# UNIVERSITY OF OSLO
## Department of Informatics


**Application of the Geographic Information System (GIS) in the Drug Logistics Management Information System (LMIS) at the district level in Malawi: Opportunities and Challenges**


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**Master Thesis**

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# Application of the Geographic Information System (GIS) in the Drug Logistics Management Information System (LMIS) at the district level in Malawi: Opportunities and Challenges

THESIS SUBMITTED AS PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE DEGREE "MASTER OF SCIENCE IN INFORMATION SYSTEMS" AT THE DEPARTMENT OF INFORMATICS, UNIVERSITY OF OSLO, NORWAY.


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# ABSTRACT

The district pharmacies use a computerised information system to monitor the flow of products from the central warehouse to health services delivery points. It helps drug logistics and health program managers to determine which health facilities are understocked or overstocked among others. But drug logistics information generated from this system is only in the table format. There is not spatial information added to it which can help the program managers to determine actual locations of health facilities and environmental factors affecting them so that they can have enriched information for their day-to-day work.

The main goal of this study was to identify some opportunities and challenges of applying the GIS in the drug LMIS at the district level in the Ministry of Health in Malawi. Since the research involved the introduction of the GIS in the drug LMIS, it was decided to experiment the GIS in the drug LMIS in order to find out opportunities and challenges. The framed field experiment was used as the research strategy and interviews, document analysis, prototype evaluation and observation as data sources whose data analysis was qualitative.

It has been found out that the idea of introducing the GIS in the drug LMIS is very good but it requires a lot of effort, commitment and resources for successful implementation. Apart from the GIS being used only by the pharmacy technicians, as the research was focusing on, other drug logistics and health staff were also interested in the project. The GIS would also help the statisticians, environmental health officers and drug logistics officers.

Some opportunities and challenges that could exist when introducing the GIS, basically involve technologies, organisation, standards and data integration. It has been observed that the technical side of implementing the GIS in the drug LMIS is not difficult because the Ministry of Health has introduced computer technologies before so some required tools and equipment are available that can be used in the GIS. The main issue for the successful implementation is organisational in the sense that if the management of the Central Medical Stores is committed, it is easy to get all necessary resources and support to do all the activities discussed above. Acquisition of tools and equipment, user training, data standards, data collection, data integration, data sharing and cooperation of participants will require support from the management in the Ministry of Health.


**Key words: Drug logistics management, Drug LMIS, GIS, Malawi**

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# ABBREVIATION AND ACRONYMS

| | |
|---|---|
| ACT | Artemisinin Combination Therapy |
| ARI | Acute Respiratory Infection |
| AQ/AS | Amodiaquine-Artesunate |
| CHAM | Christian Health Association of Malawi |
| DHIS | District Health Information System |
| DHO | District Health Office/Officer |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| HIS | Health Information System |
| IPT | Intermittent Preventive Treatment |
| ITN | Insecticide-treated Nets |
| LA | Lumefantrine-Artemether |
| LMIS | Logistics Management Information System |
| NHMIS | National Health Management Information System |
| NGO | Non-Governmental Organisation |
| NSO | National Statistical Office |
| OPD | Outpatient Department |
| QECH | Queen Elizabeth Central Hospital |
| SP | Sulphadoxine-Pyrimethamine |
| TB | Tuberculosis |
| UK | United Kingdom |
| WHO | World Health Organisation |

# 1.0 INTRODUCTION

This chapter introduces the topic of this study and provides general view of what are presented in the thesis. It contains brief introduction on the background, research question and objectives, research context, research methods, my motivation and structure of the thesis.

## *1.1 Background*

Availability of drug supplies is essential element in the delivery of quality, integrated health services The improved availability of affordable essential drugs, vaccines, and contraceptives depends on effective logistics systems to move essential commodities down the supply chain to the service delivery point, ultimately, to the end user.

There are so many problems that exist in the drug logistics management in the developing countries which result in the shortages (or stockouts) and uneven distribution of drugs, among others. This affects the customers at the health facilities. According to some studies carried out in Jordan, Malawi, Mozambique, Nepal, Tanzania, Uganda, and Zambia, some of the problems in the drug logistics management include lack of accurate information, lack of staff training and support, weak supervision and monitoring, and shortage of human resources at all levels.

Macueve (2003) argues that, in Mozambique, the flow of information and medicines are not well synchronized which leads to many problems including stock-outs, expiry dates, and poor treatment of patients among others. Sowedi et. al. (2006) find out that in Uganda there are stock-outs of drugs, particularly of contraceptive supplies, at national, district and facility levels and several logistics issues were identified to have hampered the program success in ensuring that contraceptive products are available for distribution, including inadequate drug needs assessment at district and facility levels. In Nepal (FPLM, 2000), there are inaccuracies and errors in reporting system that result the reports not being used for decision making; weak supervision of district storekeepers; no much update of stock book; lack of staff training; fewer mid-level managers; and excessive storekeepers but no enough training. Even Tanzania (DELIVER, 2007c) and Zambia (DELIVER, 2007d; Bates & Rao, 2000) face problems of lack of quality logistics data from the service delivery sites to district and central levels for proper decision making and monitoring system performance at the lower levels.

The government is the main provider of health care in Malawi and it has overall responsibility for developing policies, planning strategies and programmes and also ensuring that quality of services are provided to the population. It carries out its functions under the overall responsibility of the Ministry of Health. Drugs and medical supplies are essential commodities for delivery of health services and the government has responsibility to ensure that each sick person gets drugs and medical supplies either free or out of pocket.

Majority of population in Malawi is unable to afford basic medication. The most deaths are due to lack of quality in services provision, incorrect interventions, omissions and incorrect treatment. Delays in seeking care, poor referral systems, lack of appropriate drugs and equipment, and inadequate number of health staff also contribute to the poor health services (Conticini, 2004).

Malawi is mainly dependent on imported drugs as many developing countries. The Malawi Government intends to provide drugs free of charge at all public health facilities in order for essential drugs actually reach patients in need of them. “However, there is evidence that drug shortage is a major barrier to access essential drugs in the sub-Saharan Africa” (Lufesi et al, 2007, p. 2). One of causes of this problem is the poor drug logistics management system.

Although, in Malawi essential drugs are provided free of charge to patients at all public health facilities in order to ensure equitable access to health care which takes 30% of national health budget, still there is shortage of drugs. The Ministry of Health reports that drugs, vaccines and essential medical supplies are scarce at the public health facilities (Ministry of Health and Population, 2003c). For instance, in 2002, vital drugs were available for 40% of required days; vaccines were available for 59% of required days; and essential medical supplies were available for 47% of required days (*ibid*). World Health Organisation reports also on shortage of drugs in almost half of all facilities and main areas of concern for an efficient delivery and management of drugs (Conticini, 2004).

This problem of drug shortage in health facilities results because of several reasons and some are (Conticini, 2004; Lufesi et al, 2007; Sowedi et. al., 2006; WHO, 2006a): (1) weak data collection mechanisms to foresee customer's drug requirements; (2) the time taken between ordering and receiving the drugs; (3) weak information management; and (4) insufficient deliveries of the drugs from regional medical stores to the health facilities, among others.

The managers especially members of the district health management team, in Malawi, have a vast range of information needs including health data and drug logistic data (Galimoto, 2007). These health information systems and drug logistics systems are perceived as separate subsystems of the national health management information system, operating independently but only being linked at the national level. Galimoto (2007) suggests that there would be a potential benefit in integrating the health data and the drug logistics data, for example, on the disease trends with the drug consumption levels as this could assist in supplying more accurate required amounts of drugs and medical supplies.

In Malawi, there is a well established logistics management system called Health Commodities Logistics Management System. One component of this system is a logistics management information system (LMIS) of records and reports that are used to collect and transmit information about drugs, contraceptives, and other medical supplies dispensed to clients and in storage.

Currently, the district pharmacies at each district pharmacy use a computerised information system to monitor the flow of products from the central warehouse through intermediate warehouses to health services delivery points that distribute products to end users (patients). This computerised information system is named the Supply Chain Manager. The word "manager", here, refers to the information system which manages the supply chain information in the health commodity logistics management in the Ministry of Health in Malawi.

The Supply Chain Manager helps drug logistics and health program managers determine which health facilities are understocked or overstocked; review trends in consumption on a product-by-product basis; estimate procurement requirements for each product; identify facilities with potential inventory management problems; and plan deliveries to facilities. But information on reports generated from this system is only in the table format. There is not spatial information added to it which can help the program managers to determine actual locations of health facilities and environmental factors affecting them so that they can have enriched information for their day-to-day work. "Almost everything that happens, happens somewhere. Knowing where something happens can be critically important" (Longley et. al., 2005, p. 4).

The Geographic Information System (GIS) geographically integrate large amounts of information from different sources, programmes and sectors. Each piece of information is related in the system through specific geographical coordinates to a geographical entity, for example health facility, and the information can be displayed in the form of maps among others. The GIS is one of the issues which the government of Malawi is considering in its socio-economic policies. Even the Ministry of Health has a policy which recommends the application of GIS in the health sector in Malawi as powerful visual tool available for planning and monitoring of health services. "It is more useful in tracking and monitoring health in terms of geographical variations in types and magnitude of problems and equity in distribution of health services across the country as well as service utilisation" (Ministry of Health and Population, 2003b, p. 22).

GIS technology has been introduced to many governments and non-governmental agencies in developing countries in the past decades but there is virtually no published documentation on the adoption rate and successful use of GIS technology overtime (Hall et. al., 1997). GIS implementation in developing countries has not moved much beyond the experimental stage and installations are often driven by a desire to demonstrate the software rather than use it to address pressing needs in ways that are sustainable and decision process oriented. Problems are technical in nature and human resource-oriented (*ibid*), that is, they involve social, economic and political factors; inadequate computing skills; poor computing facilities; poor data availability and quality; and GIS software tools.

There are several challenges in the implementation of GIS in developing countries (Croswell, 1991; Mennecke & Crossland, 1996; Forster, 2000; Sieber, 2000; Ginger, 2005; Longley, 2005; Saugene, 2005) such as: (1) *organisational constraints* - existing culture within governmental agencies, that is, they tend to work in a very compartmentalized manner, making the sharing of data and other technical and organisational resources problematic; poor cooperation between system developers and subject-experts; and poor involvement of people in GIS projects; (2) *data constraints* – data are often non-existent and when existing are often hard to find due to poor data sharing culture and lack of institutional commitment to provide data; (3) *data exchange of standards* – many organisations or sections collect, store, process and transmit data without following any formal standards, which makes difficult the possibility of sharing data and resulting in duplication of work and data of poor quality; there is absence of policies to define data standards for access and exchange; (4) *education and training constraints* – lack of qualified staff (shortage of persons with GIS expertise) and problems of training and skills transfer; no established and viable GIS career structure; (5) *cost constraints* – lack of funding has been reported as a key impediment of GIS implementation including its use and maintenance.

## 1.2 Research Question and Objectives

With this background, the main objective of the research was to "enrich" the reporting of the drug logistics information through use of the Geographic Information System (GIS) for the drug logistics and health program managers at the district level. The managers would use the GIS to get additional information to the existing reports in the form of maps which would show actual locations of the health facilities and other spatial information together with the non-spatial data. This would enrich the information resources that support the logistics managers in their decision making. Particularly, the GIS could be used (1) to integrate data from different sources, for example integrating the health data with drug logistics data which provides information on drug demands and other requirements at the health facilities, so that the drug logistics managers would have all necessary information for planning and decision making on time; (2) to calculate distance between the medical store and concerned health facility and then judge how long it has to take to reach the health facility with regard to the road conditions, and which health facilities are close to each other and/or along the same road network so that delivery can be done at the same time (using a same delivery vehicle) with the consideration of transport system constraints.

The research focused specifically on the opportunities and challenges on application of the GIS in reporting of the drug logistics information in the drug logistics management information system (LMIS) at the district level in Malawi since it would be the first time to use the GIS application in the drug LMIS in Ministry of Health at the district level. Therefore, the research question was:

> *"What are opportunities and challenges on the application of the Geographic Information System (GIS) in the information reporting and analysis in the drug logistics management information system (LMIS) at the district level in Malawi?"*

In order to answer this research question, the following specific objectives were identified:

- To understand the challenges in the drug LMIS and how data is shared between the drug LMIS and the health information system (HIS) at the district level through user needs analysis;
- To identify challenges and opportunities of using GIS in the drug LMIS through development and evaluation of the GIS prototype.

In this research, the GIS was used as a database to integrate the drug logistics and health data and as an information reporting tool and also as spatial decision support by having ability to handle both spatial and non-spatial data appropriately for better support for management decision-making in a range of application because it permitted dynamics link between databases and maps so that updates were automatically reflected on maps.

## 1.3 Research Context

The research was conducted in Malawi in the health sector particularly in drug LMIS which is under the Central Medical Stores in Ministry of Health. The main focus was at the district pharmacies, therefore, Mulanje and Blantyre district pharmacies were used as the sample pharmacies for demonstrating the GIS prototype with support from the regional medical stores in the southern region of Malawi. Blantyre district was chosen because it has a big city and also a central hospital. It is also where the regional medical stores in the south is located. Mulanje district was chosen as example of the district hospital which at least far (about 70 km) from the regional medical stores in Blantyre. Both districts were also chosen with considerations of financial and transport constraints.

Since Ministry of Health in Malawi has a long list of drugs, anti-malaria drugs (artemether-lumefantrine, sulphadoxine-pyrimethamine, and quinine) were chosen to be sample data for the GIS prototype because malaria is a major public health and economic problem in Malawi and affects the poorest and keeps them poor. Young children under five years, pregnant women and those living with HIV/AIDS are the most at-risk populations for malaria-related morbidity and mortality in Malawi. The Ministry of Health has selected artemether-lumefantrine (AL or LA) as the first-line drug, amodiaquine-artesunate (AQ/AS) as the second-line, and reserving quinine for the treatment of severe malaria cases. Sulphadoxine-pyrimethamine (SP) is provided to pregnant women during the second and third trimester as a way to prevent malaria infection.

## 1.4 Research Methods

The research involved the introduction of the Geographic Information System (GIS) in the drug logistics management information system (LMIS). It was decided to experiment the GIS in the drug LMIS in order to find out opportunities and challenges. The framed field experiment was used as the research strategy and interviews, document analysis, prototype evaluation and observation as data sources whose data analysis was qualitative. The framed field experiment was used in this research with the focus on the nature of the subject pool, the nature of the information, the nature of the commodity, and the nature of the task. Since the research was about the drug LMIS, it was important to use the subjects from the area of drug logistics and health information system because of their experiences therefore, the subjects consisted of pharmacy technicians, statisticians and pharmacy-in-charge.

The main data sources were semi-structured interviews supplemented by document analysis, prototype evaluation and observation. The semi-structured interviews were chosen in this research because they gave much "room" for the interviewees (drug logistics and health staff) to provide their own point of view of the research subject. This type of interview helped me to maintain consistency for the research topics covered with each interviewee because a number of people were involved as participants from regional, district and health facility levels. Observation was done on the data entry and report generation of the Supply Chain Manager at Blantyre district pharmacy with the aim of finding out how it handles drug logistics data. Evaluation of the GIS prototype was also used to gather information through demonstrations and feedback.

Data have been analysed qualitatively through the hermeneutic as a mode of analysis where an emphasis is on the relationship between people, organisation and technology. There have been interpretations of raw data and readings based on the research objectives and the key concepts of theoretical framework of information system as social system and information infrastructure with *installed base* concept.

## 1.5 Motivation

When I was taking GIS course in Mozambique in February 2008, I came across a certain statement which says: "Almost everything that happens, happens somewhere. Knowing where something happens can be critically important" (Longley et. al., 2005, p. 4). This made me think that the GIS could be one of tools to support this statement. Even the Ministry of Health has a policy which recommends the application of GIS in the health sector in Malawi as powerful visual tool available for planning and monitoring of health services. With support from some literature on drug logistics in the developing countries including Malawi, I decided to explore on application of the GIS in drug LMIS through the GIS prototyping because,"it is often said that users can't tell you what they want, but when they see something and get to use it, they soon know what they don't want" (Sharp et. al., 2007, p. 530).

I believed that outcome from this research (challenges and opportunities) (1) would prompt for further research of GIS in the drug logistics management since I have found no literature on the application of GIS in the drug logistics management in developing countries; (2) would assist the people in the drug logistics management to understand better, how technology can affect their work especially the GIS; (3) would assist to discover some aspects applicable to the health system thereby contributing to the information system field with relation to the design and implementation of the GIS; (4) would give me a chance to explore more in the GIS technology and research thus I have improved my personal skills, knowledge and experience.

## 1.6 Structure of the Thesis

This thesis is divided into nine chapters. Chapter 1 introduces the topic of this study and provides general view of what are presented in the thesis as described above. This chapter is followed by Chapter 2 which presents the context in which the research was carried out and consists of the general profile of Malawi, its health status, drug logistics management, and geographic information system in Malawi.

The literature and theoretical framework are presented in Chapter 3. The literature is about logistics management information system (LMIS), geographic information system (GIS), and system prototyping and the information system as *social system* and the *installed base* concept of the Information Infrastructure as the theoretical framework. While the research approach and methods are described in Chapter 4 which includes ethical considerations.

Chapter 5 explains how the research was carried out, whose findings are presented in Chapter 6 and Chapter 7. The findings on the drug LMIS (Chapter 6) and on the GIS prototype (Chapter 7) are analysed in Chapter 8 to define the existing installed base, drug LMIS, which a new installed base, GIS, could be built on. Chapter 9 contains discussions on the opportunities and challenges, and also conclusion of this thesis.

# 2.0 STUDY CONTEXT

This chapter presents the context in which the research was carried out. It presents the general profile of Malawi, its health status, drug logistics management, and geographic information system in Malawi. The research was carried out in the public health sector in Malawi specifically in the drug logistics management at the district and regional levels which were Blantyre and Mulanje districts, and the regional medical stores respectively.

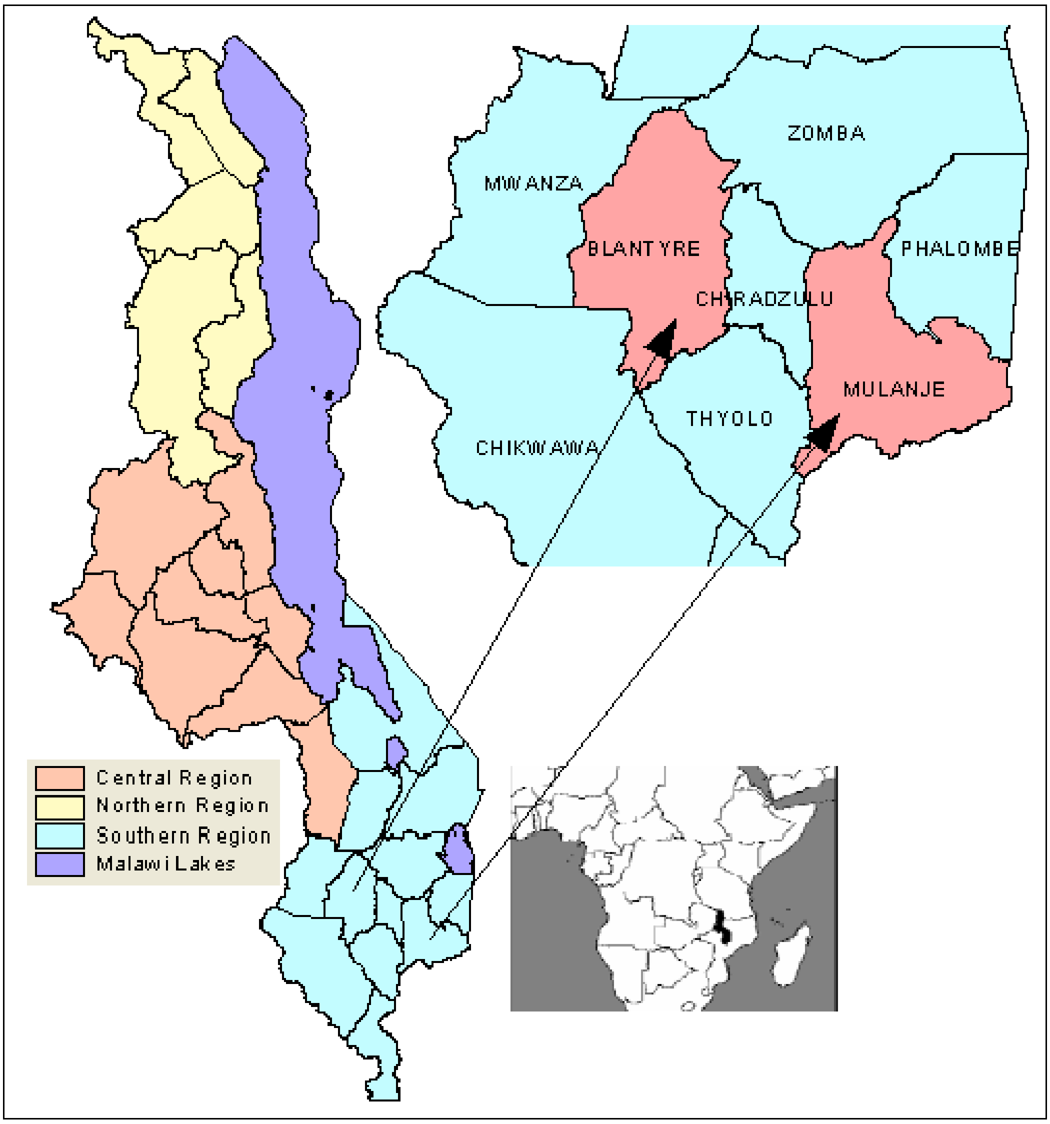



**Figure 2.1: Map of Malawi and Visited Districts (Blantyre and Mulanje)**
**(Source: GIS Prototype)**

## 2.1 Malawi Profile

Malawi is a landlocked country which is located in the southeast Africa and surrounded by Mozambique, Zambia, and Tanzania. The country is administratively divided into three regions namely northern region, central region and southern region which are divided further into districts. The case studies were conducted in two districts, Blantyre and Mulanje, in the southern region (see Figure 2.1).

Blantyre district is in the southern region of Malawi and in South West Zone of the Ministry of Health. It is bordered with five districts namely Chiradzulu to the east, Chikwawa to the south, Thyolo to the south east, Mwanza to the north west and Zomba to the north east (see Figure 2.1). Blantyre is divided into city and rural areas. All administrative works for drug logistics at district and regional levels are carried out in Blantyre city. Office of Central Medical Stores in the south and Blantyre district health office are located in the Blantyre city.

Mulanje district is bordered with country of Mozambique to the south and four districts namely Chiradzulu to the north west, Phalombe to the north east, Thyolo to the south west, and Zomba to the north (see Figure 2.1). All administrative works for drug logistics at district level are carried out at Mulanje district hospital in Mulanje Boma where district health office is also located. The word “Boma” refers to the government administrative centre where all government administrative offices are located in a district.

The preliminary results from the 2008 population and housing census give the total population in Malawi as 13,066,320 in which 49% are males and 51 % are females (NSO, 2008). The current population is an increase of 32 percent from 1998 population. At regional level, the Southern Region has the highest population of 45%, the Central Region has 42% and the Northern Region has 13%. For the cities, Lilongwe city in the centre has the highest population and seconded by Blantyre city in the south, then Mzuzu city in the north and Zomba city in the south.

For the visited districts, as shown in Figure 2.2 and Figure 2.3, Blantyre city has the highest population as compared to Blantyre rural and Mulanje district. The population in the Blantyre city is double as in the Blantyre rural area. Interestingly, in the Blantyre district as a whole, population of women and men are almost the same. In Mulanje district, women population (53%) is higher than that of men (47%).

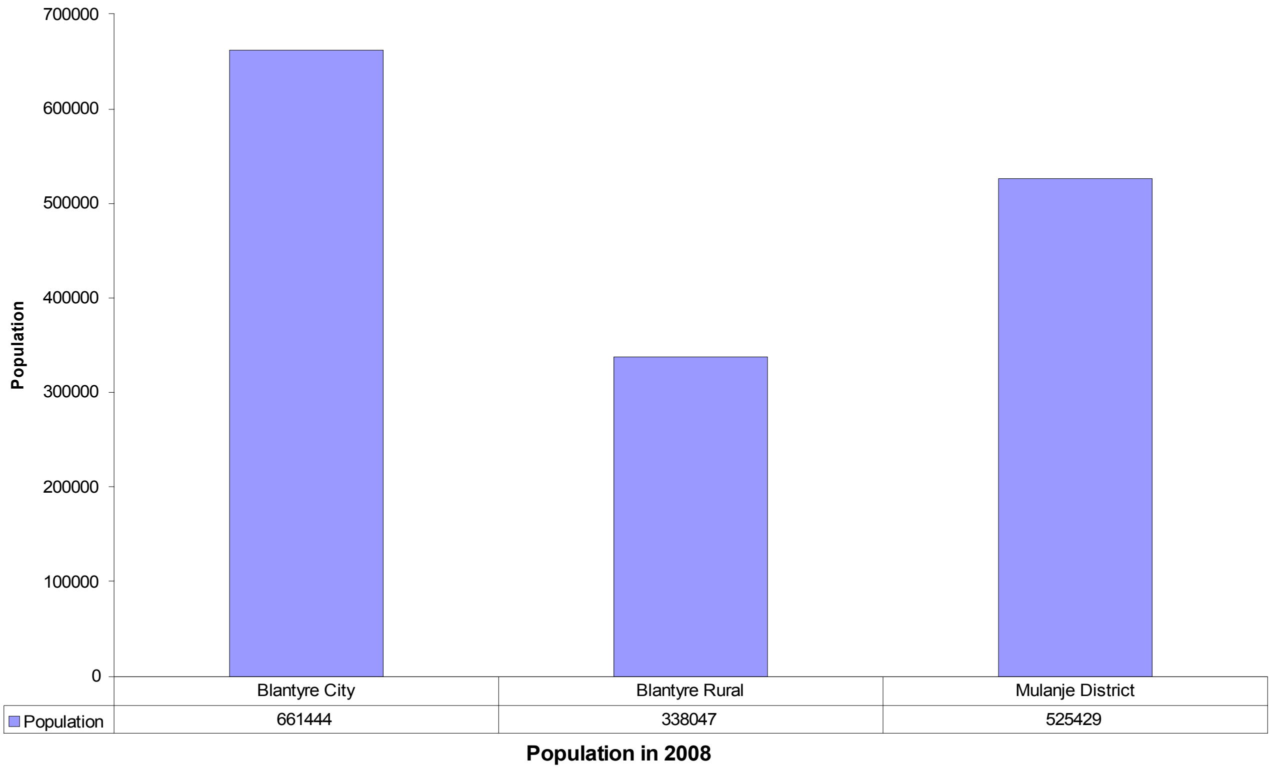



**Figure 2.2: Population in Blantyre City and Rural and Mulanje District**
**(Source: NSO, 2008)**

One of the most important social evils and a major determinant of ill health is poverty. Socio-economic position strongly determines health status and a large body of literature from developed countries demonstrates that most causes of deaths occur at greater rate in groups with lower socio-economic status (Gupta & Kumar, 2007). In Malawi poverty is widespread and pervasive, and over half (52%) of the population in 2005 live below the national poverty line, and one in five (22%) are defined as ultra poor, with income below the expenditure of minimum food requirements (International Bank for Reconstruction and Development, 2007). The overall number of the poor has remained fairly stable over the last decade. It vulnerably seems to be increasing in rural areas, largely due to repeated shocks and depletion of assets and rural poverty is more pervasive than urban poverty but urban poverty is growing faster (*ibid*).

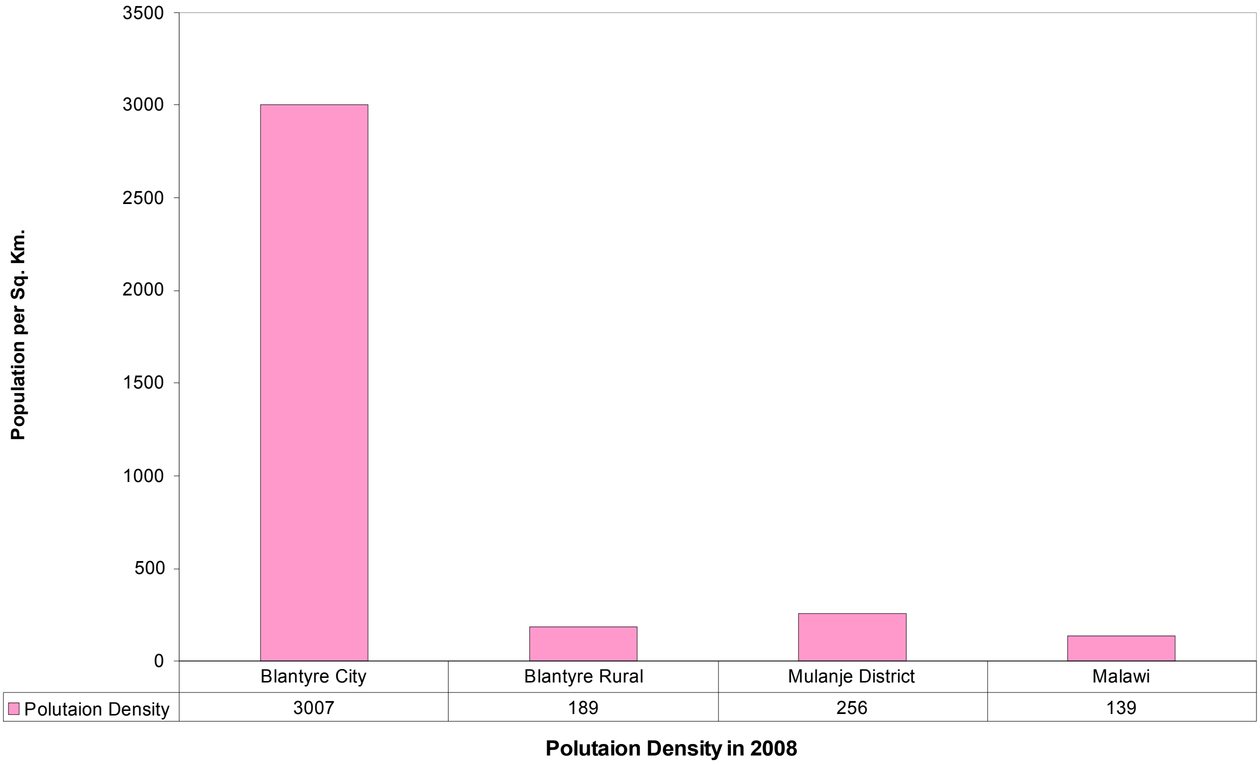



**Figure 2.3: Population Density in Blantyre City and Rural and Mulanje District (Source: NSO, 2008)**

## *2.2 Malawi Health Status*

Compared to many other developing countries the health status of Malawi is very poor and whereas allocation of resources is concerned, the health sector is not getting adequate share (Ministry of Health and Population, 2003a). Drugs and medical supplies are essential commodities for delivery of health services and the government has responsibility to ensure that each sick person gets drugs and medical supplies either free or out of pocket. Majority of population in Malawi is unable to afford basic medication (*ibid*). The most deaths are due to lack of quality in services provision, incorrect interventions, omissions and incorrect treatment. Delays in seeking care, poor referral systems, lack of appropriate drugs and equipment, and inadequate number of health staff also contribute to the poor health services (Conticini, 2004).

The government is the main provider of health care in Malawi and it has overall responsibility for developing policies, planning strategies and programmes and also ensuring that quality of services are provided to the population. It carries out its functions under the overall responsibility of the Ministry of Health. The Ministry of Health has six technical divisions namely clinical and population services, nursing, preventing health, technical support, planning, and financing and administration (ONSD, 2005). The current functions of Ministry of Health range from policy formulation and planning to delivery of health services. The Ministry of Health provides about 60% of the health services; Christian Health Association of Malawi (CHAM) provides 37%; Ministry of Local Government provides 1%; and private practitioners, commercial companies, army, and police cover 2% of the health services (*ibid*). CHAM is made up of independent church-related and other private voluntary agency facilities. It also provides training for nurses and health personnel.

The public health sector system comprises three levels namely primary, secondary and tertiary (ONSD, 2005; DELIVER. 2007a). The primary level consists of health centres, health posts, dispensaries, and rural or community hospitals. The secondary level has district and CHAM hospitals and central hospitals form the tertiary level. The secondary level provides mainly back up services to those provided at the primary level including surgical services, mostly obstetric emergencies, and general medical and pediatrics in-patient care for common acute conditions and the tertiary level hospitals provide similar to those at the secondary level, along with a small range of specialist surgical interventions. The accessibility to health facilities in Malawi is generally good, with up to 80% of the population within 5 to 8 km of health facility (ONSD, 2005).

Some leading causes of morbidity and mortality are malaria, acute respiratory diseases, and malnutrition and diarrhea diseases. Acute Respiratory Infection (ARI) and diarrhea mainly affect young children, especially under five years. Pneumonia, an infection of the lungs, is the most serious respiratory infection. About 30% of children of under five years are estimated to develop pneumonia each year (Ministry of Health and Population, 2003c). But it can be treated with affordable antibiotics.

The diarrhea causes illness and death among children which is mostly caused by bacterial, viral and parasitic infections transmitted through water, food, and contact with faecal matter. Preventing diarrhea requires better sanitation and more abundant, cleaner water supplies, immunizations, improved personnel hygiene and food handling practices.

Malaria is a major public health and economic problem in Malawi and affects the poorest and keeps them poor. Young children under five years, pregnant women and those living with HIV/AIDS are the most at-risk populations for malaria-related morbidity and mortality in Malawi (PMI, 2007). Pregnant women are four times more likely to suffer from complications of malaria than non-pregnant women (NSO, 2005).

It is estimated that 8 million episodes of malaria occur annually in Malawi of which 45% are in under five (Ministry of Health and Population, 2003a). Despite the fact that malaria can be prevented and cured, many children are dying from this disease. Almost 50% cases in outpatient department (OPD) are recorded as malaria *(ibid)*. In 2002 only, according to Ministry of Health and Population (2003c), 31% of all cases reported to health facilities were recorded as clinical malaria and about 7% of patients admitted in hospitals as malaria cases died. On average, around 238,000 cases were diagnosed as malaria every month *(ibid)*.

WHO strategies for malaria control in pregnancy in Sub-Saharan Africa in areas with stable transmission recommend (Msyamboza et. al., 2007) (1) the use of intermittent preventive treatment (IPT) with sulphadoxine-pyrimethamine (SP); (2) household use of insecticide-treated nets (ITNs); and (3) effective case management of malarial illness. Thus, the Government of Malawi has put in place the same strategies through the National Malaria Control Programme (NSO, 2005).

In line with the WHO recommendation to use artemisinin combination therapies (ACTs) in order to improve malaria treatment and prolong therapeutic life of anti-malarial drugs, the Ministry of Health selected artemether-lumefantrine (AL or LA) as the first-line drug and selected amodiaquine-artesunate (AQ/AS) as the second-line ACT, reserving quinine for the treatment of severe malaria cases and for the management of malaria in pregnancy (PMI, 2007). Malawi's policy on IPT recommends the provision of at least two doses of SP to pregnant women during the second and third trimester as a way to prevent malaria infection.

Grossly inadequate human resource is one of the problems that is affecting the access and quality of health service in Malawi (Ministry of Health and Population, 2003a) and human resource crisis has created a lack of capacity to delivery health services, especially in rural areas, where primary health care is severely compromised. The capacity erosion has been increased since 1990 due to a number of reasons including resignation resulting from poor working conditions, migration to other sectors, low salaries, deaths of employees as a result of HIV and brain drain of skilled people who depart to industrialised countries particularly United Kingdom (UK) (Conticini, 2004). The health personnel die, resign and retire all resulting in vacancy of the position and not sufficient trained people in the market to fill these positions.

There are many problems or challenges that the Ministry of Health is facing and some of them are, according to ONSD (2005): (1) health system needs strengthening at all levels, that is, rehabilitation of infrastructure, providing essential drugs and medical supplies, and reorienting the skills and knowledge of health workers to address the challenges; (2) with vacancies of the established posts up to 50% at some institutions, the health sector is faced with a collapsing human resource capacity because a good number of the skilled health workers are leaving the public services mainly due to poor salaries and working conditions and also HIV epidemic is taking its toll on caregivers and administrators alike, exacerbating an already chronic shortage of appropriately trained personnel; (3) poor implementation and management capacity both at central and district levels has hampered the effort of Ministry of Health to improve efficiency and effectiveness in the use of the limited available resources; and (4) social, human capital and income indicators in Malawi are very poor.

## *2.3 Malawi Health Management Information Systems (HMIS)*

Comprehensive but simple and manageable National Health Management Information System (NHMIS) was introduced in 2002 (Chaulagai et. al., 2005) and Logistics Management Information System (LMIS) is one of the subsystems of the NHMIS (see Figure 2.4). In the health management information system, all health facilities conduct routine surveillance of outpatient cases, inpatient cases, and inpatient deaths and they collect these health data on daily basis while delivering services or discharging other duties (Ministry of Health and Population, 2003c). Thus, Malawi has continuous monthly data on all agreed indicators for each facility, district and the nation on which analysis is done monthly, quarterly, and annually.

Each health facility performs daily, monthly, quarterly, and annual analysis of the data and takes necessary actions aimed at improvement in management of health programmes thereby improving coverage and quality of services (Ministry of Health and Population, 2003c). The health facility submits its reports to the district on quarterly basis and the district health office and central hospitals process monthly data by computers and disseminate reports on quarterly basis to all stakeholders in the district and provide a feedback copy to respective facilities. The electronic raw data are forwarded to the Ministry of Health headquarters every three months by email for further analysis and use at the national level. The Ministry of Health compiles data from both district and central hospital services and produces quarterly bulletin.

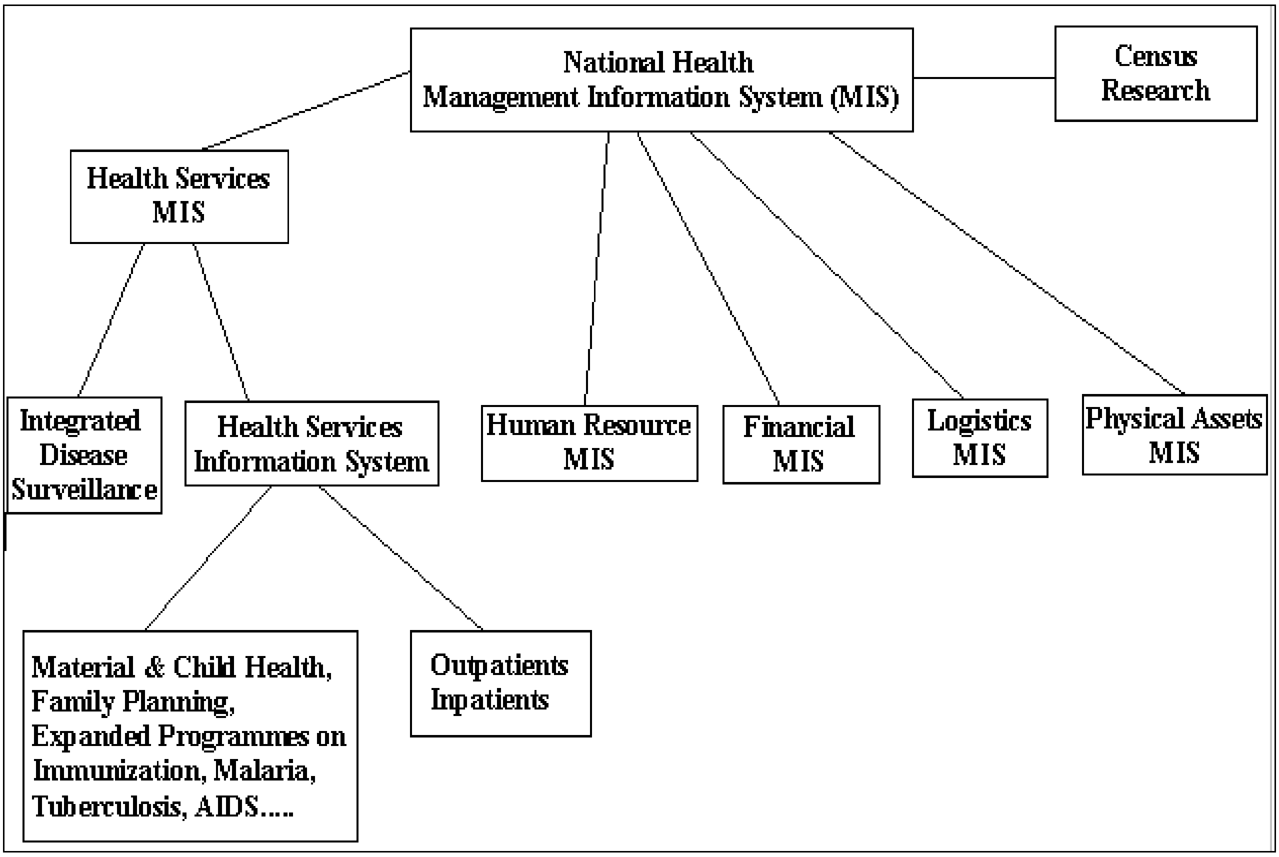



**Figure 2.4: Malawi National Health Management Information System**
**(Source: Chaulagai et. al., 2005, p. 5)**

The government of Malawi, Christian Health Association of Malawi (CHAM) and several other health service providers form a complex network of health services (Chaulagai et. al., 2005). The health facilities are formally categorized into central hospital, district hospital, sub-district hospital, community hospital, health centre, dispensary and maternity unit. Each government and CHAM health facility holds its own well-defined catchments area and population to be served and all private and Non-Governmental Organisation (NGO) facilities work within the government and CHAM health catchments facilities (Ministry of Health and Population, 2003c). Chaulagai et. al. (2005) emphasise that the catchments area maps, showing the essential features that affect the health of people, compel the health managers to think about the equity in distribution of health resources and universal access to basic minimum health.

## 2.4 Drug Logistics Management in Malawi

Malawi is mainly dependent on imported drugs and in 1987 it adopted the principle of an essential drug list for the public health sector which now contains about 384 drugs (Lufesi et al., 2007). The Government of Malawi has intention to provide drugs free of charge at all public health facilities in order for essential drugs actually reach patients in need of them. However there is evidence that drug shortage is a major barrier to access to essential drugs in Sub-Saharan Africa (*ibid*).

Malawi like most other countries in Sub-Saharan Africa relies mainly on the public sector for the delivery of health care services to its citizens. The Ministry of Health, with the support of donors, has designed a health commodity delivery system aimed at improving service delivery to clients (Berger et. al., 2006). Malawi Health Commodities Logistics Management System is a Ministry of Health medical supply system of inventory management and recording and reporting for drugs, contraceptives and other medical supplies. The system ensures that all Malawians are able to receive the products they need and receive quality treatment when they visit a service delivery point or are visited by a community-based distribution agent (DELIVER, 2006b).

There is one Central Medical Stores that acts as a transit for receiving and dispatching commodities to regional medical stores. The Central Medical Stores has limited storage facilities and goods are issued out to the regional medical stores as they are received using formula: 20% to Northern Regional Medical Stores, 35% to Central Regional Medical Stores and 45% Southern Regional Medical Stores (Berger et. al., 2006). Each regional medical stores serves the government and CHAM health facilities in the respective region (Lufesi et al., 2007). The Central Medical Stores uses population-based “push” or allocation system to determine the stocks allocated to each region. This is the simplistic system that does not take into account available consumption and morbidity data which can be used to make adjustments as necessary (Berger et. al., 2006). At the medical stores, there are various categories of staff such as pharmacists, store personnel, IT personnel, and accountants.

Each district hospital is headed by the district health officer who is responsible for the day-to-day management of the hospital and district in general, supported by the district health management team whose members include the district health officer, hospital administrator, district nursing officer, accountant, and district environmental health officer (Berger et. al., 2006). All districts have pharmacies, each with a designated store room and they are headed by pharmacy technicians who may be assisted by other pharmacy technicians or pharmacy assistants, depending on an availability of human resources.

The district hospitals are responsible for ordering all supplies for all health centres within jurisdictions, as well as for ordering their own supplies. The district pharmacies and the health centres are expected to maintain inventory levels of three months and to place orders every month. The district health officer may also serve health clinics or dispensaries which are smaller than health centres, but who order and collect their supplies directly from the district pharmacy.

The Ministry of Health has health centres under the district health officer jurisdiction in Malawi and in most cases, the health centres are managed by medical assistants, who are supported by either one or two nurses. The health centres also have health surveillance assistants who work and reside in the community. They are required to maintain three month inventory levels, while their review period is monthly.

The health facilities initiate the drug-ordering process by compiling monthly drug reports that are submitted to the district pharmacy (Lufesi et al., 2007, Berger et. al., 2006). The reports contain information on quantities used of each drug during the previous month and balance in hand. Then the district pharmacy technician assesses requirements of the health facility, completes the order part of drug report in accordance with given criteria and forwards it to the regional medical stores. The regional medical stores supplies the ordered drugs directly to the health facility. The supplies are sent directly to central hospital pharmacies, mental hospital pharmacies, district hospital pharmacies and health centres. CHAM, voluntary counseling and testing centres, and NGO facilities collect their supplies from either the district hospital pharmacy or health centre in the areas where they operate (DELIVER, 2007a).

CHAM hospitals attempt to buy drugs and other supplies from medical stores but often the drugs are not available (Berger et. al., 2006). They manage their own drug budgets and therefore they can procure supplies from private pharmaceutical companies or CHAM pharmacies. They operate a revolving drug fund at the head office with three distribution points in Lilongwe, Blantyre and Mzuzu.

According to Lufesi et al. (2007) and WHO surveys from 2002-2004 (WHO, 2006a), there are problems in the drug logistics in Malawi which include: (1) insufficient deliveries from the regional medical stores; (2) stocked supplies not recorded as having been given to the patients; (3) uneven distribution of drugs among health centres; (4) time taken from ordering to receiving of drugs; (5) lack of training and supervision (not trained in basic drug management skills and that they were rarely supervised by the district pharmacist); (6) inadequate means of communication; (7) inadequate transport; (8) lack of emergency drugs in warehouses; and (9) cholera preparedness is weak.

## 2.5 Geographic Information System (GIS) in Malawi

The Geographic Information System (GIS) is one of the issues which the government of Malawi is considering in its socio-economic policies. Even the Ministry of Health has a policy which recommends the application of GIS in the health sector in Malawi and it recommends that GIS is a powerful visual tool available for planning and monitoring of health services. "It is more useful in tracking and monitoring health in terms of geographical variations in types and magnitude of problems and equity in distribution of health services across the country as well as service utilisation" (Ministry of Health and Population, 2003b, p. 22).

The GIS has been applied in several areas in Malawi such as (1) ornithology, avian recreational activities, and conservation and preservation awareness (ESRI, 2002); (2) investigating access reproductive health services (Heard et. al., 2004); (3) land cover change assessment (Mlotha, 2001); (4) monitoring tuberculosis (TB) programme performance at district level (Nyirenda et. al., 2005); (5) increasing the effectiveness and efficiency of urban development control process (Chanza, 2003).

Since 1993, Clark Labs has been providing assistance to the Malawi Environment Monitoring Program and the Government of Malawi in use of the GIS and remote sensory technologies (Toledano, 1998). The Malawi Environment Monitoring Program seeks to enhance the capacity of the Government of Malawi agencies and departments to evaluate and monitor a rapidly changing national environment. Currently, there are several activities going on in Malawi concerning the GIS (Ministry of Health and Population, 2003b; WHO, 2006b) such as: (1) distribution of catchments' boundaries of each public health facility in entire country is underway; (2) the Global Positioning System (GPS) has been purchased for each district health office for collection of geo-referenced data on new health facilities and disease outbreak; (3) GIS technicians working at National Statistical Office (NSO) have created new datasets containing the location of all the villages, churches, health facilities, roads and rivers as preparation of 2008 census; (4) other datasets produced outside the country are also available which are based on the census data and already in a standard format; and (5) Survey Department of the government of Malawi does produce and maintain datasets of administrative boundaries, road and river networks among others.

In order to produce reliable results when applying any model using GIS, it is necessary to use information layers that are compatible in terms of projections, scale, level of accuracy and level of completeness. In case of Malawi, the main data producers have good knowledge of their data characteristic even if this information is not necessary stored in metadata records (WHO, 2006b).

Even if there are a lot of GIS capacities in place in Malawi, there are challenges. For example (WHO, 2006b; Toledano, 1998; Ebener, 2007): (1) only limited working relationships have so far been established between institutions that deal with GIS; (2) barriers to technology transfer in Malawi such as the social and cultural barriers (very centralised and hierarchical decision making process) and organisational and financial infrastructures; (3) very limited or even a complete lack of communication between institutions producing health data and/or geographic information of interest in public health; (5) existence of an important, in terms of skills, hardware and software in the country but dispersed among a large number of GIS stakeholders making each of them very thin in terms of capacity; (6) lack of agreed upon data collection standards and protocols (existence of many different coding schemes that are not linked together and very limited integration of the time dimension); and (7) lack of awareness of the data, resources and GIS skills available in the country.

# 3.0 LITERATURE REVIEW

This chapter contains the literature and the theoretical framework used in this study. The literature is about logistics systems with emphasis on the drug logistics system and logistics management information system (LMIS), geographic information system (GIS), and system prototyping. The theoretical framework consists of the information system as *social system* and the *installed base* concept of the Information Infrastructure.

## *3.1 What is Information System?*

Information is a very essential resource in any organisation. The people can only do their work effectively if they have accurate and timely information (Boddy et. al., 2005). In order to get the accurate and timely information, it is required to have very reliable information systems. The information system can be used to help an organisation to achieve improved efficiency of its operations and effectiveness through better managerial decisions. Many organisations in developing countries today realise that information systems offer potential benefits such as cost savings through increased efficiency of operations and effectiveness in running of their organisations (Kunda, 2001). The functions of the information system can include operational (process routine transactions), monitoring (check performance of activity at regular interval), decision support, and communication (Boddy et. al, 2005).

"*Information systems are the means by which people and organisation utilising technologies, gather, process, store, use, and disseminate information. The domain involves the study of theories and practices related to the social and technological phenomena, which determine the development, use and effects of information systems in the organisations and society*" (Kunda, 2001, p. 21-22). Boddy et. al. (2005) define the information system "*as set of people, procedures and resources that collects data which it transforms and disseminates*" (p. 10). Twati (2006) takes the information system as a set of interrelated components and organised procedures that collect or retrieve, process, store, and disseminate information to support decision making, control, analysis and visualisation in an organisation.

In three definitions above there are issues concerning data, information, and knowledge. Distinction between data, information, and knowledge is important for better understandings of information systems as social systems. It is commonly assumed that data itself inherently contains no meaning and for data to become information it is shaped or structured from the raw material (Hey, 2004) through people, procedures, hardware, software, paper, and so on (Boddy et. al., 2005). Data provides no judgment or interpretation or basis of action (Davenport & Prusak, 1998). Data consist of numbers, text, or symbols which are in some sense neutral and almost context-free.

Information can be taken as a message, usually in the form or a document or audible or visible communication having a meaning. "... information is differentiated from data by implying some degree of selection, organisation, and preparation for particular purposes – information is data serving some purpose, or data that have been given some degree of interpretation" (Longley et al., 2005, p. 12). Information is a necessary medium or material for eliciting and constructing knowledge (Hey, 2004) and this knowledge is valuable because it is close to action and evaluated by the decisions or actions to which it leads (Davenport & Prusak, 1998). People with different values see different things in the same situations and organise their knowledge by their values. Longley et al. (2005) argue that "knowledge does not arise simply from having access to large amounts of information. It can be considered as information to which value has been added by interpretation based on a particular context, experience, and purpose."(p. 12).

Apart from data, information and knowledge, the information system requires also people, organisation and technology as Kunda (2001) suggests three important perspectives of the information system namely human dimension, organisation and technology. The human perspective highlights various needs of the individual that use information technology to perform the jobs. People favour proposed information systems that support their interests and defavour those which threaten their interests. They favour the information system that is likely to enhance their power or consistent with accepted cultural values (Boddy et. al, 2005). The information systems are used in organisations, which are composed of different structures, goals, policies and unique culture and therefore the organisation perspective. They also use technology, such as computer hardware and software, to provide an effective and efficient way of processing data and transforming it into a variety of information products. The information system may be a mixture of human, physical (for example, computer hardware) and procedural components (for example, computer software or applications) (Twati, 2006).

## 3.2 Logistics Systems

Logistics has a major impact on a society's standard of living. It deals with the management of the flow of goods or materials from point of origin to point of consumption and in some cases to the point of disposal. The logistics is a system (Lambert et. al., 1998): it is a network of related activities with purpose of managing the orderly flow of material and personnel within the logistics channel and all functions or activities need to be understood in terms of how they affect and are affected by other elements and activities. Businesses often fail due to logistics problems (DELIVER, 2004).

### 3.2.1 What is a Logistics System?

The logistics management or system can be defined, according to Stock & Lambert (2001) and Lambert et. al. (1998), as a process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services and related information from the point-of-origin to the point-of-consumption in order to meet customer's requirements. Beith et. al. (2006) define the logistics system as the coordination of various organisations and functions to source, procure, and deliver goods and services to the customer. From both definitions, there are elements of management or coordination, movement of supplies from one point to another, storage of those supplies during the movement; and consumer requirements. Therefore, the main objective or purpose of the logistics system is to deliver the right product to the right customer, in the right quantity, in the right condition, to the right place, at the right time, and for the right cost (PIP, 2002; DELIVER, 2004; Owens & Warner, 2003). Macueve (2003) defines the logistics management or system as the task of trying to place the right good, in the right quantities and conditions, at the right place, at the right time, for the right customer, in the most cost-effective manner.

The logistics requires inputs, logistics management (management actions and logistics activities) and outputs (Lambert et. al., 1998; Stock & Lambert, 2001). It is dependent upon natural, human, financial, and information resources for inputs. The logistics manages the inputs from a supplier in the form of raw materials, in-process inventory and finished goods through the management actions (planning, implementation and control) and logistics activities. The output of logistics includes marketing orientation (competitive advantage), time and place utility, efficient movement to customer, and proprietary asset.

The logistics adds value to the product by creating utility (Lambert et. al., 1998) and the more the logistics contributes to the value of a product, the more important the logistics management is (Stock & Lambert, 2001). The product refers to the set of utilities or characteristics a customer receives as a result of the purchase. The place and time utilities are directly affected by the logistics. The place utility is a value added to a product by making it available for purchase or consumption in the right place while as the time utility is a value added by making a product available at the right time.

Lambert et. al. (1998) and Stock & Lambert (2001) suggest key logistics activities namely customer service, demand forecasting/planning, inventory management, logistics communication, materials handling, order processing from customer, packaging, parts and service support, plant and warehouse site selection, procurement, return goods handling, reverse logistics, traffic and transportation, and warehousing and storage. PIP (2002) emphasises that the customer service has become the hallmark of the good logistics management. The essentials of a good logistics include: (1) improve management and staff performance through provision of good leadership, training, supervision, clear expectation and working conditions; (2) improve information systems – strong LMIS collects and reports accurate data when and where needed; (3) improve forecasting/ procurement; and (4) improve distribution through, among other distribution activities, clean, secure and organised storage, and also good transport system.

### 3.2.2 Drug Logistics Systems

Availability of drug supplies is essential element in the delivery of quality, integrated health services (Sowedi et. al., 2006). The improved availability of affordable essential drugs, vaccines, and contraceptives depends on effective logistics systems to move essential commodities down the supply chain to the service delivery point, ultimately, to the end user (Bossert et. al., 2007).

By considering the definition of Macueve (2003) above, the drug logistics system can be defined as the task of trying to place the *right* drugs and medical supplies, in the *right* quantities, in the *right* conditions, at the *right* health service delivery points, at the *right* time, for the *right* clinic patients and other users, and for the *right* cost. For the concerned manager to make such a decision, he/she needs accurate, up-to-date, and complete information in his/her disposal.

The logistics management includes a number of activities namely customer service, product selection, forecasting and procurement, and inventory management and a logistics cycle has been developed by logisticians as a systematic approach to describe the activities (DELIVER, 2004). In the servicing customer each logistics worker selects, procures, stores, or distributes products to meet customer needs. Each activity in the logistics cycle contributes to provision of the excellent customer service.

Accurate product selection ensures that the right product is available based on what the client wants, and the system and client can afford. It can be responsibility of a national formulary and therapeutics committee, pharmaceutical board, board of physicians, or government-appointed group. It involves compilation and revision of national essential drug list and program-specific product list. Many ministries of health have regulations that confine routine procurement of products.

Forecasting and procurement cover forecasting needs, financing, quantifying products to be purchased, advertising for and evaluating tenders and selecting the most suitable supplies, awarding contracts, paying supplies, and clearing customs. Simply, this activity projects future needs and ensure that the right quantity and the right product will be available.

Inventory management involves the storage and distribution including inventory control systems, warehousing and transportation. The distribution consists of a network of storage facilities linked by transport and in developing countries, it is pyramidal with a central warehouse at the apex and service delivery points or community outlets at the base. Intermediate facilities, such as regional or district warehouses or both, are also available.

Bates et. al. (2000) claim that logistics processes in developing countries are typically conceptualized as a cycle of these four key steps. Each activity depends on each other. These key logistics steps are supported by a logistics management information system (LMIS), organizational effort (human resources, training, supervision, procedures and guidelines, equipment), financial resources (budgeting), political leadership (effective policy and legal framework), evaluation, and quality monitoring (that of the product and the work). Managers gather information about each activity in the system and analyse that information to coordinate future actions.

There are important terms in the logistics management especially in health sector which have specific meanings. As suggested by DELIVER (2004), here are some terms: (1) *supplies, commodities, goods, products* and *stock* are all items that flow through a logistics system; (2) *users, clients* and *customers* are people who receive supplies including those who collect logistics data and clinic patients; (3) *service delivery point* is a facility where customers receive supplies which is usually a clinic, hospital and district level facility; (4) *pipeline* is an entire chain of storage facilities and transportation links through which supplies move from the manufacturer to the consumer; (5) *lead time* is the time between when new stock is ordered and when it is received and available for use; (6) *push and pull* – in a *pull or requisition system* the quantity to be ordered is determined by the person placing the order and in a *push or allocation system* the quantity to be ordered is determined by the person fulfilling the order; both can be used in one system but not combined among facilities at the same level; (7) *dispensed-to-user* data provide information about the quantity of goods actually given to a customer; (8) *issues data* provide information about the quantity of goods shipped from one level of the system to another; (9) *vertical logistics system* supplies and manages products for only one program; (10) *integrated logistics system* supplies and manages products for more than one program.

### 3.2.3 Drug Logistics Management Information System (LMIS)

The purpose of LMIS is to collect, organise, and report the logistics data that will be used to make decisions. The gathered information is used to improve the customer service by improving the quality of management decisions. A well-functioning LMIS provides decision makers throughout a supply chain with accurate, timely, and appropriate data for managing and monitoring the flow of supplies, accounting for products in supply chain, reducing supply imbalances, and improve cost-effectiveness. Data from the LMIS are also useful for evaluating programs and supply chain operations. The LMIS can be manual (paper-based), semi-computerized, or fully computerized.

There are three essential data items in any LMIS namely stock on hand, rate of consumption, and losses & adjustments (DELIVER, 2004; DELIVER, 2006a; Owens & Warner, 2003; PIP, 2002), although PIP (2002) suggests additional two data items which are dates of orders and receipts, and amounts of orders. Generally, *stock on hand* are quantities of usable stock available at all levels of the system; *rate of consumption* is an average of stock dispensed to users during a particular period of time; and *losses* include the quantity of stock removed from the pipeline for any reason other than consumption and *adjustments* are made when quantities are issued to or received from other facilities at the same level of the pipeline. These data must be available for every product, at every level, and in all times.

Many information systems collect more than just the essential data items. In logistics systems, the additional data item is known as *service statistics* (DELIVER, 2004) for example, population surveys, disease cases, total number of client visited at a health facility on a particular service and so on. This data may be added depending on the needs of the users (DELIVER, 2006a). The service statistics helps logistics managers to evaluate the success of health programs.

Basically, the essential data can be recorded through three different recording systems which are stock keeping, transaction, and consumption records. At the end of a certain period, particularly monthly or quarterly, reports should be prepared and sent to the higher levels in the logistics systems for decision making, policy making, and planning among others. In most developing countries LMIS reports, such as summary and feedback reports, move from the service delivery points to the central levels on a fixed time table (DELIVER, 2004; PIP, 2002).

According to DELIVER (2004), PIP (2002) and Owens & Warner (2003), the stock keeping records keep information, especially quantity of stock on hand and quantity of losses, about products. They are completed by anyone who receives or issues stock from storage whenever products are received or issued, or who takes a physical inventory of stock. The transaction records keep information (not necessarily essential data) about the movement of stock from one storage facility to another and are prepared by the warehouse personnel or nurses at both issuing and receiving facilities when a facility issues or requests supplies. The consumption records keep information about quantity of each item dispensed to the customer (dispensed-to-user data) and completed by the service personnel at the service delivery point whenever supplies are dispensed to the customers. Only the transaction records move from one facility level to another with the product while both stock keeping and consumption records remain where they are prepared.

Reports are used to move the essential data to the logistics decision makers and the data should be available to the managers in a form suitable for decision making. DELIVER (2004) suggests six "rights" for LMIS data: the managers must receive the *right* data (essential data), in the *right* time (in time to take action), at the *right* place (where decisions are made), in the *right* quantity (having all essential data from all facilities), in the *right* quality (correct or accurate), and for the *right* cost (not spend more to collect information than spend on supplies). The summary report contains all essential data items for a specific facility and for a specific time period (usually monthly or quarterly) in the form of simple report, aggregate summary report, or report and request report. The feedback reports inform the lower levels about their performance and even inform higher level managers about how the system is performing.

### 3.2.4 Drug LMIS in Developing Countries: Problems

Logistics management information system (LMIS), whether manual or automated, seems to be one of the weakest links in the logistics chain in the developing countries which requires a lot of attention. There are so many problems that exist in the drug logistics management in the developing countries which result in the shortages (or stockouts) and uneven distribution of drugs, among others. This affects the customers at the health facilities. According to some studies carried out in Jordan, Malawi, Mozambique, Nepal, Tanzania, Uganda, and Zambia, some of the problems in Drug LMIS include lack of accurate information, lack of staff training and support, weak supervision and monitoring, and shortage of human resources at all levels. For example,

- *Jordan* (McGregor & Chandani, 1999): In 1996, the assessment of the contraceptive logistics system shows that all reports lack key logistics data elements which affect forecasting and other key logistics management efforts; lack of guidance and protocols; and severe stockouts and confusion about ordering process.
- *Malawi* (Lufesi et al., 2007; Galimoto, 2007; DELIVER, 2007a; McGregor & Chandani, 1999): Results from the studies indicate that there are unexpected shortage of drugs in health facilities due to the insufficient deliveries from the regional medical stores; poor recording of logistics data at the health facilities; uneven distribution of drugs among health centres; delays in delivering of drugs to the health facilities; lack of staff training and supervision; no integration of the logistics data and the health data; and shortage of human resources at all levels because professionals leave the civil service for "greener pasture".
- *Mozambique* (Macueve, 2003; DELIVER, 2007b): The studies indicate that there are problems of drug shortage; poor control of drugs; sometimes unneeded supplies of drugs to health units; lack of personnel which results in overworking and hence much of the work is not properly done; most of staff have very little working experience in supply chain management of medicines; staff turnover; and lack of quality and timely logistics data at the central level because of having many remote locations.
- *Nepal* (FPLM, 2000): There are inaccuracies and errors in reporting system that result reports not being used for decision making; weak supervision of district storekeepers; no much update of stock book; lack of staff training; fewer mid-level managers; and excessive storekeepers but no enough training;
- *Tanzania* (DELIVER, 2007c): The problems include understaffed and lack of quality

logistics data from the service delivery sites to district and central levels for proper decision making.

- *Uganda* (Sowedi et. al., 2006): There are stockouts of drugs at the health facilities; inadequate drug needs assessment at district and facility level; no job descriptions for logistics staff; poor update of records such as stock cards; no formal training on logistics management; lack of basic ordering skills; no integration of data at district level; lack of drug surveillance, supervision and monitoring.
- *Zambia* (DELIVER, 2007d; Bates & Rao, 2000): There are multiple pipelines for some products with no standardisation and no integration which result in facilities receiving insufficient quantities of products or not even receiving products when they need them; not provision of much useful information; and little information rises through the system which are not sufficient to enable managers at the higher levels to monitor system performance at the lower levels.

The studies make some conclusions such as (1) there would be a potential benefit in integrating the health data and the drug logistics data, for example, on the disease trends with the drug consumption levels as this could assist in supplying more accurate required amount of drugs and medical supplies; (2) cultural and political barriers to an efficient supply chain system may be too strong for training alone to be effective without also focusing on changing behaviour through better monitoring and supervision; and (3) if data and information are properly collected and sent on a timely basis to decision-makers, it could potentially be helpful on deciding what drugs and medical supplies to deliver, how much, where and when.

Drugs and medical supplies are essential commodity for delivery of health services (Ministry of Health and Population, 2003a) and the lack of drugs has been shown to discourage utilization of public health facilities (Lewis, 2006). Beith et. al. (2006) emphasise that a good LMIS ensures the right quantity at the right time and at the right place.

## 3.3 Geographic Information System (GIS)

"Almost everything that happens, happens somewhere. Knowing where something happens can be critically important" (Longley et. al., 2005, p. 4). Geographic information system (GIS) can be used to support this statement. It can acquire, store, manage, and geographically integrate large amount of information from different sources, programmes and sectors. Each piece of information is related in the system through specific geographical coordinates to a geographical entity, for example health facility, and the information can be displayed in the form of maps, graphs, charts, and tables.

The GIS utilises methods and techniques drawn from many disciplines including geography, spatial information science, cartography, information systems, statistics, economics, and business (Pick, 2005). It includes physical, biological, cultural, demographic, and economic information and hence they are valuable tools in the natural, social, medical sciences, engineering sciences, business and planning. The GIS does not, of course, in itself solve the problems of development. It is necessary to consider also non-technical issues such as application environment, organisational issues, data exchange standards, legal issues and human resources.

### 3.3.1 What is a Geographic Information System?

A geographic information system (GIS) is a computer based information system with geographical dimension and it stores, manipulates and analyses spatially linked data and displays summary information on a map (Wood & Gatrell, 2002). A GIS accesses spatial and attribute information, analyses it, and produces output with mapping and visual display (Pick, 2005). It has very powerful functions such as generating "thematic maps", for example, allowing for overlaying of different pieces of information; creating buffer areas around selected features; calculating distances between two points; and permitting dynamics link between databases and maps so that data updates are automatically reflected on maps.

GIS can be seen in different ways. For example, Pick (2005) points out that GIS can be seen as (1) the information technology as it moves from data processing applications to decision-oriented applications; (2) as a means to automate spatial operations or as a tool for obtaining better information about operations of an organisation; (3) an information reporting tool by presenting spatial and attribute data on map; (4) a database which allows queries to be generated to show only areas selected by attribute value and "query methods allow users to interact with geographic databases using pointing devices and keyboards, and GIS have been designed to present data for this purpose in a number of standard views" (Longley et al., 2005, p. 315); and also (5) spatial decision support by having ability to handle both spatial and non-spatial data appropriately for better support for management decision-making in a range of application.

According to Johnson & Johnson (2001), advantages of GIS over conventional methods (especially in health sector) include: (a) *data management:* GIS can be used to capture, store, handle and geographically integrate large amounts of information from different sources, programmes and sectors; (b) *visualisation:* GIS offer powerful tools to present spatial information to the level of individual occurrence, and conduct predictive modeling; (c) *buffer analysis:* GIS can create buffer zones around selected features; (d) *overlay analysis*: GIS can overlay different pieces of information which helps in decision making and medical research through multi-criteria modeling; (e) *network analysis:* GIS can identify catchments areas of health centres and also locate suitable site for a new health facility; (f) *query:* GIS allows interactive queries for extracting information contained within the map, table or graph; (g) *statistical analysis:* GIS can carry out specific calculations; (h) *extrapolation*: GIS provides a range of extrapolation techniques; (i) *web GIS:* Health data is stored in a central server which can be accessed from various terminals connected to the server through Internet or intranet.

### 3.3.2 GIS in Health in Developing Countries

Spatial modeling capacity offered by GIS is directly applicable to understanding the spatial variation of disease, and its relationship to environmental factors and the health care system (Tanser & le Sueur, 2002). GIS is a tool of great inherent potential for health in developing countries as the health is largely determined by environmental factors which vary greatly in space (*ibid*). GIS can be used to effectively spatially analyse health systems coverage and identify deficiencies.

Combination of GIS and human health applications with the decision-making processes can have three levels of decision making (Pick, 2005) namely: (1) *operational control (practice of health care services)* which is the management of people, assets and services using spatial information to ensure the delivery of health care services while assuring that specific tasks are carried out effectively and efficiently; (2) *management control (planning of health care services)* which encompasses the management surrounding the health delivery system as a whole, and is specifically related to the needs and provisioning of health services, health promotion, disease prevention, and health inequalities while assuring that resources are obtained and used effectively and efficiently in the accomplishment of organisation's objectives; (3) *strategic planning* which deals with the spatial distribution of diseases, their epidemiological patterns, and relation to environmental health risks and demographic characteristics while deciding on objectives of the organisation, on changes in these objectives, on the resources used to attain these objectives, on the localisation of resources and health services, and on policies that are to govern the acquisition, use, and disposition of these resources.

GIS has numerous applications in human health (Johnson & Johnson 2001) and some of them are: (a) find out geographical distribution and variation of diseases; (b) analyze spatial and temporal trends; (c) identify gaps in immunizations; (d) document health care needs of a community and assess resource allocations; (e) map population at risk and stratify risk factors; (f) forecasts epidemics; (g) plan and target interventions overtime; (h) manage patient care environments, materials, supplies and human resources; (i) monitor the utilisation of health centres; (j) route health workers, equipment and supplies to service locations; (k) public health information using maps on the Internet; and (l) locate the nearest health facility.

For example, GIS has been widely applied to the understanding and management of malaria in Africa (Tanser & le Sueur, 2002) such as to generate modes of malaria occurrence, seasonality and transmission intensity using climatic and remotely sensed data; to measure the effects of access to malaria treatment and to evaluate the effects of invention strategies. In South Africa, GIS has been used to map tuberculosis cases; analyse childhood tuberculosis; analyse distribution of treatment points and the effect of community-based (opposed to facility-based) treatment on increased access to the nearest treatment supervision point *(ibid).*

### 3.3.3 Challenges in Implementation of GIS

Many literatures (Croswell, 1991; Mennecke & Crossland, 1996; Forster, 2000; Sieber, 2000; Ginger, 2005; Longley, 2005; Saugene, 2005) have discussed about challenges, opportunities and strategies of developing and implementing the GIS in developing countries. Government agencies have discovered that how the GIS is implemented influences its successful usage and although implementation involves a considerable degree of technical issues, they are equalled or surpassed by organisational issues (Sieber, 2000). Croswell (1991) argues that the *technical side* of system implementation and operation is considered "minor" as compared to *organisational* and *institutional problems* while *standards* and *data integration* are considered very important.

Data collection is one of the most time-consuming and expensive tasks of the GIS but very important as emphasised by Saugene (2005) that the effectiveness of the GIS depends on the degree of relevant data as input. In many ways data acquisition can potentially be one of the more difficult and costly issues in the implementation of a GIS (Mennecke & Crossland, 1996). It has been observed that it is more cost-effective to capture non-spatial (attributes) separately from the spatial data. Longley (2005) explains that this is possible because it is relatively simple task that can be undertaken by lower-cost clerical staff and attributes can be entered directly which does not require expensive hardware and software. An essential requirement for separate data entry is a common identifier that can be used to relate spatial data and attributes together.

Using the Global Positioning System (GPS) technology is less time-consuming and expensive than other techniques such as the ground survey, scanning and digitising although data accuracy is not fully guaranteed. The ground survey is very time-consuming and expensive activity but it is still the best way to obtain highly accurate point locations and on other hand the GPS technology is attractive precisely because it allows its user to determine locations directly at the touch of a button. The data, collected by the GPS or ground survey, may be input directly into the GIS database or can reside in a temporary file prior to input.

Practically, it may be difficult to collect all required spatial data using the GPS for the GIS. Therefore, it is necessary to collect some geographic data using other means such as scanning, digitising and data transfer depending on the availability and sources of data. The GIS database can be created from maps, photographs and other hard-copy documents which were originally captured for another purpose. They need to be converted into suitable digital format for use in a GIS project. These techniques of scanning and digitising are labour intensive and require specialised training and equipment. Alternatively, the spatial data can be obtained from external sources and one major decision that needs to be faced is whether to build or buy part or all of a database and the issue of data formats. One of the biggest problems with the data obtained from external sources is that they can be encoded in many different formats because no single format is appropriate for all tasks and applications (Longley, 2005).

Power of the GIS application relies on the scope and quality of data used and the data should be always available and easily accessed when required. To fully realise the capability and benefits of the GIS technology, spatial data needs to be shared and systems must be designed and used by multiple organisations. According to Ginger (2005) and Croswell (1991), data exchange standards have key role to play for facilitating the integration of datasets from various distributed sources or organisations and lack of these required standards between organisations impedes data sharing.

The management plays a key role in achieving the GIS adoption and level of commitment, previous computing (or innovation) experiences, and style of leadership are some factors that influence the effective use of the GIS technology (Sieber, 2000). Existing culture within governmental agencies, that is, they tend to work in a very compartmentalized manner, make the sharing of data and other technical and organisational resources problematic including poor cooperation between system developers and subject-experts, and poor involvement of people in the GIS projects (Ginger, 2005 and Saugene, 2005)

Mennecke & Crossland (1996) argue that the GIS is likely to have significant impacts on the structure and operation of the organisation through changing the information flow within organisation and therefore the distribution of power should be expected to change as well. Even Sieber (2000) found out that the implementation of the GIS tends to alter the organisation substantively because it is expensive and complex and usually it frequently crosses departmental/subunit lines and alters power relations as the control of information changes. Croswell (1991) claims that the cooperation among participants at different levels of organisations, especially government, is a key to a successful integrated information system, such as the GIS. A sufficient structure is needed for communication channels as well as for resolution of power and control conflicts that can exist due to the introduction of the GIS.

The practical work of GIS always involves some aspects of technology which focus on the computer hardware, software and technical support. Apart from the computers, the GIS also require data collection equipment such as GPS, scanners and digitisers. It seems to be accepted by users that the technology is now available to serve a large number of users' needs and that the technology is improving rapidly (Croswell, 1991) and therefore, it is necessary to define technical needs when introducing the GIS technology. It has been observed that the GIS technological capabilities are several steps a head of their efficient application in organisations.

To make good use of the GIS technology it is needed to place proper emphasis on structuring of the organisation. The GIS technologies are not merely tools; they are a key component of all organisational and disciplinary relationships. Croswell (1991) emphasises that organisations that are better adapt their structure will achieve more benefits from the information technology.

Many countries have introduced computer equipment at the district level with attempts to strengthen the health information systems management but no qualified staff to maintain the software and hardware. Ginger (2005) points out that the GIS requires technicians with specialised skills who can operate the GIS application and even Saugene (2005) emphasises that because the GIS are expensive computer tools which require well organised data, a high level of skill is required in order to be used effectively.

The managers are responsible for decision making therefore need to be educated about the GIS concepts so they are better equipped to make nice decisions about its use. For example, through in-house workshops mid-level managers become sufficiently familiar with GIS database and software concepts to apply the technology appropriately (Croswell, 1991). Ginger (2005) argues that most training programs, if available, are normally carried out as part of software training packages and not integrated with the work practices that surround the use of the GIS technology. One problem often encountered is the scarcity of individuals experienced in the GIS who can be recruited for management and technical roles, which results in accessing services from the developed countries.

According to Sieber (2000), researchers have concluded that successful implementation of the GIS in local government is dependent on a number of well-documented factors including: (1) evaluation of user needs; (2) long-term upper management commitment to the project; (3) sufficient allocation of resources; (4) adequate staffing; (5) timely and sufficient training; (6) someone, called a “GIS champion,” who will shepherd the project from acquisition to use; and (7) organizational communication or diffusion to smooth the transition to full utilization.

### 3.3.4 GIS in Logistics Systems

The rate of growth in the GIS industry has accelerated in the 1990s as businesses have adopted the GIS to relate different sources of information to one another through a common geographic reference. Technical barriers to the widespread use of the GIS in business have been eroded in the 1990s by five factors (Forster, 2000): (1) reduced cost of computing power; (2) increased availability of digital map data; (3) availability of software component technology; (4) integration with corporate databases; and (5) growth in use of the Internet for sharing software and data. There are numerous opportunities to exploit geographic relationships in data within activities in the value chain and to support different levels of logistics decision making (see Figure 3.1).

<table>
<tr><td colspan="5">ADMINISTRATION & INFRASTRUCTURE: GIS as a tool for strategic planning; as a spatial decision support tool for asset management<br>HUMAN RESOURCES MANAGEMENT: Flexible workforce management based on project location<br>PRODUCT / TECHNOLOGY DEVELOPMENT: Examination of effects of spatialization in process/product<br>PROCUREMENT: fleet management, supply management</td></tr>
<tr><td>INBOUND LOGISTICS: optimization of warehouse usage; logistics modelling</td><td>SALES & MARKETING: GIS as a market analysis tool; simulation of dispersion of new products; target marketing and advertising</td><td>SERVICES: route planning; dealer network maintenance; customer complaints; dispatch; maintenance forecasting</td><td>OPERATIONS: enhancing the spatial content of process or product</td><td>OUTBOUND LOGISTICS: route planning; fleet management; delivery assessment</td></tr>
</table>

**Figure 3.1: GIS in the value chain**

**(Source: Forster, 2000, p. 9)**

Supply chains are vulnerable to disruptions due to political events, bad weather, and natural diseases and unforeseen events (Pick, 2005). Maps and network models have long been used to solve logistics and supply chain problems and the GIS integrates the two, creating effective tool for the management (ESRI, 2003). Route planning, service planning, business expansions, vehicle tracking, and site selection are all areas that benefits from GIS. ESRI (2007) argues that using the GIS-based, geographically focused logistics package allows users to calculate realistic travel times and distances between stops, deliveries, and depots; improve work area balancing, work scheduling and route optimisation; and create more realistic and accurate routing and scheduling plans that consider natural barriers, street-levels, travel times, traffic flows, and holdups.

## *3.4 System Prototyping*

"It is often said that users can't tell you what they want, but when they see something and get to use it, they soon know what they don't want" (Sharp et. al., 2007, p. 530). Kordon & Luqi (2002) define the prototyping as the type of development in which emphasis is placed on developing prototypes early in the development process to permit early feedback and analysis in support of the development process. A prototype is executable model of a system that accurately reflects a chosen subset of its properties, such as display formats, computed results or response time. As Lewis (2005) puts it, the prototype demonstrates a physical and material image of that is being developed.

The prototypes are also useful for formatting and validating requirements but the prototype may not satisfy all the constraints on the final version of the system.

Prototyping alleviates many of the practical problems that arise in requirements definition and improves design effectiveness by integrating users directly into the design process. Prototypes can be used to formulate and validate requirements, resolve technical design issues, and support computer-aided design of both software and hardware components of proposed systems (Kordon & Luqi, 2002). Users react to the prototype to provide feedback regarding the design, the operational activities and user interface. Prototypes eliminate the confusion and potential for misunderstanding that originate from the interpretation of abstract specifications and replace with meaningful and direct communication between system developers and users. “So a prototype is a limited representation of a design that allows users to interact with it and to explore its suitability” (Sharp et. al., 2007, p. 530).

Depending on the goals to be achieved, three broad classes of prototyping can be distinguished as: (1) *prototyping for exploration*, where the emphasis is on clarifying requirements and desirable features of the target system and where alternative possibilities for solutions are discussed; (2) *prototyping for experimentation*, where the emphasis is on determining the adequacy of a proposed solution before investing in large-scale implementation of the target system; and (3) *prototyping for evolution*, where the emphasis is on adapting the system gradually to changing requirements which cannot reliably be determined in one early phase.

### 3.4.1 Exploratory and Throw-away Prototyping

The exploratory prototyping (prototyping for exploration) focuses on the basic problem of communication between software developer and prospective users, particularly in the early stages of software development. In this type of prototyping, developers normally have little knowledge about the application field while the users have no clear idea of what the proposed system might do to them. For successful exploratory prototyping, the developers must be aware that in spite of the informality of the process the users' expectations will be deeply influenced by the exposure to the prototype and there should be a strategy pertaining to the choice of features to be demonstrated and their relation to each other.

The prototyping can be seen as consisting of four steps namely functional selection, construction, evaluation and future use of the prototype. The functional selection refers to the choice of functions which the prototype should exhibit. The selection should always be based on relevant work tasks which can serve as model cases for demonstration. Sharp et. al. (2007) take this step as for identifying needs and establish requirements which are categorised as functional requirements, data requirements, environmental requirements, user characteristics, usability goals and user experience goals.

The construction of prototype refers to the effort required to make prototype available. Its emphasis is on the intended evaluation, not on regular long-term use. In this step, certain quality requirements pertaining to the final product can be disregarded. When the construction is completed, evaluation of the prototype is done which must be considered to be the decisive step in prototyping since it provides feedback for the further development process. The evaluation is needed to check that the users can use the product and that they like it, particularly if the design concept is new (Sharp et. al., 2007).

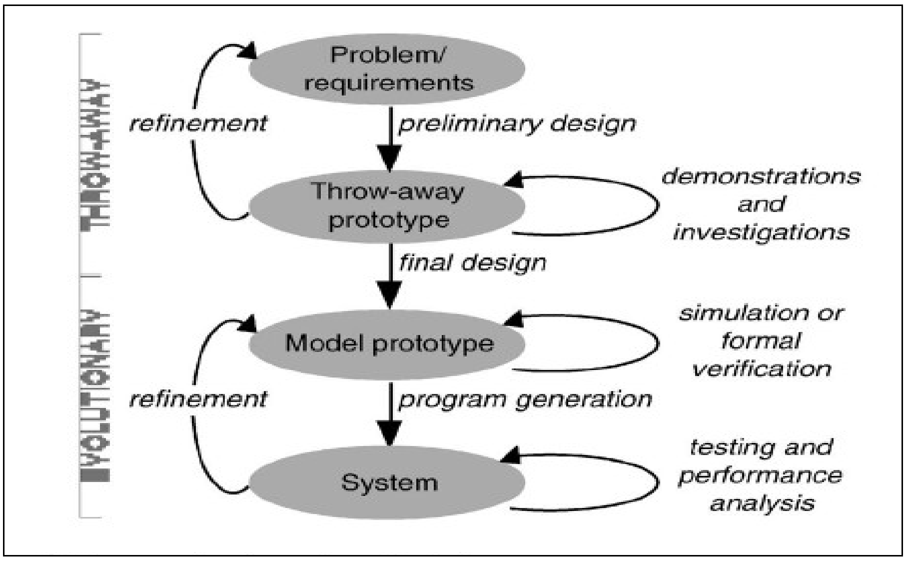



**Figure 3.2: Prototyping-based Methodology**
**(Source: Kordon & Luqi, 2002, p. 819)**

Depending on the experiences gained with the prototype and the available production environment, it may merely serve as a "learning vehicle" and be thrown away afterwards (thrown-away prototyping) or it may be used fully or partially as a component of the target system (evolutionary prototyping) (see Figure 3.2). The throw-away approach is the most appropriate project acquisition phase where prototype is used to demonstrate the feasibility of new concept while as the evolutionary approach produces series of prototypes in which the final version becomes the software product (Kordon & Luqi, 2002; Sharp et. al., 2007).

In the thrown-away prototyping, prototypes have limited functionality and precede the specification process. The prototypes are used as stepping stones towards the final design where they are thrown away and the final product is built from scratch. Available resources are limited and the ability to communicate the advantages of a new approach via a very low cost demonstration can be critical for creating a new project.

## 3.5 Information System as Social System

Since information systems consist of humans (people), organisations and technologies, they can be considered as social systems. Sawyer & Tyworth (2006) emphasise that neither technology nor social context are isolated, isolatable, or unchanging, and instead the social contexts and technological artefacts are perpetually interacting and shaping each other.

The information system does not consist of only hardware and software, but includes people and procedures. Macueve (2003) emphasises that any information system is influenced by environment, history of systems, infrastructure, socio-cultural, and economic issues. The information systems cannot be understood independently of people around them and better understanding of how people work and social practices and organisation culture in which they are engaged helps to get better understanding of the information system development, implementation, use, and research (Mukama et. al., 2005). The information system does not exist in isolation; they are used in social and organisation context (Kunda, 2001). It is important to develop both social and technical subsystems in integrated way so that integrated system functions in optimal way.

The social context (specific matrix of social relationships) of information technology development and use plays a significant role influencing the ways that people use information and technologies and thus influences for work, organisations and other social relationships (Kling, 2000). It is important to conceptualise the design of computer and networked systems as a set of interrelated decisions about technology and the organisation of work. People are not stand-alone organisation (Kling & Star, 1998) but they are social elements (Sawyer & Tyworth, 2006). They have individual motivations, interests, practices, values that influence how and why they use technologies. People have individual agency that both shapes social institutions, in which they are embedded, and influences their adoption and use of technologies.

For instance, experiences and many studies show that the major cause of most software failures is the social and organisational factors rather than technical issues (Kunda, 2001). Most developing countries have not yet fully benefited from information systems because of problems experienced by them such as lack of adequate skilled human resources; economic constraints; systems infrastructure deficiency; and social, cultural and applications problems (Kunda, 2001). Even Mukama et. al. (2005) point out that problems of information system development, implementation and use are considered to be more severe in developing countries in terms of factors such as current state of skills and knowledge; availability of suitable tools and infrastructure; lack of financial resources; shortage of technically competent personnel; and constraints imposed by the social and political context.

Boddy et. al. (2005) argue that every computer-based information system has both technological and social elements. The technological elements of computer-based information system include hardware, software, telecommunications, and data. The social elements of computer-based information system are people, procedures, and organisation. People include staff and managers who enter data into the system and those who receive information from it and use the results. Procedures are rules or routines that people are expected to use when interacting with the information system. Procedures and actions of people using the information system are the immediate parts of the information system and they are set within the elements that make up the organisational context of the information system. Results of an information system depend on the interaction between people, system and context. "While IS systems enable companies to create new products and services, they also raise the challenge of substantial organisational and human change" (Boddy et. al., 2005, p. 14).

As discussed in Chapter 2 and Chapter 3, the drug LMIS and GIS are social systems because both require human resource, organisation and technology. They involve data collection, processing, analysis and reporting which need people to perform them by using various tools and technologies and bound by procedures, policies, and standards.

## 3.6 Information Infrastructure

Information infrastructure is composed of independent and interconnected collections of socio-technical components which, together, provide an underlying platform which upon other components can provide services and applications (Nielsen & Aanestad, 2006). Changes in organisation and technology are analysed as emerged, dynamic phenomena that are dynamically and continuously defined and redefined within their use. Van Loenen (2006) views information infrastructure as a technical framework of computing and communications technologies, information contents, services, people, all of which interact in complex and often unpredictable ways. The information infrastructure can be defined as shared, evolving, heterogeneous installed base of information technology capabilities among a set of user communities based on open and/or standardised interfaces (Hanseth & Lyytinen, 2005).

Information infrastructure perspective helps to emphasise that social and technical contexts are not separable and are instead constituted and constitutive of one another (Sahay & Walsham, 2006). There are several aspects of the information infrastructure and only *installed base* was used to analyse the findings of this research. Infrastructures are never developed from the scratch. They develop through extending and improving the *installed base.* When a part of an infrastructure is changed, each new feature or component has to fit with the as-is infrastructure or *installed base* (Hanseth & Lyytinen, 2005). The *installed base* heavily influences how a new infrastructure can be designed. An infrastructure inherits both strengths and limitations of the *installed base* upon which it builds (van Loenen, 2006).

### 3.6.1 Drug LMIS as Installed Base which GIS would be built on

This research aimed at the opportunities and challenges on the application of GIS in the drug logistics management information system (LMIS). Therefore, the concept of installed base was used to analyse the drug LMIS with a reason of identifying opportunities existing in it for introducing the GIS and what challenges could affect the successful implementation of the GIS. The installed base helped to answer the following questions:

- Has the drug LMIS as existing the installed base heavily influenced how the GIS as a new installed base could be designed?
- Could the GIS develop through extending and improving the drug LMIS or replacing a part of the drug LMIS?

When designing a new infrastructure it will always be integrated into and thereby extending others or it will replace one part of another infrastructure. The drug LMIS consists of work processes, systems, users, and procedures among other components. By understanding how these components link or integrate, it is possible to identify which parts of the drug LMIS should be improved and extended in order to accommodate the GIS and also to determine which new components of the GIS should be introduced and being integrated with existing components. A new infrastructure must be designed in a way making the old and the new linked together and "interoperable" in one way or another.

# 4.0 RESEARCH METHODS

This chapter contains research approach, data collection and analysis techniques or methods which were used in this thesis. It also includes ethical considerations. The research involved the introduction of the geographic information system (GIS) in the drug logistics management information system (LMIS). It was decided to experiment the GIS in the drug LMIS in order to find out opportunities and challenges. The framed field experiment was used as the research strategy and interviews, document analysis, prototype evaluation and observation as data sources whose data analysis was qualitative.

## *4.1 Research Approach*

There are several research methods and some are action research, case study research, experiment and ethnography. In this thesis the field experiment was used.

### 4.1.1 Field Experiment

The field experiment was found by Peter Bohm (1935-2005) with clear understanding of the differences between laboratory experiments and experiments with field counterparts. The field experiments answered questions he was interested in (Dufwenberg & Harrison, 2008). The word "field" is used attributively to denote an investigation, study, etc., carried out in the natural environment of a given material, language, animal, etc., and not in the laboratory, study or office (Harrison & List, 2004). Peter's research was a clear precursor to the methodology that is now becoming widely accepted as a complementary to laboratory experiments. He came to field experiments because it was just obvious to him that experiments needed field referents to be interesting. Bohm repeatedly stressed the importance of recruiting subjects who have some field experience with the task or who have an interest in the particular task.

Field experiments occupy a middle ground between laboratory experiments and naturally occurring field data and the idea is to perform a controlled experiment that captures important characteristics of the real world. According to List and Reiley (2008), in economics, there are a number of reasons why a field experiment could produce different results from a laboratory experiment, for instance: (a) different types of subjects (participants) might behave differently and this affects results; (b) the laboratory environment might not be fully representative of the field environment; (c) in the laboratory, experimenters usually impose all the structural modelling assumptions of a theory and examines whether subjects behave as predicted by the model; (d) in a field experiment, one accepts the actual preferences and institutions used in the real world, jointly testing both the structural assumptions and the behavioural assumptions.

There are six suggested factors that can be used to determine the field context of an experiment (Harrison & List, 2004; List & Reiley, 2008) as follows: (1) the nature of the subject; (2) the nature of the information that the subjects bring to the task; (3) the nature of the commodity; (4) the nature of the task or trading rules applied; (5) the nature of the stakes; and (6) the nature of the environment that the subject operates in. The subject pool can be designed to represent a target or general population and non-standard subject pool might bring experience with the commands or the task to the experiment, quite apart from their wider array of demographic characteristics (Harrison & List, 2004). The subjects bring certain information to the trading activities in addition to their knowledge of the trading institution. The commodity, stakes, and environment also affect the results of the field experiment. For instance, one would expect that field experience could play a major role in helping individuals develop heuristics for specific tasks. The nature of the stakes and the environment of the experiment influence field responses and behaviour respectively.

With these factors, the experiments can be classified as a conventional lab experiment, an artefactual field experiment, a framed field experiment, and a natural field experiment but certain studies may not fall neatly into this classification. According to Harrison and List (2004), List and Reiley (2008), and Dufwenberg and Harrison (2008), (a) the conventional lab experiment is one that employs a standard subject pool of students, an abstracting framing, and an imposed set of rules; (b) the artefactual field experiment is the same as the conventional lab experiment but with a non-standard subject pool; (c) the framed field experiment is the same as the artefactual field experiment but with field context in either the commodity, task or information set that the subjects can use; and (d) the natural field experiment is the same as a framed field experiment but where the environment is one where the subjects naturally undertake tasks and where the subjects do not know that they are in an experiment.

### 4.1.2 Framed Field Experiment

The framed field experiment was the one used in this research with the focus on the nature of the subject pool, the nature of the information, the nature of the commodity, and the nature of the task.

The non-standard subject pool was considered which consisted of pharmacy technicians, statisticians and pharmacy-in-charge. Since the research was about the drug LMIS, it was important to use the subjects from the area of drug logistics and health information system because of their experiences. As mentioned earlier, the pharmacist-in-charge and the pharmacy technicians are responsible for the drug LMIS at the regional and district levels respectively while the statisticians are responsible for the health information system at the district health office.

The experiences and information that the pharmacy technicians, statisticians and pharmacist-in-charge already have, were very important in the evaluation of the GIS prototype. The main focus was on the knowledge of the subjects on the GIS and computer operations in general; and the specific people who could use the GIS effectively on daily work.

Harrison and List (2004) claim that many field experiments involve real, physical commodities and the values that subjects place on them in their lives but the use of the real commodities, rather than abstract commodities, is not unique to the field; it does have consequences that apply to both lab and field experiments. In this research, the nature of the commodity was also considered. The commodity was the GIS prototype which was used in the evaluation and treated as a real new commodity to the drug logistics and health staff. The GIS prototype was presented to the subjects through demonstration in their respective working places and the main role of the subjects was to participate and provide feedback or comments.

## 4.2 Data Collection Methods

There are several techniques for collecting data in the information system research. The choice of techniques to be used may depend on the research strategies employed in the research. For example, a case study researcher can use interviews and documentary materials first and foremost, without using participant observation (Myers, 1997). Another consideration is the interaction between researchers and participants. Nandhakumar & Jones (1997) argue that different data collection techniques provide different levels of interaction between a researcher and participants. For instance: (1) analysis of published data requires no direct interaction between the researcher and participants which results in “thin” descriptions of actors' interpretations; (2) in interviews, the degree of engagement between researcher and research subject depends on whether interview is unstructured, structured or semi-structured; similarly (3) in observation, the degree of involvement depends whether the observation is passive (direct) or participant observation.

Data collection methods include archives, interviews, questionnaires, observations, documents and texts, and impressions and reactions of researchers. The data sources can be primary, secondary or both. Thus, I used semi-structured interviews, prototype evaluation and direct observation as the primary data sources, and document review as the secondary data source. According to Myers (1997) the primary sources are data which are unpublished and which a researcher has gathered from people or organisation directly and the secondary sources refer to any materials which have been previously published.

### 4.2.1 Semi-structured Interviews

The interview is probably the most widely employed method in the qualitative research with the initial purpose of discovering the everyday lived world of the participants which is followed by an exploration of the key meaningful themes of this world using ordinary, qualitative language. The interview can be conducted as unstructured, semi-structured, structured (Sharp et. al., 2007; Myers & Newman, 2006), or group interview (Myers & Newman, 2006). But much emphasis is on the less structured qualitative interview because it gives more "room" (than structured interview) for the interviewee to provide his or her own point of view of the research subject. In the qualitative research there is an emphasis on greater generality in the formulation of initial research ideas and on interviewee's own perspectives. Therefore, I used semi-structured interviews for data collection at all levels (regional, district and health facility).

Sharp et. al. (2007) claims that the semi-structured interview contains questions, which are both closed-ended and open-ended and combinations of features of structured and unstructured interviews in order to maintain consistency for topics covered with each interviewee. Each level had its own set of questions different from those of another because each level has different responsibilities. The semi-structured interview allowed questions that were not included in the guide to be asked. Some questions were predetermined, but the approach gave me freedom to stray from these questions as the participant's response unfolded. The list of topics was given to participants at the regional and district levels before a day of interview. I was asked to do so because they were busy with official duties so they wanted to prepare in advance in order to minimise the interview time. At the health facility level, the topics were not given in advance.

The interviews were conducted in the hierarchical manner starting from the regional medical stores in Blantyre down to the district pharmacies and district health offices and then health centres.

Before interviewing a particular level the authorisation was obtained from its upper level. For instance, I obtained the authorisation from the Central Medical Stores in Lilongwe for the interviews at the regional office. In order to interview the district pharmacies and district health offices, I obtained the authorisation from the regional medical stores (south). This happened also at the district level, where I obtained the authorisation from district health officers in order to visit their respective health centres. The upper level also guided me which part of the lower level to concentrate on and people to meet. Each interview took about thirty to sixty minutes.

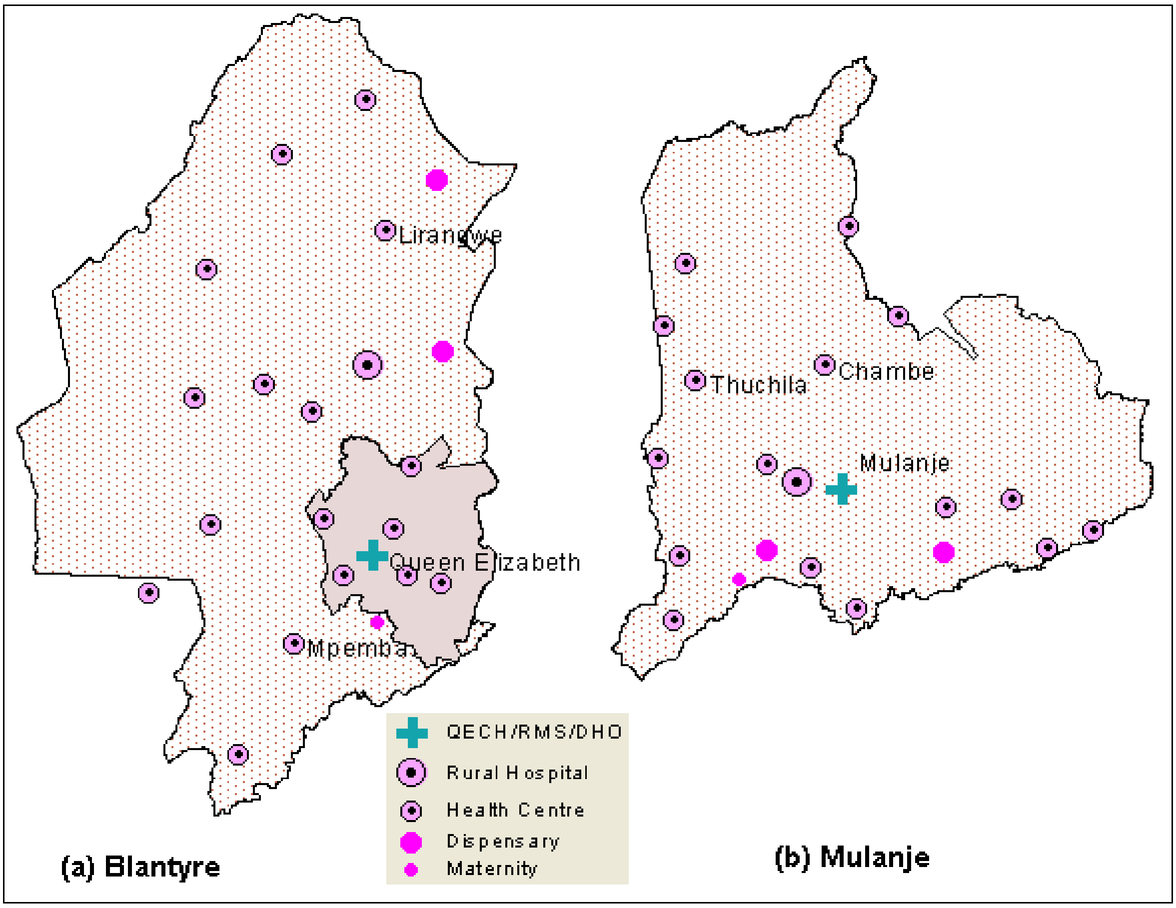



**Figure 4.1: District maps showing visited places**

**(Source: GIS Prototype)**

I visited different places in Blantyre and Mulanje at different times to collect data. These were regional medical stores in Blantyre, pharmacy of Queen Elizabeth Central Hospital (QECH), Mulanje and Blantyre district pharmacies, Thuchila and Chambe health centres in Mulanje, and Lirangwe and Mpemba health centres in Blantyre (see Figure 4.1).

It is important for the researcher to put in mind some issues or considerations when applying the interviews especially in the qualitative research. During these interviews I always made sure that (a) emphasis was on how the interviewee frames and understands issues and events in his or her social setting; (b) biased questions were avoided; (c) questions were opened as much as possible as they do not limit the natural responses of the participant; (d) I showed empathy, understanding, and respect to the interviewee; (e) I clearly explained the purpose of the interview and what he or she hoped to achieve; (f) I minimised social dissonance, respected various voices, maintained flexibility, confidentiality of disclosures, and ethical standards.

### 4.2.2 Document Analysis

Document analysis is a form of qualitative research in which documents are used to give voice, interpretation and meaning. In a case of my research, I used mainly standard operating procedures manual of health commodities logistics management system (DELIVER, 2006b) which provides standardised operating procedures and guidelines for the management of health commodities in the integrated supply chain of the Ministry of Health. It is used by staff members of the Ministry of Health, CHAM, NGOs, and public voluntary organisations who manage drugs, contraceptives, and other medical supplies. I also studied the data collection forms and some generated reports for drug logistics at district pharmacies and health facilities (see Appendix A, B, C, D, E).

### 4.2.3 Evaluation of GIS Prototype

Some data was collected through the evaluation of the GIS prototype. The GIS prototype was used as a tool for getting feedback from the participants during evaluation. Evaluations were done through demonstrations at the district and regional levels to pharmacy technicians and assistants, pharmacist-in-charge and other health staff (especially statisticians) at their respective work places at different times.

An evaluation is integral to the design process. It collects information about users' or potential users' experiences when interacting with a prototype in order to improve its design. Running effective evaluation involves understanding not only why evaluation is important but also what aspects to evaluate, where evaluation should take place, and when to evaluate.

The GIS prototype was evaluated by applying the DECIDE framework for evaluation suggested by Sharp et. al. (2007). The DECIDE framework provides a checklist that helped me to plan the evaluation studies. The checklist has six items:

**Determine the goals:** Main goals of the evaluation of the GIS prototype were: (1) to find out if the drug logistics managers and other health staff could welcome the idea of using the GIS in drug LMIS and then (2) to get more ideas from them on the use of GIS in drug LMIS. These goals guided the evaluation by helping to determine its scope.

**Explore the questions:** Questions to be answered by the GIS prototype evaluation were clearly articulated in order to make the goals operational. The questions focused on the capturing of required non-spatial data, data processing, integration of health and drug logistics data, and reporting of information using the GIS prototype.

**Choose the evaluation approach and methods:** The GIS prototype was demonstrated to the drug logistics staff (pharmacist-in-charge, pharmacy technicians) and health staff (statisticians) in Blantyre at the district and regional levels for their comments which were collected through interviews and discussions.

**Identify the practical issues:** “There are many practical issues to consider when doing any kind of evaluation, and it is important to identify as many of them as possible before starting the study” (Sharp et. al., 2007, p. 630). Practical issues such as users, schedule, facilities and equipment were identified for the evaluation. The GIS prototype was demonstrated separately to the district pharmacy technicians, statisticians and the pharmacy in-charge in Blantyre. At each occasion the demonstration took about an hour. It was also planned to demonstrate the GIS prototype to district health officers and environmental officers in Blantyre but there was no time because they were engaged with official duties.

**Decide how to deal with the ethical issues:** It is particularly important to consider ethical issues for evaluation because the participants are often put into unfamiliar situations (Sharp et. al., 2007). When the GIS prototype was being evaluated the following issues were considered in order to ensure that the evaluation was done ethically and that adequate steps to protect users' rights had been taken: (1) the participants were told the goals of the evaluation and exactly what they should expect if they participate; (2) all sensitive information such as demographic, financial, and health were kept confidential; (3) the participants were advised that they were free to stop the evaluation if they felt uncomfortable; and (4) the participants and users were asked for their permission in advance to quote them and promised anonymity.

**Evaluate, analyse, interpret and present the data:** The outcome of the evaluation was analysed, interpreted and presented as part of this thesis because the GIS prototype evaluation was used as one way of the data gathering.

### 4.2.4 Observation on Data Entry and Report Generation of Software System

Direct observation was done on the data entry and report generation of the Supply Chain Manager at Blantyre district pharmacy with the aim of finding out how it handles drug logistics data. The software system (Supply Chain Manager) at district pharmacies is a software tool, developed in Microsoft Access 2000, which provides critical logistics information to managers of the distribution system. It monitors the flow of products from the central warehouse through intermediate warehouses to health services delivery points that distribute products to end users. It helps program managers determine which health facilities are understocked or overstocked; review trends in consumption on a product-by-product basis; estimate procurement requirements for each product; identify facilities with potential inventory management problems; and plan deliveries to health facilities.

The Supply Chain Manager has two modules namely logistics management (product tracking) and distribution resource planning. The logistics management helps logistics managers maintain appropriate stock levels throughout the supply chain, ensuring that products are available when they are needed, provided that stock levels are regularly reported and recorded. The distribution resource planning module allows logistics managers allocate distribution resources such as vehicles and personnel for effective delivery of products to storage and delivery points within the distribution system.

Currently, the Supply Chain Manager is used at the district level by pharmacy technicians in all districts in Malawi. The observation was for a single day at the Blantyre district pharmacy in the month of November 2008 and focused on data entry and report generation. Data is collected at health facilities through traditional paper-based systems (LMIS forms) and entered into the Supply Chain Manager at the district level which is then processed to determine which health facilities are understocked or overstocked.

## 4.3 Data Analysis Techniques

Data analysis is the most complex and mysterious of all phases of a qualitative research (Thorne, 2000) and is determined by both the research objectives and interpretations of the raw data (Thomas, 2003). Findings are derived from both the research objectives outlined by the researcher and findings arising directly from the analysis of raw data. Thomas (2003) argues that the primary mode of analysis is the development of categories from the raw data into a model or framework that captures key themes and processes judged to be important by the researcher. Myers (1997) suggests three common used modes and one of them is the hermeneutics which aims at making sense of the whole and relationship between people, the organisation and the information technology through understanding of text as a whole and interpretation of its parts, in which descriptions are guided by anticipated explanations.

Data have been analysed qualitatively through the hermeneutic as a mode of analysis where an emphasis is on the relationship between people, organisation and technology. There have been interpretations of raw data and readings based on the research objectives and the key concepts of theoretical framework of information system as social system and information infrastructure with installed base concept.

It was necessary to identify main key users in the drug LMIS and how the system is shared by them. How each user interprets the system and what standardised interfaces link the users. Apart from people, other components such as organisations, data and information, procedures, policies, tools and technologies have been analysed. With this analysis an installed base was identified which a GIS prototype was built on.

## 4.4 Ethical Consideration

Before starting the qualitative research, it is required for researchers to obtain consent (authorisation) from organisation under study in order to have access to data sources in that organisation. One of the possible scenarios for obtaining the consent is that a researcher obtains the consent from the top management, such as the chief executive, and the top management sends out a statement to all staff requesting their cooperation.

First and foremost I obtained the consent from the Ministry of Health through the National Health

Sciences Research Committee. This authorisation enabled me to visit regional medical stores in Blantyre, district pharmacies and health facilities for data collection on drug logistics. Apart from that consent I also obtained introductory letter from the Central Medical Stores and Regional Medical Stores (South) which I was asked to show in all places I visited.

# 5.0 CASE STUDY DESCRIPTION

The research fieldwork was carried out from July 2008 to January 2009 and it was done in two steps. The first step was to establish requirements for the GIS prototype. I gathered, analysed and interpreted users' needs in the drug logistics management information system (LMIS) at the district level. This helped me to produce a set of requirements that formed a sound basis to move forward into thinking about design of the GIS prototype.

After establishing the requirements, the next step was to develop the GIS prototype which was evaluated through demonstrations to the staff of health and drug logistics information management in order to get their feedback. This step allowed me to find out some opportunities and challenges on application of the Geographic Information System (GIS) in drug LMIS at the district level in the Ministry of Health in Malawi.

## *5.1 Establishing Requirements*

Understanding user requirements is an integral part of information system design. Successful systems and products begin with understanding of needs and requirements of users. A requirement is a statement about intended product that specifies what it should do or how it should perform (Sharp et. al., 2007). According to Maguire & Bevan (2002) some benefits of the requirements analysis are: increased productivity; enhanced quality of work; reductions in support and training costs; and improved user satisfaction.

### 5.1.1 Requirements Analysis

The main goal of the requirements analysis is to obtain a thorough and detailed understanding of the business need and to break it down into discrete requirements, which are then clearly defined, reviewed and agreed upon with the customer decision makers. Maguire & Bevan (2002) and Sharp et. al. (2007) suggest steps in the requirements analysis which are information gathering, user needs identification, envisioning and evaluation, and requirements specification (see Figure 5.1).

In the information gathering, background information is gathered about the users and stakeholders and the process that currently takes place. To achieve this in my research, I firstly analysed various documents including articles written by different people on the drug logistics and also an operating manual on health commodities logistics management system from the Central Medical Stores in Malawi. Secondly, I visited the regional medical stores in Blantyre to gather further information on the drug logistics with the aim of verifying what I gathered from the documentation and getting general information on what is happening currently. I identified all the users and stakeholders who may influence or be impacted by the GIS system. This helped me ensure that the needs of all those involved are taken into account.

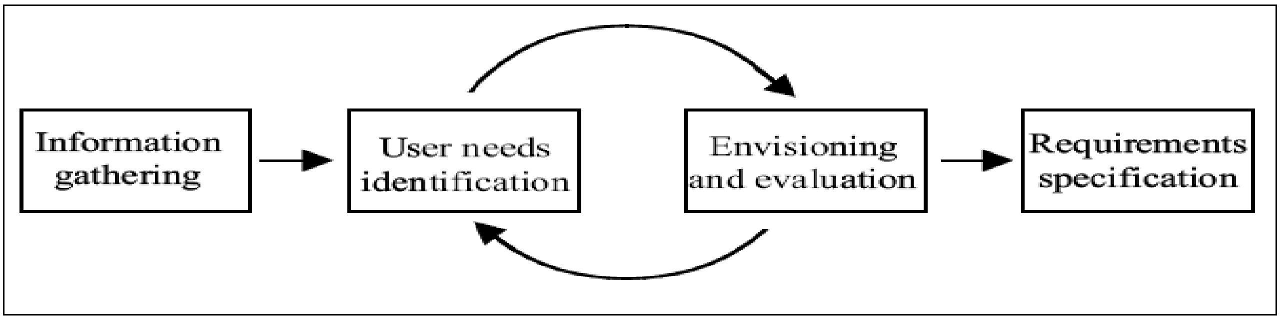



**Figure 5.1: General Process for User Requirements**
**(Source: Maguire & Bevan, 2002, p. 2)**

Once the user data had been collected, I started identifying user needs. Interviews were conducted at the district and health centre levels with the district pharmacy technicians and health center in-charges respectively. As earlier stated in Chapter 4, I visited three pharmacies and four health centres (see Figure 4.1). The main aim of the interviews was to gather detailed information on the user needs in the drug LMIS at the district and health center levels in the following areas: (1) different type of reports prepared at each level, when and by whom are required, and how they are sent to the next level; (2) any health data required in the drug LMIS; (3) tools used for data collection, processing and presentation; (4) resources required in the drug LMIS; (5) any problems faced and what they think can be done to minimise those problems; (6) any existing technologies used in the drug LMIS; and (7) feedback mechanisms which exist between different levels.

Apart from the interviews, during the collection of drug logistics data at Blantyre district pharmacy, I also did some observations on the Supply Chain Manager (computerised information system) to find out how it handles drug logistics data. The pharmacy technician demonstrated the system on data entry and report generation. Even he printed some reports on Stock Imbalances and Monthly LMIS Report - Summary(see Appendix E, D).

The gathered requirements were specified clearly by categorising them into functional and non-functional requirements. The functional requirements are what the system should do and the non-functional requirements are what constraints there are on the system and its development (Sharp et. al., 2007). In this thesis, the non-functional requirements are further categorised into data requirements and environmental requirements.

### 5.1.2 Functional Requirements

Functional requirements capture intended behaviour of the system. The behaviour may be expressed as services, tasks or functions the system is required to perform. From the requirements analysis done in this research, the following functional requirements were identified:

**Data Capturing:** Data input interface was required for entering non-spatial data for the GIS prototype. The interface was designed for entering health data (catchments population and malaria cases) and drug logistics data (anti-malaria drug consumption) of each health facility in a particular month.

**Data Processing:** The catchments population was categorised into population ranges and malaria cases were presented in percentages based on the catchments population for easy comparisons among health facilities. The required quantity and months of stock of each drug for each health facility were calculated. The months of stock is the number of months a drug, contraceptives, or other medical supply item will last based on the present consumption rate and it is used to determine whether available stock is adequate, overstocked, or understocked.

**Integration of Spatial and Non Spatial Data:** The processed health and drug logistics data were then integrated with each health facility in a specified month.

**Spatial Information Reporting:** The information was reported using the Geographic Information System. The map showed the health facilities and their categories (hospital, health centre, dispensary, and maternity), catchments population, malaria cases, road network for distance calculation, and stock status of each anti-malaria drug.

### 5.1.3 Data Requirements

The data, which was required by the GIS prototype, was in two categories namely spatial and non-spatial data. The spatial data included administrative boundaries of districts and cities, catchments health facilities, and road networks. The non-spatial data for each health facility included the catchments population, malaria cases, and anti-malaria drug consumptions.

The GIS prototype entirely depended on the electronic data to provide necessary information. Therefore it was required to make sure that the quality of data was well maintained in terms of accuracy, consistency, up-to-date, completeness, and validity for a particular period of time.

### 5.1.4 Environmental Requirements

The environmental requirements refer to circumstances in which the system will be expected to operate. Technical and organisational requirements were identified for the GIS prototype. The understanding of the organisational requirements helped me to prototype the GIS that could support the management structure of the drug logistics management in the Ministry of Health.

The GIS prototype was designed to support the information reporting of the drug logistics at the district level. It was proposed that the system would support the district pharmacy technicians and assistants, district health officers, environmental health officers and officers who are responsible for health information system (statisticians). It was designed to run on a stand alone personal computer on Windows operating system environment.

## *5.2 Geographic Information System (GIS) Prototyping*

Prototype is a useful aid when discussing ideas with stakeholders. It is a communication device among team members and effective way to test out ideas. The thrown-away GIS prototype was developed to demonstrate how the GIS could be applied in the drug LMIS with the aim of enriching drug logistics information at the district level.

The GIS prototype was developed using ArcView GIS 3.1 and Visual Basic 6.0 with anti-malaria drugs, catchments population and malaria cases as examples. The ArcView GIS was used for spatial analysis and reporting. User interfaces, developed in the Visual Basic 6.0 programming language, were used for accessing non-spatial data. The drug consumption and health data were updated through the Visual Basic interface and access the output through the ArcView GIS (see Figure 5.2).

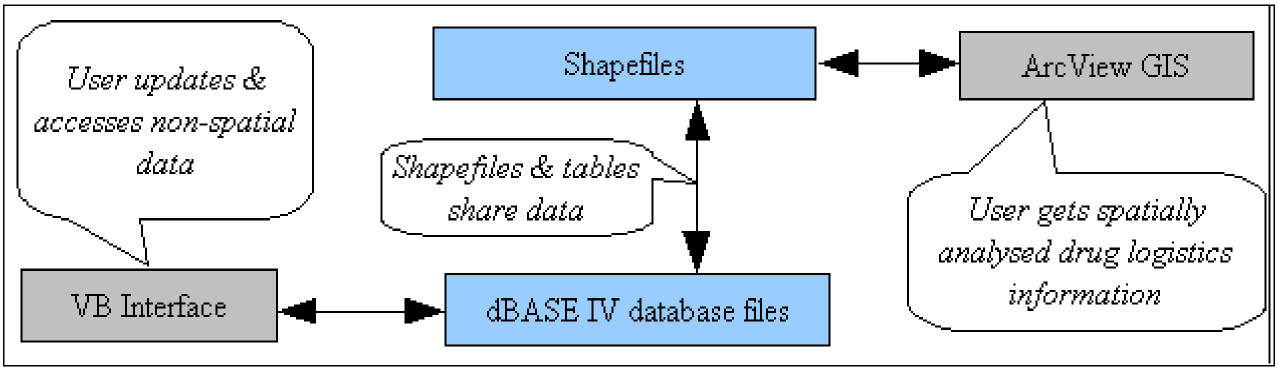



**Figure 5.2: General Structure of the Prototype**

### 5.2.1 Identifying Spatial Data for the GIS Prototype

Spatial data for the GIS prototype required was collected from the Roads Authority and the Survey Department in Malawi. The spatial data consisted of administrative boundaries of districts, health facilities, road networks, rivers, villages among others. Since the GIS require high quality spatial data, I made sure that all necessary spatial data was accurate and complete especially districts, health facilities, pharmacies, and road networks. For demonstration purposes, it was needed to update all catchments health facilities and pharmacies in Blantyre and Mulanje districts particularly names to match with those used in the drug LMIS and health information system.

After verification of the required spatial data for the GIS prototype, I created all required layers for both Blantyre and Mulanje districts namely: (1) administrative district boundaries including Blantyre city; (2) catchments health facilities; and (3) district road networks (see Figure 5.3).

According to Blantyre and Mulanje district health offices, there are twenty-one catchments health facilities in each district of Blantyre and Mulanje (see Figure 5.3). These health facilities collect health data on monthly basis and other facilities report to them. The collected non-spatial data for the GIS prototype was only for these health facilities.

### 5.2.2 Capturing and processing non-spatial data for the GIS prototype

The drug logistics and health data from August to October 2008 was collected from the Blantyre district health office which was used to demonstrate the GIS prototype to the health and drug logistics staff at the Blantyre district health office and regional medical stores. Three interfaces were designed: first interface was for entering the drug logistics data; second interface was for entering health data; and third one was for linking the processed health and drug logistics data with the health facilities in the GIS application.

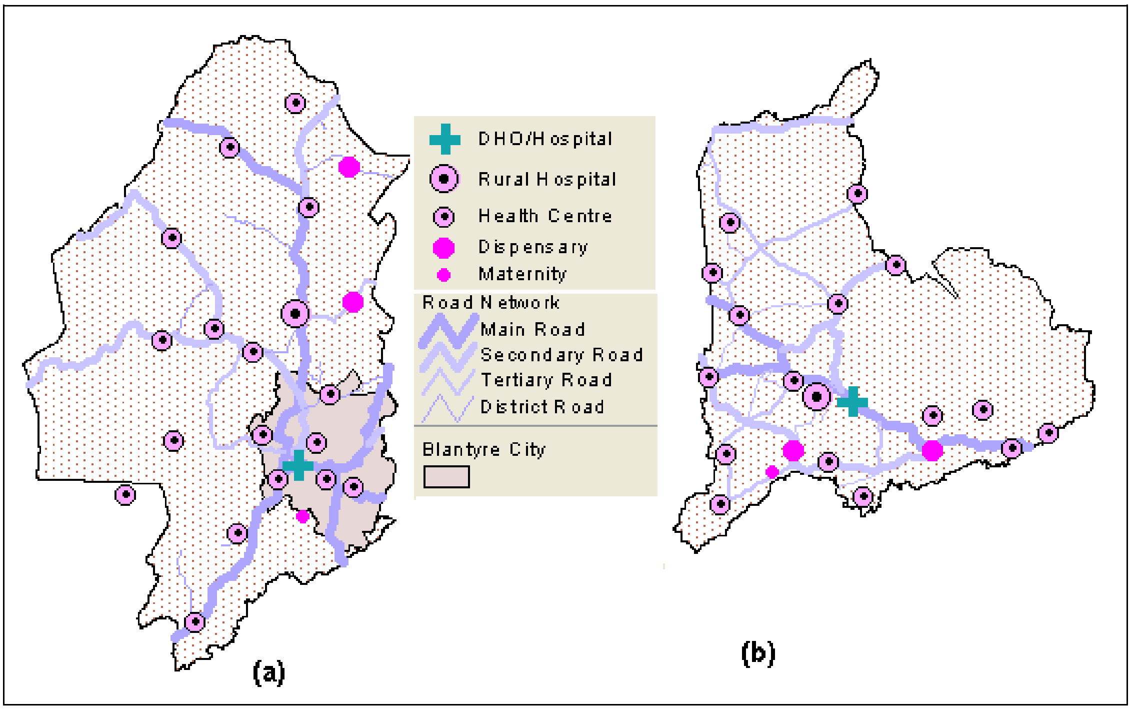


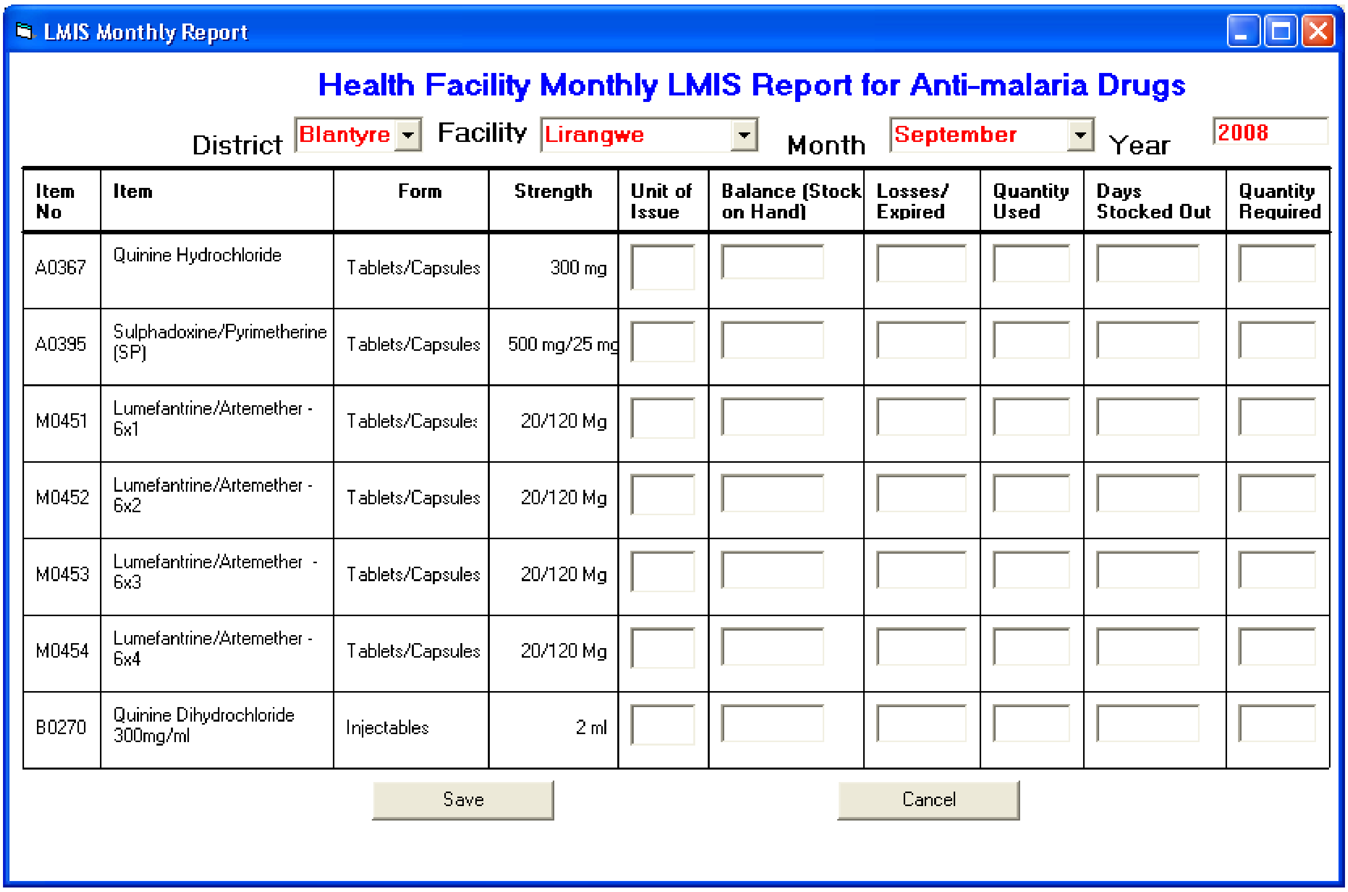

**Figure 5.3 (a): Blantyre district health office and catchments health facilities**
**(b): Mulanje district health office and catchments health facilities**

Drug logistics data is reported monthly by filling LMIS forms at the clinic, health centre, and district levels (see Appendix A, B, C). The main different among these forms is kind of items required by the health facility. The data to be filled in the forms is the same and all health facilities require anti-malaria drugs. Therefore, I designed one input interface for entering the anti-malaria drug data (see Figure 5.4).

The drug logistics data for the GIS prototype was extracted from the Supply Chain Manager software at the Blantyre district pharmacy and it included the anti-malaria drugs namely Quinine Hydrochloride, Quinine Dihydrochloride, Sulphadoxine/Pyrimetherine (SP), Lumefantrine Artemether (LA) 6x1, LA 6x2, LA 6x3 and LA 6x4. The data values collected for each drug were balance (stock on hand) and quantity used which are used for calculating quantity required (to be ordered) and months of stock for each health facility on each drug. The stock on hand is a quantity of drugs remaining at a health facility to be given to patients and the quantity used is a quantity of drugs that have been given to patients in the previous month. The quantity required is a quantity to be ordered for a health facility.

The quantity used is taken as estimated consumption rate and in order to estimate required balance of stock to last for at least three months the consumption rate is multiplied by three. Hence, the quantity required is calculated by the following formula:

*quantity required = quantity used x 3 – stock on hand.*


LMIS Monthly Report

Health Facility Monthly LMIS Report for Anti-malaria Drugs

District Blantyre Facility Lirangwe Month September Year 2008

| Item No | Item | Form | Strength | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days Stocked Out | Quantity Required |
|---|---|---|---|---|---|---|---|---|---|
| A0367 | Quinine Hydrochloride | Tablets/Capsules | 300 mg | | | | | | |
| A0395 | Sulphadoxine/Pyrimetherine (SP) | Tablets/Capsules | 500 mg/25 mg | | | | | | |
| M0451 | Lumefantrine/Artemether - 6x1 | Tablets/Capsules | 20/120 Mg | | | | | | |
| M0452 | Lumefantrine/Artemether - 6x2 | Tablets/Capsules | 20/120 Mg | | | | | | |
| M0453 | Lumefantrine/Artemether - 6x3 | Tablets/Capsules | 20/120 Mg | | | | | | |
| M0454 | Lumefantrine/Artemether - 6x4 | Tablets/Capsules | 20/120 Mg | | | | | | |
| B0270 | Quinine Dihydrochloride 300mg/ml | Injectables | 2 ml | | | | | | |

Save Cancel

**Figure 5.4: The interface for capturing the anti-malaria drug data**

Similarly, to estimate number of months for the stock on hand to last, it is divided by the consumption rate and therefore, the months of stock is calculated by the following formula:

*months of stock = stock on hand / quantity used.*

From the months of stock, the stock status is determined by using the following criteria: (a) available stock is adequate when months of stock is between 1 and 3 months; (b) available stock is understocked when months of stock is equal to or less than 1 month and an emergency order can be requested and this includes out of stock status; and (c) available stock is overstocked when months of stock is greater than 3 months and some stock may be transferred to another health facility that may be able to distribute it more quickly. All these calculations and criteria were included in the GIS prototype and were performed during the capturing of the drug logistics data.

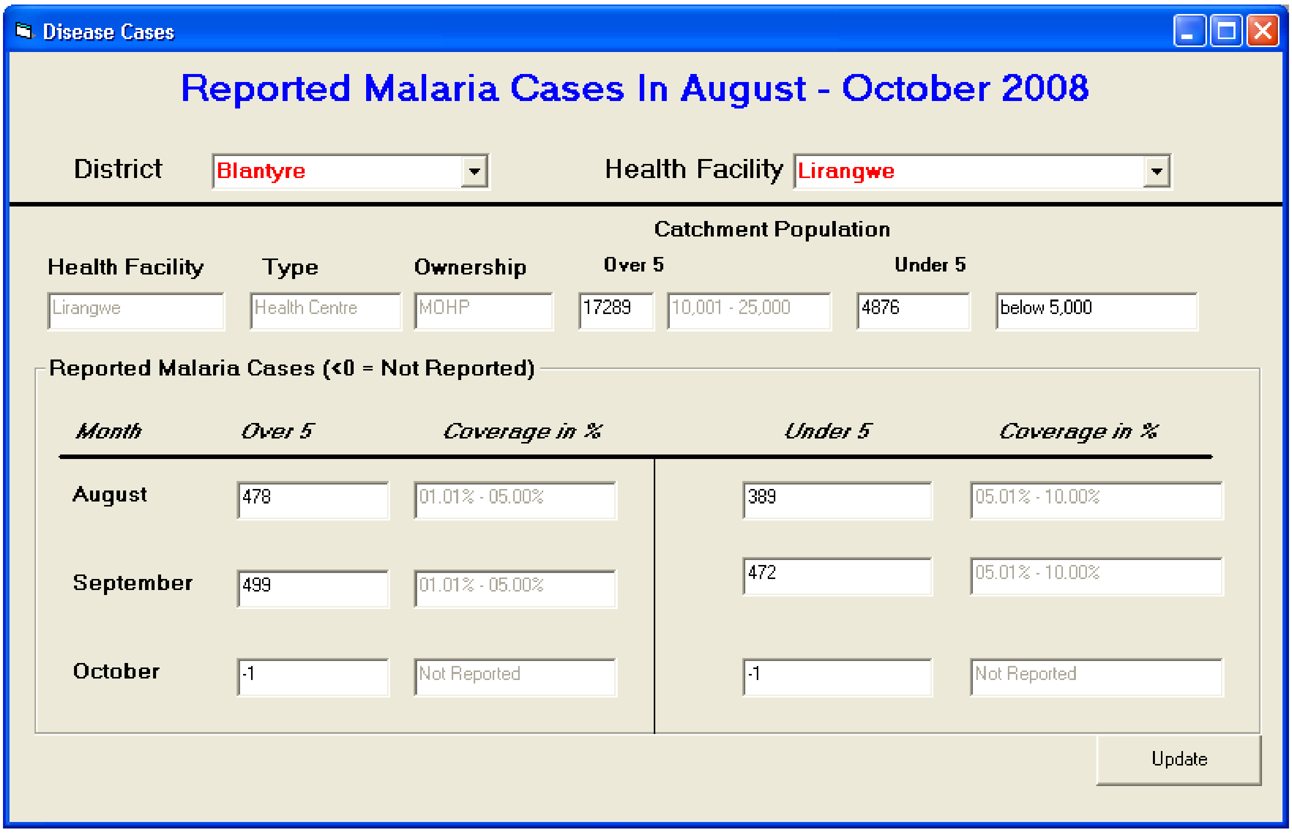



**Figure 5.5: The interface for capturing malaria cases and catchments population**

The health data included the latest catchments population (last half of 2008) and monthly malaria cases of August, September and October 2008 of each health facility but by then the malaria data for October was not available. Both the catchments population and malaria cases were categorised into two groups of children less than five years and people who are equal to or greater than five years old (see Figure 5.5) and presented in terms of population ranges and percentages respectively. Currently, catchments population and malaria cases are presented as raw data. Therefore, these ranges and percentages were suggested just for the demonstration of the GIS prototype in order to compare different health facilities.

### 5.2.3 Reporting Drug Logistics Information

After capturing all necessary drug logistics and health data as described above, the data was then linked with the spatial data ready for information reporting using the GIS prototype. The drug logistics data was reported within a particular month and for a particular district.

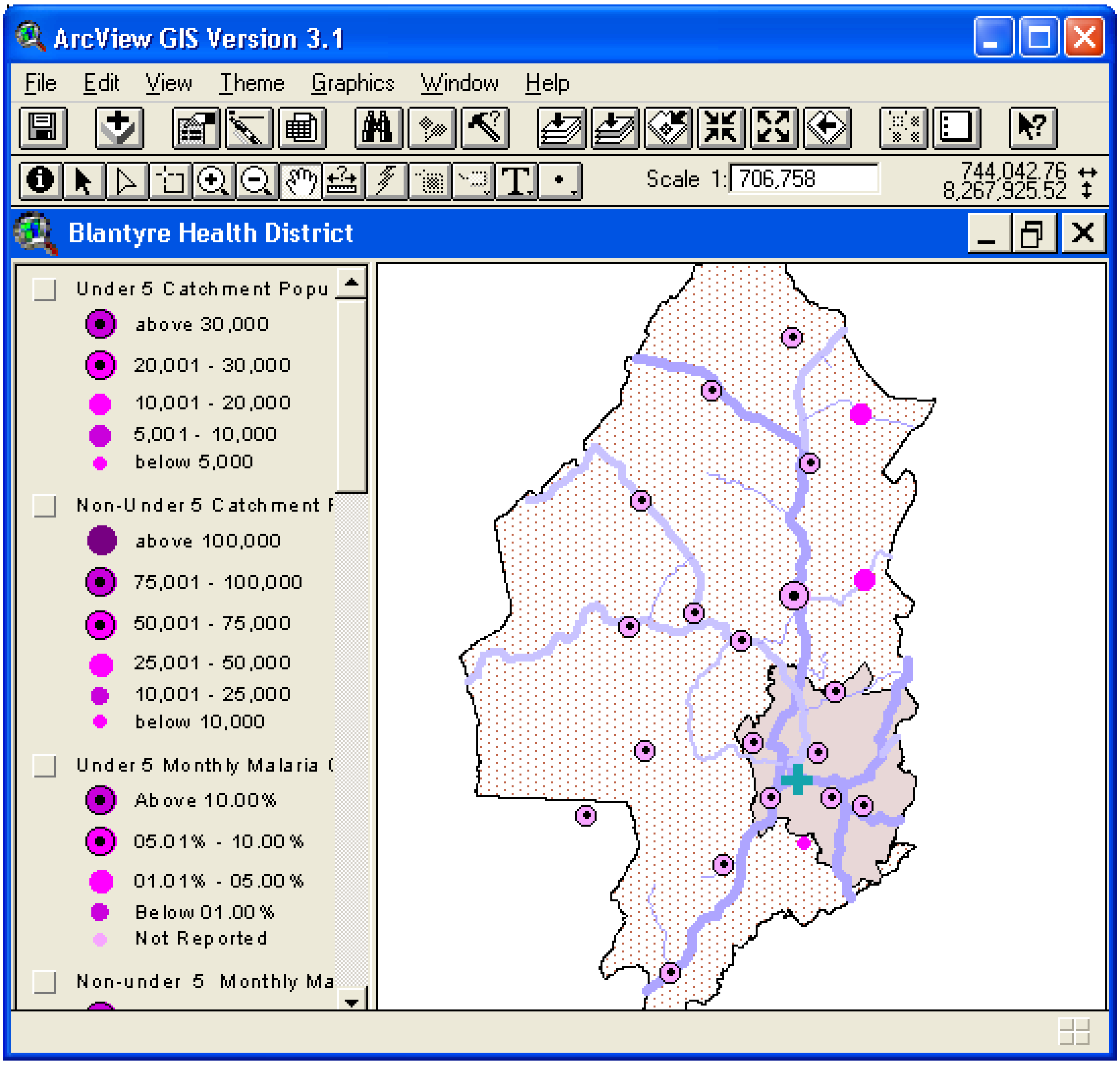



**Figure 5.6: The interface for reporting the drug logistics information**

For the demonstration purposes, the data of September 2008 from Blantyre health district was used. The interface was designed for linking the processed non-spatial data (catchments population, stock status of anti-malaria drugs, malaria cases) with the spatial data in this case the health facilities. The interface for reporting the drug logistics information is shown in Figure 5.6.

Below shows how the GIS prototype could be applied in the drug LMIS in the information reporting. The main focus was on the catchments population, malaria cases, stock status of anti-malaria drugs and road networks for distance calculation.

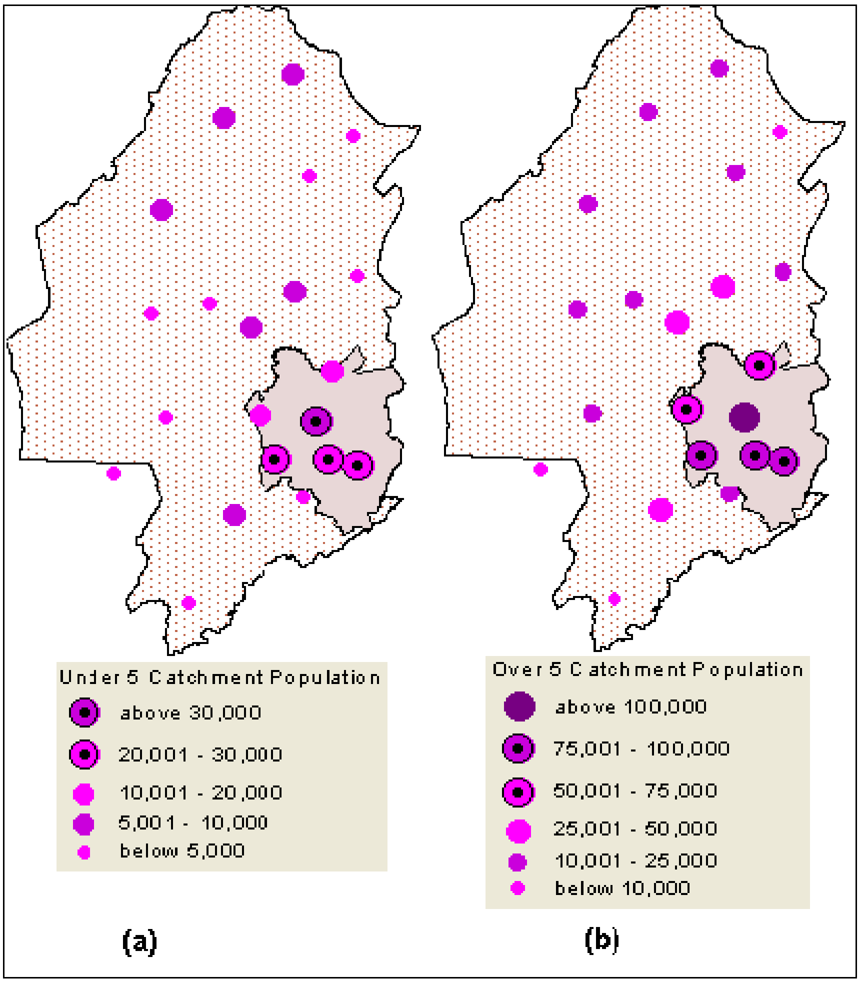



**Figure 5.7: (a) Under 5 & (b) Over 5 catchments population in Blantyre**

**Catchments Population:** It was observed that the drug logistics staff requires also catchments population of each health facility in order to estimate level of drug distribution. The population was categorised into two groups: (1) children who are below five years old (this group was titled *under 5* in this thesis ) and; (2) people who are equal or above five years old (this one was titled *over 5* in this thesis).

Figure 5.7 shows that the Blantyre city has more catchments population than the Blantyre rural in both categories. For example, the maximum catchments population range for under 5 children in the rural is 5,001-10,000 which is the minimum catchments population range of the same group in the city. In the rural, the catchments population is very high in the central and north as compared to the south.

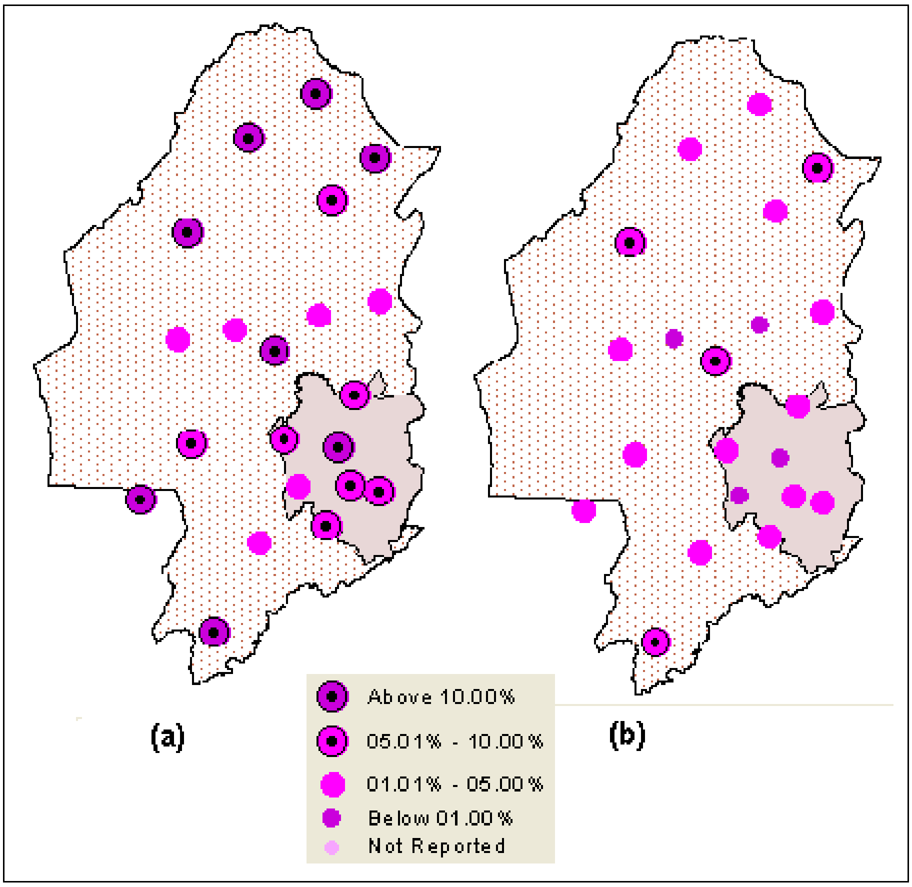



**Figure 5.8: (a) Under 5 & (b) Over 5 malaria cases in September 2008 in Blantyre**

**Malaria Cases:** Apart from the catchments population, it is also important to have the disease coverage which also used to determine the level of drug distribution. In this thesis, malaria cases were used as an example. The coverage of malaria was determined based on the catchments population.

As shown in Figure 5.8, in the month of September 2008 children under 5 were affected with malaria more than people in the over 5 category in both Blantyre urban and rural. But children who are under 5 in the rural area were much affected as compared to those in the urban area. For instance, almost half of health facilities in the rural area reported malaria cases above 10% for under 5 children while in the urban area the majority of health facilities reported malaria cases between 5% and 10%. For over 5 category, the malaria coverage was the same in both the urban and rural although very few health facilities reported between 5% and 10% malaria coverage. The more the malaria cases are reported the more the anti-malaria drugs are required.

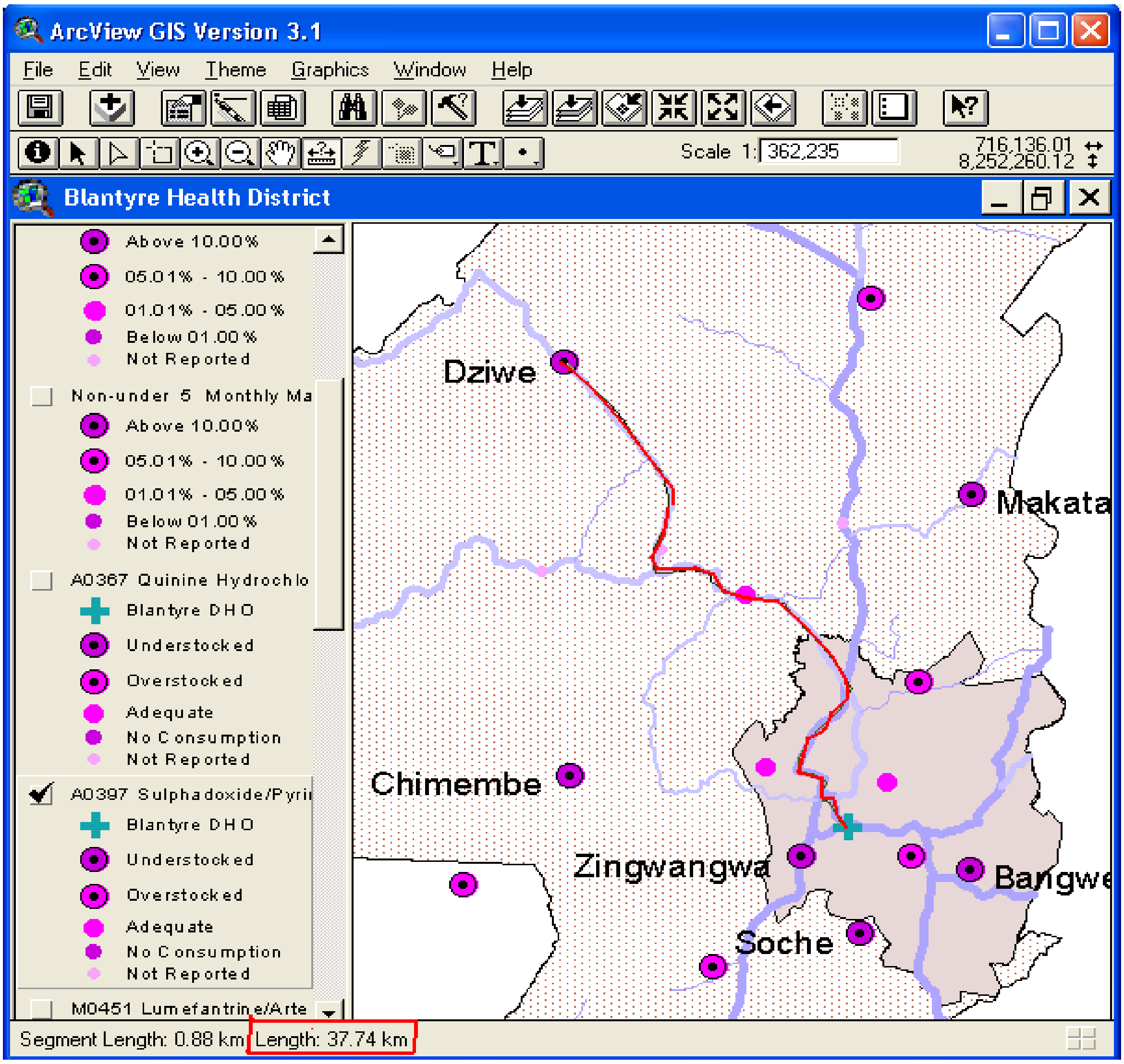



**Figure 5.9: Calculating Distance between health facility and district pharmacy**

**Distance Calculation:** All health facilities which are understocked need to place emergency orders to its district pharmacy. The district pharmacy is responsible for handling all these emergency orders as quickly as possible. The information about distances between the district pharmacy and the concerned health facilities and how close they are to each other, is very important in this circumstance. But the distance itself cannot help much due to poor road conditions in developing countries. It is important for the drug logistics managers to consider also the road conditions when making decision on the travel time to health facilities.

Considering the sulphadoxine/pryrimetherine (SP) in September 2008, it can be observed that Zingwangwa, Bangwe and Soche health centres are very close to the district pharmacy (Blantyre district health office) as compared to Chimembe, Makata and Dziwe health centres and, for example, Dziwe health centre is about 37 km from the Blantyre district health office (see Figure 5.9). In terms of distances between health facilities, Dziwe and Makata health centres are much closer to each other than to Chimembe health centre and in the same direction from the Blantyre district health office. For logistics purposes, therefore, this information can help.

**Stock status of anti-malaria drugs:** The software system which is used at the district pharmacy only produces reports in table form. One of the reports is a stock imbalances report which contains the health facility, product, closing balance, quantity used, months of stock, quantity required and status. This report is only for the health facilities that are overstocked and understocked. For instance, the stock imbalances report of the sulphadoxine/pryrimetherine (SP) of September 2008 shows that out of 21 catchments health facilities in Blantyre, six were understocked (stocked out or below minimum) and seven were overstocked as shown in the Appendix D but it was not known what happened to other eight health facilities, whether they were adequately stocked, or did not give SP to patients (no consumption), or did not report. Comparing with the Figure 5.10, it was found that the spatial reporting can be a supplement to the original report which shows actual location of the health facility and how far it is from the district pharmacy. It shows that in September 2008, three health facilities did not report any data on the sulphadoxine/pryrimetherine (SP) and only five were adequately stocked.

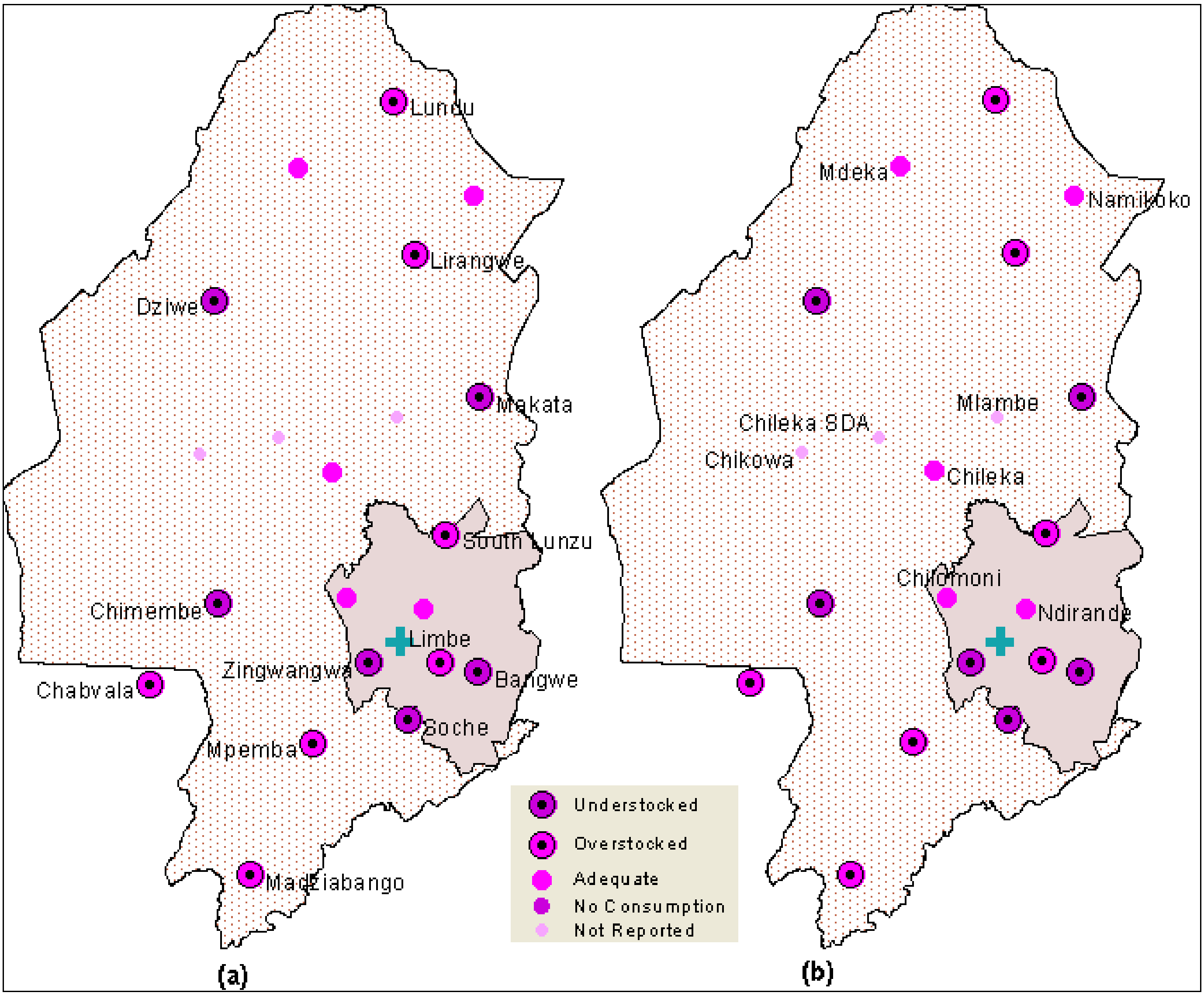



**Figure 5.10: (a) Health facilities understocked & overstocked of SP in September 2008 (b) Health facilities adequately stocked & not reported**

The presentation of the sulphadoxine/pryrimetherine (SP) above as example can also be similar to other drugs and health commodities.

## 5.3 Evaluation of the GIS prototype

The evaluation was done through demonstrations of the GIS prototype to the pharmacy technicians and statisticians from the Blantyre district health office and the pharmacist-in-charge from the regional medical stores also in Blantyre. There were three sessions of the demonstration. Firstly, the

GIS prototype was demonstrated to the pharmacy technicians; secondly to the statisticians; and thirdly and lastly to the pharmacist-in-charge.

The demonstration was done separately due to time constraint. It was very difficult to find common time convenient to all participants to attend the demonstration, therefore, the GIS prototype was demonstrated to these officers in their convenient times.

The evaluation, in all three sessions, was performed by applying the DECIDE framework discussed in Chapter 4. Although drug logistics and health data was collected for August, September and October 2008, only data for September was used as explained in Section 5.2. Data for August and October was only used during the testing of the GIS prototype before the demonstrations.

The demonstration focused on four areas: (1) capturing of the drug logistics and health data using the interface as shown in Figure 5.4 and Figure 5.5; (2) how to access main features in the GIS interface for drug logistics information reporting as shown in Figure 5.6; (3) discussing about the integration of the spatial data, drug logistics and health data; and (4) reporting of the drug logistics information such as catchments population (see Figure 5.7), malaria cases (see Figure 5.8), stock imbalances (see Figure 5.10), and distance calculation (see Figure 5.9).

In every demonstration session, there was one laptop which was connected to the computer LCD screen and placed on a working table. I was responsible for running the GIS prototype on the laptop while explaining what the system was doing and at the same time getting some comments and suggestions from the participants.

The first demonstration took place in the office of the pharmacy technicians which is located inside the Blantyre district pharmacy. Two participants were present: the pharmacy technicians. This demonstration concentrated on three areas of main features of the GIS interface, data integration and drug logistics information reporting and analysis. The main area of discussion was on the comparison between reports generated by the drug LMIS and the GIS prototype, for example, the report of stock imbalances of SP in September 2008 generated by the Supply Chain Manager (see Appendix D) and by the GIS prototype (see Figure 5.10).

The second demonstration took place in the office of the statisticians where all health data is processed. Here, only one statistician was present. The main focus of the demonstration was on the health data capturing, main features of the GIS interface, data integration and spatial information reporting and analysis. The discussion centred on the different users and other uses of the GIS in the health sector. The technician proposed the GIS prototype to also be demonstrated to the Blantyre district health management team during the quarterly meeting but time was not convenient because it was scheduled two months after my fieldwork.

The third demonstration took place in the office of the pharmacist-in-charge at the regional medical stores in Blantyre and only one participant (the pharmacist-in-charge) was present. The main focus of the demonstration was also on the main features of the GIS interface, data integration and spatial information reporting and analysis. The discussion was mainly on uses of the GIS in the drug logistics at the regional and national level.

After the demonstration in each session, the participants were interviewed on the following areas: (a) what they feel about the GIS in the drug LMIS; (b) previous knowledge in the GIS in particular and the computer operations in general; (c) issues about the GIS interface and the drug logistics information reporting and analysis; (d) how computer user training is conducted at the Blantyre district health office; (e) a part from the pharmacy technicians, who other health staff can use the GIS; and (f) also a part from in the drug LMIS, in which other systems the GIS can be used.

# 6.0 RESEARCH FINDINGS ON DRUG LMIS

The first objective outlined in the Chapter 1 is to understand the challenges in the drug LMIS and how data is shared between the drug LMIS and the health information system (HIS) at the district level through user needs analysis. Therefore, this chapter describes findings from the fieldwork with emphasis on how the health commodities logistics management system works; different roles in the system; how data is collected, processed and reported and feedback at all levels. It contains also comparisons between the drug LMIS and the health information system in terms of data sharing and integration.

## *6.1 Health Commodities Logistics Management System*

In Malawi, there is a well established logistics management system called Health Commodities Logistics Management System. It is the Ministry of Health medical supply system of inventory management and recording and reporting for drugs, contraceptives, and medical supplies, which ensures that all Malawians are able to receive the products they need, and receive quality treatment when they visit a health facility.

The health commodities move from the major stores down to the health facilities while the information moves from the health facilities to the upper levels (see Figure 6.1). Both Ministry of Health and Donors supply drugs, contraceptives, and medical supplies to the Central Medical Stores which distributes them to three regional medical stores. At regional medical stores the health commodities are packed for and sent directly to each health centre, district pharmacy, pharmacies of central and mental hospitals on monthly basis. District pharmacists work with regional medical stores and health centres to coordinate the management and distribution of health commodities, while pharmacists of central and mental hospitals work directly with the regional medical stores.

The Central Medical Stores uses the population-based “push” or allocation system in which the health commodities are distributed as they are received to the three regional medical stores as explained in Chapter 2. While at the regional level, the “pull” or requisition system is used in which the health commodities are distributed to the health facilities based on monthly demands from those facilities. There is a policy of “no report no drug” which means that a health facility can only get required drugs, contraceptives, and medical supplies when it sends previous month LMIS report to its district pharmacy by fifth day of every month. District pharmacies send these LMIS reports to the regional medical stores by tenth day of the same month.

During the interviews, one of medical assistants said:

> *"Nowadays we cannot get drugs from the regional medical stores until we send logistics reports on time every month."*

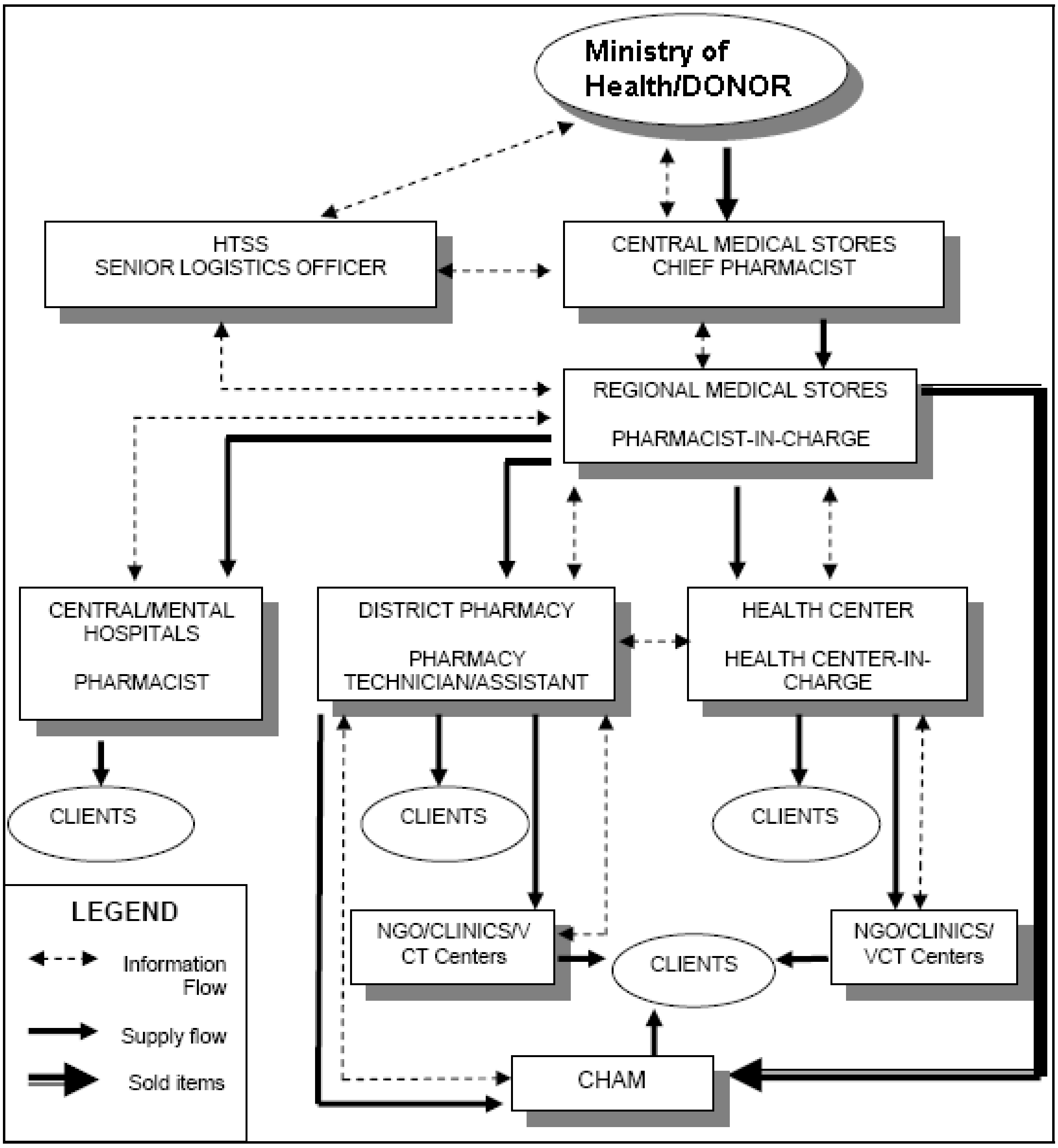



**Figure 6.1: Movement of Health Commodities to Clients and Movement of Information between Levels**

**(Source: DELIVER 2006b, p. 4)**

Any logistics system deals with the flow of goods or materials from point of origin to point of consumption and in some cases to the point of disposal. In the case of the health commodities logistics system in Malawi, the point of origin is the Ministry of Health and/or Donors through the Central Medical Stores and the point of consumption consists of mental hospitals, central hospitals, district pharmacies, health centres, clinics and VCT centres being considered as health facilities which distribute the health commodities to the clients (see Figure 6.1). In this case the client includes a person who is sick and visits a health facility for treatment and any other person who is not sick but just visits a health facility for a certain kind of health service, for example, vaccination. In the case of Blantyre where there is no district hospital, Blantyre district health office is taken as the health facility because it distributes health commodities to the clients when doing mobile clinic services in the Blantyre district but it is not taken as the catchments health facility.

The regional medical stores uses mainly the integrated logistics system when distributing the health commodities to the health facilities in which products of more than one program are managed and supplied although in certain occasions the vertical logistics system is also used for instance vaccines programs. In order to have smooth continuous movement of products from the Central Medical Stores to the clients, it is very important to maintain adequate stocks. This is achieved through establishment of maximum months of stock and an emergency order point. The maximum months of stock is the greatest amount of each drug, contraceptive, or other medical supply item a health facility should hold at any time while the emergency order point is the level at which the risk of stocking out is very high and emergency order should be placed immediately.

| **Level** | **Maximum Months of Stock** | **Minimum Months of Stock** | **Emergency Order Point** |
|---|---|---|---|
| Regional Medical Stores | 12 months | 9 months | 6 months |
| District | Does not store commodities for health centres | | |
| Clinics, health centres, district hospitals, and central/mental hospitals | 3 months | 1 month | 1 month |

**Table 6.1: Minimum and Maximum Months and Emergency Order Points of Tablets, Injectables and Medical Supplies**
**(Source: DELIVER, 2006b, p. 52)**

As shown in the Table 6.1, the normal situation at the regional medical stores is when the months of stock are between 6 and 12 months and no action is taken. Otherwise, when the months of stock is greater than 12 months, the stock should be redistributed by the Central Medical Stores to another regional medical stores where it is understocked, and when the months of stock is at or less than 6 months, place an emergency order to Central Medical Stores. Similarly, this also happens at the health facility level by using the maximum months of stock of 3 months and minimum of one month. This is where a district pharmacy is responsible for correcting any overstocked or understocked situation except the central and mental hospitals which report directly to the regional medical stores.

It was found that the redistribution of drugs, contraceptives and other medical supplies by a concerned district pharmacy or regional medical stores is not usually done and one medical assistant commented:

> *"I have been at this health centre for four years but I have had no such experience of redistribution. ... Yes, sometimes we have overstocked drugs and other medical supplies, but no action from our district pharmacy."*

Even one of pharmacy technicians said:

> *"This exercise of redistribution or adjustment is difficult to be carried out because it requires additional resources such as time, personnel, vehicles and fuel among others and these resources are already limited."*

At all four health centres I visited, they did not complain on the emergency orders. They all receive emergency orders from their respective district pharmacies. Only concern is the transport to the district pharmacy. Each health centre is responsible to find its own means of collecting emergency order from the district.

## 6.2 Different Roles in Drug Logistics Management Information System

One component of the Health Commodities Logistics Management System is a logistics management information system (LMIS) of records and reports that are used to collect and transmit information about drugs, contraceptives, and other medical supplies dispensed to clients and in storage. As products move down to health facilities through the medical supply system, information moves up the LMIS from the health centres, VCT centres, and CHAM/NGO facilities to districts and on to the regional medical stores and then to the Central Medical Stores and Health Technical and Services Support Department of the Ministry of Health. From central and mental hospitals, the information moves directly to the regional medical stores which is later consolidated with the national information. This information is used to make supply decisions to order and issue health commodities at the appropriate time and in adequate quantities.

Figure 6.1 shows that there are a number of officers responsible for managing drug logistics information at different levels. The officers are a senior logistics officer from the Health Technical and Services Support Department, a chief pharmacist from the Central Medical Stores, pharmacist-in-charge from the regional medical stores, pharmacists from the central and mental hospitals, pharmacy technicians and assistants from the district pharmacies, health centre in-charge, and in-charge from the community clinic and CHAM/NGO facilities. Each officer has a different role to play in LMIS. Health surveillance assistants also assist the drug logistics officers in management of information at the community level.

### 6.2.1 Different Roles at National and Regional Levels

At the national level, there are two senior officers that are responsible for the logistics management namely the senior logistics officer and chief pharmacist. Main responsibilities, relevant to the LMIS, of the senior logistics officer include compilation of consumption data, issues data, and stock data for health commodities at the national level; using of logistics data from the LMIS to produce health commodity forecasts; monitoring of stock status of commodities throughout the country and advising authorities where the situation requires immediate action; and ensuring availability of forms and reports to be used in the LMIS at all levels. On the other hand the chief pharmacist reports the national stock status to the senior logistics officer for discussions and takes action as needed; provides supervision to all three regional medical stores; and monitors stock movement from suppliers and within the system.

Every regional medical stores has a regional pharmacist-in-charge who ensures that all issues and receipts of health commodities are recorded on the stock card; manages the receipt and processing of monthly orders from districts for health centres and district hospitals; carries out quarterly a physical inventory of health commodities and reports to the Health Technical and Services Support

Department and Central Medical Stores on stock status; and also provides supervision and training to the district pharmacy technicians and assistants.

### 6.2.2 Different Roles at Health Facility Level

In Malawi the health facilities are in different categories depending on type of services they provide to their communities. There are mental hospitals, central hospitals, district hospitals, rural hospitals, health centres, and clinics. The pharmacy of each mental and central hospitals is managed by the pharmacist whose responsibilities in LMIS are to record all issues and receipts of health commodities for the hospital pharmacy on the stock card; to assess and inform its regional medical stores monthly on the stock status of health commodities for the hospital; to order health commodities for the hospital monthly; and to compile monthly, quarterly, and annual logistics reports which are submitted to Hospital Drug Committee and the regional medical stores.

The district pharmacies are managed by the district pharmacy technicians and assistants whose responsibilities in LMIS are to record all issues and receipts of health commodities for the district pharmacy on the stock card; to assess the stock status of health commodities in the health centers and district hospital monthly, and inform the district health office and regional medical stores; to monitor the reporting rates of forms from the health centres and clinics; to order commodities for the health centers and district hospitals; to compile monthly, quarterly, and annual logistics reports which are submitted to the district health management team and regional medical stores.

Health centres are headed by clinical officers, medical assistants, or nurses who are responsible for logistics management of drugs, contraceptives and other medical supplies. They record all issues and receipts of health commodities on the stock card; conduct a physical inventory of commodities monthly; and complete the monthly LMIS report and send to district pharmacy technician. Health surveillance assistants also help the health centres in recording and reporting of logistics information. They record every issue in the out-patient register; review the stock for every week; and complete the community clinic drug requisition forms and personally take them to the health centre in-charge for review.

For all these officers to perform their duties, they use the well-established manual called Health Commodities Logistics Management System Standard Operating Procedures Manual. This manual provides standardised operating procedures and guidelines for the management of health commodities in the integrated supply chain of Ministry of Health. The procedures and guidelines are on storage, conducting physical inventory, recording and reporting, reviewing stock status, and logistics monitoring and supervision. A few products require special handling, for example vaccines, and are managed separately.

## *6.3 Data Collection, Processing and Reporting*

Data, at each level in the drug LMIS, is collected and processed using different tools in order to produce required logistics information for decision making. The responsible level reports what it has collected and processed within a fixed period of time to the upper level which is supposed to send feedback to the lower level and concerned stakeholders.

### 6.3.1 Tools for data collection, processing and reporting

There are several forms that are used for recording and reporting of logistics data as part of LMIS. The forms include stock card, monthly LMIS reports, delivery note, district monthly aggregated order report, requisition for medical supplies, requisition and issue form, and requisition and issue voucher (see Table 6.2). Patient registers are also used in some health facilities for verifying the logistics data when reporting. In case of this thesis, stock cards and monthly LMIS reports are the mostly important ones.

| Form | Description | Where It Is Used |
|---|---|---|
| LMIS-SC | Stock Card | Clinic, CHAM/NGO facility, health centre, district pharmacy, central/mental hospital pharmacy, regional medical stores |
| LMIS-DN | Delivery Note | Health centre, district pharmacy, central/mental hospital pharmacy, regional medical stores |
| LMIS-01A | Monthly LMIS Report | Health centre, district pharmacy |
| LMIS-01B | Monthly LMIS Report | District pharmacy |
| LMIS-01C | Monthly LMIS Report | Clinic, district pharmacy |
| LMIS-01D | Monthly LMIS Report | Central hospital pharmacy |
| LMIS-01E | Monthly LMIS Report | Mental hospital pharmacy |
| LMIS-RI | Requisition and Issue Form | District pharmacy, |
| LMIS-RIV | Requisition and Issue Voucher | District pharmacy, central/mental hospital pharmacy |
| MED 194 | Requisition of Medical Supplies | District pharmacy, central/mental hospital pharmacy, regional medical stores |
| LMIS-02 | District monthly aggregated order | District pharmacy |

**Table 6.2: Types of Forms used for drug logistics data collection and reporting**

A stock card is type of a form which is used to maintain a continuous record of all transactions of drugs, contraceptives and other medical supplies and also to record results of the a physical inventory. When conducting a physical inventory and whenever issuing or receiving health commodities, it is required to update the stock card. As shown in the Table 6.2, the stock card is used at all health facilities and regional medical stores. Every transaction on the stock card contains product, date of transaction, quantity received, quantity issued, losses or adjustments, and quantity on hand. The stock cards are used to prepare LMIS monthly reports of the health facilities.

By the end of each month, each and every health facility is supposed to report logistics data of every health commodity by filling the monthly LMIS report. This is a responsibility of the health centre-in-charge, clinic-in-charge, pharmacy technician or assistant, pharmacist, and pharmacist-in-charge. Regardless on the level, the monthly LMIS report should contain facility, district, month, year, balance (stock on hand), losses/expired, days out of stock, quantity used, and quantity required (see Appendix A, B, C).

### 6.3.2 Health Center and Clinic

The health centre-in-charge completes the LMIS-01A at the end of every month in order to report information on stock balances, losses and adjustments, and quantity used by the health centre. The form is completed by using the data from the stock cards. This also applies to the clinic-in-charge. Then the form is sent by fifth day of the month to the district pharmacy technician or assistant who calculates the quantity of each health commodity required by the health centre or clinic. In case of the clinic, the form is either sent directly to the district pharmacy or via the health centre depending on the catchment area in which the clinic is located (see Figure 6.1).

Each health centre collects the forms from its respective district pharmacy monthly or sometimes quarterly. The health centre-in-charge is supposed to go to the district pharmacy on his or her convenient time to collect the forms. Sometimes the forms are collected when having meetings, supervision or training.

The in-charge of health centre or clinic needs to make sure that the data on the LMIS form is valid all the time before sending to the district pharmacy. Some health centres use registers and physical inventory to verify that the data is correct while others use only the physical inventory as one medical assistant explained:

> *"Yes. To use register to verify data is good idea but in our case that is impossible. We receive a lot of patients in a month and to check each entry in the register takes time and there are no enough personnel to do that."*

A physical inventory is the process of counting by hand the total number of each drug, contraceptive, and other medical supply item in a store or health facility at any given time. The main purpose is to (1) verify the quantity of usable stock available for distribution; (2) identify discrepancies between actual supplies and the stock balance on the stock card; and (3) detect damaged or expired items; and (4) provide opportunity for store reorganisation.

### 6.3.3 District Pharmacy

The district pharmacy technician or assistant reviews the LMIS-01A and LMIS-01C forms carefully when they are received from the health centre and clinic respectively. The technician then calculates the quantity required but this can be adjusted according to the technician decision due to some factors such as availability of health commodities, consumption in previous months among others. The district pharmacy technician and pharmacists of central and mental hospitals also complete their respective forms including the quantity required using the stock cards. The stock cards are updated as it is done at the health centre.

In order to determine whether a health facility is adequately stocked, overstocked or understocked, it is required to review stock status by determining how much of each drug, contraceptive, and other medical supply item is available at the health facility and how long the stocks will last (known as months of stock). The months of stock are determined by comparing the amount of the product that is in storage (stock on hand) with how much has been dispensed in the previous month (quantity used). Once stock status has been determined for each health commodity of the clinic, health centre, district, central or mental hospital, actions to be taken should be decided in order to correct any discovered overstocking or understocking.

At the district level, there is the software system, the Supply Chain Manager, which is used to provide critical logistics information to the district health management team and regional medical stores. All LMIS reports from the health centres, clinics and district pharmacy in a particular district are captured into the software system and then it calculates the quantity required of each health commodity for each health facility and determines which facilities are adequately stocked, overstocked or understocked. It also reviews trends in consumption on a product-by-product basis and identifies facilities with potential inventory management problems.

The district pharmacy technician or assistant reviews the stock status of the reporting health centre, clinic and district hospital. This is important monitoring activity to ensure that there are always adequate stocks available in all health facilities in the district. The pharmacists of central and mental hospitals also review the stock status of their respective hospitals. With the computerisation of the recording and reporting of logistics information at the district level, this activity is simplified. The software system generates the stock status reports and other logistics reports that are used to review stock status of a particular health facility.

All required reports such as stock imbalances report, monthly LMIS report – summary, and monthly LMIS report– individual (see Appendix D, E), are printed and sent to the regional medical stores by tenth day of the month. The stock imbalances report is for indicating all health facilities that are understocked or overstocked on particular drug, contraceptive and other medical supply item. The summary monthly LMIS report accumulates the stock on hand, quantity used and quantity required of each and every health commodity for the district. The individual monthly LMIS report is similar to the summary report and only difference is that it is for a particular health facility.

### 6.3.4 Regional Medical Stores

The regional medical stores expects to receive all reports from all health facilities in their respective regions by tenth day of each month. The regional medical stores use these reports to determine what health commodity and quantity to be supplied to a health facility. The reports are also used to prepare reports such as monthly drug stock status report, essential drug trace report, and distribution report that are sent to the Central Medical Stores. The regional medical stores also conduct the physical inventory quarterly with the same purpose as the health facilities.

Each regional medical stores has employed a logistics officer who goes around the region to collect logistics data from the district pharmacies in every month. The logistics officer collects the electronic data into his/her laptop computer. This minimises delays of the reports from some districts due to distance and transport problems and also lack of resources such as papers, functional printers, or printer toner/ink to print those reports. Like at Mulanje district health office, sometimes the pharmacy technician uses printers from other offices to print his reports.

## 6.4 Feedback at all levels

It was found that the feedback is available at all levels of the LMIS. There is a good communication between the national and regional levels, the regional and district levels, and the district and health centre levels. The feedback is in the form of reports, supervision, meetings, training and medical supplies.

As explained earlier, the regional medical stores sends different reports to the Central Medical Stores for decision making process. In turn the Central Medical Stores response accordingly by conducting supervisory visits to all the regional medical stores and provide feedback and on-the-job training, as necessary, every quarter. When there is a need of emergency order from the regional medical stores, the Central Medical Stores responds as quickly as possible.

The regional medical stores, in response to the health facilities in its region, sends monthly drug distribution schedule, and newsletters for new drugs and any other developments. The regional pharmacist-in-charge also provides supervision to the district pharmacies as a requirement. The regional medical stores tries its best to respond to emergency orders from district pharmacies as soon as possible.

Most health centres get enough support from the district pharmacies on health commodity logistics issues which makes the health facilities not run out of essential drugs. When there is an emergency order, the district pharmacy makes sure that the requested drugs are sent to concerned health facility. During the interviews, a nurse emphasised:

> *"There is no stock out of essential drugs at our health centre. We get enough from the Central Medical Stores and also from the district health office for emergency orders."*

Supervision and training are also provided by the district pharmacy technician or assistant to the health facilities where and when necessary.

## 6.5 General Problems in drug LMIS

There exist problems at each level of the logistics management system and some are common to different levels. The problems that are faced at the regional medical stores include:

- late reporting from some districts which affects the distribution of the health commodities to the health facilities in that district because of “no report no drug” policy;
- lack of vehicle and fuel for distribution of the health commodities to individual health facilities;
- shortage of manpower at the warehouse which forces sometimes “packers” (people who pack health commodities for deliveries to the health facilities) to fill data collection forms but with supervision;
- currently there is no software system therefore much of the work is done manually
- *“According to my experience, sometimes data from some health centres and districts is not correct.”*, the regional pharmacist-in-charge pointed out. *“They just guess or ‘cook’ figures.”* he added.

At the district level, main problems are:

- lack of personnel therefore available pharmacy technicians are overloaded with work;
- late reporting or even not reporting from the health centres and clinics;
- lack of transport and fuel for supervisory visits to the health centres and clinics and due to lack of transport, even one day I gave the in-charge of Thuchila health centre a lift from Mulanje district health office when I went to collect some data;
- sometimes some health centre-in-charges fill the LMIS reports right there at the district health office when they come to perform other duties, which likely brings invalid data;
- sometimes the computer system and/or its peripherals do not work when they are needed the most.

The health centres have their own problems which include:

- migration of people from neighbouring catchment areas or districts because some health centres are closed on certain days of the week and others, like Thuchila, are near trading centres or markets which are visited by people outside the catchments area who need health services from those health facilities;
- staff is not enough and sometimes labourers are asked to help on basic activities but with supervision;
- inconsistent drug supply due to theft within the health centres by staff and poor storage, like at Chambe health centre there is a lot of mice that destroy drug and documents;
- lack of LMIS forms and for example, at Chambe health centre the in-charge gets only one

LMIS form in a month otherwise when lost or damaged it is difficult to get another one as quickly as possible.

## 6.7 Drug LMIS and Health Management Information Systems

In the health management information system (HMIS), as shown in the Figure 6.2, the information is originated from the health facilities and sent to the district health office (DHO) and then the Ministry of Health. The lower level receives feedback accordingly from the higher level.

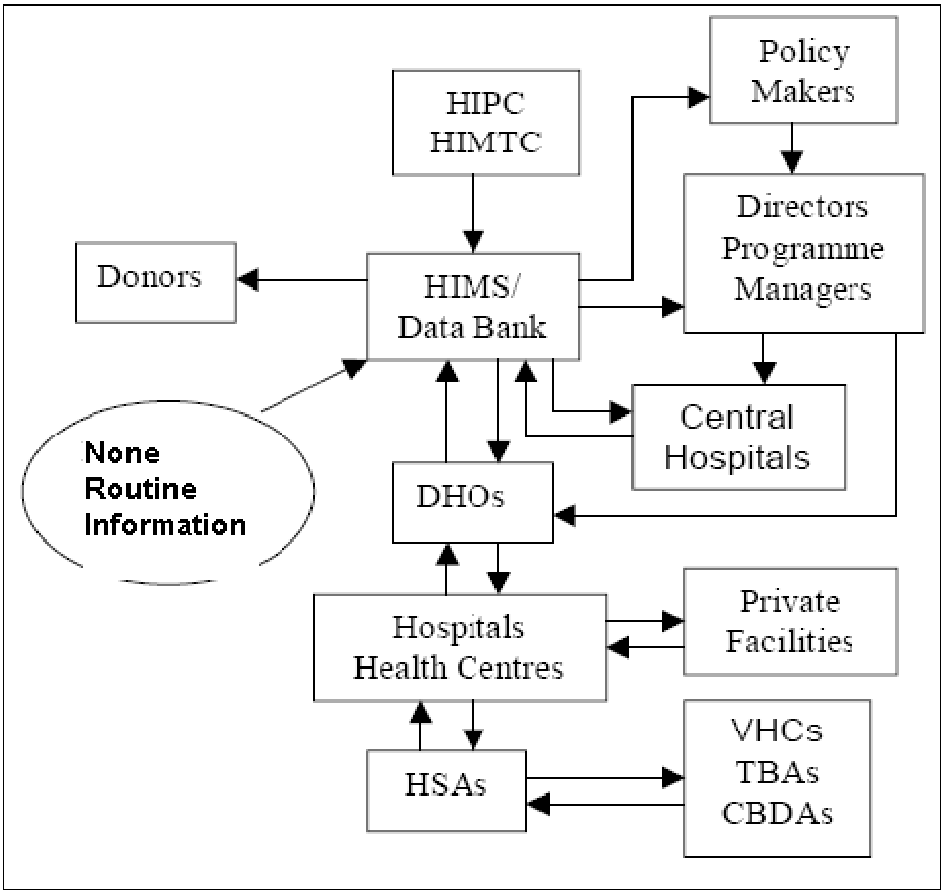



**Figure 6.2: Information Flow in Health Information System in Malawi (Source: Ministry of Health and Population, 2003b, p. 21)**

A catchments health facility collects data from all public and private facilities in its catchments area and performs analysis on monthly basis and takes necessary actions aimed at improvement in management of health programmes. The district health office receives data and reports quarterly from all catchments health facilities in its district. By using a computer system called District

Health Information System (DHIS), a statistician compiles reports quarterly which are used for decision making at the district level. The district health offices and central hospitals send the raw health data quarterly to the Ministry of Health for data analysis at the national level.

### 6.7.1 Similarities and differences between drug LMIS and HMIS

By comparing the HMIS with the drug LMIS, there exist similarities and differences as explained below:

- **Data Collection:** In both systems, data is collected at the health facility level by the same health staff on daily basis while performing their official duties but the drug LMIS uses different forms for data collection from those used in the HMIS. The HMIS uses catchments health facility as a data collection point in a particular catchments area and any other health facilities report to it except the central and mental hospitals. The drug LMIS uses any health facility as a data collection point provided it gets health commodities from a district pharmacy and/or the regional medical stores. At the end of each month the both logistics and health data are aggregated and analysed ready to be forwarded to the upper level.
- **Reporting:** Both logistics and health data from the health facilities in a district are sent to the district health office for data analysis at the district level and then to be used by the district health management team and stakeholders. The logistics data is sent monthly to the pharmacy technician or assistant while the health data is sent quarterly to the statistician. From the district health office, the health data is sent quarterly to the Ministry of Health while the logistics data is sent monthly to the regional level (regional medical stores) and then to the Central Medical Stores and Ministry of Health.
- **Data Processing at district health office:** It was observed that the most of data processing is done at the district level using computer software systems. The statistician uses the DHIS (computerised information system) to compute the health data and the pharmacy technician uses the Supply Chain Manager (also computerised information system) to process the logistics data. Both systems were developed in Microsoft Access and are running on the same platform, Windows operating system.

# 7.0 RESEARCH FINDINGS ON GIS PROTOTYPE

The second objective outlined in the Chapter 1 is to identify opportunities and challenges of using GIS in the drug LMIS through development and evaluation of the GIS prototype. Therefore, this chapter describes findings from the evaluation of the GIS prototype.

## 7.1 Findings on the spatial data

In Malawi there is an effort on the GIS application in different sectors and institutions and collection of the spatial data. For example, the National Statistical Office collects spatial data to be used in various surveys and census; the Roads Authority also collects its own spatial data for road network planning and design; and the Survey Department also collects spatial data for town planning and development among other uses. The Ministry of Health is not remaining behind on the GIS. It has the policy on GIS and each district health office has the Global Positioning System (GPS) for getting geo-references for new health facilities and disease outbreak although training has not been provided on how to use the equipment.

The geographical data for the GIS prototype was collected from the Roads Authority and Survey Department of the Government of Malawi in the form of “shapefiles”, PDF and image. Mainly, the data include health facilities, roads and rivers, district boundaries, among others. The maps in PDF and image formats have detailed features including contours (see Appendix H & I). The maps in PDF format require to be converted into the image format so that they can be accessed by GIS software like ArvView GIS.

The shapefiles are easy to use in the ArcView GIS as compared to image and PDF files which require transformation or digitisation into the shapefiles. Another advantage of the shapefiles is the availability of database files which can be linked very easily to other software application, for example Visual Basic and Microsoft Access. With these reasons it was decided to use only shapefiles in the GIS prototype.

The required spatial data for the GIS prototype include the administrative district boundaries, road networks, cities, and health facilities. It has been observed that it is required to update the spatial database in order to make it accurate before using in the GIS. The health facilities are grouped according to administrative districts which are also considered as the health districts. But one district called Neno is missing. In 2003 Mwanza was split into Neno and Mwanza districts under the decentralisation program but government implementation was not complete until 2007 and most of the geographical data of Malawi, used in this research, were created before 2007. Similarly, in 1998 Machinga was split into Balaka and Machinga, and Mulanje was split into Phalombe and Mulanje but their administrative offices were implemented earlier than Neno (see Figure 7.1). In this case it means that all health facilities, that are supposed to be under Neno district, are under Mwanza district. This will bring administrative problems to the regional medical stores and higher levels if this spatial data is used in the GIS. Even Neno and Mwanza district health offices will have difficulty to use the GIS with this spatial data in the drug LMIS.

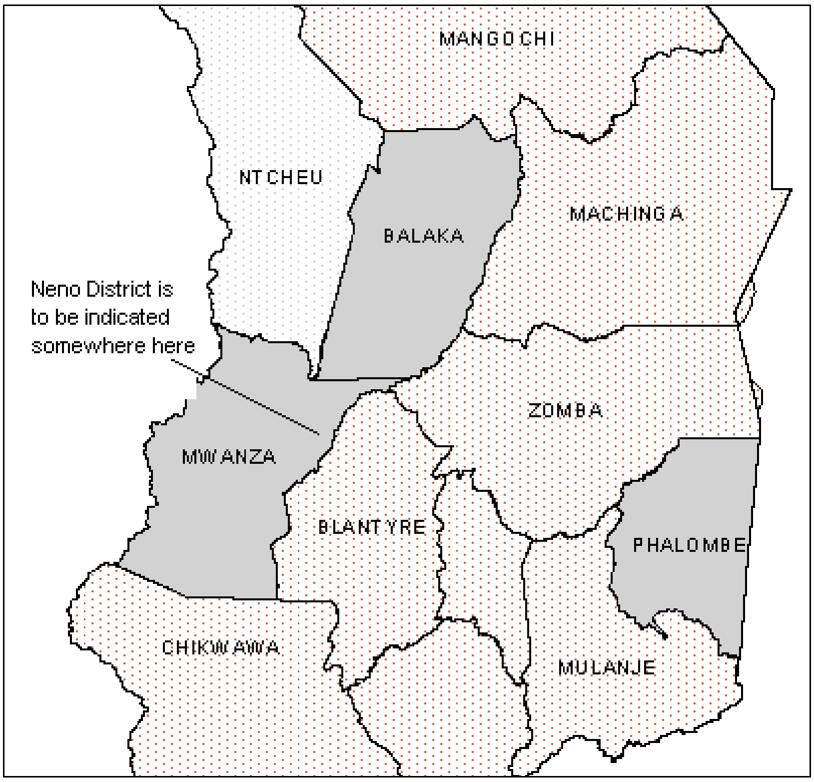



**Figure 7.1: Part of Southern Region of Malawi showing position of Neno District**

Apart from the administrative district boundaries, the drug LMIS also requires the road networks and health facilities. The spatial data on road network is almost complete and accurate with appropriate codes and road class such as main road, district road, secondary road and tertiary road (see Appendix J). In logistics, a good network road is essential and all roads must be well labeled both physically and on the map. It has been observed that some roads cross administrative boundaries especially at the regional level. For example, roads in the southern region cross the boundaries as shown in Figure 7.2. This shows a problem of data inaccuracy.

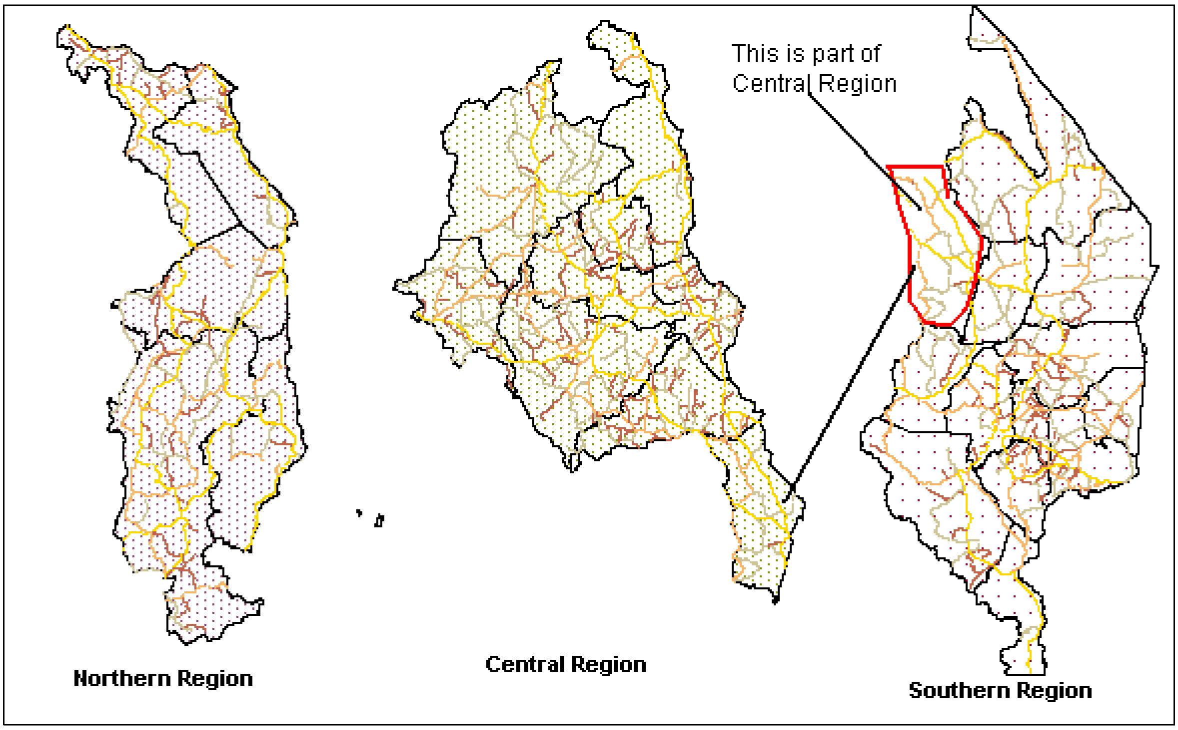



**Figure 7.2: Road Networks in Northern, Central and Southern Regions in Malawi**

The shapefiles for health facilities contain all required catchments facilities for Blantyre and Mulanje as health data collection points as described earlier but for the logistics data some health facilities are not available in the shapefiles. For example, there are over hundred health facilities in Blantyre but the shapefiles contain only thirty-four health facilities from which twenty-one are catchments facilities (see Figure 7.3 and Appendix F). The catchments facilities are also for the drug LMIS with addition of Blantyre district health office and CHAM facilities of Lumbila and St Vincent but these additional facilities are not available in the shapefiles. With this situation, only the catchments health facilities were used for demonstration of the GIS prototype.

In some places health facilities are physically located in one district but administratively they report to another district. As shown in the Figure 7.3, one health facility (Chavala), in the south west of Blantyre, is physically located in Chikwawa but administratively it reports to Blantyre district health office. During the evaluation at the Blantyre district health office, one of the pharmacy technicians commented:

> *"Chavala health centre is in Chikwawa but it reports here at Blantyre district health office because people need to cross rivers to Chikwawa district health office. It is easier to come here."*

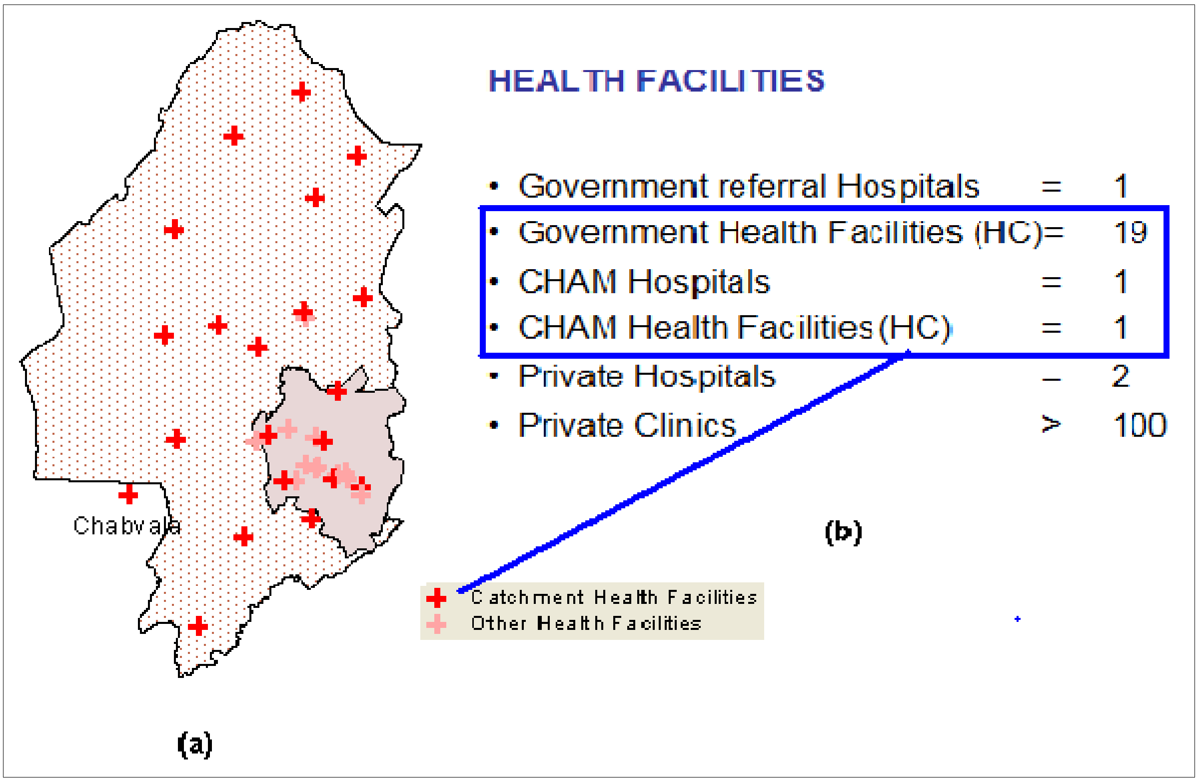



**Figure 7.3 (a) Catchments Health Facilities**

**(b) Number of Health Facilities in Blantyre**

**(Sources: (a) The GIS Prototype, (b) Blantyre District Health Office)**

## *7.2 Findings on the non-spatial data*

The non-spatial data for the GIS prototype was divided into two groups. There were attributes that describe the health facilities such as names, type, district, and facility identity or code (see Appendix G). All health facilities are classified as clinics, health centres, hospitals, etc. and belong to respective districts but some health facilities are missing the codes or IDs and the codes are not consistent. The codes are in four digit format but some have less or more than four digits or start with letter “T”.

Second group of attributes or non-spatial data consists of the drug logistics and health data from the drug LMIS and health information system (HIS) respectively and readily available. For the data to be integrated with the spatial data, it is necessary to find out the common attribute like health facility code. In the case of the GIS prototype, the facility name was used to integrate the spatial data with the drug logistics and health data because names are common in all three systems (GIS, drug LMIS and HIS) (see Appendix D, F, & G). But the facility name is not good attribute for integration because health facility can change its name any time or two or more health facilities can have similar name. For example, in Mulanje there are a clinic under NGO (Banja La Mtsogolo), a rural hospital under CHAM and a district hospital under the Government of Malawi bearing the same name “Mulanje”. So it is very important to use unique attribute such as the code and what is needed is just to update all codes of the health facilities and maintain their consistence in all three systems (GIS, drug LMIS and HIS).

### 7.2.1 Anti-malaria drugs and malaria cases as non-spatial data for the GIS prototype

Malaria cases were used as sample non-spatial health data for the GIS prototype, as explained earlier. They are collected monthly at the catchments health facility level as any other health data and grouped using age group of less than five years and equal to or greater than five years (see Appendix F). The data of malaria cases is presented as raw figures when reporting to the next level, that is, from the health level up to the national level. During the analysis each level can decide how to present the malaria cases such as by using graphs and tables. Even one of statisticians commented:

> *“I cannot remember presenting the malaria cases in any other formats apart from the raw figures to the next level. ... We just send it as raw figures.”*

The drug logistics data is also collected as raw figures from the health facilities. In the case of anti-malaria drugs, the Lumefantrine Artemether (LA) is used as the first line drug for malaria while quinine is for severe malaria. The Sulphadoxine/Pyrimetherine (SP) is for pregnant women. The anti-malaria drug dosage is given to a patient based on his/her body weight and not age group. For instance, when a patient is suffering from severe malaria whether under five years or not, his/her body weight is checked in order to get the right dosage of quinine. This also applies to the LA with a minimum patient's weight of five kilograms. Although the body weight is used to determine the dosage, it is not included in the data collection. The LMIS form only indicates accumulated amount of a particular anti-malaria drug given to patients in a particular month.

In this situation, it is difficult to match particular anti-malaria drug consumption with malaria cases. For example, to know which malaria cases were on quinine or LA 6x1 in the previous month is hard using the available data.

## 7.3 Feedback from Evaluation on GIS Prototype

The GIS prototype was demonstrated on different times to three different offices in Blantyre. It was very difficult to find common time convenient to all participants to attend the demonstration, therefore, the GIS prototype was demonstrated at Blantyre district health office to pharmacy technicians, statisticians and at the regional medical stores to pharmacist-in-charge separately in their convenient times. All participants were very interested with the GIS prototype and recommended to apply this technology in the drug LMIS and also in health information system at the district level.

Depending on the feedback from the participants, it has been observed that at the district level, the GIS can help in many areas such as:

- The GIS can be used to determine how far the health facilities are away from the district pharmacy and this information can help the pharmacy technicians in management of vehicles and fuel. Even the pharmacist-in-charge commented that the GIS could be helpful in planning and management of transport system at the regional medical stores when delivering health commodities to health facilities.
- The GIS can integrate data from different systems such as the drug LMIS and health information system in so doing the managers can get all necessary information as quickly as possible by “clicking a button”, instead of getting it separately from different sources. The pharmacy technicians felt that it would be very helpful to integrate the GIS with the Supply Chain Manager so it can get the drug logistics data directly from the system and reported in a form of maps. They were happy with the integration of the drug logistics data with health data because they need that data in their decision making on drug supplies to the health

facilities.

- The GIS can be used by different officers like district health officers, environmental health officers, and statisticians, instead of only the pharmacy technicians, since these officers also require the same data for day-to-day work.
- A GIS map can be helpful in human resource (health staff) allocation to health facilities by transferring the staff between health facilities that are close to each other. Through the map it is easy to know which facilities are close to each other. It is believed that this minimise logistics costs of transferring staff. But this to happen there is a need to integrate the GIS with the human resource database.

During the demonstration of the GIS prototype, the pharmacist-in-charge at the regional medical stores commented:

> "*This GIS can also be useful to the Senior Logistics Officer, from Ministry of Health headquarters, in planning and distribution of health commodities especially when combined with disease patterns.*"

On the issue of user training, one of the pharmacy technician said:

> *"We have been promised training on computer technologies but it is now three years without any training. We are just waiting."*

even the statistician also commented,

> *"The GIS is in great need to our section but the problem now is training. ... . One day I was asked by one NGO to provide data on catchments population 5 km around each health facility in Blantyre but I could not manage because I do not know how to use the GIS program."*

This shows that the GIS can be used by different officers and managers at the district health office for various purposes and also from different levels: district, regional and national levels as suggest and in order to apply the GIS effectively in the drug LMIS, it requires enough training to the technicians and management. It seems the training provision on computer technologies is a great problem in the Ministry of Health.

# 8.0 ANALYSIS OF FINDINGS

This chapter analyses the research findings by using the theoretical framework with concepts of social systems and installed base drawn in Chapter 3. It is considered that drug logistics management information system (LMIS) and Geographic Information System (GIS) are information systems and as well as social systems from which the drug LMIS is the installed base that would be extended and improved in order to accommodate the GIS as a new installed base.

## *8.1 Drug LMIS and GIS as Social Systems*

Since information systems consist of humans (people), organisations and technologies, they can be considered as social systems. The social contexts and technological artefacts are perpetually interacting and shaping each other. Before considering the drug LMIS and GIS as social systems, it is necessary firstly to answer this question: "*Are drug LMIS and GIS information systems?*"

### 8.1.1 Drug LMIS and GIS are Information Systems

Depending on the definition of the information system from Boddy et. al (2005) and Twati (2006), every information system requires people, procedures and processes which include the data collection, processing, storage and dissemination of information with the aim of supporting decision making, control, analysis and visualisation in an organisation. These requirements are also available in the drug LMIS and GIS as described in the research findings, which demonstrate that both systems are the information systems.

The drug LMIS needs people at all levels, that is, from the health facility up to the national level who are responsible for data collection, processing, analysis, reporting and information use. These processes are carried out using variety of tools such as LMIS forms, stock cards, registers, papers, computer hardware and software and bound by operating procedures, policies, and standards. The drug logistics information is used at the district, regional and national levels for decision making, planning, controlling, coordination, assessment, among others.

Similarly, the GIS experiment has shown that the GIS in the drug LMIS requires people, especially at the district level, to be responsible for collecting and updating data (particularly spatial data), processing, analysing, integrating spatial and non-spatial data, reporting and using information. The required resources include computers, printers, GIS software tools, documented maps, GPS, scanners, digitisers, and papers. The spatial information would be used mainly at the district level. There already exist policies on the GIS and it is required for procedures and standards to be defined on spatial data collection, sharing and integration.

The GIS prototype has demonstrated that the GIS could be used as a tool for reporting information by displaying the drug logistics and heath data on the map. Even Pick (2005) points out that the GIS can be seen as an information reporting tool by presenting spatial and attribute data on map. Currently, the reports from the drug LMIS are in table form and the GIS could be used to report the information on the map by adding the spatial data but the GIS prototype has required other processes, apart from reporting the spatial information, such as spatial data collection and updating, manipulating the drug logistics and health data and integration with spatial data, and storing data. From this observation, it can be argued that this GIS prototype has also been considered as a subsystem of the drug LMIS on the information reporting.

By summarising, both drug LMIS and GIS are considered as the information systems. For the GIS to be used in drug LMIS, it would be taken as the subsystem in the part of information reporting at the district level and some data, such as drug logistics data, health data, and health facilities, need to be updated and manipulated depending on needs of users before being presented on the map. The GIS would depend on the drug LMIS in terms of resources including mainly existing human capacity, technology, data, policies, and procedures.

From the discussions above, both the drug LMIS and GIS require people, organisation and technology as Kunda (2001) suggests three important perspectives of the information system namely human dimension, organisation and technology. Therefore, in the next three sections the drug LMIS and GIS are analysed in terms of these perspectives.

### 8.1.2 Human Perspective of drug LMIS and GIS

The information systems cannot be understood independently of people around them (Mukama et. al., 2005) and the human perspective highlights various needs of the individuals that use information technology to perform the jobs. People include staff and managers who enter data into the system and those who receive information from it and use the results. These concepts also apply to the drug LMIS and GIS.

The drug LMIS requires data collection, processing, analysis, reporting and information use in various levels and all these processes need people (see Table 8.1). The drug logistics data is collected at the health facility by the health staff and reported to the district pharmacy technicians for processing and analysis. People from the regional and national offices of Central Medical Stores get the processed data and analyse it for the use at the regional and national levels respectively. The drug logistics information is also used at the district by the pharmacy technicians, district health management team, and stakeholders. This means that the drug LMIS cannot function without people.

| Activity | Level | Human Resource |
|---|---|---|
| Data Collection | Health Facility | Health Centre-in-Charge, HSA, Pharmacy Technician, Pharmacist |
| Data Processing & Analysis | District, Regional, National | Pharmacy Technician, Pharmacist, Logistics Officer, Chief Pharmacist, Senior Logistics Officer, Pharmacist-in-charge |
| Information Use | District, Regional, National | Pharmacy Technician, Pharmacist, district health management team, Logistics Officer, Stakeholders, Pharmacist-in-charge, Chief Pharmacist, Senior Logistics Officer |

**Table 8.1: Human Resource Needed in Drug LMIS**

The processes of data collection, processing and analysis, and information use existing in the drug LMIS explained above would be also required in the GIS with extensions or additional processes. The GIS experiment has shown (see Table 8.2) that apart from data collection, it is necessary to update the spatial data and attributes especially on health facilities, road networks and other important features and also to integrate the spatial data with non-spatial data. All processes would require well skilled people particularly on data collection, updating and processing.

There exist several categories of staff at different levels in the drug LMIS with different roles. They are well trained in specific health fields such as pharmacies, logistics, nursing, clinical and medical sciences. The availability of these human resources will support the application of GIS in the drug LMIS, especially the pharmacy technicians and statisticians who have already skills, knowledge and experience in computing, but from the research findings, the drug LMIS is experiencing a shortage of staff which will affect the application of GIS in terms of human capacity. Another issue to consider is the GIS technology transfer to the drug logistics and health staff in order to provide all necessary technical support. Both drug logistics and health managers and staff will require the GIS training as Ginger (2005) and Saugene (2005) emphasise that it is necessary to have well skilled technicians to support the GIS. The drug logistics and health managers also require the knowledge of GIS for better decision making about its use.

| **Activity** | **Level** | **Human Resource** |
|---|---|---|
| Data Collection and Updating | District | Pharmacy Technician, Health Staff |
| Data Manipulation, Integration, & Analysis | District | Pharmacy Technician |
| Information Use | District, Regional | Pharmacy Technician Logistics Officer, Stakeholders, District Health Management Team, Pharmacist-in-charge |

**Table 8.2: Human Resource Needed in GIS Subsystem**

Since there are a number of officers responsible for managing drug logistics data and information at different levels and the proposed GIS would also require people, they need resources and to understand policies, procedures and standards which govern the work processes, thus the organisation.

### 8.1.3 Organisation Perspective of drug LMIS and GIS

The drug LMIS is one of the components of the health commodities logistics management system of the Central Medical Stores in the Ministry of Health of the Malawi Government. The Central Medical Stores is an organisation having structure, goals, procedures, policies, standards, and so on. It has a well defined structure having different levels of management (see Figure 6.1) in which the personnel and other resources are organised according to their responsibilities and use with one goal of ensuring that all Malawians are able to receive the products they need, and receive quality treatment when they visit a health facility.

In the drug LMIS, there are policies, procedures and standards that are used to control the flow of the drug logistics information. The policies include "no report no drug" and fixed time table of sending reports to the upper level (see Table 8.3). According to responses from participants, it has been found out that these policies have brought discipline to health facilities on sending reports on time in every month although there are some few problems of late or no reporting and data quality as discussed in Section 8.2 below. The well documented operating procedures (DELIVER, 2006b) are available at all health facilities and pharmacies for guiding daily operations on the drug logistics.

| From | To | When to report | Responsibility |
|---|---|---|---|
| Health Facility | District Pharmacy | By 5th of every month | Health Centre-in-Charge, Pharmacy Technician |
| District Pharmacy | Regional Medical Stores | By 10th of every month | Pharmacy Technician |
| Central/Mental Hospital Pharmacy | Regional Medical Stores | By 10th of every month | Pharmacist |
| District Pharmacy | District Health Management Team, Stakeholders | Quarterly and when requested | Pharmacy Technician |
| Central/Mental Hospital Pharmacy | Hospital Drug Committee | Monthly and when requested | Pharmacist |

**Table 8.3: Time for Sending Drug Logistics Reports to Next Levels and Stakeholders**

Standards are also observed mainly on data collection, reporting and processing which are achieved by: (a) training and supervising responsible staff at all levels on how to collect, report and process data; (b) using standard LMIS forms for data collection and reporting from health facilities and standard software system (Supply Chain Manager) for data processing at all district pharmacies; (c) identifying essential data to be collected at the health facilities; (d) updating drug list on the standard LMIS form; (e) verifying collected data through conducting monthly physical inventory.

There are several categories of the drug logistics staff and therefore, it is important to have good mechanism of communication for easy flow of information from one level of management to another and at the same level. In the drug LMIS different ways of communication have been observed such as reporting, feedback and meetings. As shown in the Figure 8.1, each level prepares reports which are sent to the next level and in return it gets a feedback in the form of the medical supplies, supervisory visits, training and newsletters. The district health management team conducts meetings for every three months to assess the health programs in its district and it needs the logistics reports from the pharmacy technicians among reports from other systems and programs. This also applies to the hospital drug committees of the central hospitals who meet monthly and at these meetings they need drug logistics reports from their respective hospital pharmacies.

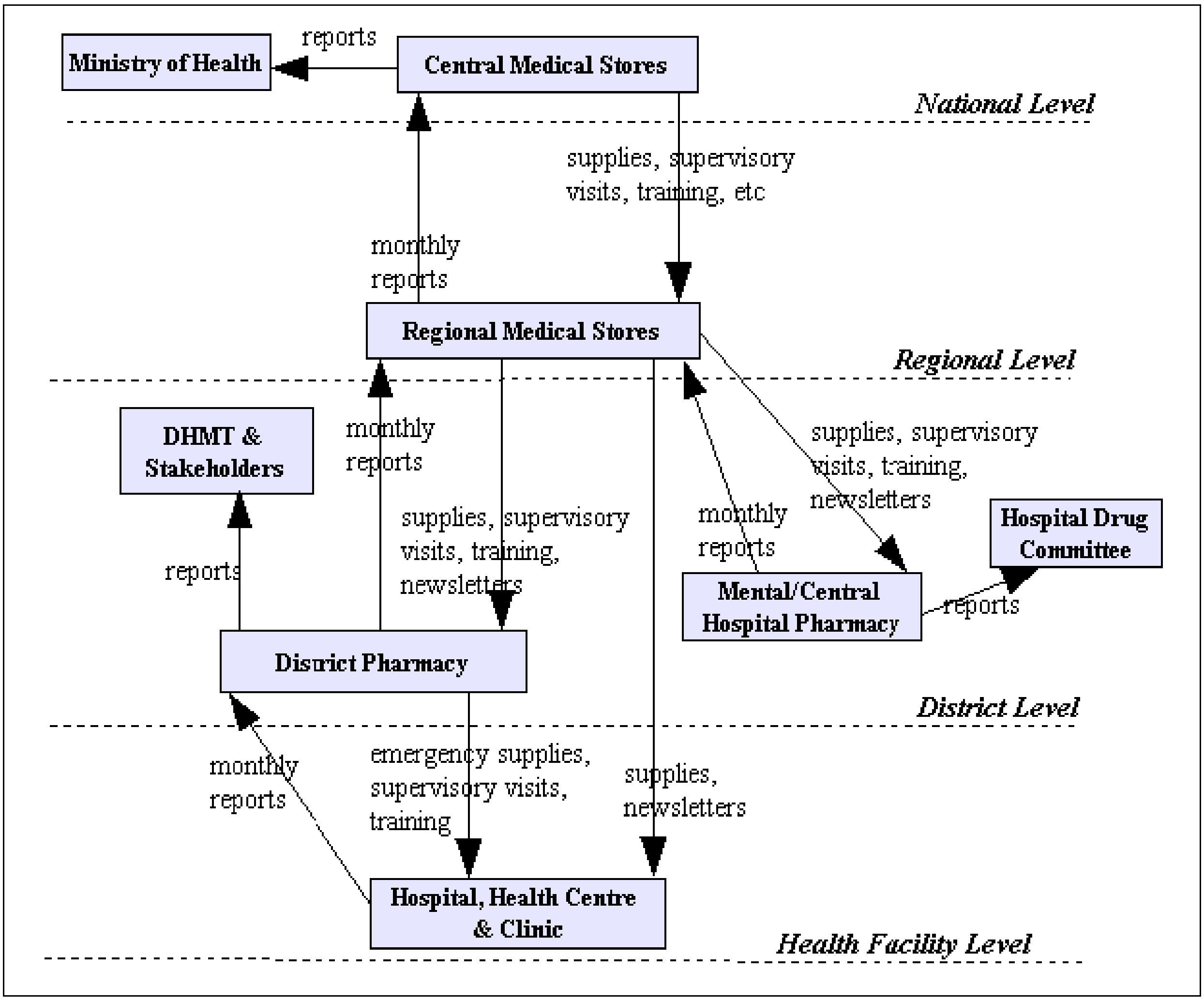



**Figure 8.1: Information Flow and Feedback between Levels in the Drug LMIS**

Since it has been demonstrated that the GIS could be the subsystem of the drug LMIS as the part of information reporting, the proposed GIS would be used in the same organisation of that of the drug LMIS, Central Medical Stores, which has well defined structure, procedures, policies, standards and communication mechanism. It has been proposed that the GIS would be used at the district pharmacy because it is where all drug logistics data in a district are processed and sent to all necessary “bodies” or parties for use in decision making.

In order to control the performance of various processes of the proposed GIS as discussed above, it is important to set up all required standards, procedures, policies and communication mechanism. Apart from the communication between levels of management and at the same level in the drug

LMIS, it is also required by the Central Medical Stores to establish well communication and work partnerships, particularly on the spatial databases, with other organisations that deal with the spatial data for easy data sharing and integration.

The GIS experiment has demonstrated that it is necessary to maintain standards of data in order to achieve data sharing and integration goals. The spatial data is always shared and integrated with non-spatial data as shown in the experiment that the Ministry of Health has no spatial datasets so depending on other institutions. These institutions collect the spatial datasets with specific purposes that are different from those of the Ministry of Health therefore standards are important. The spatial data has been integrated with drug logistics and heath data in order to have the required information from the GIS. Data exchange standards have key role to play for facilitating the integration of datasets from various distributed sources or organisations and lack of these required standards between organisations impedes data sharing (Ginger, 2005; Croswell, 1991).

Currently, the GIS policies are availability. It is needed to set up specific GIS policies on spatial data for Central Medical Stores as it was done with the drug LMIS but they should be aligned with those of the Malawi Government in general and the Ministry of Health in particular. It is also necessary to draw standard procedures on spatial data collection, processing, sharing, integration, and other processes. These policies and procedures will help to maintain data and service quality of applying the GIS in the drug LMIS.

### 8.1.4 Technology Perspective of drug LMIS and GIS

As shown in Table 8.4, the logistics data collection at the health facility is fully manual. The data is collected using forms, registers, and cards. While at the district level, the pharmacy technicians and assistants have computers, software, and printers that they use to process and produce the reports which are sent as hard copies to the district health management team and regional medical stores. The central and mental hospital pharmacists also use computers for data processing and send logistics reports as hard copies to the regional medical stores.

From the GIS experiment, it has been found out that the collection and updating of spatial data require some equipment such as GPS, computers and GIS software which means that this system is not manual as in the case of the drug LMIS but referred to as a computerised system and performed at the district level (see Table 8.5). This also applies in data integration, processing and analysis except the information reporting which is to be manual as in the drug LMIS since the GIS subsystem is to enrich the existing information reporting and its reports are to be sent as hard copies. All processes for the GIS application would be done at the district level.

| Activity | System | Level | Resources |
|---|---|---|---|
| Data Collection | Manual | Health Facility | Forms, registers, cards |
| Data Processing & Analysis | Computerised | District | Computers, software, printers |
| Information Reporting | Manual | District | Hard-copy reports |

**Table 8.4: Technologies in the Drug LMIS**

| Activity | System | Level | Resources |
|---|---|---|---|
| Data Collection & Updating | Computerised | District | GPS, computers, GIS software |
| Data Integration, Processing & Analysis | Computerised | District | Computers, GIS software, printers |
| Information Reporting | Manual | District | Hard-copy reports |

**Table 8.5: Proposed Technologies of the GIS Application in the Drug LMIS**

### 8.1.5 Drug LMIS and GIS as Social Systems

From the analysis above, it has been seen that both the drug LMIS and the GIS subsystem require people who perform variety of activities by using different technologies and being bound by goals, policies and procedures of Central Medical Stores as an organisation. The people, technologies and organisation are related and influence each other. Both drug LMIS and GIS cannot function without drug logistics and health staff who require materials, equipment, and managerial support from the organisation to perform day-to-day activities with, in mind, specific goals to achieve and communication channels, procedures, policies and standards to observe. Therefore, they are considered as social systems.

## *8.2 Determining Quality of Drug LMIS and GIS data Using Six Rights for LMIS Data*

The six “rights” for LMIS data suggested by DELIVER (2004), as explained in Chapter 3, have also been observed in the drug LMIS. These “rights” are factors to determine the reliability of logistics data for decision making at different levels. The logistics managers must receive the *right* data, in the *right* time, at the *right* place, in the *right* quantity, in the *right* quality, and for the *right* cost. The same "rights" would be used to determine the quality of data in the GIS since the proposed GIS would use the same data but with some extensions. Every data must be complete, timely, accurate, cost-effective, and consistent among others.

### 8.2.1 The Right Data

The drug LMIS ensures that all logistics managers receive all essential data which includes stock *on hand*, *quantity used* and *quantity required*. This data is considered essential in the sense that it is used to determine the stock status of each health commodity which is the main information for the logistics decision making by the logistics managers at the district and regional levels.

For the GIS, this is the same data to be used for reporting logistics spatial information since the stock status would be presented using maps but the stock status alone is not enough. The GIS experiment has shown that the GIS would also require essential spatial data which includes the administrative boundaries of districts and cities, health facilities, road networks and others that could be required time to time by the logistics managers, for example, disease patterns.

The main challenge is the lack of personnel which results in work overload. This forces some health facilities to use other staff to collect the logistics data even when the responsible personnel are available. This brings the problem of the data quality because these people have not been trained on data collection. Currently, there is no logistics or health staff trained in the spatial data collection and updating for the GIS at the district level. Therefore, training should be considered.

### 8.2.2 The Right Time

The essential data is supposed to be available in time for the logistics managers to take decision. In the drug LMIS, this is achieved by setting deadlines for receiving reports from the lower levels (see Table 8.3). Although there is the fixed time table for reporting the logistics data, there is still a problem of late or even not reporting from the lower levels which affects the distribution of the health commodities to concerned health facilities because of "no report no drug" policy.

If the pharmacy technicians receive data, including spatial data, in time, it means that the GIS subsystem will provide updated spatial information to the logistics managers and other users. It can be good for the Ministry of Health to cooperate with other institutions that involve in spatial data management in the country so it can get all necessary updates on the spatial data in time. This cooperation is also important between departments in the Ministry of Health for easy spatial data sharing.

### 8.2.3 The Right Place

It has been observed that the essential logistics data is always sent to where decisions are made such as the district pharmacies, district health management team, and central/mental hospital pharmacies and their hospital drug committees, regional medical stores, central medical stores and ministry itself (see Figure 8.1). The right place to send the spatial data is the district pharmacy because it is where the GIS subsystem would be used and other users would just get the spatial logistics information.

### 8.2.4 The Right Quantity

The district pharmacies make sure that all their respective health facilities report essential data every month so that they can have complete data. The policy of "no report no drug" forces the health facilities to report data with fear of not receiving health commodities due to not reporting. But this is not the case for some health facilities especially CHAM facilities. For example, depending on the drug logistics data used in the prototype for Blantyre district, there were two CHAM health facilities which did not report any logistics data in the months of August, September and October 2008 (see Figure 8.2).

From the research findings on the application of GIS in the drug LMIS, it has been observed that the current spatial database misses some essential data such as Neno district, health facilities and attributes of health facilities. This gives an evidence of incompleteness of spatial data and that it is difficult to use which demonstrates the importance of data update.

### 8.2.5 The Right Quality

The drug LMIS makes sure that all essential data is correct or accurate before using them which is achieved through the supervision, physical inventory and training at all levels of the logistics management system. But still there is the lack of trust on the accuracy of the logistics data. Sometimes some health centre-in-charges fill the LMIS reports right there at the district health office when they come to perform other duties, which likely brings invalid data. Even the regional medical stores experience the same problem of some health facilities just guess or 'cook' figures.

What they need is just a report being sent to the district pharmacy so that they get drugs and other health commodities.

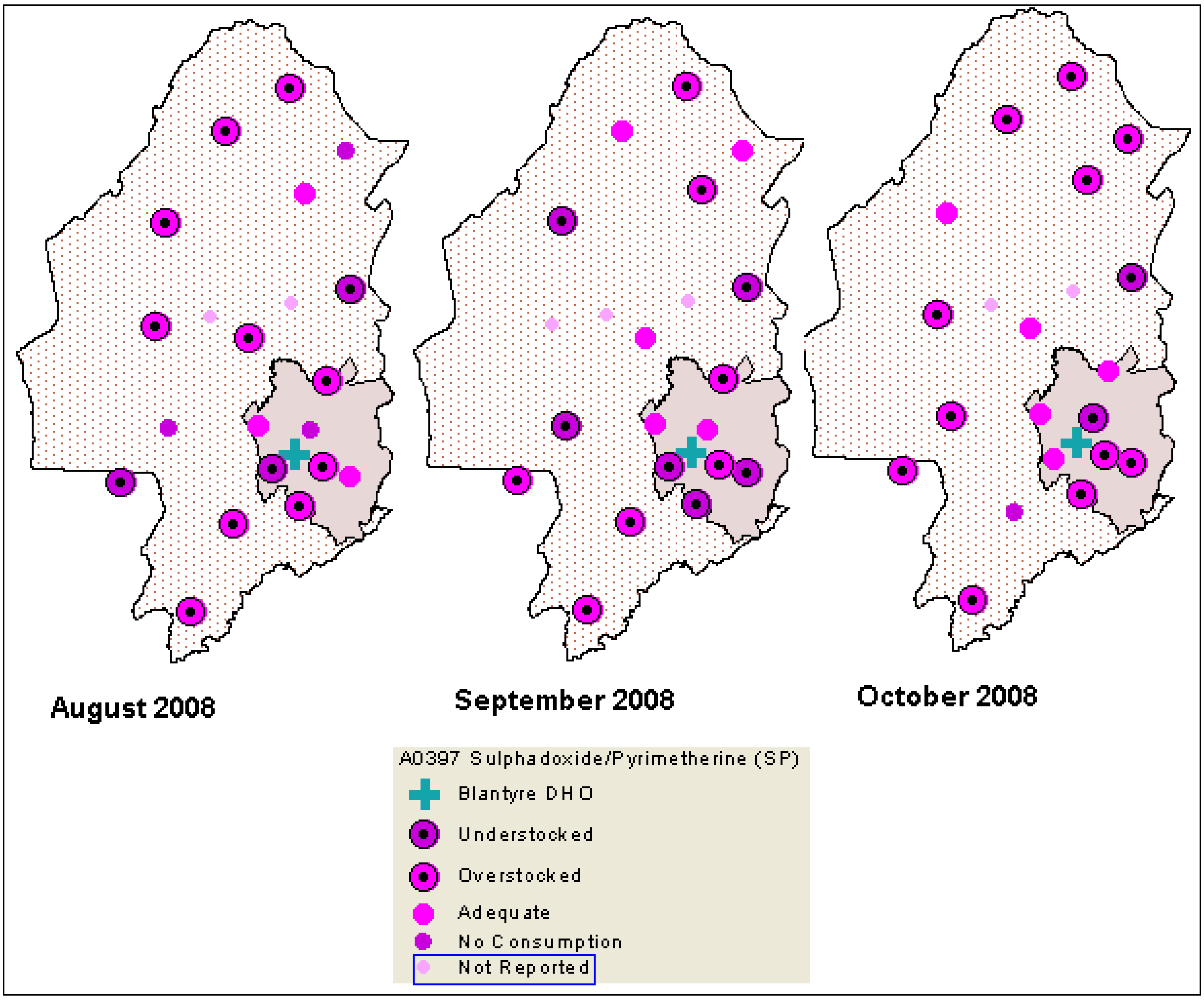



**Figure 8.2: Facilities which did not report SP in months of August, September & October 2008 (Source: GIS Prototype)**

It is also necessary to make sure that the spatial data is accurate before using in the GIS application. The GIS experiment has shown one example of road network (see Figure 7.2). It is important to update the spatial data to make it accurate.

### 8.2.6 The Right Cost

Every information system requires the data collection and it is important not to spend more time on this process than on other duties. The software system used at the district pharmacies has simplified the work of the pharmacy technicians to prepare reports in time so that they can perform other duties such as attending meetings, supervision and training. Much of the work is done at the health facilities where the data is collected manually. There is a long list of health commodities whose data should be filled in and this requires a lot of time. For example, the LMIS form for district health facility contains 16 pages to be filled by a pharmacy technician manually.

This data collection is also time-consuming for the spatial data. As observed in the GIS experiment, it has been a requirement of collecting and then updating the spatial data. Although spatial data used in the GIS prototype was already prepared by other institutions like Roads Authority and Survey Department, it was necessary to update it for missing attributes, health facilities, districts and inaccurate road networks among others. This update exercise has required a lot of time. This process of data collection for the GIS can be simplified by collecting spatial data and attributes separately as observed by Longley (2005).

## *8.3 Drug LMIS as Installed Base of the GIS*

Infrastructures as *installed base* are considered as always already existing. They are never developed from the scratch and when designing a new infrastructure it will always be integrated into and thereby extending others or it will replace one part of another infrastructure. This section analyses the drug LMIS as the installed base and how the GIS can fit into the drug LMIS by answering the following questions:

- Has the drug LMIS, as the installed base heavily influenced how the GIS could be designed?
- Could the GIS develop through extending and improving the drug LMIS or replacing a part of the drug LMIS?

### 8.3.1 Drug LMIS as Installed Base

From the analysis as, for the drug LMIS to function properly, it requires people, data, procedures, policies, work processes, tools, equipment, and transport system among others. The relationships and interactions of these elements form an installed base which the proposed GIS can be built on.

The work processes in the drug LMIS include data collection, reporting, and data processing and analysis which are governed by the standard procedures and policies. During the data collection at a health facility, a health staff records drug logistics data on stock cards and registers and then transfers essential data (*stock on hand* and *quantity used)* on the LMIS form which is sent to a pharmacy technician at the district level. The pharmacy technician uses the LMIS form to capture the essential data into the computer system (Supply Chain Manager) which calculates the *quantity required* and *months of stock* which determines the *stock status* of each health commodity. Printers are used to print the drug logistics reports which are sent to the pharmacist-in-charge (regional medical stores), district health management team, and stakeholders for various uses.

It can be seen that these work processes are linked together through data sharing, paper-based forms, computer systems and staff. The data which has been collected at the health facility is the same data reported to district where it is processed and analysed and then reported to the decision makers. The LMIS form is used at the health facility for data collection and reporting to the next level where it is used to capture data into the computer system. The computer system is used to capture, process and analyse the drug logistics data and then produce different reports. All these are supported by the health and drug logistics staff.

The personnel of the drug LMIS involves the health staff at health facilities, pharmacy technicians, pharmacists, members of district health management team, and stakeholders such as NGOs. They have different responsibilities in the drug LMIS such as data collection, reporting, processing, analysis and information use. They interact with each other in different ways such as through LMIS forms, reports, meetings and feedback (drug supplies, training, supervisory visits, and newsletters) as shown in the Figure 8.1. The health staff at the health facility interacts with the pharmacy technician through the LMIS form and feedback such as drug supplies, training and supervisory visits. On the other hand, the pharmacy technician interacts with pharmacist from the regional medical stores, members of district health management team and stakeholders through reports and also feedback including drug supplies, training, newsletters and supervisory visits. Staffs from different levels and within the same level also interact through official and unofficial meetings. For instance, the members of district health management teams conduct meetings quarterly.

The staffs use tools and equipment when performing their daily duties. The tools and equipment are stock cards, registers, LMIS forms, computers and printers. The data is recorded on stock cards and registers by the health staff. The same data is transferred onto LMIS forms by the same staff. The data is captured by staff into the computers from the LMIS form and then the computers produce reports through printing and these reports are used by people. Therefore, data and people play the great role to relate these tools and equipment to each other.

Since the logistics system involves movement of goods and services from a point-of-origin to a point-of-consumption, it requires good transport systems for efficient and effective delivery of these goods and services. This has been evidenced in the drug LMIS where the transport system plays a great role. It has been observed that the transport system is required not only for goods and services but also for movement of health and logistics staff involved in the drug LMIS.

According to the findings on the drug LMIS, there are two types of transport system: the internal (private) and public transport systems. The internal transport system supports delivery of health commodities to health facilities and movement of staff during supervisory visits, meetings, training, and delivery of reports. Practically, the public transport system is also used to supplement the internal transport system where and when it is insufficient. Both transport systems require road networks which connect health facilities, district pharmacies and regional medical stores. This shows that the drug LMIS is also supported by the transport infrastructure.

The logistics data is processed and analysed using computers which run different software systems such as the Windows operating systems, Supply Chain Manager, database management system, word processors and spreadsheets. For the Supply Chain Manager to run properly, it requires the Windows operating system and Microsoft Access (database management system) because it was developed in the Microsoft Access. A part from printing, logistics reports can also be generated in the form of spreadsheet which is accessed through the programs such as Microsoft Excel. The pharmacy technician uses the word processor and spreadsheet such as Microsoft Word and Excel respectively when preparing additional reports to the ones generated by the Supply Chain Manager. These technologies are also part of the *installed base.*

When members of district health management team are meeting, they need both health data and drug logistics data which are from the health information system and drug LMIS respectively. The pharmacists and logistics officers need also the health data to “beef up” the required information for their decision making. This means that the drug LMIS and health information system are linked together through people who use the information from these two systems.

Therefore, in the drug LMIS, there exist various systems, work processes, users, tools, equipment, policies and procedures which are linked together in one way or another. The interconnections among these elements form the *installed base* which the GIS as a new system (installed base) can be built on. It is important to identify which systems, work processes, users' responsibilities, tools, equipment, policies and procedures of the drug LMIS should be extended and improved in order to accommodate the GIS.

### 8.3.2 The GIS as a new Installed Base on the drug LMIS

According to Mennecke and Crossland (1996), the GIS can be defined as a computer-based information system that provides tools to collect, integrate, manage, analyse, model and display data that is referenced to an accurate cartographic representation of objects in space. From the GIS experiment, it has been observed that the GIS also requires various systems, work processes, people (users), tools, equipment, policies and procedures as in the drug LMIS. These elements need also to interact and relate in order to work as a system which means that the GIS can be considered as an installed base. It can be argued that the proposed GIS is a new installed base on the drug LMIS installed base. Below are discussions on extensions in the drug LMIS based on the elements outlined above in order to accommodate the GIS as a new installed base.

The work processes in the proposed GIS are data collection, data integration, data management, data processing and analysis, and reporting (see Figure 8.3). As compared to the work processes in the drug LMIS there are processes in the proposed GIS namely data integration and data management which do not exist in the drug LMIS. Although data collection, reporting, processing and analysis are available in the drug LMIS, they need some extensions in order to be supported in the proposed GIS.

The data collection in the drug LMIS involves only drug logistics data which is part of non-spatial data of the proposed GIS. According to the GIS experiment, the data collection in the proposed GIS involves the spatial data and non-spatial data because every GIS requires those two categories of data. Since the drug LMIS needs road networks, health facilities and pharmacies which are grouped by a district, it is essential to collect spatial data of district administrative boundaries, health facilities, pharmacies and road networks as demonstrated in the GIS experiment. The spatial data mainly provides a cartographic representation of objects in space and hence, it is a need to add non-spatial data in order to have complete information for drug logistics managers. It has been observed that the non-spatial data consists of drug logistics data, health data, and attributes of districts, health facilities, pharmacies and roads. The collection of drug logistics and health data is already in place because there are drug LMIS and health information system that do the work. Hence, the collection of spatial data and attributes is a concern of the discussion in this thesis.

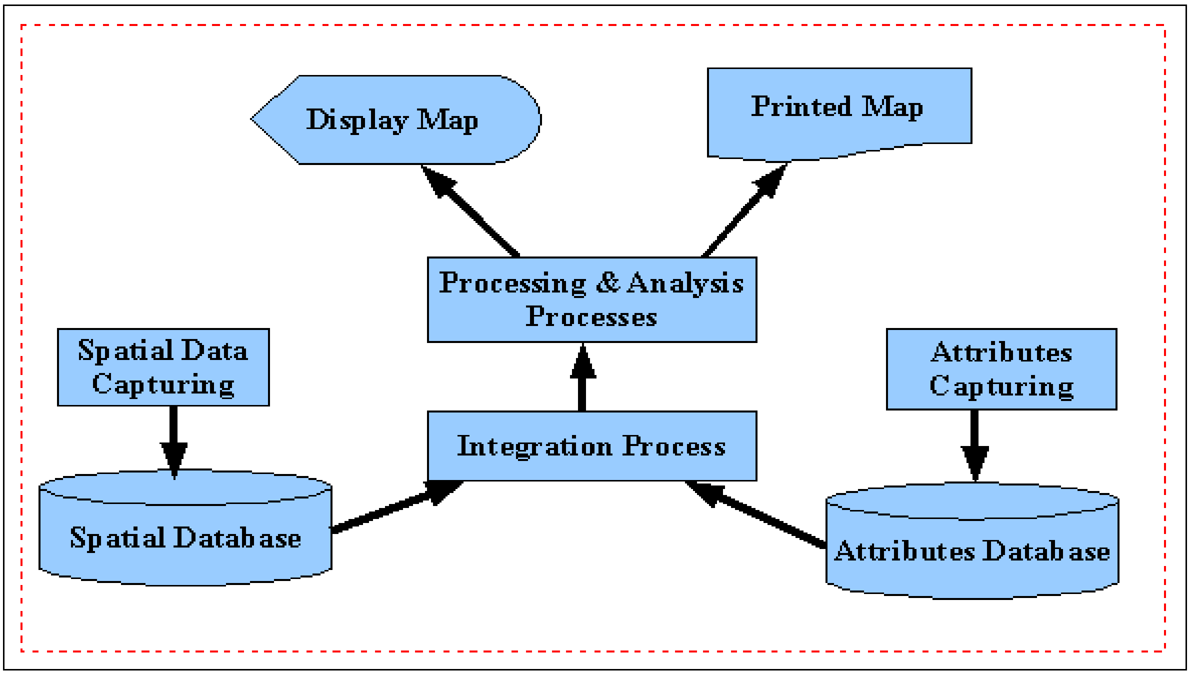



**Figure 8.3: Suggested GIS Structure on Existing Installed Base**

The data integration is a new work process to be introduced due to the introduction of the GIS. This integration can be analysed in two ways: (1) integration of spatial data and attributes (descriptions of objects) (see Figure 8.3); and (2) integration of spatial data, drug logistics data and health data. Every health facility, district, pharmacy and road should have complete descriptions for easy identification. For instance, every health facility must have name, district, type or category, and owner among others (Appendix G). It is also important to integrate the spatial data especially the health facilities with the drug logistics and health data. The GIS prototype has demonstrated this integration (see Figure 8.4) but there are some options that could be also considered.

The logistics and health data at the district level is not integrated in any way. The drug LMIS and the health information system are separated systems. The district health management team uses both the logistics and health data at the meetings and the logistics staff also requires health data. Therefore, the proposed GIS can be used as an integration tool to link the logistics and health data together through a common geographical reference system of health facility. At the district level, the

Supply Chain Manager and DHIS are used for logistics and health data management respectively and both systems use Microsoft Access database management system which can easily be linked to majority of GIS databases. Three options have been suggested and they are also part of discussions: (1) integrate the spatial data with the drug logistics and health data as shown in Figure 8.4 and in this case the proposed GIS requires an interface to access data from all databases; (2) first integrate the drug logistics data with health data, and then integrate results with the spatial data; and (3) integrate the spatial data with the drug logistics data only without health data.

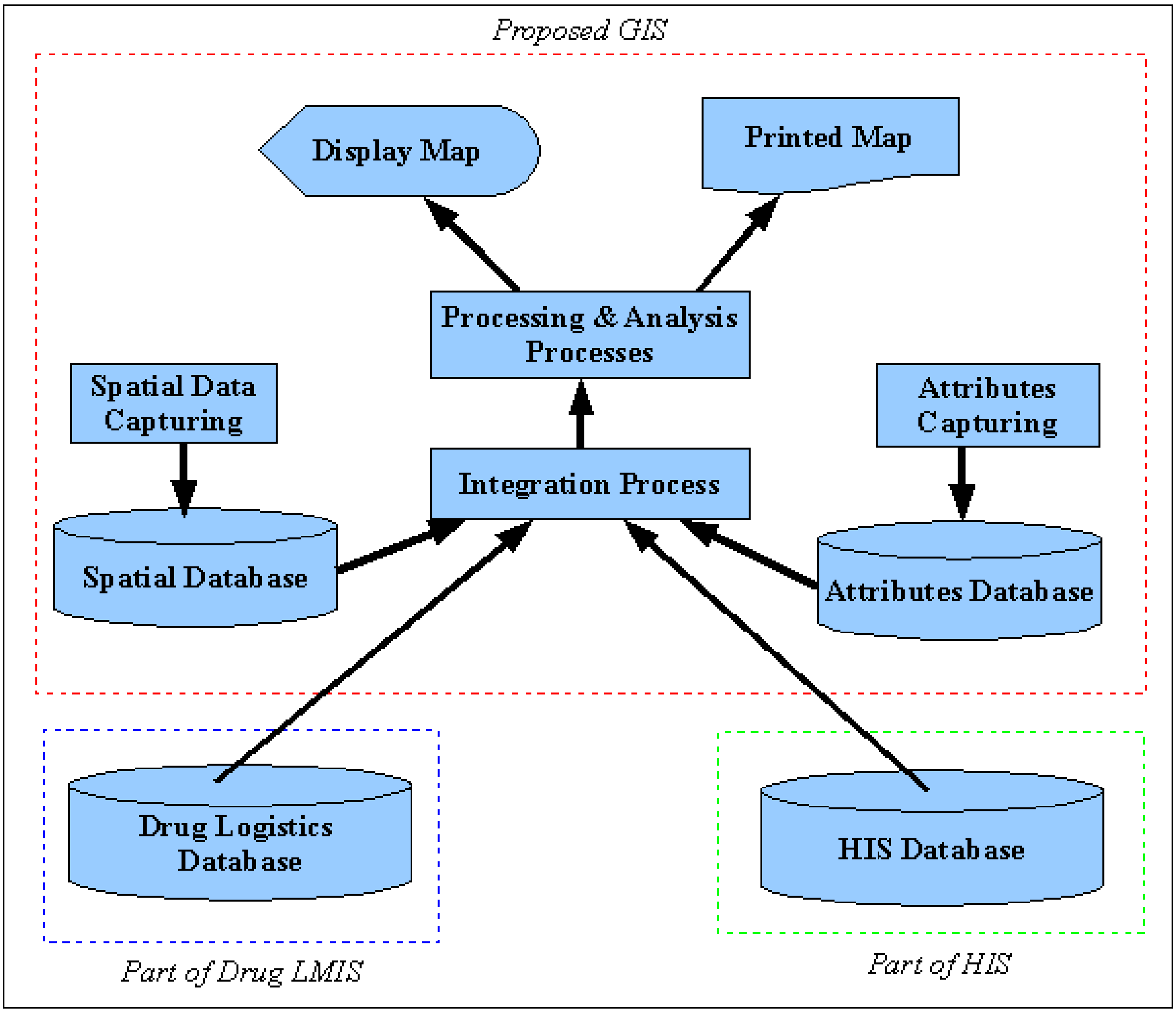



**Figure 8.4: Integrating Databases of GIS, Drug LMIS and HIS**

Another new work process to be added is the data management which will involve updating of spatial data and attributes, that is, to add new features, modify existing features, and delete unwanted features. For instance, the spatial data used in the GIS prototype has required some updates of districts, health facilities, and road networks. The attributes of health facilities need to be modified now and again. Currently, Ndirande health centre in Blantyre is being upgraded to the rural hospital meaning that in a near future its type will change which will require updates in the attributes database.

The processing and analysis in the proposed GIS involve the data which has been already integrated ready to be mapped. The specific processing and analysis of drug logistics and health data are performed by their respective systems. For example, the drug LMIS processes and analyses the logistics data which result in the stock status (adequately stocked, overstocked or understocked ) of each health commodity and this information can now be integrated with the spatial data and displayed on the map as demonstrated in the GIS prototype. The GIS experiment has also demonstrated that it is required to process and analyse data after integration with spatial data for better presentation on the map. For example, catchments population and malaria cases have been categorised for better comparisons between health facilities.

The drug LMIS mainly produces reports as hard copy for easy distribution to the users. The proposed GIS also requires producing reports for use but since the reports contain graphics it is important to consider the best way of production. It has been suggested that the map display is main method of reporting because the pharmacy technicians are the ones using the information and they need to interact with the map, for instance, when calculating distances. Printing can be taken as second option when hard copy is required and it requires high quality colour printer.

| Work Process | Tools and Equipment | Human Resource |
|---|---|---|
| Data Collection | GPS, scanners, digitisers, computers, GIS software | Pharmacy technician, health staff, or outsourcing |
| Data Integration | Computers, GIS software | Pharmacy technician, health staff |
| Data Management | GPS, scanners, digitisers, computers, GIS software | Pharmacy technician, health staff |
| Processing and Analysis | Computers, GIS software | Pharmacy technician |
| Reporting | Computers, GIS software, printers | Pharmacy technician |

**Table 8.6: Proposed Tools, Equipment, and Human Resource of the proposed GIS**

As in the drug LMIS, it has been found out that the proposed GIS also needs people, tools and equipment to support the work processes as shown in Table 8.6. The human resource includes pharmacy technicians, health staff and sometimes outsourcing from other organisations that deal with the spatial data collection. The tools and equipment are mainly GPS, scanners, digitisers, computers, GIS software and printers.

Since it has been proposed that the GIS should be used at the district pharmacies to support the reporting of drug logistics information, it means that the main user of this system is the pharmacy technician. The pharmacy technician can be assisted by health staff especially in data collection, integration and management because these work processes are too involving in terms of time and skills. Another reason is that health facilities are in the management of health staff so it is very important to have them involved. Sometimes, human resource outsourcing is critical particularly in data collection of spatial data. As demonstrated by the GIS experiment, there are some organisations that deal with the spatial data collection in the country. It is also wise to outsource their expertise in human resource or even tools and equipment in the spatial data collection as Mennecke and Crossland (1996) point out that data acquisition can be difficult and costly issue in the implementation of the GIS. Since it will be the first time to use the GIS at the district pharmacy, it is necessary to train the pharmacy technicians and health staff on how to use the GIS software, tools and equipment.

At the district health office, there are computers used by, for example, pharmacy technicians and statisticians for daily work in drug LMIS and health management system programs. This means that these computers can be used to “host” the proposed GIS and it needs to acquire the GIS software and high quality colour printers. For data collection and management, each district health office has already GPS which can do the most of work and the scanners and digitisers can be outsourced since they will not frequently be required.

From the analysis above, the GIS as a new installed base would consist of work processes, people, tools and equipment, procedures, policies, standards and systems. The spatial and attributes would be collected by the pharmacy technicians, health staff and outsourced using different tools and equipment such as the GPS, scanners, digitisers, GIS software and computers. Then they would manage and integrate the data with the drug logistics and health data from the drug LMIS and health information system respectively. The pharmacy technicians would process, analyse and report the spatial drug logistics information with the support of computers, GIS software and printers.

As shown in Figure 8.3 and Table 8.6, the work processes for the proposed GIS consist of data collection, data integration, data management, processing, analysis and reporting which are linked together through data sharing, computer systems and staff. The pharmacy technicians and health staff would interact through data sharing during data collection, integration and management, and also through official and unofficial meetings. The pharmacy technicians and health staff would use tools and equipment such as GPS, computers, GIS software and printers. The GPS would use to collect spatial data and use computers running the GIS software to capture, integrate, manage, process and analyse the data which would then reported through the displaying or printing.

It has been observed that the GIS software to run properly it requires some software systems such as the Windows operating systems and database management systems for spatial and attributes databases. At the district level, the health information system (HIS) would feed the proposed GIS with health data during the integration process (see Figure 8.4) and this HIS is a different infrastructure having its own work processes, systems, people, tools and equipment, standards, policies and procedures. Since some data and services would be outsourced from other organisations having their own systems and infrastructures, it means that the proposed GIS would also be supported by those infrastructures.

From the analysis above, it is summarised that the existing installed base could accommodate the GIS by doing the following: (a) extending the work processes to accommodate the spatial data collection, integration and management; (b) extending policies, procedures and standards for governing the work processes. (c) extending the use of the computers to run the GIS software which would provide tools for integrating the drug logistics, health and spatial data; (d) extending the staff's responsibilities and tasks to those who are involved in spatial data collection, integration and management and in using the GIS software and hardware tools; (e) establishing links between the Ministry of Health and other organisations, that deal with spatial data, for sharing of spatial data and outsourcing of expertise (human resource) and tools; and (f) improving the printing quality for colour graphics output of maps. Challenges and opportunities of fulfilling these suggested activities in order to apply the GIS in the drug LMIS are discussed in the next chapter with reference to previous studies.

# 9.0 DISCUSSION AND CONCLUSION

Croswell (1991) conducted a content analysis of 39 articles selected from major GIS and information system publications in order to assess common problems and approaches for overcoming these problems in the system implementation activities. It was found that obstacles related to the *technical side* of system implementation and operations were considered “minor” as compared to those related to the *organisation and management* which were identified as “major”. Obstacles related to the *standards and data integration* were considered “very important”. Croswell (1991) concluded that major obstacles to successful system implementation are institutional. “In the end, it comes down to people – senior management with vision, mid-level managers with talent and dedication to direct system development and operation, and users who must apply GIS tools to real problems” (p. 55). Afterwards, some studies (Mennecke & Crossland, 1996; Forster, 2000; Sieber, 2000; Ginger, 2005; Saugene, 2005) have discussed about challenges, opportunities and strategies of developing and implementing the GIS in developing countries in the same “lines” of technology, organisation and institution, standards and data integration. Therefore, opportunities and challenges of applying the GIS in the drug LMIS are discussed in terms of data standards and integration, organisation, and technology.

## *9.1 Opportunities and Challenges on Technology*

The practical work of GIS always involves some aspects of technology which focuses on the computer hardware, software and technical support. The availability of computers, printers, GPS, software systems and users having computing capabilities can be considered as an opportunity in the sense that they will provide technical support to the application of the GIS in the drug LMIS. The same computers, that are used in the drug LMIS at the district health office, can also be used to run the GIS software and therefore, no need to purchase new computers unless otherwise. Apart from computers, each district health office has got the GPS which is very important in the spatial data collection due to its advantage of less time-consuming, less expensive, and simpler to use than other techniques such as ground survey, scanning and digitising. The users of these computers, particularly pharmacy technicians, have computing skills and experiences which will provide basic technological background for easy knowledge transfer of the GIS technology when it comes the time of user training.

Availability of the technologies discussed above is not enough to have the full operational GIS in the drug LMIS. Every GIS requires the software tools which include interface, database, analytical and communication tools among others. Currently, the district health office has no any GIS software which is in use. It is needed to purchase or acquire necessary GIS software that will provide all required functionalities. For instance, in the United Kingdom well-known GIS products include ArcInfo and ArcView from ESRI, GeoMedia from Intergraph, MapInfo Professional from MapInfo Corp, and GeoConcept from GeoConcept (Forster, 2000). This shows that there are several GIS software technologies from various vendors or organisations with specific purposes and therefore, it is important for the Ministry of Health to do a certain software analysis to recommend the best GIS software that will be used in all district health offices.

Another issue to consider is the user training to the pharmacy technicians, health staff and other concerned parties on the GIS technologies mainly on the data collection and GIS software tools. Since the acquisition of GPS, there has not been any type of training on how to use the technology. It seems that it will need a lot of effort and commitment in order to conduct the suggested user training because according to the research findings there have been some plans before for user training on the GIS but not yet fulfilled.

## *9.2 Opportunities and Challenges on Organisation*

The management plays a key role in achieving the GIS adoption and some factors that influence the effective use of the GIS technology are a level of commitment, previous computing experiences, and style of leadership. There are several things that have already been done at the district health office, which can be considered as opportunities, but still there is a lot of work that the ministry should do in order to implement the GIS technologies at the district level, which can be considered as challenges.

The Government of Malawi, in general, and the Ministry of Health, in particular, have shown some level of commitment on the use of GIS in Malawi in terms of policies and support. The government has come with the GIS policy among socio-economic policies which results in various governmental departments, such as Roads Authority, Survey Department and National Statistical Office, to be now involved in the GIS. Even the Ministry of Health also plays its role to promote the GIS usage by, for example, documenting the GIS policy in the health sector and purchasing GPS for the district health offices for the spatial data collection. The government also works with the international communities on the GIS such as Clark Labs.

The Ministry of Health has already implemented some information systems at the district level and experiences that were got during those implementations can be applied to determine ways of implementing the GIS at the district health office. The mentioned information systems include the district health information system (DHIS) and the supply chain manager for the drug LMIS. I argue that these systems are different from the GIS and therefore, its implementation can be somehow different from those of the two systems. It has been found that the GIS requires some specific work processes that are not needed in the DHIS and supply chain manager such as spatial data collection, data integration and sharing which require specialised training and equipment, and special consideration in terms of a cooperation among participants from different levels of the drug LMIS and relationship between the Ministry of Health and other institutions including governmental departments.

Currently, at the district health office, there are some health and logistics staff members, especially pharmacy technicians and statisticians, who are capable of using different information technologies. They use computer systems in their daily work and they have necessary computing skills, knowledge and experiences. It is possible that they can be given further training on the GIS technologies especially on data collection, spatial database management, and use of the GIS software applications. But this will result on extra responsibilities and tasks to the pharmacy technicians and statisticians who are already overloaded with work due to the lack of human resource in the Ministry of Health. Alternatively, the Ministry of Health can outsource the GIS expertise from institutions or organisations such as the Survey Department, particularly on the spatial data collection and building its necessary database, which is very complicated and expensive exercise. It needs well skilled and experienced people. The drug logistics and health staff can only be trained on data management (updates) and use of the GIS software tools.

The issue is now how the user training will be conducted. Some studies have shown that the most programs are normally carried out as part of software training packages and not integrated with the work practices that surround the use of the GIS technology. I argue that for the GIS to be implemented successfully, the Ministry of Health should analyse user needs especially work practices of the pharmacy technicians and health staff in order to incorporate them in the training. It is also necessary to educate the health and drug logistics managers on the benefits of the GIS technologies so that they can provide their necessary support to the implementation of GIS in the drug LMIS.

The effective use of GIS at the district level requires cooperation among participants from all levels as emphasised by Croswell (1991) that the cooperation among participants at different levels of organisations, especially government, is a key to a successful integrated information systems, such as the GIS. The research findings have shown that the cooperation exists in the drug LMIS between staff from all levels, from health facilities up to the national level. The Ministry of Health, in general, and the Central Medical Stores, in particular, need to maintain that cooperation when introducing the GIS in the drug LMIS. It is very important to extend this cooperation to health staff and other departments in order to, for example, share the spatial data and expertise. Apart from the pharmacy technicians, it has been observed that the GIS would be used by the health staff and logistics staff at the district and regional levels. All parties should agree on common goals and individual benefits should also be identified.

A sufficient structure, at the district health office, is needed for communication channels as well as for resolution of power and control conflicts that can exist due to the introduction of the GIS in the drug LMIS. Mennecke & Crossland (1996) argue that the GIS is likely to have significant impacts on the structure and operation of the organisation. It seems that this can also happen at the district health office through changing of the information flow which definitely affects the distribution of power. There will be some changes on structure due to changing of responsibilities and tasks of some staff as discussed above. Through extending responsibilities and tasks of the pharmacy technicians and statisticians, they will get additional power and will definitely share the power with other individuals due to collaborations and interactions. The new operations such as spatial data collection, sharing and integration will also be added to the existing ones. Even Sieber (2000) found out that the implementation of the GIS tends to alter the organisation substantively because it is expensive and complex and usually it frequently crosses departmental/subunit lines and alters power relations as the control of information changes.

## 9.3 Opportunities and Challenges on Standards and Data Integration

From the analysis above, it has been observed that the main new work processes, due to the introduction of the GIS in the drug LMIS, include the spatial data collection, data integration and data management. These processes are the most time-consuming and expensive GIS tasks but very important because effectiveness of the GIS depends on the degree of relevant data as input. For the district health office to successfully implement the GIS in the drug LMIS, it is important to consider carefully data standards and integration particularly between the GIS, drug LMIS and health information system.

The cost-effective way for capturing data in the proposed GIS is to capture spatial and non-spatial data separately. The district health office can minimise the cost of data collection by outsourcing the expertise from some organisations that are experienced in spatial data collection. The main reason is that this exercise requires well-skilled people, very powerful equipment and also time which is very expensive to the district health office. The available GPS can only be used to collect new spatial data for updating the spatial database. I argue that it is not necessary to spend a lot of resources to acquire those equipment for and train user on spatial data collection, which is already being done by some organisations. It has been observed that most of organisations that deal with spatial datasets are from the Government of Malawi which the Ministry of Health is part of and hence it is very easy to establish relationship between the ministry and those government departments for spatial data sharing.

The main challenge is the data standards for data sharing. Since the spatial data will be outsourced, it is needed for the district health office, in particular, and the Ministry of Health, in general, to determine data standards for easy sharing of spatial data with other organisations because the data from external sources can be encoded in many different formats. For instance, although the Department of Surveys is the national mapping agency and mandated by the legislation to carry out base mapping and control mapping in Malawi, it has its own spatial data standards and formats that may not be relevant to the Ministry of Health to use in its GIS as observed in the GIS experiment.

Apart from the spatial data, the district health office requires to collect non-spatial data including attributes, drug logistics and health data. This exercise should be done separately from the spatial data collection because it is relatively simple task that can be undertaken by lower-cost staff and attributes can be entered directly which does not require expensive hardware and software. The health and drug logistics data, as non-spatial data, are collected by health and logistics staff using simple materials and equipment such as forms and ordinary computers. This process does not require well-skilled person and complicated techniques and equipment as compared to the collection of spatial data. There are already systems that handle the drug logistics and health data and therefore, the collection of this non-spatial is not issue to worry about by the meantime. What the district health office will need is to concentrate on the updates of attributes of health facilities, road networks, pharmacies, districts and other required features in the spatial database.

Although, it is taken very cheap to collect non-spatial data at the district level, the GIS experiment has demonstrated that it is not easy to integrate the data from health information system, drug LMIS and the spatial database. Currently, the health information system and drug LMIS are independent systems having their respective policies, standards and procedures. So the issue is that how to integrate the data from these three sources in order for the proposed GIS to use. Three options have been identified and discussed in this thesis just to demonstrate some issues of standards and data integration.

As shown in Figure 8.4, there are four databases for spatial, attributes, drug logistics data and health data that are integrated at a single point. A common identifier is required in all databases for easy integration and management. It is necessary to determine standards for the common identifier, in this case the health facility and naming of different features such as health facilities, pharmacies and districts. All databases should use the common codes and names for health facilities and pharmacies. If this is to be implemented, it means that the district health office will have a lot of work to modify all the codes and names of health facilities and pharmacies in the drug LMIS and health information system to match with those in the spatial database.

Hence, the district health office needs to modify some existing policies and standards in the drug LMIS and health information system in order to come with common policies and standards for coding and naming of those health facilities and pharmacies. If there is a certain change in the health facility, it will be necessary to update all databases in order to maintain data consistency and this update will be in hands of two offices which are hard to coordinate, the pharmacy technician (for drug logistics databases) and statistician (for health database). Since both the drug LMIS and health information system will not only be used to feed the GIS, it is important to make sure that the databases have complete data, for example full descriptions of health facilities and pharmacies, for other services. Therefore, when it is needed, for example, to change a name of pharmacy or health facility, all databases should be updated and likely, missing changes in some databases which will result in data inconsistency.

Another challenge is a definition of data collection points in the drug LMIS and health information system as experienced in the GIS experiment. In the health information system data is collected from the catchments health facility while in the drug LMIS data is collected from any health facility which gets health commodities from either the regional medical stores or district pharmacy. It means that to integrate data from the two systems, it is required to define common collection points for both drug logistics and health data. Otherwise data from some health facilities, that are not data collection points in either one of the systems, will not be considered in the GIS because it will be difficult to integrate them.

Another option is to firstly integrate the drug logistics and health data and then link the GIS to the drug LMIS. This option will have the same challenges as the first one because it will also focus in the integration of dug logistics and health data.

The simpler and cheaper way, than two ways discussed above, is to only integrate the spatial data with the drug logistics data and ignore the health data integration. This will bring a relief on standards and data integration as follows: (a) much of the effort needed to integrate drug logistics and health data will not be required; (b) time and effort to modify the codes and names of health facilities and pharmacies will be reduced because only two main databases will be affected; (c) even data inconsistency will be minimised because only two databases will be required for updates and managed by one person, the pharmacy technician; (d) there will be no need to redefine collection points for the drug logistics data; (e) all health facilities used for drug logistics data collection will be available in the GIS which means that no missing data due to the data integration.

## *9.4 Conclusion of the thesis*

The main goal of this study was to find out some opportunities and challenges of applying the GIS in the drug LMIS at the district level in the Ministry of Health in Malawi. In order to meet the research goal, the GIS prototyping was applied with the framed experiment in which the GIS prototype was demonstrated to the pharmacy technicians, statisticians and pharmacist-in-charge for feedback.

It has been found out that the idea of introducing the GIS in the drug LMIS is very good but it requires a lot of effort, commitment and resources for successful implementation. Apart from the GIS being used only by the pharmacy technicians, as the research was focusing on, other drug logistics and health staff were also interested in the project. The GIS would also help the statisticians, environmental health officers and drug logistics officers.

Some opportunities and challenges that could exist when introducing the GIS, basically involve technologies, organisation, standards and data integration. It has been observed that the technical side of implementing the GIS in the drug LMIS is not difficult because the Ministry of Health has introduced computer technologies before so some required tools and equipment are available that can be used in the GIS. The main issue for the successful implementation is organisational in the sense that if the district health office and the Central Medical Stores are ready to implement the GIS in the drug LMIS, everything will be fine. If the management of the Central Medical Stores is committed, it is easy to get all necessary resources and support to do all the activities discussed above. For example, acquisition of tools and equipment, user training, data standards, data collection, data integration, data sharing and cooperation of participants will require support from the management in the Ministry of Health.

I suggest that the GIS can be taken as the information reporting tool in the dug LMIS in which the GIS will integrate drug logistics data with the spatial data and display on the map. The integration of the drug logistics and health data is very difficult by meantime due to differences in how data is handled in these two systems in terms of standards, policies and procedures. It needs to conduct a study on how to standardise the drug logistics and health data for easy integration.

It can be concluded that successful implementation of the GIS in the drug LMIS at the district level in the Ministry of Health will depend on: (a) good evaluation of needs of the pharmacy technicians; (b) long-term commitment to the proposed GIS project of the various program managers in the Ministry of Health especially those dealing with the drug logistics; (c) sufficient allocation of resources and adequate staffing; (d) timely and sufficient training to the pharmacy technicians; and (e) good establishment of cooperation of participants and with other organizations and departments for easy sharing of the spatial data and expertise.

# REFERENCES

BATES, J. & RAO, S. 2000. *Zambia: Implications of Health Sector Reform for Contraceptive Logistics.* Arlington, Va: Family Planning Logistics Management (FPLM)/John Snow, Inc. (JSI), for the U.S. Agency for International Development (USAID)

BATES, J., CHANDANI, Y., CROWLEY, K., DURGAVICH, J. & RAO, S. 2000. *Implications of Health Sector Reform for Contraceptive Logistics: A Preliminary Assessment for Sub-Saharan Africa.* Arlington. Va: Family Planning Logistics Management (FPLM)/John Snow, Inc. (JSI), for the U.S. Agency for International Development (USAID)

BEITH, A., QUESADA, N., ABRAMSON, W., SÁNCHEZ, A. & OLSON, N. 2006. *Decentralizing and Integrating Contraceptive Logistics Systems in Latin America and the Caribbean, With Lessons Learned from Asia and Africa.* Arlington, VA: DELIVER, for the U.S. Agency for International Development.

BERGER, R., TEOH, N., & MUNGAI, T. 2006. *MALAWI DELIVER End of Project Evaluation.* United States Agency for International Development, USA.

BODDY, D., BOONSTRA, A. & KENNEDY, G. 2005. *Management Information Systems: An Organisational Perspective.* 2nd Edition, Prentice Hall.

BOSSERT, T. J., BOWSER, D. M. & AMENYAH, J. K. 2007. *Is decentralization good for logistics systems? Evidence on essential medicine logistics in Ghana and Guatemala.* Health Policy and Planning 2007; 22:73–82, Oxford University Press in association with The London School of Hygiene and Tropical Medicine

CHANZA, C. 2003. *A GIS based Manucipal Information System for Management of Urban Development Control Process – Case Study: Blantyre City Assembly, Blantyre, Malawi.* Master Thesis, ITC.

CHAULAGAI, C. N., MOYO C. M., KOOT, J., MOYO, H. B. M., SAMBAKUNSI, T. C., KHUNGA, F. M. & NAPHINI, P. D. 2005. *Design and implementation of a health management information system in Malawi: issues, innovations and results.* Oxford University Press in association with The London School of Hygiene and Tropical Medicine.

CONTICINI, A. 2004. *Macroeconomics and Health in Malawi: What Way Forward.* Macroeconomics and Health, WHO Geneva.

CROSWELL, P., 1991, *Obstacles to GIS Implementation and Guidelines to Increase the Opportunities for Success.* Journal of the Urban and Regional Information Systems Association, 3(1), 43-56

DAVENPORT, T. H. & PRUSAK, L. 1998. *Working Knowledge - How Organizations Manage What They Know.* Harvard Business School Press Boston

DELIVER. 2004. *The Logistics Handbook: A Practical Guide for Supply Chain Managers in Family Planning and Health Programs.* Arlington, Va.: John Snow Inc./DELIVER, for the U.S. Agency for International Development (USAID).

DELIVER. 2006a. *Guidelines for Implementing Computerized Logistics Management Information Systems (LMIS). Second Edition.* Arlington, Va.: DELIVER, for the U.S. Agency for International Development.

DELIVER. 2006b. *Malawi: Health Commodities Logistics Management System Standard Operating Procedures Manual.* Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development.

DELIVER. 2007a. *Malawi: Final Country Report.* Arlington, Va.: DELIVER, for the U.S. Agency for International Development.

DELIVER. 2007b. *Mozambique: Final Country Report.* Arlington, Va.: DELIVER, for the U.S. Agency for International Development.

DELIVER. 2007c. *Tanzania: Final Country Report*. Arlington, Va.: DELIVER, for the U.S. Agency for International Development.

DELIVER. 2007d. *Zambia: Final Country Report*. Arlington, Va.: DELIVER, for the U.S. Agency for International Development

DUFWENBERG, D. & HARRISON, G. 2008. *Peter Bohm: Father of field experiments*: Economic Science Association 2008, Springer.

EBENER, S. 2007. *When health drives the SDI process: the example of Zambia and Malawi.* UN Geographic Information Working Group (UNGIWG), Eighth Plenary Meeting, 28-30 November 2007, Bangkok. [Online]: http://www.ungiwg.org/docs/8th_meeting/Presentations/WHO_ZMB_MWI_Project.pdf [Accessed: 26-04- 2008].

ESRI, 2002. *GIS for Africa.* New York.

ESRI, 2003. *GIS for Transportation in Europe*, New York.

ESRI, 2007. *GIS Best Practices - Mobile Resource Planning and Logistics.* New York.

FAMILY PLANNING LOGISTICS MANAGEMENT (FPLM). 2000. *Nepal: Contraceptive and Drugs Logistics System, Review of Accomplishments and Lessons Learned (1993 – 2000).* Arlngton, Va.: Family Planning Logistics Management (FPLM)/John Snow, Inc. (JSI), for the U.S. Agency for International Development (USAID).

FORSTER, M. 2000. *Review of the use of Geographical Information Systems in the Marketing and Planning of Logistics Services.* Christian Salvesen Logistics Research Paper no. 3, September 2000. [Online]: http://www.sml.hw.ac.uk/logistics/pdf/cs3.pdf, [Accessed 30-04-2008].

GALIMOTO, M. S. 2007. *Integration of Health Information Systems, Case Study from Malawi.* Master Thesis, University of Oslo.

GINGER, L. J. 2005. *Introducing Geographical Information Systems for Health Care in*

*Developing Countries: Challenges and Approaches, A case study from Mozambique.* Master Thesis, University of Oslo

GUPTA, R. & KUMAR. P. 2007. *Social evils, poverty & health - Review Article.* Indian J Med Res 126, October 2007, pp 279-288

HALL, G. B., FEICK, R. D. & BOWERMAN, R. L. 1997. *Problems and Prospects for GIS-based Decision Support Applications in Developing Countries.* Faculty of Environmental Studies, University of Waterloo, Ontario, CANADA

HANSETH, O. & LUNDBERG, N. 2001. *Designing Work Oriented Infrastructures.* Computer Supported Cooperative Work 10: 347–372, 2001. Kluwer Academic Publishers, Netherlands.

HANSETH, O. & LYYTINEN, K. 2005. *Theorizing about the design of Information Infrastructures: design kernel theories and principles*. Working paper at University of Oslo, Department of Informatics. [Online]:http://heim.ifi.uio.no/~oleha/Publications/ISRinfrastructurefinal05-12-05.pdf, [Accessed 30-04-2008].

HANSETH, O. & MONTEIRO, E. *1998. Understanding Information Infrastructure.* Manuscript 27. Aug., 1998. [Online]: http://heim.ifi.uio.no/~oleha/Publications/bok.html, [Accessed 30-04-2008].

HARRISON, G. W. & LIST, J. A. 204. *Field Experiments:* Journal of Economic Literature. Vol.XLII (December 2004) pp. 1009-1055.

HEARD, N. J., LARSEN, U. & HOZUMI, D. 2004. *Investigating Access to Reproductive Health Services Using GIS: Proximity to Services and the Use of Modern Contraceptives in Malawi.* JSTOR.

HEY, J. 2004. *The Data, Information, Knowledge, Wisdom Chain: The Metaphorical link.* Intergovernmental Oceanographic Commission 2004, UNESCO.

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT. 2007. *Malawi*

*Social Protection Status Report, Report No. 40027-MW.* Sustainable Development Network, AFTCS, Country Department 2, Malawi, Africa Region, The World Bank.

JOHNSON, C.P. & JOHNSON, J. 2001. *GIS: A Tool for Monitoring and Management of Epidemics.* Map India 2001 Conference, New Delhi.

KLING, R. 2000. L*earning About Information Technologies and Social Change: The Contribution of Social Informatics.* The Information Society, 16:217–232, 2000, Taylor & Francis.

KLING, R. & LEIGH S. 1998. *Human Centered Systems in the Perspective of Organizational and Social Informatics.* Computers and Society 28(1) (March 1998):22-29, ACM, New York.

KORDON, F. & LUQI. 2002. *An Introduction to Rapid System Prototyping.* IEEE Transactions on Software Engineering, Vol. 28, No. 9, September 2002.

KUNDA, D. 2001. *A social-technical approach to selecting software supporting COTS-Based Systems.* PhD Thesis, Department of Computer Science, University of York.

LAMBERT, D. M., STOCK, J. R. & ELLRAM, L. M. 1998. *Fundamentals of Logistics Management.* International Editions, McGraw-Hill, Singapore.

LEWIS, J. 2005. *Design and Development of Spatial GIS Application for Primary Healthcare Sector: Case Studies from India and Mozambique.* Master Thesis, University of Oslo.

LEWIS, M. 2006. *Tackling Healthcare Corruption and Governance Woes in Developing Countries – CDC Brief.* Center for Global Development.

LIST, J. A. & REILEY, D. 2008. *Field Experiments in Economics: Palgrave Entry.* Discussion Paper No. 3273, January 2008, IZA, Germany.

LONGLEY, P., GOODCHILD, M., MAGUIRE, D. & RHIND, D. 2005. *Geographic Information Systems and Science.* 2nd Edition, John Wiley & Sons, Ltd.

LUFESI, N. N., ANDREW, M. & AURSNES, I. 2007. *Deficient supplies of drugs for life* *threatening diseases in an African community.* BMC Health Services Research, BioMedical Central.

MACUEVE, G. A. 2003. *Drugs Logistics Management Information System in Mozambique: Challenges and Opportunities.* Master Thesis, University of Oslo

MAGUIRE, M. & BEVAN, N. 2002. *User requirements analysis - A review of supporting methods.* Proceedings of IFIP 17th World Computer Congress, Montreal, Canada, 25-30 August 2002, p133-148. Kluwer Academic Publishers.

MENNECKE, B. E. & CROSSLAND, M. D. 1996. *Geographic Information Systems: Applications and Research Opportunities for Information Systems Researchers.* Proceedings of the 1996 Hawaii International Conference on System Sciences (HICSS-29) [Online]: http://csdl.computer.org/comp/proceedings/hicss/1996/7330/00/73300537.pdf [Accessed 03- 03-2009].

McGREGOR, K. & CHANDANI, Y. 1999. *Experiences from the Field: Strategies for Skills Transfer in Supply Chain Management for Developing Countries.* Arlington, Va.: John Snow, Inc./Family Planning Logistics Management (FPLM), for the U.S. Agency for International Development.

MINISTRY OF HEALTH AND POPULATION. 2003a. *Measuring Health Sector Performance – Handbook of Indicators.* Malawi Government.

MINISTRY OF HEALTH AND POPULATION. 2003b. *Health Information System: National Policy and Strategy.* Malawi Government.

MINISTRY OF HEALTH AND POPULATION. 2003c. *Health Management Information Bulletin – Special Issue 2002.* Malawi Government.

MLOTHA, M.J. 2001. *Remote sensing and GIS linked to socio-analysis for land coverchange assessment,.* IEEE Xplore.

MSYAMBOZA, K., E SENGA, E. TETTEH-ASHONG, P. KAZEMBE4 & B. J. BRABIN. 2007.

*Estimation of effectiveness of interventions for malaria control in pregnancy using the screening method.* International Journal of Epidemiology 2007;36:406–411 the International Epidemiological Association Oxford University Press

MUKAMA, F., KIMARO, H. C. & GREGORY, J. 2005. *Organisation Culture and its impact in information systems development and implementation: A case from the health information system in Tanzania.* Hogskolen i Agder, Agder University College.

MYERS, M. D. 1997. *Qualitative Research in Information Systems, MIS Quarterly* (21:2). June 1997, pp. 241-242. *MISQ Discovery*, archival version, June 1997, http://www.misq.org/discovery/MISQD_isworld/. *MISQ Discovery*, updated version, last modified: January 4, 2008 www.qual.auckland.ac.nz [Accessed on 03-03-2008]

MYERS, M. D. & NEWMAN, M. 2006. *The qualitative interview in IS research*: *Examining the craft.* Information and Organization 17 (2007) 2–26, Elsevier Ltd

NANDHAKUMAR, J. & JONES, M. 1997. *Too close for comfort? Distance and engagement interpretive information system research.* Info System J (1997) 7, 109-131, Blackwell Science Ltd.

NATIONAL STATISTICAL OFFICE (NSO). 2005. *Demographic and Health Survey 2004*. Zomba, Malawi

NATIONAL STATISTICAL OFFICE (NSO). 2008. *2008 Population and Housing Census - Preliminary Report.* National Statistical Office, Malawi

NIELSEN, P. & AANESTAD, M. 2006. *Control Devolution as Information Infrastructure Design Strategy: A case study of a content service platform for mobile phones in Norway".* Journal of Information Technology, vol.21. no.3, September 2006, pp. 185-194.

NYIRENDA, T., BOXSHALL, M., SALANIPONI, F. & KEMP, J. 2005. *Not just pretty pictures: Geographical Information Systems in TB control.* African Journals Online

ONSD. 2005. *Appraisal Report - Support to the Health Sector Programme - Republic of Malawi*. Health Development Division, Social Development Department, North - East - South Region, African Development Fund.

OWENS, R. C. & WARNER, T. 2003. *Concepts of Logistics System Design.* Arlington, Va.: John Snow, Inc./DELIVER, for the U.S. Agency for International Development (USAID).

PICK, J. B. 2005. *Geographic Information Systems in Business.* Idea Group Publishing, Hershey, U.S.A.

POPULATION INFORMATION PROGRAM (PIP). 2002. *Family Planning Logistics: Strengthening the Supply Chain.* [Online]: http://www.infoforhealth.org/pr/j51/j51.pdf, [Accessed 30-04-2008].

PRESIDENT'S MALARIA INITIATIVE (PMI). 2007. *Malaria Operational Plan (MOP) – Malawi* [online]: http://www.fightingmalaria.gov/countries/mops/malawi_mop-fy07.pdf, [Accessed 28-11-2008]

SAHAY, S. & WALSHAM, G. 2006. *Scaling of Health Information Systems in India: Challenges and Approaches*. Information Technology for Development, Vol. 12 (3) 185–200 (2006), Wiley Periodicals, Inc. Wiley InterScience.

SAUGENE, Z. B. 2005. *Challenges, Opportunities and Strategies for Using Geographic Information Systems for Public Health Management - An Action Research Study from Mozambique.* Master Thesis, University of Oslo.

SAWYER, S. & TYWORTH, M. 2006. *Social Informatics: Principles, Theory, and Practice.* Federation for Information Processing-Publications-IFIP, 2006, Volume 223/2006, Springer Boston.

SHARP, H., PREECE, J. AND ROGERS, Y. 2007. *Interaction Design: Beyond Human Computer Interaction.* John Wiley & Sons; 2nd Edition

SIEBER, R. E. 2000. *GIS implementation in the grassroots.* Journal of the Urban and Regional Information Systems Association 12(1):15-29.

SOWEDI, M., DAVID, V., OLUPOT, G., EKOCHU, E., SEBAGENZI, E., KIRAGGA, D. & NGABIRANO, T., 2006. *Baseline Assessment of Drug Logistics Systems in Twelve DISH-supported Districts and Service Delivery Points (SDPs).* Delivery of Improved Health Services (DISH) II Project, Health Management and Quality Assurance Component, Uganda.

STOCK, J. R. & LAMBERT, D. M. 2001. *Strategic Logistics Management.* Fourth Edition, McGraw-Hill, Singapore.

TANSER, F. C & le SUEUR, D. 2002. *The application of geographical information systems to important public health problems in Africa.* International Journal of Health Geographics 2002, 1:4, BioMed Central.

THOMAS, D. R. 2003. *A general inductive approach for qualitative data analysis.* School of Population Health, University of Auckland, New Zealand

THORNE, S. 2000. *Data analysis in qualitative research.* Evid. Based Nurs. 2000; 3; 68-70, Volume 3 July 2000 EBN

TWATI, J. M. 2006. *Societal and Organisational Culture and the Adoption of Management Information Systems in Arab Countries.* PhD Thesis, Brisbane, Australia.

Van LOENEN, B. 2006. *Developing geographic information infrastructures - The role of information policies.* Haveka, Alblasserdam.

WOOD, D.J. & GATRELL, A.C. 2002. *Equity of geographical access to inpatient hospice care within North West England: A Geographical Information Systems (GIS) approach.* Institute for Health Research, Lancaster University, England.

TOLEDANO, J. 1998. *An International Perspective on the Development of Professional GIS Capacities.* Clark Labs, Clark University.

WORLD HEALTH ORGANIZATION (WHO), 2006a. *Health Action in Crises, Malawi,* updated August 2006, WHO, USA. [Online]: http://www.who.int/hac/crises/mwi/background/Malawi_June06.pdf, [Access: 20-04-2008]

WORLD HEALTH ORGANIZATION (WHO), 2006b. *Measuring availability and accessibility coverage. Result of the GIS capacity and data availability analysis: Malawi;* WHO internal document, September 2006. [Online]: http://www.gsdi.org/SDIA/docs2007/apr07links/GIS_Malawi_final.pdf, [Acessed: 25-04-2008].

# Appendix A: Part of Health Centre Monthly LMIS Report

LMIS -01A

**REPUBLIC OF MALAWI**
**MINISTRY OF HEALTH**
**Health Centre Monthly LMIS Report**

| Facilty | | District | | Month | | | |
|---|---|---|---|---|---|---|---|
| | | | | Year | | | |
| Item No | Item | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days stocked out | Quantity Required |
| | | | | | | | |
| **Class A: Tablets and Capsules** | | | | | | | |
| A0230 | Albendazole 200mg | 1000 | | | | | |
| A0028 | Aminophylline 100mg | 1000 | | | | | |
| A0034 | Amitriptyline 25mg | 100 | | | | | |
| A0039 | Amoxycillin 250mg | 1000 | | | | | |
| A0046 | Aspirin 300mg | 1000 | | | | | |
| A0114 | Chlorpheniramine 4mg | 1000 | | | | | |
| A0111 | Chlorpromazine 100mg | 1000 | | | | | |
| A0405 | Cotrimoxazole 480mg | 1000 | | | | | |
| A0414 | Doxycycline 100mg | 1000 | | | | | |
| A0173 | Erythromycin 250mg | 1000 | | | | | |
| A0456 | Ferrous sulphate 200mg | 1000 | | | | | |
| A0185 | Ferrous sulphate 200mg Plus folic acid 250 mg | 1000 | | | | | |
| A0189 | Frusemide 40mg | 1000 | | | | | |
| A0121 | Hydrochlorothiazide 25mg | 100 | | | | | |
| A0123 | Hydrochlorothiazide 25mg | 1000 | | | | | |
| A0228 | Magnesium trisilicate compound | 1000 | | | | | |
| A0265 | Nalidixic acid 500mg | 1000 | | | | | |
| A0296 | Paracetamol 500mg | 1000 | | | | | |
| A0302 | Penicillin V 250mg | 1000 | | | | | |
| A0336 | Praziquantel 600mg | 1000 | | | | | |
| A0344 | Promethazine hydrochloride 25mg | 100 | | | | | |
| A0377 | Salbutamol 4mg | 1000 | | | | | |
| A0395 | Sulphadoxine 500mg / pyrimethamine 25mg (SP) | 1000 | | | | | |
| A0444 | Vitamin A 100,000 IU | 1000 | | | | | |
| A0445 | Vitamin A 200,000 IU | 1000 | | | | | |
| A0448 | Vitamin, multiple | 100 | | | | | |
| M10451 | LA 1 X 6 | 30 | | | | | |
| M10452 | LA 2 X 6 | 30 | | | | | |
| M10453 | LA 3 X 6 | 30 | | | | | |
| M10454 | LA 4 X 6 | 30 | | | | | |
| | Artesunate + Amodiaquine 50 +153 Mg - 3+3 | | | | | | |
| | Artesunate + Amodiaquine 50+ 153 Mg - 6-6 | | | | | | |
| | Artesunate + Amodiaquine 50 + 153 Mg - 12 + 12 | | | | | | |
| | | | | | | | |
| **Class B: Injectables** | | | | | | | |
| B0006 | Adrenaline 1/1000, 1ml | | | | | | |
| B0012 | Aminophylline 25mg/ml, 10ml | | | | | | |
| B0024 | Atropine sulphate 600 micrograms/ml, 1ml | | | | | | |
| B0224 | Benzathine benzylpenicillin 1.44g (2.4MU), PFR | | | | | | |
| B0220 | Benzylpenicillin 1g , PFR | | | | | | |
| B0034 | Chloramphenicol succinate 1g, PFR | | | | | | |
| B0454 | Darrows half-strength in dextrose 5%, 1000ml | | | | | | |
| B0406 | Dextrose (glucose) 5%, 1000ml | | | | | | |
| B0062 | Dextrose 50%, 20ml | | | | | | |
| B0064 | Diazepam 5mg/ml, 2ml | | | | | | |
| B0081 | Ergometrine maleate 500mcg/ml + Oxytocin 10IU/ml, 1ml | | | | | | |
| B0082 | Ergometrine maleate 500micrograms/ml, 1ml | | | | | | |
| B0097 | Gentamicin 40mg/ml, 2ml | | | | | | |

| Item No | Item | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days stocked out | Quantity Required |
|---|---|---|---|---|---|---|---|
| B0144 | Lignocaine hydrochloride 1%, 25ml | | | | | | |
| B0143 | Lignocaine hydrochloride 2%, 25ml | | | | | | |
| B0218 | Paraldehyde, 10ml | | | | | | |
| B0262 | Promethazine hydrochloride 25mg/ml, 2ml | | | | | | |
| B0270 | Quinine dihydrochloride 300mg/ml, 2ml | | | | | | |
| B0450 | Sodium chloride 0.9%, 1000ml,viaflex ( pouch). | | | | | | |
| B0457 | Sodium lactate + glucose (paed), 20ml | | | | | | |
| B0458 | Sodium lactate compound (Ringer's lactate), 1000ml,viaflex (pouch) | | | | | | |
| B0346 | Water for injections, 10ml | | | | | | |
| | | | | | | | |
| **Class C:Vaccines** | | | | | | | |
| C0010 | Tetanus antitoxin 1500 IU | | | | | | |
| | | | | | | | |
| **E: Galenicals** | | | | | | | |
| E0014 | Alcohol 96% | | | | | | |
| E0248 | Amoxycillin 125mg/5ml suspension | | | | | | |
| E0192 | Benzoic acid + salicylic acid compound lotion | | | | | | |
| E0330 | Benzoic acid 6% + salicylic acid 3% ointment | | | | | | |
| E0002 | Benzyl benzoate application 25% | | | | | | |
| E0012 | Black disinfectant | | | | | | |
| E0191 | Calamine lotion + sulphur 2% | | | | | | |
| E0189 | Calamine lotion aqueous | | | | | | |
| E0534 | Cetrimide 15% + chlorhexidine 1.5% soln.for dilution (Savlon) | | | | | | |
| E0312 | Chloramphenicol 1% eye ointment | | | | | | |
| E0036 | Chloramphenicol eye drops 0.5% | | | | | | |
| E0535 | Chlorhexidine 1.5% soln | | | | | | |
| E0552 | Chlorinated lime, pharmaceutical grade, 30% chlorine | | | | | | |
| E0205 | Cotrimoxazole 240mg/5ml | | | | | | |
| E0356 | Emulsifying ointment | | | | | | |
| E0266 | Erythromycin suspension 125mg/5ml | | | | | | |
| E0268 | Ferrous sulphate mixture paediatric 60mg/5ml | | | | | | |
| E0404 | Gentian violet paint, aqueous 1% | | | | | | |
| E0554 | Iodine solution, weak (iodine tincture) | | | | | | |
| E0574 | Methylated spirit | | | | | | |
| E0282 | Metronidazole oral suspension 200mg /5ml | | | | | | |
| E0602 | Multivitamin syrup | | | | | | |
| E0278 | Nystatin oral suspension 100,000 IU/dose | | | | | | |
| E0589 | Nystatin pessaries 100,000 IU | 15 | | | | | |
| E0006 | Oral rehydration salt, satchet (WHO formula) for 1L solution | | | | | | |
| E0279 | Paracetamol syrup 120mg/5ml | | | | | | |
| E0286 | Promethazine hydrochloride elixir 5mg/5ml | | | | | | |
| E0064 | Silver nitrate eye drops | | | | | | |
| E0327 | Silver nitrate ointment 15% | | | | | | |
| E0548 | Silver sulphadiazine cream 1% | | | | | | |
| E0325 | Tetracycline eye ointment 1% | | | | | | |
| E0416 | Zinc oxide & salicylic acid paste BP (Lassar's) | | | | | | |
| E0390 | Zinc oxide 15% ointment (in EO base) | | | | | | |
| E0392 | Zinc oxide 15% ointment +sulphur 5% | | | | | | |
| | | | | | | | |
| **Class F: Surgical dressings** | | | | | | | |
| F0002 | Bandage, crepe 5cm | | | | | | |
| F0004 | Bandage, crepe 7.5cmx 4m, 140g/m skin colour, striped red, with clip | | | | | | |
| F0096 | Bandage, WOW 10cm x 4m | 10 | | | | | |
| F0098 | Bandage, WOW 15cm x 4m | 10 | | | | | |
| F0092 | Bandage, WOW 5cm x 4m, 24x20 mesh,17thread/sq cm | 10 | | | | | |

| Item No | Item | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days stocked out | Quantity Required |
|---|---|---|---|---|---|---|---|
| ST0261 | Metronidazole, 200mg | | | | | | |
| CS0040 | Norplant | | | | | | |
| ST0590 | Nystatin pessaries, 100,000IU | | | | | | |
| CS0006 | Ovrette | | | | | | |
| ST0624 | Podophyllum paint 15% in compound bezoic tincture | | | | | | |
| GF0091 | SD Bioline: each | | | | | | |
| SM0450 | Sodium chloride | | | | | | |
| SM0081 | Syntometrine (Ergometrine 0.5mg+Oxytocin 10IU/ml) | | | | | | |
| ST0072 | Syringe hypoluer disposable | | | | | | |
| ST0090 | Unigold | | | | | | |
| GF0090 | Unigold: 20 | | | | | | |
| ST0092 | Veronostika | | | | | | |
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Submitted by [Name]:………………………………………… Signature:…………………… Date:………………..

Processed by[Name]:………………………………….. Signature:…………………… Date:………………..

Remarks……………………………………………………………………………………………………………………………………..

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# Appendix B: Part of District Hospital Monthly LMIS Report

LMIS -01B

## REPUBLIC OF MALAWI
### MINISTRY OF HEALTH
### District Hospital Monthly LMIS Report

| Facilty | | District | | Month / Year | | | |
|---|---|---|---|---|---|---|---|
| Item No | Item | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days Stocked Out | Quantity Required |
| **Class A: Tablets and Capsules** | | | | | | | |
| A0004 | Acetazolamide 250mg | 100 | | | | | |
| A0006 | Acyclovir 400mg | 100 | | | | | |
| A0230 | Albendazole 200mg | 1000 | | | | | |
| A0026 | Allopurinol 100mg | 100 | | | | | |
| A0028 | Aminophylline 100mg | 1000 | | | | | |
| A0034 | Amitriptyline 25mg | 100 | | | | | |
| A0039 | Amoxycillin 250mg | 1000 | | | | | |
| A0046 | Aspirin 300mg | 1000 | | | | | |
| A0067 | Benzhexol 5mg | 100 | | | | | |
| A0069 | Bisacodyl 5mg | 1000 | | | | | |
| A0089 | Captopril 12.5mg | 100 | | | | | |
| A0090 | Carbamazepine 200mg | 1000 | | | | | |
| A0091 | Carbimazole 5mg | 100 | | | | | |
| A0094 | Cephalexin 250mg | 100 | | | | | |
| A0102 | Chloramphenicol 250mg | 1000 | | | | | |
| A0114 | Chlorpheniramine 4mg | 1000 | | | | | |
| A0111 | Chlorpromazine 100mg | 1000 | | | | | |
| A0110 | Chlorpromazine 25mg | 100 | | | | | |
| A0115 | Cimetidine 400mg | 100 | | | | | |
| A0116 | Ciprofloxacin 250mg | 100 | | | | | |
| A0405 | Cotrimoxazole 480mg | 1000 | | | | | |
| A0136 | Dexamethasone 0.5mg | 100 | | | | | |
| A0141 | Diazepam 5mg | 1000 | | | | | |
| A0008 | Diclofenac sodium 25mg | 100 | | | | | |
| A0138 | Dihydrocodeine 30mg | 100 | | | | | |
| A0414 | Doxycycline 100mg | 1000 | | | | | |
| A0173 | Erythromycin 250mg | 1000 | | | | | |
| A0456 | Ferrous sulphate 200mg | 1000 | | | | | |
| A0185 | Ferrous sulphate 200mg / folic acid 250 micrograms | 1000 | | | | | |
| A0177 | Flucloxacillin 250mg | 100 | | | | | |
| A0187 | Fluconazole 200mg | 100 | | | | | |
| A0186 | Fluoxetine 20mg | 1000 | | | | | |
| A0012 | Folic acid 5mg | 1000 | | | | | |
| A0189 | Frusemide 40mg | 1000 | | | | | |
| A0433 | Glibenclamide 5mg | 1000 | | | | | |
| A0194 | Griseofulvin 125mg | 100 | | | | | |
| A0195 | Griseofulvin 250mg | 100 | | | | | |
| A0202 | Hydralazine 25mg | 100 | | | | | |
| A0121 | Hydrochlorothiazide 25mg | 100 | | | | | |
| A0123 | Hydrochlorothiazide 25mg | 1000 | | | | | |
| A0120 | Hydrocortisone acetate 20mg | 100 | | | | | |
| A0457 | Ibuprofen 200mg | 1000 | | | | | |
| A0210 | Imipramine Hcl 25mg | 1000 | | | | | |
| A0214 | Indomethacin 25mg | 1000 | | | | | |
| A0017 | Isosorbide dinitrate 10mg | 1000 | | | | | |
| A0224 | Ivermectin 6mg | 100 | | | | | |
| A0226 | Ketoconazole 200mg | 100 | | | | | |
| A0092 | Loperamide HCl 2mg | 1000 | | | | | |
| A0228 | Magnesium trisilicate compound | 1000 | | | | | |
| A0249 | Methyldopa 250mg | 1000 | | | | | |
| A0261 | Metronidazole 200mg | 1000 | | | | | |

| Item No | Item | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days Stocked Out | Quantity Required |
|---|---|---|---|---|---|---|---|
| A0263 | Morphine sulphate 10mg (slow release) | 50 | | | | | |
| A0265 | Nalidixic acid 500mg | 1000 | | | | | |
| A0022 | Nicotinamide 50mg | 1000 | | | | | |
| A0288 | Nitrofurantoin 50mg | 250 | | | | | |
| A0290 | Omeprazole 20mg | 100 | | | | | |
| A0296 | Paracetamol 500mg | 1000 | | | | | |
| A0302 | Penicillin V 250mg | 1000 | | | | | |
| A0318 | Phenobarbitone 30mg | 1000 | | | | | |
| A0325 | Phenytoin sodium 100mg | 1000 | | | | | |
| A0324 | Phenytoin sodium 25mg | 1000 | | | | | |
| A0332 | Potassium chloride 600mg (slow release) | 1000 | | | | | |
| A0336 | Praziquantel 600mg | 1000 | | | | | |
| A0334 | Prednisolone 5mg | 100 | | | | | |
| A0342 | Proguanil hydrochloride 100mg | 100 | | | | | |
| A0344 | Promethazine hydrochloride 25mg | 100 | | | | | |
| A0348 | Propantheline bromide 15mg | 100 | | | | | |
| A0345 | Propranolol 40mg | 1000 | | | | | |
| A0353 | Pyridoxine (Vitamin B6) 20mg | 1000 | | | | | |
| A0367 | Quinine hydrochloride 300mg | 1000 | | | | | |
| A0377 | Salbutamol 4mg | 1000 | | | | | |
| A0395 | Sulphadoxine 500mg / pyrimethamine 25mg (SP) | 1000 | | | | | |
| A0444 | Vitamin A 100,000 IU | 1000 | | | | | |
| A0445 | Vitamin A 200,000 IU | 1000 | | | | | |
| A0446 | Vitamin B complex strong | 1000 | | | | | |
| A0448 | Vitamin, multiple | 100 | | | | | |
| MI0451 | Lumefantrine/Artemether 20/120 Mg - 6x1 | 30 | | | | | |
| MI0452 | Lumefantrine/Artemether 20/120 Mg - 6x2 | 30 | | | | | |
| MI0453 | Lumefantrine/Artemether 20/120 Mg - 6x3 | 30 | | | | | |
| MI0454 | Lumefantrine/Artemether 20/120 Mg - 6x4 | 30 | | | | | |
| | Artesunate + Amodiaquine 50 +153 Mg - 3+3 | | | | | | |
| | Artesunate + Amodiaquine 50+ 153 Mg - 6-6 | | | | | | |
| | Artesunate + Amodiaquine 50 + 153 Mg - 12 + 12 | | | | | | |
| | | | | | | | |
| ***Class B: Injectables*** | | | | | | | |
| B0006 | Adrenaline 1/1000, 1ml | | | | | | |
| B0012 | Aminophylline 25mg/ml, 10ml | | | | | | |
| B0013 | Amphotericin B 50mg, | 5 | | | | | |
| B0015 | Ampicillin injection 250mg, PFR | | | | | | |
| B0017 | Ampicillin injection 500mg, PFR | | | | | | |
| B0024 | Atropine sulphate 600 micrograms/ml, 1ml | | | | | | |
| B0224 | Benzathine benzylpenicillin 1.44g (2.4MU), PFR | | | | | | |
| B0220 | Benzylpenicillin 1g , PFR | | | | | | |
| B0222 | Benzylpenicillin 3g (5MU), PFR | | | | | | |
| B0032 | Cefotaxime 500mg, PFR | | | | | | |
| B0034 | Chloramphenicol succinate 1g, PFR | | | | | | |
| B0040 | Chlorpromazine hydrochloride 25mg/ml, 2ml | | | | | | |
| B0454 | Darrows half-strength in dextrose 5%, 1000ml | | | | | | |
| B0060 | Dexamethasone 5mg/ml, 5ml | | | | | | |
| B0406 | Dextrose (glucose) 5%, 1000ml | | | | | | |
| B0062 | Dextrose 50%, 20ml | | | | | | |
| B0064 | Diazepam 5mg/ml, 2ml | | | | | | |
| B0081 | Ergometrine maleate 500mcg/ml + Oxytocin 10IU/ml, 1ml | | | | | | |
| B0082 | Ergometrine maleate 500micrograms/ml, 1ml | | | | | | |
| B0083 | Flucloxacillin 250mg, vial, PFR | | | | | | |
| B0084 | Fluconazole 2mg/ml, 25ml | | | | | | |
| B0086 | Fluphenazine decanoate 25mg/ml, 2ml | | | | | | |
| B0088 | Frusemide 10mg/ml, 2ml | | | | | | |
| B0446 | Gelatin (as polygeline) 500ml pack iv infusion | | | | | | |

| Item No | Item | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days Stocked Out | Quantity Required |
|---|---|---|---|---|---|---|---|
| CS0024 | Copper T | | | | | | |
| SM0242 | Cotton wool, 500g | | | | | | |
| CS0012 | Depo Provera | | | | | | |
| GF0088 | Determine HIV: 100 | | | | | | |
| ST0087 | Determine Syphillis: 100 | | | | | | |
| SM0064 | Diazepam 5mg/ml, 2ml | | | | | | |
| ST0414 | Doxycycline | | | | | | |
| ST0173 | Erythromycin | | | | | | |
| SM0170 | Gauze swabs 8ply | | | | | | |
| B0097 | Gentamycin | | | | | | |
| ST0404 | Gentian violet paint, aqueous | | | | | | |
| GF0089 | Helmastrip: each | | | | | | |
| ST0325 | Hepatitis B | | | | | | |
| CS0002 | Lofemenol | | | | | | |
| SM0238 | Maternity pads | | | | | | |
| ST0261 | Metronidazole, 200mg | | | | | | |
| CS0040 | Norplant | | | | | | |
| ST0590 | Nystatin pessaries, 100,000IU | | | | | | |
| CS0006 | Ovrette | | | | | | |
| ST0624 | Podophyllum paint 15% in compound bezoic tincture | | | | | | |
| GF0091 | SD Bioline: each | | | | | | |
| SM0450 | Sodium chloride | | | | | | |
| SM0081 | Syntometrine (Ergometrine 0.5mg+Oxytocin 10IU/ml) | | | | | | |
| ST0072 | Syringe hypoluer disposable | | | | | | |
| ST0090 | Unigold | | | | | | |
| GF0090 | Unigold: 20 | | | | | | |
| ST0092 | Veronostika | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Submitted by [Name]:………………………………………… Signature:…………………… Date:………………..

Processed by[Name]:………………………………….. Signature:…………………… Date:………………..

Remarks……………………………………………………………………………………………………………………………

………………………………………………………………………………………………………………………………

# Appendix C: Clinic Monthly LMIS Report

LMIS -01C

## REPUBLIC OF MALAWI

### MINISTRY OF HEALTH

### Clinic Monthly LMIS Report

| Facilty | | District | | Month | |
|---|---|---|---|---|---|
| | | | | Year | |

| Item No | Item | Unit of Issue | Balance (Stock on Hand) | Losses/ Expired | Quantity Used | Days Stocked Out | Quantity Required |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| ***Family Planning and STI Items*** | | | | | | | |
| ST0224 | Benzathine Penicillin, 1.44g | | | | | | |
| SM0012 | Black disinfectant (SM) , 5L | | | | | | |
| SM0214 | Catgut chromic 0 on needle rb 1/2c | | | | | | |
| CS0020 | Conceptrol | | | | | | |
| CS0036 | Condoms | | | | | | |
| CS0024 | Copper T | | | | | | |
| SM0242 | Cotton wool, 500g | | | | | | |
| CS0012 | Depo Provera | | | | | | |
| GF0088 | Determine HIV: 100 | | | | | | |
| ST0087 | Determine Syphillis: 100 | | | | | | |
| SM0064 | Diazepam 5mg/ml, 2ml | | | | | | |
| ST0414 | Doxycycline | | | | | | |
| ST0173 | Erythromycin | | | | | | |
| SM0170 | Gauze swabs 8ply | | | | | | |
| B0097 | Gentamycin | | | | | | |
| ST0404 | Gentian violet paint, aqueous | | | | | | |
| GF0089 | Helmastrip: each | | | | | | |
| ST0325 | Hepatitis B | | | | | | |
| CS0002 | Lofemenol | | | | | | |
| SM0238 | Maternity pads | | | | | | |
| ST0261 | Metronidazole, 200mg | | | | | | |
| CS0040 | Norplant | | | | | | |
| ST0590 | Nystatin pessaries, 100,000IU | | | | | | |
| CS0006 | Ovrette | | | | | | |
| ST0624 | Podophyllum paint 15% in compound bezoic tincture | | | | | | |
| GF0091 | SD Bioline: each | | | | | | |
| SM0450 | Sodium chloride | | | | | | |
| SM0081 | Syntometrine (Ergometrine 0.5mg+Oxytocin 10IU/ml) | | | | | | |
| ST0072 | Syringe hypoluer disposable | | | | | | |
| ST0090 | Unigold | | | | | | |
| GF0090 | Unigold: 20 | | | | | | |
| ST0092 | Veronostika | | | | | | |
| MI0451 | Lumefantrine/Artemether 20/120 Mg - 6x1 | 30 | | | | | |
| MI0452 | Lumefantrine/Artemether 20/120 Mg - 6x2 | 30 | | | | | |
| MI0453 | Lumefantrine/Artemether 20/120 Mg - 6x3 | 30 | | | | | |
| MI0454 | Lumefantrine/Artemether 20/120 Mg - 6x4 | 30 | | | | | |
| | Artesunate + Amodiaquine 50 +153 Mg - 3+3 | | | | | | |
| | Artesunate + Amodiaquine 50+ 153 Mg - 6-6 | | | | | | |
| | Artesunate + Amodiaquine 50 + 153 Mg - 12 + 12 | | | | | | |

Submitted by [Name]:………………………………………… Signature:……………………. Date:……………….

Processed by[Name]:………………………………… Signature:……………………. Date:……………….

Remarks……………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………

# Appendix D: Stock Imbalances Report of SP in September 2008

Supply Chain Manager
Ministry of Health
Blantyre District

**Stock Imbalances**
Report Period: September, 2008
All Facility Type
Health Centre

Run Date:
Run Time: 04:19 PM
Page: 1 of 1

| Facility | Product | Closing Balance | AMC | Months of Stock | Quantity Required | Status |
|---|---|---|---|---|---|---|
| Chimembe HC | Sulphadoxine 500mg/pyrimetherine | 0 | 4,000 | 0.0 | 12,000 | Stocked Out |
| Bangwe HC | Sulphadoxine 500mg/pyrimetherine | 3,000 | 4,333 | 0.7 | 9,999 | Below Minimum |
| Dziwe HC | Sulphadoxine 500mg/pyrimetherine | 5,000 | 6,000 | 0.8 | 13,000 | Below Minimum |
| Makata HC | Sulphadoxine 500mg/pyrimetherine | 1,000 | 4,000 | 0.3 | 11,000 | Below Minimum |
| Soche HC | Sulphadoxine 500mg/pyrimetherine | 2,000 | 4,000 | 0.5 | 10,000 | Below Minimum |
| Zingwangwa HC | Sulphadoxine 500mg/pyrimetherine | 13,000 | 15,667 | 0.6 | 34,001 | Below Minimum |
| Chavala HC | Sulphadoxine 500mg/pyrimetherine | 21,000 | 1,667 | 12.6 | -15,999 | Overstocked |
| Limbe HC | Sulphadoxine 500mg/pyrimetherine | 11,000 | 3,333 | 3.3 | -1,001 | Overstocked |
| Lirangwe HC | Sulphadoxine 500mg/pyrimetherine | 19,000 | 2,000 | 9.5 | -13,000 | Overstocked |
| Lundu HC | Sulphadoxine 500mg/pyrimetherine | 17,000 | 2,667 | 6.4 | -8,999 | Overstocked |
| Madziabango HC | Sulphadoxine 500mg/pyrimetherine | 10,000 | 333 | 30.0 | -9,001 | Overstocked |
| Mpemba HC | Sulphadoxine 500mg/pyrimetherine | 21,000 | 1,333 | 15.8 | -17,001 | Overstocked |
| South Lunzu HC | Sulphadoxine 500mg/pyrimetherine | 12,000 | 2,333 | 5.1 | -5,001 | Overstocked |

# Appendix E: Part of Monthly LMIS Report of December 2008

Supply Chain Manager
Ministry of Health
Blantyre District

**Monthly LMIS Report - Summary**
Report Period: December, 2008

Run Date: #Name?
Run Time: 04:08 PM
Page: 1 of 4

**Health Centre** Facility Count: 23

| Category Item No. | Item | Unit of Issue | Balance on Hand | Quantity Used | Quantity Required |
|---|---|---|---|---|---|
| Antiretrovirals | | | | | |
| B0006 | Adrenaline 1/1000, 1ml | | 701 | 106 | 156 |
| B0012 | Aminophylline 25mg/ml, 10ml | | 563 | 111 | 148 |
| B0024 | Atropine sulphate 600 micrograms/ml, 1ml | | 133 | 20 | 40 |
| B0222 | Benzylpenicillin 3g (5MU), PFR | | 3,117 | 940 | 626 |
| B0040 | Chlorpromazine hydrochloride 25mg/ml, 2ml | | 0 | 20 | 160 |
| B0454 | Darrows half-strength in dextrose 5%, 1000 | | 276 | 194 | 395 |
| B0406 | Dextrose (glucose) 5%, 1000ml | | 1,037 | 239 | 295 |
| B0062 | Dextrose 50%, 20ml | | 481 | 315 | 663 |
| B0064 | Diazepam 5mg/ml, 2ml | | 1,910 | 443 | 815 |
| B0081 | Ergometrine maleate 500mcg/ml + Oxytocin | | 456 | 1748 | 6,519 |
| B0144 | Lignocaine hydrochloride 1%, 25ml | | 1,394 | 198 | 239 |
| B0143 | Lignocaine hydrochloride 2%, 25ml | | 1,692 | 284 | 100 |
| B0218 | Paraldehyde, 10ml | | 136 | 93 | 55 |
| B0262 | Promethazine hydrochloride 25mg/ml, 2ml | | 796 | 241 | 360 |
| B0270 | Quinine dihydrochloride 300mg/ml, 2ml | | 6,290 | 4196 | 2,328 |
| B0450 | Sodium chloride 0.9%, 100ml, viaflex (pouc | | 433 | 179 | 430 |
| B0458 | Sodium lactate compound (Ringer's lactate), | | 975 | 381 | 788 |
| B0346 | Water for injections, 10ml | | 6,178 | 3007 | 2,637 |
| CLASS A: Tablets and Capsules | | | | | |
| A0230 | Albendazole 200mg | 1000 | 61,700 | 29000 | 72,400 |
| A0028 | Aminophylline 100mg | 1000 | 294,000 | 66500 | 47,000 |
| A0034 | Amitriptyline 25mg | 100 | 3,000 | 1050 | 1,000 |
| A0039 | Amoxycillin 250mg | 1000 | 182,000 | 189000 | 397,000 |
| A0046 | Aspirin 300mg | 1000 | 1,851,000 | 536000 | 409,000 |
| A0114 | Chlorpheniramine 4mg | 1000 | 141,000 | 115000 | 207,000 |
| A0111 | Chlorpromazine 100mg | 1000 | 186,000 | 26000 | 12,000 |
| A0405 | Cotrimoxazole 480mg | 1000 | 629,740 | 245820 | 576,520 |
| A0456 | Ferrous sulphate 200mg | 1000 | 70,000 | 37000 | 41,000 |
| A0185 | Ferrous sulphate 200mg/folic acid 250 micr | 1000 | 850,000 | 285000 | 352,000 |
| A0189 | Frusemide 40mg | 1000 | 17,000 | 10000 | 29,000 |
| A0121 | Hydrochlorothiazide 25mg | 100 | 15,300 | 11600 | 22,800 |
| A0123 | Hydrochlorothiazide 25mg | 1000 | 10,600 | 19600 | 54,200 |
| A0214 | Indomethacin 25mg | 1000 | 542,000 | 206500 | 143,000 |
| MI0451 | Lumefantrine/Arthemether 1 x 6 | | 199,358 | 101722 | 154,686 |
| MI0452 | Lumefantrine/Arthemether 2 x 6 | | 197,908 | 67572 | 81,090 |
| MI0453 | Lumefantrine/Arthemether 3 x 6 | | 239,160 | 76822 | 119,862 |
| MI0454 | Lumefantrine/Arthemether 4 x 6 | | 471,728 | 294410 | 482,004 |

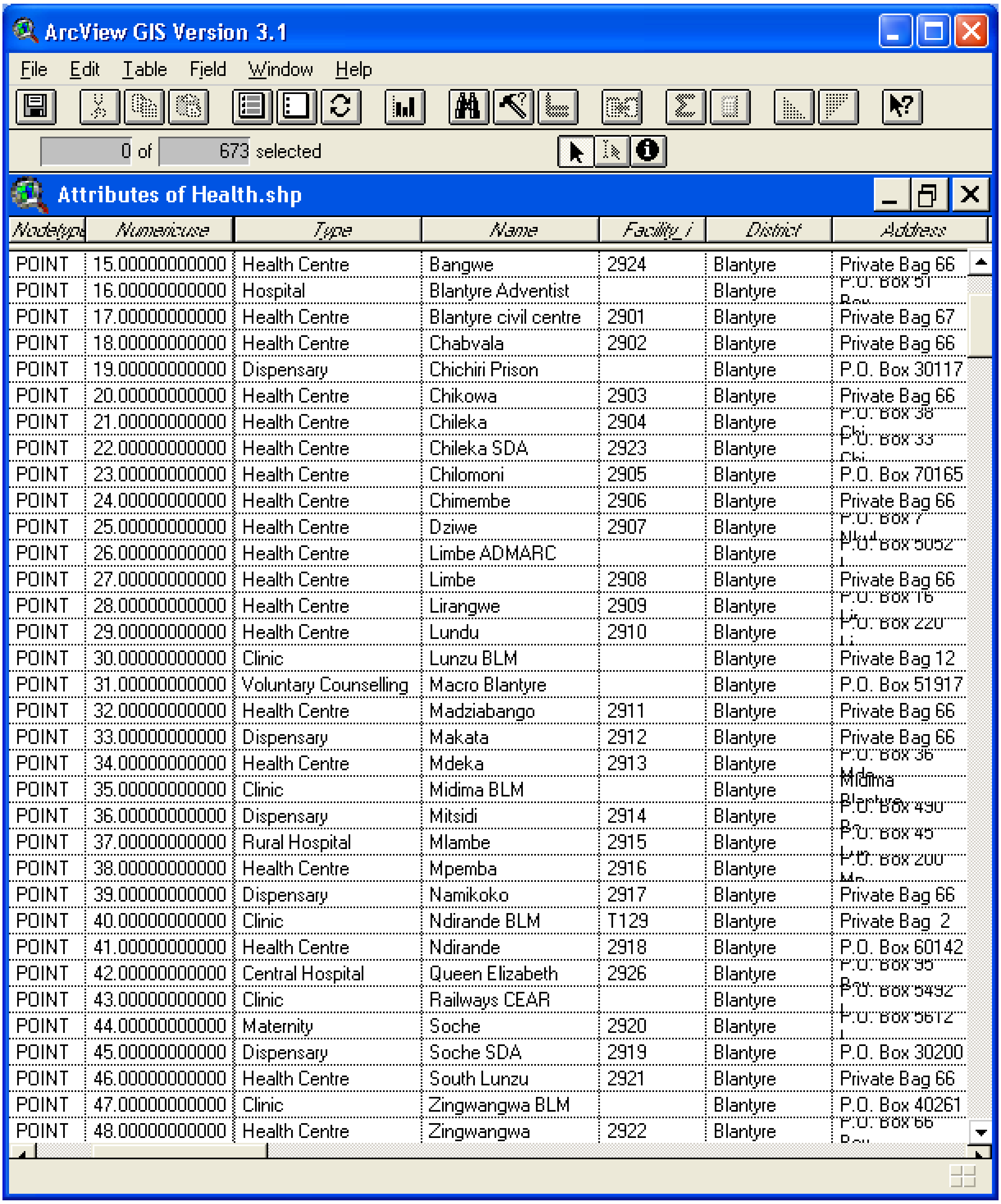
Quantity Required = (Quantity Used x 3) – Balance On Hand

# Appendix F: Reported Malaria in Blantyre District in 2008

## REPORTED MALARIA CASES IN BLANTYRE DISTRICT APART FROM QECH IN 2008

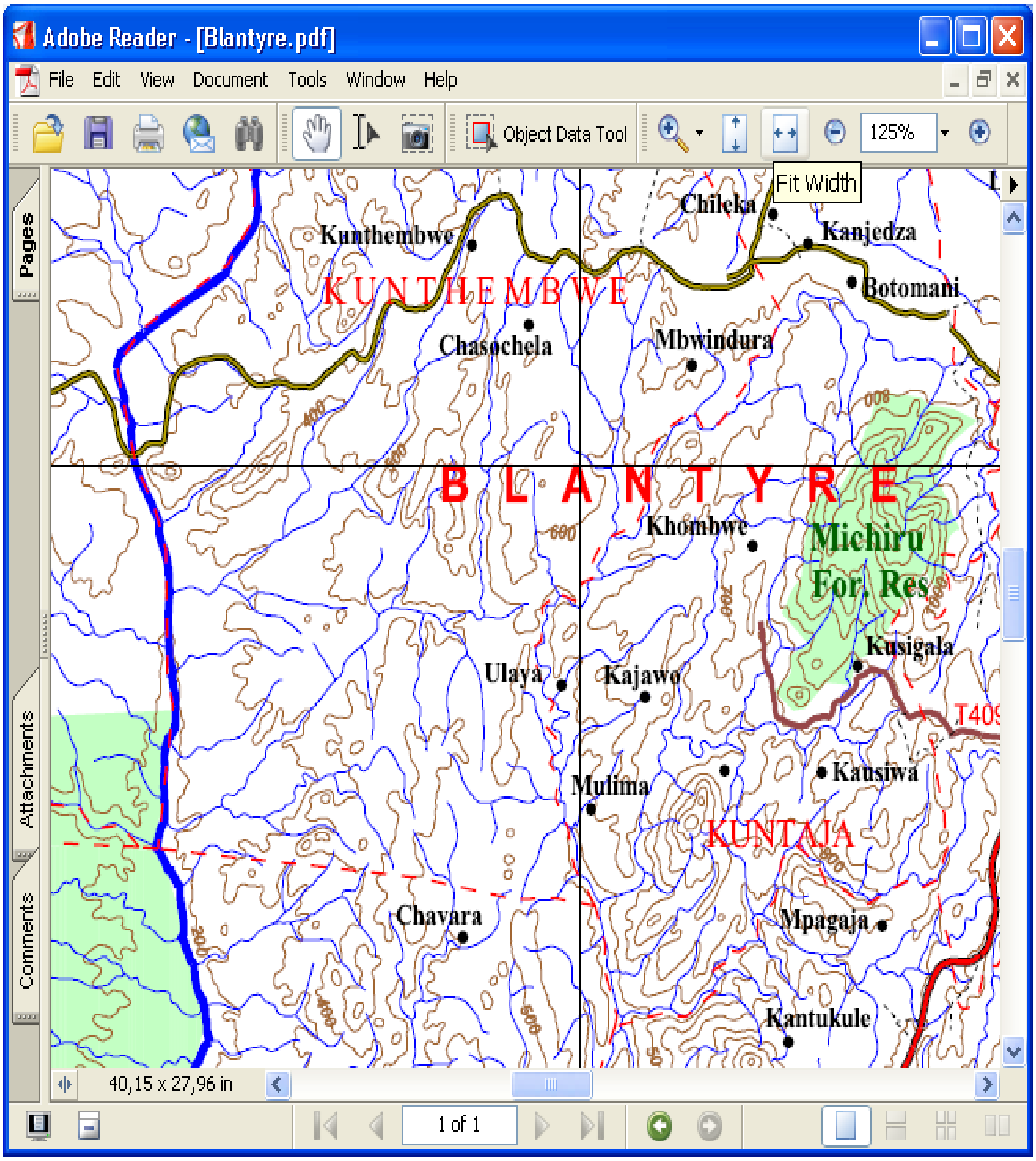
| HEALTH CENTRE | CONDITION | Jan-08 | Feb-08 | Mar-08 | Apr-08 | May-08 | Jun-08 | Jul-08 | Aug-08 | Sep-08 |
|---|---|---|---|---|---|---|---|---|---|---|
| Bangwe | Malaria <5 - new | 817 | 1 253 | 1 796 | 718 | 2 834 | 1 200 | 956 | 1 709 | 2 593 |
| Bangwe | Malaria >=5 - new | 911 | 1 355 | 1 867 | 938 | 2 211 | 1 078 | 831 | 1 804 | 2 676 |
| Chabvala | Malaria <5 - new | 301 | 420 | 350 | 450 | 300 | 293 | 203 | 290 | 287 |
| Chabvala | Malaria >=5 - new | 318 | 392 | 330 | 411 | 291 | 280 | 190 | 250 | 258 |
| Chikowa | Malaria <5 - new | 936 | 539 | 653 | 545 | 664 | 473 | 360 | 461 | 242 |
| Chikowa | Malaria >=5 - new | 1 043 | 715 | 631 | 453 | 640 | 332 | 404 | 352 | 371 |
| Chileka | Malaria <5 - new | 1 154 | 1 452 | 1 531 | 1 149 | 1 013 | 1 506 | 857 | 959 | 1001 |
| Chileka | Malaria >=5 - new | 1 321 | 1 582 | 1 821 | 1 363 | 1 285 | 1 105 | 1158 | 1182 | 1191 |
| Chileka SDA | Malaria <5 - new | 225 | 206 | 235 | 183 | 116 | 100 | 30 | 87 | 89 |
| Chileka SDA | Malaria >=5 - new | 111 | 88 | 140 | 78 | 84 | 48 | 41 | 13 | 33 |
| Chilomoni | Malaria <5 - new | 1 403 | 1 307 | 1 026 | 1 211 | 1 106 | 1 075 | 1 202 | 705 | 912 |
| Chilomoni | Malaria >=5 - new | 894 | 1 078 | 863 | 1 279 | 978 | 821 | 973 | 844 | 1 040 |
| Chimembe | Malaria <5 - new | 270 | 204 | 216 | 266 | 183 | 184 | 84 | 165 | 244 |
| Chimembe | Malaria >=5 - new | 297 | 427 | 320 | 251 | 132 | 209 | 65 | 157 | 237 |
| Dziwe | Malaria <5 - new | 671 | 687 | 617 | 421 | 491 | 687 | 534 | 681 | 673 |
| Dziwe | Malaria >=5 - new | 1 268 | 1 288 | 1 241 | 890 | 966 | 1 260 | 1 032 | 1 278 | 1 297 |
| limbe | Malaria <5 - new | 1 247 | 1 997 | 1 400 | 2 863 | 2 941 | 2 796 | 1 720 | 1 960 | 1 480 |
| limbe | Malaria >=5 - new | 3 176 | 2 057 | 2 251 | 4 544 | 4 782 | 4 127 | 3 120 | 3 078 | 3 213 |
| Lirangwe | Malaria <5 - new | 363 | 483 | 438 | 856 | 12 | 902 | 308 | 389 | 472 |
| Lirangwe | Malaria >=5 - new | 46 | 323 | 391 | 609 | 522 | 824 | 423 | 478 | 499 |
| Lundu | Malaria <5 - new | 1 169 | 2 175 | 1 357 | 816 | 698 | 658 | 631 | 884 | 928 |
| Lundu | Malaria >=5 - new | 908 | 1 559 | 1 185 | 791 | 762 | 778 | 771 | 738 | 915 |
| madziabango | Malaria <5 - new | 688 | 650 | 238 | 281 | 260 | 215 | 501 | 355 | 329 |
| madziabango | Malaria >=5 - new | 679 | 625 | 472 | 557 | 354 | 254 | 395 | 440 | 409 |
| makata | Malaria <5 - new | 694 | 613 | 501 | 694 | 613 | 501 | 172 | 156 | 166 |
| makata | Malaria >=5 - new | 841 | 762 | 629 | 841 | 762 | 629 | 164 | 150 | 207 |
| mdeka | Malaria <5 - new | 566 | 714 | 669 | 624 | 517 | 416 | 672 | 525 | 680 |
| mdeka | Malaria >=5 - new | 900 | 991 | 821 | 718 | 621 | 273 | 940 | 871 | 763 |
| Mlambe | Malaria <5 - new | 670 | 274 | 350 | 276 | 302 | 270 | 135 | 211 | 253 |
| Mlambe | Malaria >=5 - new | 370 | 346 | 207 | 250 | 170 | 152 | 83 | 164 | 180 |
| mpemba | Malaria <5 - new | 1 074 | 561 | 497 | 964 | 790 | 786 | 359 | 359 | 425 |
| mpemba | Malaria >=5 - new | 1 537 | 1 031 | 874 | 0 | 1 020 | 1 201 | 389 | 389 | 789 |
| Namikoko | Malaria <5 - new | 380 | 223 | 251 | 128 | 118 | 197 | 245 | 263 | 281 |
| Namikoko | Malaria >=5 - new | 283 | 278 | 272 | 173 | 149 | 187 | 309 | 328 | 359 |
| Ndirande | Malaria <5 - new | 1 982 | 1 793 | 1 020 | 800 | 789 | 768 | 3 330 | 3 420 | 4 220 |
| Ndirande | Malaria >=5 - new | 2 857 | 2 968 | 1 437 | 1 242 | 1 322 | 1 006 | 1 490 | 2 200 | 900 |
| soche martenity | Malaria <5 - new | 206 | 425 | 305 | 210 | 301 | 296 | 207 | 195 | 178 |
| soche martenity | Malaria >=5 - new | 430 | 530 | 517 | 270 | 370 | 306 | 283 | 265 | 206 |
| south lunzu | Malaria <5 - new | 2 157 | 2 237 | 2 453 | 1 314 | 1 341 | 1 123 | 719 | 707 | 952 |
| south lunzu | Malaria >=5 - new | 4 380 | 3 710 | 2 270 | 2 531 | 1 554 | 1 467 | 1 058 | 843 | 875 |
| zingwangwa | Malaria <5 - new | 1 346 | 1 193 | 1 241 | 850 | 988 | 957 | 956 | 598 | 855 |
| zingwangwa | Malaria >=5 - new | 1 515 | 1 453 | 1 571 | 1 306 | 859 | 705 | 831 | 878 | 984 |
| Blantyre Totals | **Malaria <5 - new** | **18 319** | **19 406** | **17 144** | **15 619** | **16 377** | **15 403** | **14 181** | **15 079** | **17 260** |
| Blantyre Totals | **Malaria >=5 - new** | **24 085** | **23 558** | **20 110** | **19 495** | **19 834** | **17 042** | **14 950** | **16 702** | **17 402** |

# Appendix G: Part of Spatial Data for Health Facilities in Shapefiles Format

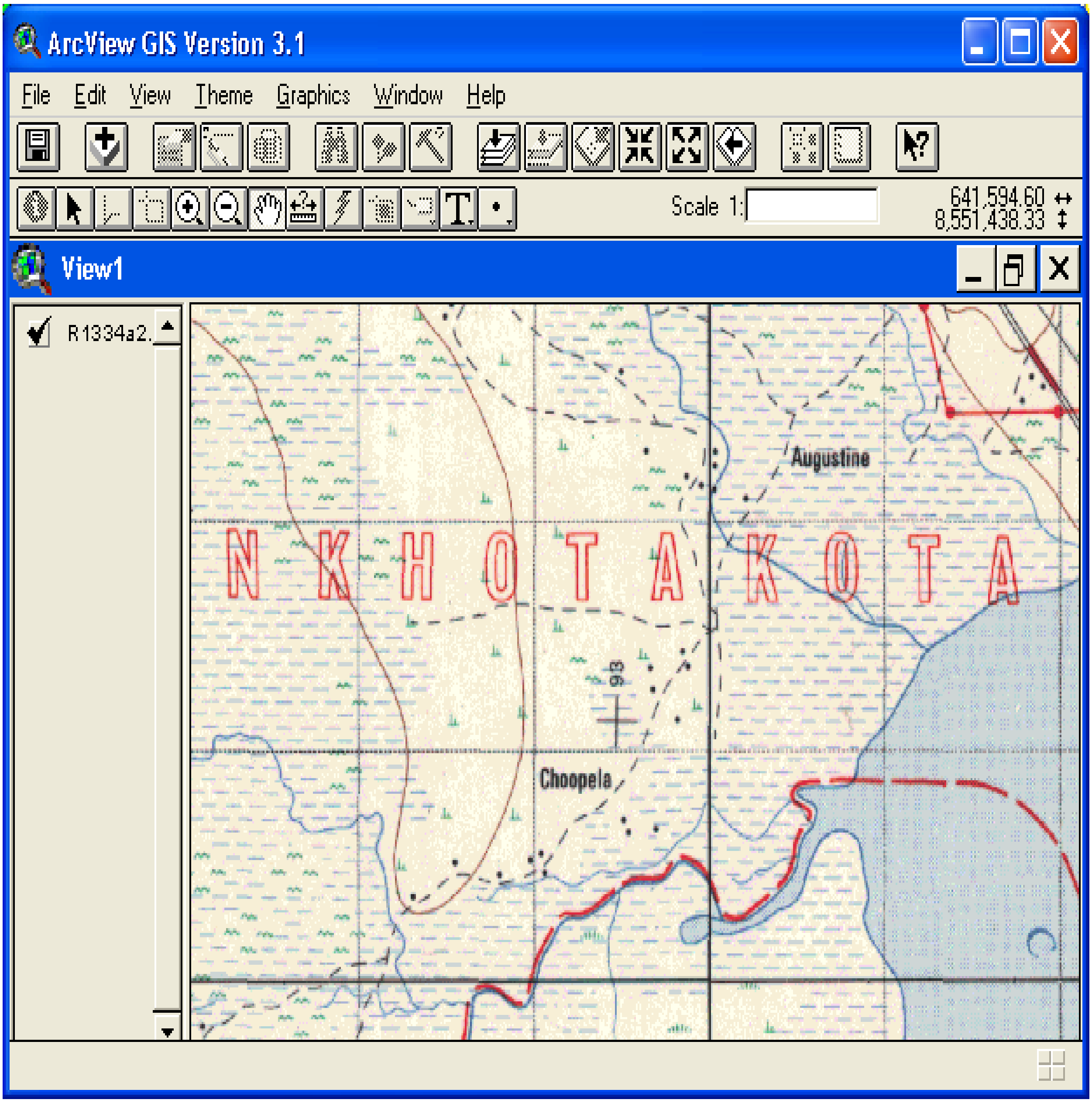



| Nodetype | Numericuse | Type | Name | Facility_i | District | Address |
|---|---|---|---|---|---|---|
| POINT | 15.00000000000 | Health Centre | Bangwe | 2924 | Blantyre | Private Bag 66 |
| POINT | 16.00000000000 | Hospital | Blantyre Adventist | | Blantyre | P.O. Box 51 |
| POINT | 17.00000000000 | Health Centre | Blantyre civil centre | 2901 | Blantyre | Private Bag 67 |
| POINT | 18.00000000000 | Health Centre | Chabvala | 2902 | Blantyre | Private Bag 66 |
| POINT | 19.00000000000 | Dispensary | Chichiri Prison | | Blantyre | P.O. Box 30117 |
| POINT | 20.00000000000 | Health Centre | Chikowa | 2903 | Blantyre | Private Bag 66 |
| POINT | 21.00000000000 | Health Centre | Chileka | 2904 | Blantyre | P.O. Box 38 |
| POINT | 22.00000000000 | Health Centre | Chileka SDA | 2923 | Blantyre | P.O. Box 33 |
| POINT | 23.00000000000 | Health Centre | Chilomoni | 2905 | Blantyre | P.O. Box 70165 |
| POINT | 24.00000000000 | Health Centre | Chimembe | 2906 | Blantyre | Private Bag 66 |
| POINT | 25.00000000000 | Health Centre | Dziwe | 2907 | Blantyre | P.O. Box 7 |
| POINT | 26.00000000000 | Health Centre | Limbe ADMARC | | Blantyre | P.O. Box 5052 |
| POINT | 27.00000000000 | Health Centre | Limbe | 2908 | Blantyre | Private Bag 66 |
| POINT | 28.00000000000 | Health Centre | Lirangwe | 2909 | Blantyre | P.O. Box 16 |
| POINT | 29.00000000000 | Health Centre | Lundu | 2910 | Blantyre | P.O. Box 220 |
| POINT | 30.00000000000 | Clinic | Lunzu BLM | | Blantyre | Private Bag 12 |
| POINT | 31.00000000000 | Voluntary Counselling | Macro Blantyre | | Blantyre | P.O. Box 51917 |
| POINT | 32.00000000000 | Health Centre | Madziabango | 2911 | Blantyre | Private Bag 66 |
| POINT | 33.00000000000 | Dispensary | Makata | 2912 | Blantyre | Private Bag 66 |
| POINT | 34.00000000000 | Health Centre | Mdeka | 2913 | Blantyre | P.O. Box 36 |
| POINT | 35.00000000000 | Clinic | Midima BLM | | Blantyre | Midima Blantyre |
| POINT | 36.00000000000 | Dispensary | Mitsidi | 2914 | Blantyre | P.O. Box 490 |
| POINT | 37.00000000000 | Rural Hospital | Mlambe | 2915 | Blantyre | P.O. Box 45 |
| POINT | 38.00000000000 | Health Centre | Mpemba | 2916 | Blantyre | P.O. Box 200 |
| POINT | 39.00000000000 | Dispensary | Namikoko | 2917 | Blantyre | Private Bag 66 |
| POINT | 40.00000000000 | Clinic | Ndirande BLM | T129 | Blantyre | Private Bag 2 |
| POINT | 41.00000000000 | Health Centre | Ndirande | 2918 | Blantyre | P.O. Box 60142 |
| POINT | 42.00000000000 | Central Hospital | Queen Elizabeth | 2926 | Blantyre | P.O. Box 95 |
| POINT | 43.00000000000 | Clinic | Railways CEAR | | Blantyre | P.O. Box 5492 |
| POINT | 44.00000000000 | Maternity | Soche | 2920 | Blantyre | P.O. Box 5612 |
| POINT | 45.00000000000 | Dispensary | Soche SDA | 2919 | Blantyre | P.O. Box 30200 |
| POINT | 46.00000000000 | Health Centre | South Lunzu | 2921 | Blantyre | Private Bag 66 |
| POINT | 47.00000000000 | Clinic | Zingwangwa BLM | | Blantyre | P.O. Box 40261 |
| POINT | 48.00000000000 | Health Centre | Zingwangwa | 2922 | Blantyre | P.O. Box 66 |

# Appendix H: Example of Geographic Data in PDF Format



# Appendix I: Example of Geographic Data in Image Format



# Appendix J: Part of Shapefile of Roads in Malawi

| Mw_roads_ | Mw_roads_i | Mroad_type | Road_class | Shape_leng | Enabled |
|---|---|---|---|---|---|
| 51750 | 664 | T423 | Tertiary Road | 2058.656 | 1 |
| 64503 | 19680 | Unclassified | Other Roads | 606.955 | 1 |
| 64503 | 19680 | Unclassified | Other Roads | 315.480 | 1 |
| 52892 | 2379 | D379 | District Road | 139.723 | 1 |
| 44750 | 33093 | Unclassified | Other Roads | 667.850 | 1 |
| 44930 | 33376 | M10 | Main Road | 4721.299 | 1 |
| 44931 | 33377 | Unclassified | Other Roads | 2447.764 | 1 |
| 44932 | 33378 | Unclassified | Other Roads | 38.248 | 1 |
| 45016 | 33496 | D236 | District Road | 2474.872 | 1 |
| 45032 | 33517 | S127 | Secondary Road | 1077.510 | 1 |
| 45138 | 33663 | M5 | Main Road | 681.335 | 1 |
| 45157 | 33697 | M1 | Main Road | 2793.761 | 1 |
| 45157 | 33697 | M1 | Main Road | 2793.761 | 1 |
| 45157 | 33697 | M1 | Main Road | 2793.761 | 1 |
| 45186 | 33744 | M10 | Main Road | 648.325 | 1 |
| 45187 | 33745 | M10 | Main Road | 1604.254 | 1 |
| 46026 | 35124 | T379 | Tertiary Road | 630.314 | 1 |
| 46027 | 35125 | Unclassified | Other Roads | 1384.126 | 1 |
| 46028 | 35126 | T379 | Tertiary Road | 83.952 | 1 |
| 46029 | 35128 | Unclassified | Other Roads | 1192.030 | 1 |
| 46030 | 35132 | Unclassified | Other Roads | 1001.133 | 1 |
| 46031 | 35133 | T379 | Tertiary Road | 693.845 | 1 |
| 46032 | 35134 | T379 | Tertiary Road | 1175.475 | 1 |
| 46033 | 35135 | Unclassified | Other Roads | 818.733 | 1 |
| 46034 | 35136 | T379 | Tertiary Road | 281.971 | 1 |
| 46035 | 35138 | Unclassified | Other Roads | 1067.118 | 1 |
| 46036 | 35140 | Unclassified | Other Roads | 750.077 | 1 |
| 46037 | 35142 | Unclassified | Other Roads | 593.225 | 1 |
| 46038 | 35143 | T379 | Tertiary Road | 1191.836 | 1 |
| 46039 | 35145 | Unclassified | Other Roads | 1258.022 | 1 |
| 46040 | 35146 | Unclassified | Other Roads | 1349.211 | 1 |
| 46041 | 35148 | T379 | Tertiary Road | 1346.398 | 1 |
| 46042 | 35149 | Unclassified | Other Roads | 864.681 | 1 |
| 46043 | 35152 | Unclassified | Other Roads | 1752.363 | 1 |
| 46044 | 35153 | Unclassified | Other Roads | 599.165 | 1 |
| 46045 | 35155 | Unclassified | Other Roads | 2371.958 | 1 |
| 46046 | 35156 | Unclassified | Other Roads | 1053.074 | 1 |