related resources.

6. **Enhanced Presentation and Quick Mapping**

GIS offers better visualization and presentation features than traditional information systems that reveal trends, dependencies and inter-relationships that would be more difficult to discover in tabular formats (C. Johnson & J. Johnson 2001). There are times when data is better presented in a map than using graphs and tables but where a mapping tool does not exist people are forced to use the other two alternatives. This takes away a valuable aspect of the information: the spatial dimension (Tanser & Sueur 2002; Saugene 2005). Thus by introducing GIS to monitoring and management of HIV/AIDS the presentation of HIV/AIDS information stands to be enhanced.

One of the characteristics of GIS is speed (Hugo 2000). GIS can extract and relate vast amounts of data from database and produce maps in a moment. The same task can take hours and possibly days using other means. For example, in the Malawian health sector the way out has often been hand drawn maps which are tedious, time consuming, prone to errors and often lack quality. Despite the information they carry such maps are less likely to be taken serious or make their way into a formal meeting. On the other hand, GIS offers the possibility of quick mapping alongside the quality that comes with it. Thus, GIS would be of great assistance in addressing the mapping needs in the monitoring and management of HIV/AIDS.

8.1.4 Challenges

Albeit having the potential benefits outlined above, there are some challenges associated with using GIS in monitoring and management of HIV/AIDS in Malawi that this study identified which have been discussed in the earlier chapter.

1. **Lack of Local GIS Expertise**

First among the challenges is the lack of local GIS expertise. The Malawian health sector does not have enough GIS expertise to sustain its routine use in HIV/AIDS and other related issues. The Ministry of Health, for example, has only one statistician conversant with GIS. Thus, there is a reliance on consultants who in most cases have come from outside the country. The National AIDS Commission has similar concerns

and has had to engage consultants in its ongoing GIS project. Thus, lack of local GIS expertise is a challenge towards sustainable use of GIS and at the same time can prove costly.

2. Data Quality and Availability

Secondly, there are problems with data quality and availability for both non-spatial and spatial data especially at the district level. The unavailability of data limits what can be done with GIS. For example, lack of prevalence data for years before 2007 prevented us from mapping trends in HIV prevalence at the district level and lack of spatial data on villages meant that a buffer analysis of health facilities against villages could not be done.

3. Limited Financial Resources

Another challenge is limited financial resources at the disposal of the institutions concerned. Collection and maintenance of spatial data is not cheap (Van Loenen 2006). In addition, most reputable GIS software requires payment of software licenses which the health sector in developing countries cannot afford (Hall et al. 1997; Vanmeulebrouk et al. 2008). As a result of failure to pay licenses software versions in use fall increasing behind current versions. To this end, the study found that the Ministry of Health was still using ArcGIS 3.1 when the current version on the market is ArcGIS 9.x.

4. Lack of Knowledge about GIS

As this study found out there is little or no knowledge of GIS and its possible applications in the health sector, especially at the district level. Diffusion in the application of GIS is directly related to the diffusion of knowledge in the potential contribution it can make to planning human service delivery in important areas, such as health and education (Hall et al. 1997). Awareness of some technology and its potential benefits to a particular field is a driving factor in its adoption and diffusion. Thus, the slow diffusion of GIS in the Malawian health sector is partially due to a lack of awareness of its benefits by a majority of health personnel.

8.1.5 Opportunities

In addition to the challenges summarized above, the study also identified some opportunities that work in favour of the intended use of GIS and should be harnessed.

1. **The National AIDS Commission GIS Project**

   As mentioned above, the National AIDS Commission has an ongoing project whose aim is to develop a GIS system to be used for monitoring and management of HIV/AIDS. This project and the prospective GIS system represent one of the major opportunities for using GIS for monitoring and management of HIV/AIDS in Malawi. They provide a learning platform where GIS potential benefits can be put to test and therefore contribute to creating an awareness that will help counteract the slow diffusion that has so far been associated with GIS within the Malawian health sector. As people use information systems to improve their processes they learn what is possible which helps them to become more confident in breaking out of the old mindset (Boddy et al. 2005). Thus, once the system being built is put to practice an increase in GIS knowledge can be expected which will help make other possible applications more apparent and hence act as a catalyst to further diffusion of GIS within the scope of monitoring and management of HIV/AIDS as well as the health sector at large.

2. **GIS Technology Existence**

   Another plus towards the use of GIS in monitoring and management of HIV/AIDS is the existence of GIS technology at the ministry of health, although its usage has been limited to research only. This works in favour of any subsequent projects to extend usage of GIS to other areas of applications, including HIV/AIDS. Such projects will not have to start from scratch but will benefit from the GIS traits of installed base resulting from current usage. This includes the spatial data currently in use, established partnerships with other institutions as well as pockets of knowledge, experience and expertise in GIS.

3. **Sharing of Spatial Data**

Furthermore, with several institutions in Malawi exploring the use of GIS in their activities there is a possibility of sharing spatial data amongst these institutions which can prove more cost-efficient than having each institution collect its own spatial data right from scratch. Evidence from the prototype constructed as part of this study supports the cost-effectiveness of spatial data sharing. All the spatial data used in the prototype was obtained for free from Ministry of Health and SAHIMS GIS Data Server. Although, it might not always be possible to build a GIS system entirely out of free and shared spatial data still the cost where data is shared would be less than building the system entirely on new spatial data.

4. **External Support**

Last but not least, there are offers of training and external support from international health and development agencies in GIS. The WHO and the University of Pennsylvania in USA have offered to facilitate training of staff at the AIDS commission and Ministry of Health in GIS. Training is a crucial aspect of local capacity building which is itself critical to sustainability and scalability of GIS projects.

8.2 Recommendations

Comparatively, the national level is more ready for GIS than the district level. There are still organizational issues to be dealt with at the district level. For example, the lack of GIS expertise, data continuity, procedures for computation of prevalence levels and aggregation of data for health zones (health facility catchment areas) need to be addressed. Furthermore, the district level is more exposed to the effects of not having an up-to-date health geospatial register. Without addressing these issues there can only be limited application of GIS at district level. On the other hand, at the national level some of these challenges do not exist or are least severe. In light of this observation, it is recommended that endeavors to use GIS for monitoring and management of HIV/AIDS

should start at the national level and trickle down to the district level as the impeding organizational issues are dealt with.

Considering financial and resource constraints faced by the health sector in Malawi, and other developing nations, it is recommended that spatial data sharing opportunities be fostered. This, as discussed earlier, entails putting in place standards and building partnerships and infrastructure to facilitate the exchange of data. These standards can include agreements on the scaling of spatial data, embedded content (essential metadata to include in shape files), identification (codes to identify geographical features) and nomenclature (how to name shape files and other shareable spatial data elements). Sharing of spatial data would not only reduce duplication of efforts and produce data of better quality but would also prove attractive to donors as it is more cost-effective.

There is a need to invest resources in building local expertise and capacity in GIS in order to circumvent the problem of lack of expertise and skills. As much as possible, it is recommended that such training should be carried out within participants' operating environment using their own hardware. That is, the training environment should be as close as possible to their operating environment. This will enhance the transfer of experience from training to actual work ensuring participants' productivity in their own working environment. On the other hand, if the technology gap between the training environment and the operating environment is huge the productivity of participants' after the training can be shortchanged.

8.3 Contributions

Through this study there have been a number of contributions both theoretical and practical. This section outlines these contributions.

8.3.1 Theoretical Contributions

Theoretically, this study drew from the Information Infrastructure theory as well as the Socio-Technical View of Information Systems in order to explain and understand the intricacies involved in extending HIS, in this case with GIS for purposes of monitoring

and management of HIV/AIDS. These theories have been used before together by a number of researchers on HIS. Nonetheless, the mere use of these theories in this research further strengthens their ground as viable theories for use in studies on HIS.

From the II theory this study made use of the installed base concept. Literature has pointed at the influence that the installed base exerts on the development and the growth of the information infrastructure. Hanseth (2002) says the installed base is an actor in the II development process that heavily limits and influences how it can be designed and in fact how it can evolve. Drawing from this view of the installed base this study sees certain challenges involved in using GIS in monitoring and management of HIV/AIDS as emanating from the power of influence and constraint that the installed base has. For example, some established procedures and practices (*as part of the installed base*) in the National HIV/AIDS Monitoring and Evaluation System created barriers to availability of certain information required for the GIS prototype. At the same time, the existence of GIS technology at the Ministry of Health turned out to be a good starting point for the GIS prototype as a ready source of required spatial data. Thus, by using the installed base concept this study demonstrates its ability to explain both challenges and opportunities that exists in IS development projects within the scope of HIS.

Apart from the installed base concept, the study also made use of the *heterogeneity* and standardized (*standardization*) concept out of the II theory. Hanseth & Monteiro (1998) summarize an infrastructure as being a shared, evolving, open, *standardized*, and *heterogeneous* installed base. In the course of this study the two concepts have been found to be linked. Heterogeneity translates into disparate interests, procedures and so on. In the multi-sectoral national response to HIV/AIDS in Malawi the number of stakeholders and the differences between them is overwhelming. This translates into challenges particularly in collection and reporting of data; a lot of guesswork was applied. Faced with such heterogeneity-induced challenges, standardization is carried out to put in place standards that ensure a common way of doing things. In the case of Malawi, this came in the form of the National HIV/AIDS Activity Reporting Form. Thus, standardization is seen in this study as a way out of challenges related to heterogeneity. The two concepts are somehow mutually reinforcing. Standards make it easier for others

to get on board the infrastructure. The more the stakeholders enrolled into the II the more inadequate the standards become leading to further standardization and so on.

Related to the concepts of heterogeneity and standardization is the concept of *sharing*. An II is a *shared* entity (Hanseth 2002). Sharing requires establishment of links with other stakeholders. These links entail standards because the stakeholders involved are not always homogeneous. In addressing the issue of cost GIS systems, particularly the cost of spatial data the study proposes sharing as more cost-effective way out. Analysis of sharing modes led to two possibilities: (a) networked sharing (b) infrastructural sharing. With networked sharing a stakeholder establishes a direct link and therefore shared standards with another stakeholder with whom data will be exchanged. In this mode the number of links and standards to be established and maintained increases with the number of stakeholders involved. This works well with a few stakeholders but with large number of stakeholders establishing and maintaining links/standards can be overwhelming. The infrastructural sharing is inspired by the II theory and advocates for a common repository of spatial data with one standard applicable to all stakeholders. This prevents a proliferation of disparate standards and makes sharing itself more cost-effective. Thus, this study shows that information infrastructure theory is not only applicable to IS development but can also be used as guide to effective information sharing.

Prior to this study other researchers had found out that there is little literature about GIS projects related to HIV/AIDS in the Sub Saharan Africa (Tanser & Sueur 2002; Montana et al. 2006). This study concerned challenges and opportunities in using GIS for monitoring and management of HIV/AIDS. In the course of discussing these challenges and opportunities strategies to address those challenges and harness the identified opportunities have been put forward. Thus, apart from contributing strategies as outlined the study also contributes to the body of literature concerning GIS and HIV/AIDS in Sub Saharan Africa, particularly Malawi.

8.3.2 Practical Contributions

Through this study I was brought into contact with individuals involved in coordinating and managing monitoring and evaluation HIV/AIDS both at the district and at the national level. Through the ensuing interaction I was able to register my concerns as well as observations, as a citizen and someone with an interest in HIS as well as information systems in general, on how certain things could be improved. At the Ministry of Health, in particular, my interactions with personnel at the HIV/AIDS Unit translated into a fruitful discussion on how GIS could be used to assist in the fight against HIV/AIDS. Prior to this study the prevailing perception of GIS was that it was a research tool with mapping capabilities and the usage pattern supports that observation. However, through this discussion it became clear that GIS had far more applications in the health sector other than research.

As part of this study, I developed a GIS prototype to support monitoring and management of HIV/AIDS. Although the main aim of the prototype was to facilitate understanding practical issues surrounding use of GIS in this regard the prototype itself was developed using an evolutionary approach so that it could be useful beyond the scope of this study. Due to time constraints I was unable to deliver a prototype that covered all essential areas in monitoring and management of HIV/AIDS. However, a few mapping needs can still be addressed using the prototype. It is my intention to continue where I left off when I go back to Malawi.

Despite the limitations faced, the prototype proved to be an important tool to creating awareness about GIS and its abilities at the district level. It aroused interest from the personnel at the district health office in Zomba, the HIV/AIDS unit at the nearby Central Hospital and the Zomba District Assembly. Thus, the study through the prototype and its ensuing demonstration contributed to the creation of knowledge and awareness on GIS and its potential benefits with respect to HIV/AIDS and the health sector in general.

The study identifies challenges and opportunities to using GIS in monitoring and management of HIV/AIDS and at the same time puts across strategies for addressing

those challenges and harnessing the opportunities. In addition as part of this concluding chapter recommendations have been made. All this informs subsequent GIS projects on how to address potential challenges not only within the scope of HIV/AIDS but also in other areas of application.

8.4 Further Research

Open Source GIS software is emerging as an alternative solutions to commercial GIS software in developing countries where there have been reported problems with payment of software licenses. With this interest in using open source GIS solutions comes questions about the viability of such alternatives considering long-standing debates about open source software usability, stability, security and user support. Hence, the shift towards open source GIS software has its own implications in terms of challenges and other dynamics. Nevertheless, the significant savings that can be realized from not paying software licenses cannot be dismissed just like that. Thus, further research is needed to look at the dynamics involved in using open source software in management of important health problems like TB, HIV/AIDS and Malaria in developing countries.

The evolution of GIS has seen GIS move from being considered the domain of a relatively few cloistered techno-geeks in its early years to everyone's desk today (Berry 2007). The new GIS processing environment is characterized by the full integration the global positioning system and remote sensing imagery with GIS and together GPS and the digital map bring GIS to the palm of your hand (*ibid*). Thus, GIS applications are increasingly becoming available on PDAs and mobile phones. One path in the future of GIS lies in portable GIS applications that are accessed on PDA, mobile phones and Mobile Internet Devices (MIDS) as compared to stationary GIS applications on desktop computer. These portable devices have given rise a broad range of new applications, *Location Based Applications* (LBA), that dynamically obtain information that is relevant to their current location (Premasudha et al. 2007). These advances translate into new possibilities for HIS in terms of how spatial information is collected, accessed and processed. Technological advances like these play out differently under the resource constrained contexts of developing countries compared to those of developed nations.

Thus, further research is needed to look at the role of location based applications or mobile GIS applications in Health Information Systems and dynamics involved in the implementation of such applications in developing countries.

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Appendices

Appendix A: Ethical Clearance

Approved, Please go ahead conduct your research

Telephone: + 265 789 400
Facsimile: + 265 789 431
e-mail doccentre@malawi.net
All Communications should be addressed to:
The Secretary for Health and Population

In reply please quote No. MED/4/36c
MINISTRY OF HEALTH
P.O. BOX 30377
LILONGWE 3
MALAWI

8 October 2008

THE DEPUTY DISTRICT HEALTH OFFICER
24 OCT 2008
ZOMBA DISTRICT HEALTH OFFICE
PRIVATE BAG 14, ZOMBA

Brown Chawanangwa Msiska
Chancellor College
Box 280
Zomba
Dear Sir,

RE: Protocol # 564: Application of GIS in Monitoring and Management of HIV

Thank you for the above titled proposal that you submitted to the National Health Sciences Research Committee (NHSRC) for review. Please be advised that the NHSRC has **reviewed** and **approved** your application to conduct the above titled study.

- **APPROVAL NUMBER** : NHSRC 564
  The above details should be used on all correspondence, consent forms and documents as appropriate.
- **APPROVAL DATE** : 08/10/2008
- **EXPIRATION DATE** :This approval expires on 07/10/2009
  After this date, this project may only continue upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the NHSRC secretariat should be submitted one month before the expiration date for continuing review.
- **SERIOUS ADVERSE EVENT REPORTING** :All serious problems having to do with subject safety must be reported to the National Health Sciences Research Committee within 10 working days using standard forms obtainable from the NHSRC Secretariat.
- **MODIFICATIONS**: Prior NHSRC approval using standard forms obtainable from the NHSRC Secretariat is required before implementing any changes in the Protocol (including changes in the consent documents). You may not use any other consent documents besides those approved by the NHSRC.
- **TERMINATION OF STUDY**: On termination of a study, a report has to be submitted to the NHSRC using standard forms obtainable from the NHSRC Secretariat.
- **QUESTIONS**: Please contact the NHSRC on Telephone No. (01) 789314, 08588957 or by e-mail on doccentre@malawi.net
- **Other:**
  Please be reminded to send in copies of your final research results for our records as well as for the Health Research Database.

Kind regards from the NHSRC Secretariat.

.....
FOR CHAIRMAN, NATIONAL HEALTH SCIENCES RESEARCH COMMITTEE

PROMOTING THE ETHICAL CONDUCT OF RESEARCH
Executive Committee: *Dr.C.Mwansambo (Chairman), Prof. E. Molyneux (Vice Chairperson)*
Registered with the USA Office for Human Research Protections (OHRP) as an International IRB
(IRB Number IRB00003905 FWA00005976)

Appendix B: PowerPoint Slides for the Interview Guide

GIS Questions

NAC/MoH/Districts

HIV/AIDS M & M

- Explain briefly what is involved in HIV/AIDS monitoring and management? [at district or national level]
  - Who is responsible for HIV/AIDS M & M?
  - What stakeholders are involved?
  - What Information Systems are used?

Data Collection

- Where does HIV/AIDS M & E come from?
  - How is the data collected?
  - What tools are used?
  - What is the Data Flow like?
- Why is the data collected?
  - How is the data stored?

Data Processing

- How is the HIV/AIDS M & E data processed?
  - What is the outcome of the processing?
  - Who receives the results?
- What tools are used?
  - For processing?
  - Transmitting results?

Data Analysis & Presentation

- How is the data collected analysed? [district and national level]
  - What indicators are computed?
  - What tools are used?
  - Who receives the results?
    - How are the results used?
- How is the information presented?
  - To whom is it presented?

Spatial Data in HIV/AIDS M & M

- To what extent is spatial (location) information used in HIV/AIDS M & M?
- In what format is the information made available? [Maps, Tables]
  - If Maps are not used, why?
- How does the format used affect the decision making processes?
  - Problems/Challenges/Benefits?

GIS Usage

- Is GIS used in HIV/AIDS M & M? [district and national level]
  - Is GIS available?
- If yes:
  - What necessitated the use of GIS?
  - What GIS tools exist?
  - How does GIS help the monitoring and management activities of HIV/AIDS?
- If not, why?

GIS Challenges

- What are the challenges being faced in using GIS?
  - Challenges with Development?
  - Challenges with Usage?
  - Challenges with Resources?
    - Technological?
    - Human?
- What strategies have been employed to address these challenges?

GIS integration with HIS [where GIS exists]

- Is the GIS technology built into the HIS?
- If not, what activities are performed to facilitate exchange of data between the two?
  - What challenges are faced?

Conclusion

- Further comments?

Appendix C: National Activity Report Form

Malawi National AIDS Commission

NAC Activity Report Form

For Activities for THIS MONTH ONLY

1. REPORT DETAILS

Report date:											RD1
Month reporting on	From:			to:							RD2
Name of Organisation											RD3
Type of Organisation	*NGO*		*CBO*		*FBO*		*Private Sector*		*Public Sector*		RD4
NAC Grants Management Code											RD5
Report Compiled by											RD6
For more information / questions about the report, contact:	**Name:**										RD7
	Tel number:					**Fax:**					
	Email:										
District											RD8

2. INTERVENTIONS FOCUSING ON YOUR OWN EMPLOYEES

REPORT ON ACTIVITIES FOR **THIS** MONTH ONLY

Does your organisation have an HIV/AIDS workplace policy?	YES	NO

TYPE OF INTERVENTION	DATA NEEDED		TYPE OF INTERVENTION		TOTAL
HIV Prevention	WP1	Number of interventions this month	Workshops		
			Individual counselling		
			Other (specify)		
		PERSONS REACHED	MALE	FEMALE	TOTAL
	WP2	Total # of current employees & spouses in organisation			
	WP3	Number of employees & spouses reached this month			
Care and Support	WP4	Number of employees & spouses reached this month			

3. INTERVENTIONS FOCUSING ON THE BENEFICIARIES OF YOUR PROJECT/S

REPORT ON ACTIVITIES FOR **THIS** MONTH ONLY

a) Information, Education and Communication (IEC) materials		RADIO #	RADIO Hours aired	TV #	TV Hours aired	PRINTED # types	PRINTED # printed	PRINTED # distributed
IEC1	# new radio / TV programmes this month							
IEC2	# IEC materials printed and distributed this month							
IEC3	# interventions (workshops, counselling sessions and others)							
IEC4	# of people directly reached this month through interventions listed in IEC3							

b) Socially marketed condoms		Male condoms Rural	Male condoms Urban	Female condoms Rural	Female condoms Urban	TOTAL
ABC1	# of condoms distributed to end users this month					

c) Life skills education		In-school Male	In-school Female	Out-of-school Male	Out-of-school Female	TOTAL
ABC2	# of young people aged 15 – 24 exposed to life skills education					

Monthly Form Page 1

d) Prevention of Mother to Child Transmission (PMTCT)		0-24 years	Older than 24	TOTAL
PMT1	# pregnant women who have been seen by provider this month			
PMT2	# pregnant women counselled on PMTCT, tested for HIV & receiving serostatus results this month			
PMT3	# of pregnant women tested for HIV who are HIV positive this month			
PMT4	# HIV positive pregnant women provided with Nevirapine this month			
PMT5	# HIV positive pregnant women provided with replacement infant feeding this month			
PMT6	# of HIV positive pregnant women referred for care & support services this month			

e) Voluntary Counselling and Testing (VCT)		0 – 12 years		12+ to 24 years		Older than 24 years		TOTAL
		Male	Female	Male	Female	Male	Female	
VCT1	# clients who receive pre test counselling							
VCT2	# clients counselled and tested this month							
VCT3	# VCT clients receiving their test results this month							
VCT4	# VCT clients who are HIV positive							
VCT5	# HIV positive VCT clients referred to care & support services							
VCT6	# standalone VCT sites supported							

f) Community Home Based Care (CHBC)		RURAL	URBAN	TOTAL
CAR1	# of NEW persons who enrolled for CHBC services in this month			
CAR2	TOTAL # persons who received CHBC services in this month			
CAR3	# community home based care visits by health care worker/s in this month			
CAR4	# community home based care visits by volunteer/s in this month			

		0 – 15 years		15+ to 24 years		Older than 24 years		TOTAL
		Male	Female	Male	Female	Male	Female	
CAR5	# new persons enrolled at PLWA organisations in this month							
CAR6	TOTAL # of persons enrolled at PLWA organisation in this month							
CAR7	TOTAL # of persons enrolled at PLWA organisations that received support this month							

CAR8	Total # households with one or more chronically ill adult where your organisation has provided help this month	

		TYPE OF SUPPORT	*# OF RURAL HOUSEHOLDS*	*# OF URBAN HOUSEHOLDS*
CAR9	List the types of support that your organisation provides during community home based care visits, and the # of households that has been targeted through each type of support this month	Psychosocial support		
		Nutrition / food support		
		Financial / resource support		
		Medical support		
		Domestic Support		

g) ARV treatment		0 – 12 years		12+ to 20 years		Older than 20 years		TOTAL
		Male	Female	Male	Female	Male	Female	
ARV1	Total # of PLWA currently on ARV							
ARV2	# people started ARV for first time this month							
ARV3	# PLWA who fail to adhere this month							

h) Support to orphans and other vulnerable children		TYPE OF SUPPORT	# Male	# Female
OS1	List the # of orphans and other vulnerable children that received the following types of support:	Psychosocial support		
		Nutrition		
		Financial		
		Other, please specify		

i) Training		Subject of training (align with HIV intervention categories	# Male	# Female
CB1	# project staff trained this month			
CB2	# volunteers trained this month			

I verify that this information is complete and correct and that I have not misrepresented any information in this report

Signed: _____ **Designation:** _____

Date: _____

Appendix D: Major HIV/AIDS Indicators in Malawi

Malawi National AIDS Commission

List of Major Indicators

No.	Category	Indicator
1.	Disease Burden	HIV Prevalence (percentage of people infected with HIV)
2.	Disease Burden	Percentage of infants born to HIV-infected mothers who are infected
3.	Disease Burden	HIV prevalence among women in sentinel sample
4.	Disease Burden	STI prevalence among pregnant women in the sentinel survey
5.	Treatment	Percentage of HIV+ persons with advanced HIV infection receiving ARVs
6.	Treatment	% adults and children with HIV still alive 12 months after initiation of ARVs
7.	Treatment	Percentage of HIV+ pregnant mothers receiving a complete course of ARV for PMTCT
8.	Treatment	Percentage of facilities delivering ART experiencing stock-out of >=1 week
9.	Treatment	TB cure rate
10.	Impact Mitigation	Ratio of current school attendance among orphans to that among non-orphans
11.	Impact Mitigation	Number of households with vulnerable people reached with impact mitigation interventions
12.	Knowledge	Percentage of males correctly identifying ways of preventing HIV/ rejecting misconceptions
13.	Knowledge	Percentage of females correctly identifying ways of preventing HIV/ rejecting misconceptions
14.	Preventive Behaviour	Median age at first sex among 20-24 year olds (Males)
15.	Preventive Behaviour	Median age at first sex among 20-24 year olds (Females)
16.	Preventive Behaviour	Percentage of sexually active men who had sex with a non-regular partner
17.	Preventive Behaviour	Percentage of sexually active females who had sex with a non-regular partner
18.	Preventive Behaviour	Percentage of men using of a condom the last time they had sex with a non-regular partner
19.	Preventive Behaviour	Percentage of women using a condom the last time they had sex with a non-regular partner

No.	Category	Indicator
20.	Preventive Programmes	Number of facilities providing HTC services
21.	Preventive Programmes	Number of clients tested for HIV at CT sites and receiving their serostatus results
22.	Preventive Programmes	Number of free government condoms distributed to end users in the last 12 months
23.	IEC	Number of information, education and behaviour change communication materials disseminated to end users
24.	IEC	Number of peer educators trained/retrained in the year
25.	IEC	Number of peer educators who were active in the year