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THE APPLICATION OF GIS IN MAPPING, ANALYSIS, MONITORING AND MANAGEMENT OF HIV/AIDS IN ETHIOPIA

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ADULT HIV PREVALENCE 2007

BY
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The Application of GIS in Mapping, Analysis, Monitoring and Management of HIV/AIDS in Ethiopia

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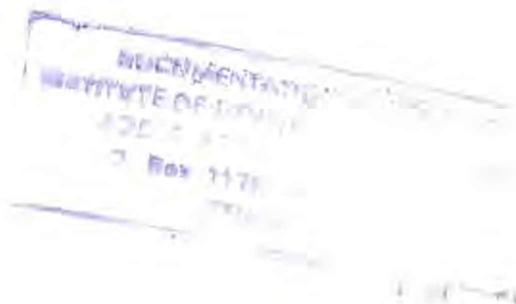

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ABBREVIATIONS

AAHAPCO... Addis Ababa HIV/AIDS Prevention and Control Office

AHAPCO.... Amhara HIV/AIDS Prevention and Control Office

AIDS.......... Acquired Immune Deficiency Syndrome

ANC .... Antenatal Care

ART........... Anti-Retroviral Therapy

BSS .... Behavioral surveillance survey

CD4 .... Cluster of differentiation 4

CDC .... Center for Disease Control and Prevention

CSA .... Central Statistical Agency

DBMS......... Data Base Management System

EDHS......... Ethiopia Demographic and health survey

ESRI .... Environmental Systems Research Institute

FHI ....Family Health International

FSW .... Female sex worker

GIS ....Geographic Information System

GISA............Geographic Information System Analysis

GPS ....Global Positioning System

HAART ....Highly Active Anti-Retroviral Therapy

HAPCO........ HIV/AIDS Prevention and Control Office

HIV .... Human Immunodeficiency Virus

HSEP........... Health Service Extension Programme

HC .... Health Center

IDU ....Injecting drug user

IEC ....Information, Education and Communication

MTCT.......... Mother-to-Child Transmission

MOFED....... Ministry of Finance and Economic Development

MOH ....Ministry of Health

PLWHA ...... People living with HIV/AIDS

PMTCT ....Prevention of Mother to Child Transmission

NGO....... ....Non-Governmental Organization

SNNPR……...South Nation Nationality People Region

STD …………Sexually Transmitted Disease

TB…………. Tuberculosis

UNAIDS ……United Nations Program on HIV/AIDS

WHO ………..World Health Organization

VCT ………...Voluntary counseling and testing

ABSTRACT

Ethiopia is experiencing an HIV/AIDS pandemic of shattering dimensions. A total of 1,319,795 persons were estimated to be living with HIV/AIDS in the year 2005 in Ethiopia (MOH, 2006) .The HIV/AIDS epidemic had already spread to all the administrative provinces of Ethiopia. However, the prevalence levels were different, suggesting a difference in the times when the epidemic started in the provinces.

In Ethiopia, the application of GIS to benefit our society has not been optimized. The argument of the present thesis is that recent developments in Geographical Information Systems (GIS) can greatly increase our capacity to undertake the spatial tasks needed to improve monitoring and management of the spread of HIV/AIDS.

GIS a powerful computer based technology; is involved in the storage, analysis, retrieval, and visualization of spatially referenced information for monitoring, planning, assessment and management due to the options and capabilities for data maintenance and manipulation through add/ delete/ change,overlay,query ,proximity, display and data retrieval and reporting. Visualization of maps in various combinations and permutations as initial and final output (ranged color maps or proportional symbol maps to denote the intensity of a mapped variable) to depict various ART Hospitals and health centers for general monitoring health infrastructure.

The study strongly supports the usefulness of advanced technology like GIS for the Management and handling of large database of spatial and aspatial nature in context of communicable and non-communicable diseases.

Key words: HIV/AIDS, GIS, ART Health centers and Hospitals, Mapping, Analysis.

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

AIDS (Acquired Immune deficiency Syndrome) a disease caused by HIV (Human Immunodeficiency virus). This virus attacks a person's immune system (white blood cells). This weakens the immune system and makes the person vulnerable to opportunistic diseases e.g. tuberculosis. HIV was first diagnosed more than twenty years ago and up to now there is no known cure for the disease (Armstrong, 2002).

People and the factors that cause diseases are dispersed, often unevenly, across communities and regions, and the processes that bring the people and the disease-causing agents into contact are geographically variable too. The environment, be it physical, climate, social, or economic, affects people's health. People's behavior too cannot be divorced from the environment and social context it occurs in, as much of it is not under the individual control. The role of geography and its advances in geographical information systems in understanding health related issues cannot be underrated. The identification of the spatial distribution pattern, the spatial diffusion characteristics, and the magnitude of the affected population, forms the first step in identifying the regional epidemic impacts of the epidemic (Moses, 2006).

Every day, over 6800 persons become infected with HIV and over 5700 persons die from AIDS, mostly because of inadequate access to HIV/AIDS prevention and treatment services. The HIV/AIDS pandemic remains the most serious of infectious disease challenges to public health. When HIV/AIDS first emerged, no-one could have predicted how the epidemic would spread across the world and how many millions of lives it would change. Already, more than twenty-five million people around the world have died of HIV/AIDS-related diseases. In 2007, around 2.1 million men, women and children lost their lives. About 33.2 million People around the world are now living with HIV. The

most recent UNAIDS/WHO estimates show that, in 2007 alone, 2.5 million people were newly infected with HIV (AVERT, 2008).

In Africa, that the impact of the virus has been most severe. At the end of 2005, there were 10 countries in Africa where more than one tenth of the adult population aged 15-49 was infected with HIV/AIDS. In four countries, all in the southern cone of the continent, at least one adult in five is living with the virus. In Botswana, a shocking 24.1% of adults are now infected with HIV, while in South Africa, 18.8% are infected. With a total of around 5.5 million infected, South Africa has more people living with HIV than any other country. Rates of HIV infection are still extremely high in sub-Saharan Africa, and an estimated 1.7 million people in this region became newly infected in 2007. This means that there are now an estimated 22.5 million people living with HIV/AIDS. In this part of the world, particularly, women are disproportionately at risk. As the rate of HIV/AIDS infection in the general population rises, the same patterns of sexual risk result in more new infections simply because the chances of encountering an infected partner become higher (AVERT, 2008).

According to the Ministry of Health (MOH, 2006) estimate, approximately 1.3 million Ethiopians are living with HIV/AIDS in 2007. The corresponding figures for estimated numbers of new HIV infections in 2007 only was 132,154 while the number of new AIDS cases and AIDS deaths were 132,744 and 101,180 respectively. The estimated number of persons requiring ART for 2007 was 287,881. It is disappointing that the global numbers of people infected with HIV continue to rise, despite the fact that effective prevention strategies already exist

Application of Geographical Information System (GIS) in health is relatively a new concept. Since mapping is an excellent means of communicating a message clearly even to those who are not necessarily familiar with the methodology, GIS can be used effectively by leaders at various levels. Hence, GIS can be used as a management support tool through integrated database management to prepare combined maps for state, districts or maps down to block / village levels. *The public health sector in some Africa*

countries and many other countries have, for some time now, widely used GIS and researched on how it can be applied on the management of HIV/AIDS but in Ethiopia it is not widely used in the management of public health.

GIS methodology and technology can greatly increase our capacity to undertake the spatial tasks needed to improve monitoring of the spread of HIV/AIDS, in planning the timely allocation of resources to prevent the spread of the disease and to treat those who already have fallen victim to it.

GIS has the potential to assist in the fight against HIV/AIDS. Since time is of essence in the fight against the pandemic, data exchange between various hospitals, municipalities and decision-making bodies is becoming more and more important. The logical response to such a need is a computerized system, which will collect and administer HIV/AIDS related information within the regional context and allow a monitored access to the data from a number of stakeholders.

1.2. STATEMENT OF THE PROBLEM

Now we know from bitter experience that AIDS is caused by the virus HIV, and that it can devastate families, communities and whole continents. We have seen the epidemic knock decades of countries national development, widen the gap between rich and poor nations and push already-stigmatized groups closer to the margins of society. We are living in an international society, and HIV/AIDS has become the first truly international epidemic, easily crossing oceans and borders. Today many serious health problems arise in Ethiopia and sometimes the health needs of the population seem overwhelming in the face of limited resources. HIV/AIDS is one of health challenge among many; that will have a devastating impact on the regions. There is now a wealth of compelling evidence from a wide range of settings across the world and at various scales to suggest that location and place shape our health, our exposure to environmental features that impact on our health and our access to those goods and services that either promote health or

treat episodes of diseases that we encounter (Ngigi, 2007). The geographical patterns and spatial diffusion characteristic of the HIV/AIDS epidemics has been of interest in the investigation of the factors influencing the heterogeneity of the pandemic.

From as early as the nineteenth century when John Snow used simple maps to identify contamination sources in the spread of cholera, geography has contributed immensely in many fields in exploring the role of space and place in epidemiology and public health. Striking advances in data collection methods, geographic visualization techniques, exploratory spatial data analysis, and geographic modeling, have contributed a lot in understanding spatial patterns and identifying disease probability spread; crucial for mitigation efforts (Moses, 2006).

In 2007 in Ethiopia an estimate of 1,319,902 people are living with HIV/AIDS and it was estimated that 101,180 persons died from HIV/AIDS (MOH, 2006). The HIV/AIDS epidemic had already spread to all the administrative provinces of Ethiopia *.However, the number of people living with HIV/AIDS were different which showed Amhara region with the highest and Harari region with the lowest levels in 2006* (MOH , 2006).

The issue of HIV/AIDS is a current area of discourse .The potential effects of the most productive age group and thereby on the economy is fully recognized. *What is not given a due emphasis is, perhaps to investigate and demonstrate how GIS technology can be optimized for the management and monitoring of HIV/AIDS in Ethiopia.* The central idea is to make the fight against HIV/AIDS pro-active. GIS and Mapping technology are used to graphically represent the data and derive relations between the transmission sites and other parameters. This study attempt to explore the powers of simple thematic mapping and map query. Thematic mapping and query when combined with simple functions offered by most GIS software become an unmatched combination of technology to provide valuable solutions to the complex problems faced by health authorities today. Modern GIS has been and can be of utility in combating HIV/AIDS. It is true that in Ethiopia, and indeed in the world generally, the potential of GIS to analyze issues in HIV/AIDS specifically as well as in epidemiology more generally, is extremely limited

despite its obvious utility. In the area of human services, emergency service allocation and provision of services by the private and public sectors it has been used to only a very small degree. This stems partly from a lack of understanding of what GIS can actually do among the executive policy makers and planners in these areas. The application here to combating HIV/AIDS is obvious. It is possible to have a map and model which allows the deployment of resources to be modified as the situation being dealt with changes.

1.3. OBJECTIVES OF THE STUDY

1.3.1. GENERAL OBJECTIVE

The general objective of the study is:

- To demonstrate the usefulness of GIS for HIV/AIDS monitoring and management in Ethiopia.

1.3.2. SPECIFIC OBJECTIVES

On the basis of the general objective, the specific objectives of this study are the following:

- To demonstrate how GIS technology can be optimized for the management of HIV/AIDS in Ethiopia.
- Show the occurrences of HIV/AIDS patterns in the form of a map (digital / hard copy) showing high prevalence and low prevalence areas, and
- Generate maps of the location and distribution of ART Hospitals and health centers in Ethiopia.

1.4. RESEARCH QUESTION

The research work will try to investigate and give answers for the following key research questions pertaining to the specific objective:

- How can spatial information systems (GIS) optimized in the fight against HIV/AIDS?
- Where are the highest HIV prevalence's in Ethiopia In terms of their regional locations?
- How are the spatial distribution of ART Hospitals and health centers in Ethiopia?
- What role does GIS play in the fight against HIV/AIDS?

1.5. SIGNIFICANCE OF THE STUDY

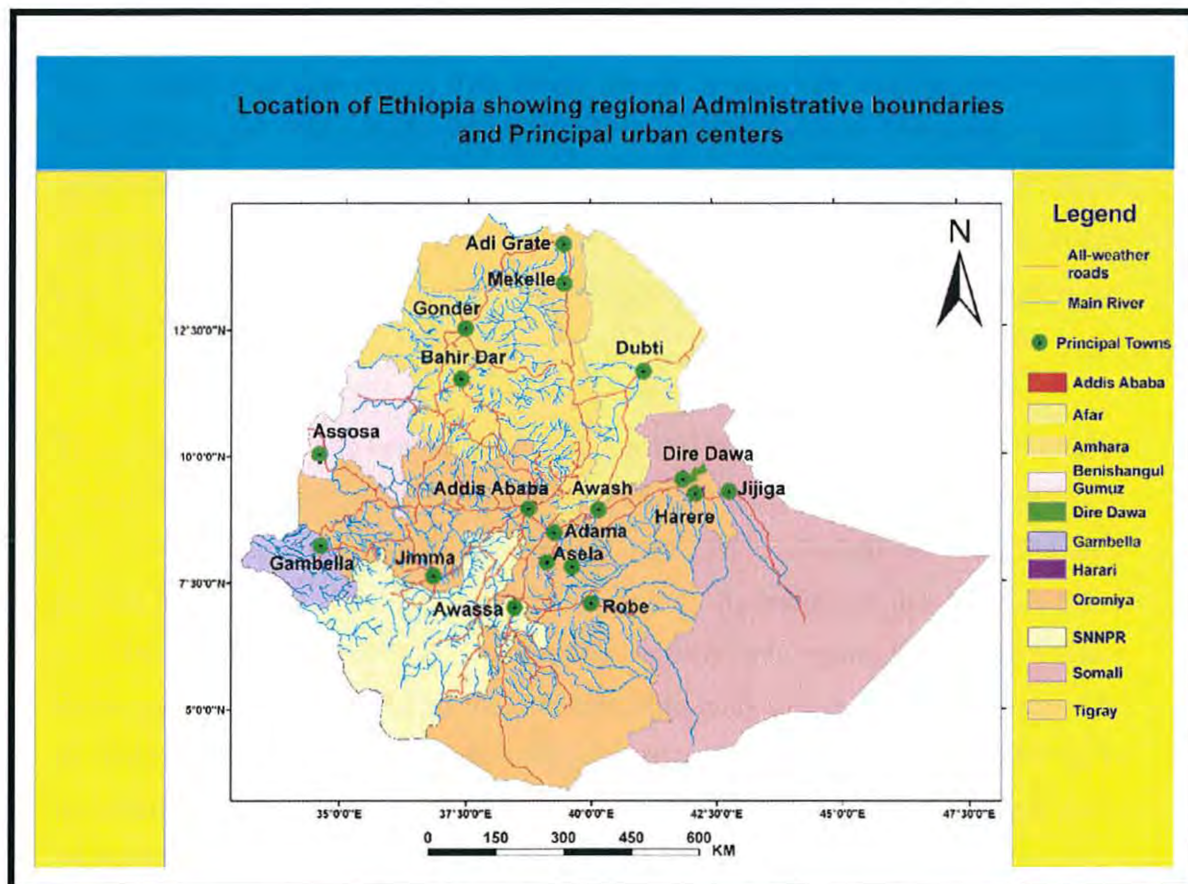
The research attempts to clarify the characteristics of HIV/AIDS in Ethiopia from a geographical point of view. The research hopes to enhance the currently existing programs that are in place in the mitigation of the epidemic. The study by utilizing the potential use of GIS technology assist in controlling and monitoring the spread of HIV/AIDS .This can help the authorities in the planning process by identifying suitable sites to set up facilities required in the fight against HIV/AIDS. It is imperative therefore that to explore all the possibilities information technology can offer in enabling use resources in an efficient and sustainable manner.

As an information technology, The World Health Organization describes GIS as, "an excellent means of analyzing epidemiological data, revealing trends, dependencies and inter-relationships that would be more difficult to discover…" using traditional tabular approaches .Moreover, it is "a powerful tool for monitoring and management of disease and other public health programmes" (Sigodi, 2005). Its optimized implementation can only be of tremendous good to our society.

The application of GIS to benefit our society has not been optimized. Very little work has been put on the use of GIS in the management of HIV/AIDS. This is so either because of the lack of understanding about the potential of GIS or limited or lack of trained personnel in the area. Therefore partly in response to the realization that HIV/AIDS is a global disaster and the call for commitment to the partnership against HIV/AIDS and also in recognition of the severity of the epidemic, this study did to bring forth a new and dynamic way in which the epidemic can be viewed and managed. Further, the findings of this study will be a reference tool for those involved in the mitigation efforts of HIV/AIDS and for further research by other scholars.

1.6. SCOPE OF THE STUDY

The scope of this study will be limited to assessing the spatial pattern of the HIV/AIDS pandemic in Ethiopia by using GIS as tool. Hence, the study does not promise an exhaustive presentation of all HIV/AIDS related issues. Although the author believes that the two chartered cities require exclusive study using GIS, the nine Regional states of Ethiopia and the two chartered city are considered and this research focuses on the role that GIS can play for HIV/AIDS management and monitoring in Ethiopia.



Prepared by the Author

Fig 1.1: Map of Ethiopia showing regional administrative boundaries and the principal urban centers including main road and rivers.

1.7 DATA SOURCE, MATERIAL AND METHOD OF THE STUDY

1.7.1 DATA SOURCES AND MATERIALS

The study is mainly based on secondary data. The data used for the provincial scale mapping and analysis were sourced from, surveillance reports, publications and tabular data, published and unpublished sources of governmental and non-governmental organizations, from the National HIV/AIDS Prevention and Control Office, Reports from the Federal Ministry of Health, Books, research reports, and the Ethiopia Demographic and Health Survey were used to acquire the necessary data. Population and Population density data were collected from the office of the Central Statistical Agency (CSA).

The topographic map (spatial data) refers to land related data i.e. boundaries, roads, river, cities, etc. of the study area have been accessed from authorized body. Table 1.1 shows the list of data used in the present study and sources from which they were obtained.

Table 1.1 Material used and Data Sources of the Study.

Materials Used	Data Sources
Topographic Map • boundaries, • roads, • river, • Cities,etc.	Ethiopian Mapping Authority: Produced by UN emergencies unit and Ethiopian Mapping Authority; March 2000.
Demographic Details (2005)	Central statistical Authority (CSA)And Ministry of finance and economic development
Regional HIV/AIDS indicators	Federal Ministry of Health and HAPCO

Facility and Software's
• Arc GIS 9.0 • Arc GIS 9.1 • Arc view 3.2

1.7.2 METHOD

Arc GIS is the software used for this study. The methods include the mapping of HIV/AIDS indicators, spatial distribution of ART hospitals and Health centers in Ethiopia and maps of cumulative deaths due to HIV/AIDS in different counties in Ethiopia. These maps were used for GIS analysis (GISA). These data maps provide various epidemiological profiles including maps of HIV/AIDS indicators. The HIV/AIDS indicators provided by the state are regional tables on the incidence and prevalence of HIV/AIDS.

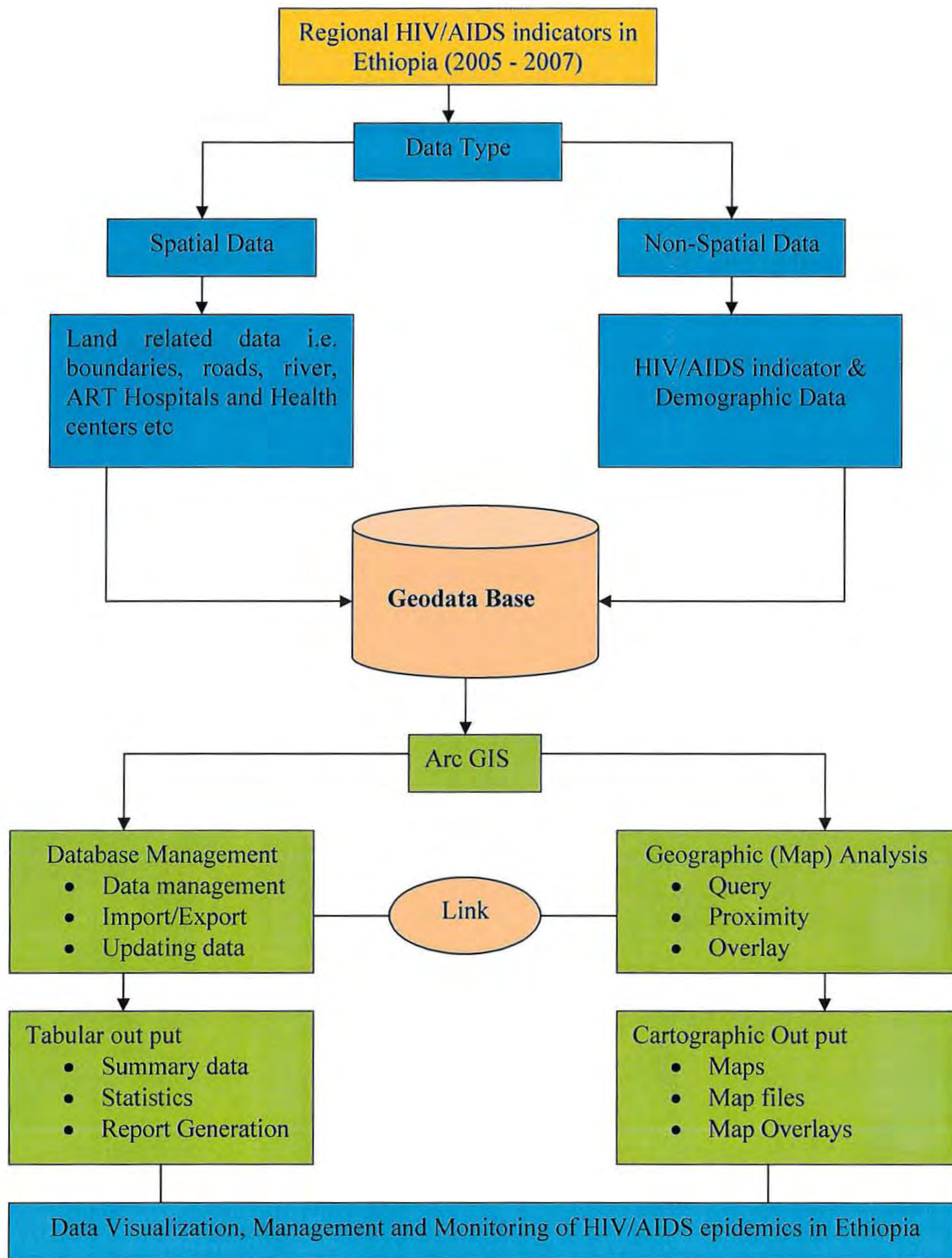


Figure 1.2: Analytical frame work of the study.

1.8 THESIS STRUCTURE

The dissertation is composed of six chapters. The Introduction was put under Chapter one. Chapter two discus about review of literature. Chapter three delves HIV/AIDS pattern and demographic and socio-economic characteristics of Ethiopia. Chapter four deals with using GIS as tool for Analysis, Monitoring and Management of HIV/AIDS epidemic and its application in health. Chapter five presents atlas of the spatial distribution of ART hospitals and health centers and HIV/AIDS indicators in Ethiopia. Chapter six gives the concluding remarks of the study and recommendations.

CHAPTER TWO
REVIEW OF LITERATURE

2.1. BASIC CONCEPTS ON GEOGRAPHIC INFORMATION SYSTEMS (GIS)

2.1.1. DEFINITION

GIS in full stands for Geographic Information Systems. These are computer-based systems that are used to store and manipulate all kinds of spatially referenced land related data. A GIS is designed to collect, store, analyze and retrieve data in a structured form. GIS may be summarized as having the following characteristics (Rolf, 2001).

- **Geographic**: the system is concerned with data relating to geographic scales of measurement, and which are referenced by some coordinate system to locations on the surface of the earth.

- **Information**: It is possible to use the system to ask questions of the geographic database, obtaining information about the geographic world. This represents the extraction of specific and meaningful information from a diverse collection of data, and is only possible Because of the way in which the data are organized into a 'model' of the real world.

- **System**: This is the environment which allows data to be managed and question to be posed. In the most general sense, a GIS involves the sequence of input, process and output.

2.1.2 COMPONENTS OF GIS

A GIS is a complex system that includes people, data, methods, software and hardware. Each of the five components is required for the GIS to operate effectively (Rolf, 2001).

- People operate the system and create analysis questions
- Methods (Procedures) are the techniques used to manage the GIS, conduct analysis, and interpret the results generated by the GIS
- Data is the spatial and attribute information collected for analysis
- Software provides the functionality to manage, display, manipulate, analyze, link, and query data.
- Hardware includes the computer that stores and processes data, and devices used to input and output data. The general hardware component of a GIS consists of a digital computer and other devices such as a digitizer, plotter etc. The computer or central processing unit (CPU) is linked to a disk storage unit, which provides space for storing data and programs.

2.1.3. GIS AND EPIDEMIOLOGY

Understanding the determinants of a disease, and its spread from person to person and community to community has become increasingly global (ESRI White Paper, 1999). GIS plays a vital tool in strengthening the whole process of epidemiological surveillance information management and analysis. GIS provides excellent means for visualizing and analyzing epidemiological data, revealing trends, dependencies and inter-relationships that would be more difficult to discover in tabular formats. Public health resources, specific diseases and other health events can be mapped in relation to their surrounding environment and existing health and social infrastructures. Such information when mapped together creates a powerful tool for monitoring and management of diseases and public health programmes. The underlying factors likely to lead to increased incidence of diseases, including adverse environmental, behavioral and socio-economic conditions, need to be monitored regularly (Johnson, 2001)

GIS is being used by public health administrators and professionals, including policy makers, statisticians, epidemiologists, regional and district medical officers. Some of its applications in public health are find out geographical distribution and variation of diseases, Analyze spatial and temporal trends, Manage patient care environments, materials, supplies and human resources, Monitor the utilization of health centers, Route health workers, equipments and supplies to service locations, Publish health information using maps on the Internet, Locate the nearest health facility (Johnson, 2001).

2.1.4 THE APPLICATION OF GIS IN DEMOGRAPHY

GIS is a relatively new and fast developing methodological approach designed to look at data geographically and spatially. The U.S. Census Bureau for example, utilizes GIS capabilities to map to look at median household income, level of education, employment and a host of indicators gathered from their survey of the universe of United States residents at a fine resolution down to the street level (Nathan Daun and Britany Affolter, 2005).Environmental Systems Research Institute (ESRI), one of the leading GIS software manufacturers, characterizes this software as linking the location of information with

what information represents (2002). GIS has been frequently applied in a variety of ways, including market research, Demography , landscape design, epidemiology, and classroom instruction. The only requirement is that data be clearly linked with some map-able characteristic, which may include a city, state, county, zip code, census tract or a variety of others (Nathan, 2005).

GIS is now being utilized in the academy in a variety of disciplines, primarily demography, environmental and other applied sciences. Individual scholars from the social sciences and humanities are beginning to incorporate GIS as an analytical tool in their research as well, including history (e.g., Black, MacDonald, & Black, 1998; Knowles, 2000), economics (e.g., Healey & Stamp, 2000), demography (Brewer & Suchan, 2001), and public health (e.g., de Lepper, Scholten, & Stern, 1995). Its greatest application, however, is in support of developing and implementing policy at the federal, state, and local levels (Nathan, 2005).

Population dynamics are composed of "events"that happen across both space and time and the production of the 'Population Density by District' map was the first GIS based link between the Demography Section and the Mapping Unit (Nathan, 2005). A dot density map is a basic function of the GIS software where the population count is represented as 1 dot per X number of persons (Figure 5.1).In addition Thus it is also possible to provide demographic information with the appropriate settlement map.

Arc GIS as a tool for Demography serves for (Jack, 2005):

- Managing complex geospatial data.
- Allocating demographic "events"in space to allow estimation and projection of populations.
- Analysis of demographic data within an explicitly "spatial"framework.

2.2. THE ROLE OF GIS TO ASSIST IN THE FIGHT AGAINST HIV/AIDS

Given that there are systems that can handle spatial data, database management and data analysis, the major driving force for the adoption of GIS for use in mapping, analysis and evaluation of HIV/AIDS occurrence patterns can be viewed in terms of the following advantages over other conventional methods. It is suggested here that GIS has the potential to assist in the fight against HIV/AIDS and some of the ways in which this might occur are discussed (Graeme, 2000).

2.2.1. VISUALIZATION CAPABILITIES

Where GIS has been used in epidemiological areas it has been predominantly as a mapping tool. It is argued here that while the mapping of the incidence of HIV infection and the location of people with AIDS is an important function of GIS which is useful in the fight against HIV/AIDS, its utility goes way beyond mapping. It has a range of analytical capabilities which make it a more powerful took in the battle. Nevertheless, it is important at the outset to make some observations on how GIS can visualize the geographical incidence of HIV/AIDS.

With respect to GIS being used to visualize the incidence of HIV/AIDS a number of general points need to be stressed...

- Modern GIS have the capacity to analyze huge amounts of spatially referenced information and present it in the form of maps *extremely quickly*. This speed element means that the information can be made available to policy makers and planners in a form which allows patterns and trends to be readily identified in a very timely way. This allows action to be planned and taken immediately and hence enhances the chances of it being effective. The systems are so powerful that in the use of GIS in emergency services data can be fed in so that maps of the spread of a fire can be produced in virtually real time.

- GIS has achieved new levels in terms of *the way in which data can be presented* to highlight patterns and trends. For example, it allows an infinite ability to

experiment with scales, class intervals, coloring, density of shading, symbols used, etc. to derive the most effective map. Moreover, it readily allows maps to be presented in three dimensions rather than two. It is possible to depict changing distributions over time (e.g. of HIV infection) in an animation rather than presenting a series of static maps.

- As indicated earlier, GIS involves the overlaying of a number of layers of information. It is important to realize that there are few limits in terms of the amount and type of information that can be included. In the HIV-AIDS case the layers of information can include distributions of all the elements thought to influence the spread of the disease such as:
  - Location of roads
  - Location of health centers
  - Cultural attributes of the population
  - Migration patterns
  - Incidence of prostitution
  - Population density
  - Drug use

The simplest use of the visualization capabilities of GIS is to produce maps of the incidence of HIV/AIDS, for example, of the distribution of HIV/AIDS in African nations. More useful analyses, however, would involve more detailed mapping down to the local level. GIS has the ability to 'zoom in' to very local or regional scales of visualization. Clearly such maps of the incidence of infection have utility in planning interventions whether they are preventative measures or providing services to those already infected.

Producing maps of the incidence of HIV/AIDS and overlaying on those maps other distributions can give indications of the factors associated with the spread of the disease. Hence it is possible, for example, to overlay the location of main transport routes. Thus, in some areas of mainland Southeast Asia, it has been found that truck drivers and their assistants are a major element in spreading the disease along those routes (Graeme, 2000). While it is shown later that GIS allows more sophisticated analyses to be made of

such relationships the production of maps can be strongly suggestive of causal relationships, possible intervention measures and where those measures are likely to be most effective.

A final aspect of GIS as a visualization tool which should be mentioned is that the maps produced can be very effective in advocacy. A graphic map can often have more impact on policy makers and potential donors on the one hand but also in information campaigns and spreading the message of the need for prevention (Decosas, 1995).

2.2.2. DEPLOYMENT OF RESOURCE

One of the major elements in GIS in recent years is what could be referred to as "real time mapping". This involves feeding in information into a map as an event is happening so that the map is able to be updated and reflect the situation at any given point in time. This is usually linked to a model within the GIS that can generate solutions to problems which are optimal given the changing conditions being fed into the map. That optimal solution can be constantly updated.

The application here to combating HIV/AIDS is obvious. It is possible to have a map and model which allows the deployment of resources to be modified as the situation being dealt with changes. One of the most extensive applications in GIS is optimization of allocation of resources. Hence optimizing where to locate points of presence for particular HIV/AIDS treatment and prevention activity is highly feasible. Where to place permanent structures, where to allocate mobile units, information programs, condom distribution programs, etc. are the types of problems which this type of analysis can provide solutions for and provide them quickly (Graeme, 2000).

2.2.3. MODELING CAPABILITIES

One of the capabilities of GIS which is least used in epidemiological analyses is its ability to model. However, the potentialities here are of considerable relevance to the study of HIV/AIDS. For example, GIS can be used to model the likely diffusion of HIV/AIDS from particular points of presence according to sets of rules derived from empirical experience. These rules can include migration patterns, transport routes,

trucking routes, cultural practices, etc. Clearly anticipating the likely pattern of spread of HIV/AIDS can allow information programmes, condom supply programmes and other preventative initiatives to be spatially targeted so that they are concentrated in areas most vulnerable to the spread of the disease. Another area of modeling where GIS may be of use in the analysis of HIV/AIDS relates to the established connection between migration and the disease (Graeme , 2000). GIS facilitates the modeling of the spread of HIV/AIDS along established migration routes. This, of course, also applies to situations where HIV/AIDS is spread by truck drivers along transport routes, by traders along market cycles, etc.

2.2.4. EVALUATION AND MONITORING

Another major area where GIS can play a major role in the effective allocation of resources to combat HIV/AIDS applies *after* those allocations have been made. This lies in its ability to assist in monitoring and evaluation of the effectiveness of that allocation. It allows the effects of the provision of services to be benchmarked against national and international standards. GIS provides a methodology and technology to facilitate such assessments in a timely and objective way. This is of crucial importance because (Graeme, 2000):

- The population and other characteristics of areas are in a constant state of change so that the nature and extent of need in an area will also be subject to continual change.
- If provision of services is effective it should reduce the extent of need in the areas where the resources are deployed. GIS can assist in the evaluation of how well programs are operating in particular areas by monitoring changes in the conditions in those areas which the programs are aimed at addressing.

Again one of the major advantages that GIS offers is its ability to analyze massive amounts of spatial data very quickly. Hence the monitoring can be constant, weekly, fortnightly etc. as well as annually. This allows fine tuning of policy and programme interventions to be undertaken continually rather than waiting until the end of a fixed

period. It also may promote efficiencies because it allows the spatial matching of available resources and incidence of disease to be optimized even though the spatial patterning of the latter may change.

2.2.5 WEB BASED APPLICATIONS

In recent times the integration of web and GIS technologies has opened up a huge range of possibilities. In particular the ability to add a more user friendly front end onto a GIS to allow individuals not technically proficient in GIS to access the functions of an GIS through a simpler operating environment (such as windows) have been important. This allows operatives in the field or in decentralized locations to access manipulate and add to data sets to assist their planning or operational activities. This considerably empowers operational staff but also enables central decision making to be better informed by local knowledge and on the spot advice (Johnson, 2001).

2.3. THE USE OF GIS IN THE MONITORING AND MANAGEMENT OF HIV/AIDS OCCURENCES IN ETHIOPIA.

Recent advances in geographical information and mapping technologies have created new opportunities for public health administrators to enhance planning, analysis, monitoring and management of health systems. Health mapping has evolved from Dr. John Snow's cholera death mapping in mid-nineteenth century to the latest Internet-based mapping where data have been shared across the Internet. Since much of the data used and generated by health and social service agencies has a spatial dimension, geographic information system (GIS) is particularly useful to health professionals and administrators in planning and day-to-day management.

The public health sector in South Africa, Kenya, Uganda and many other countries have, for some time now, widely used GIS and researched on how it can be applied on the management of HIV/AIDS. The Ministry of Health and the Medical Research Council are well known users of this technology in this sector. The Ministry of Health has focused a lot on using GIS to capture Health Service Infrastructure whereas more of the analytical research in terms of accessibility to health services has been conducted by the Medical Research Council (Sigodi, 2004).

Despite the millions of Birr that have been spent on trying to address public health management related issues in Ethiopia, the application of GIS to benefit our society has not been optimized. Very little work has put emphasis on accurately revealing what the spatial dimension of public health problems actually looks like. This is so either because of the lack of understanding about the potential of GIS or limited or lack of trained personnel in the area. Despite tremendous potential of GIS, the health sector in Ethiopia has not fully explored it. Majority of the health departments and research organizations in Ethiopia do not have the hardware, software or trained staff that would enable them to apply GIS technology. However, the interest in GIS has increased during the late 1990s; the Addis Ababa HIV/AIDS prevention and control office (AAHAPCO); HIV/AIDS Service Map uses GIS technology to examine the geographic and spatial distribution of

HIV/AIDS related health service providers throughout Addis Ababa. It provides the names, contact information and geographically referenced data of the location, and distribution of health service providers, hospitals, health centers, clinics and higher and middle clinics, health posts, anti-AIDS clubs, schools, food mill factories, local kebele offices, International NGOs, Local NGOs, and the types of HIV/AIDS related services and activities they are involved in and many health organizations and Research Centers are exploring its potential utility in medical research and disease control.

CHAPTER THREE
HIV/AIDS PATTERN AND DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERSTICS OF ETHIOPIA

3.1 OVERVIEW OF HIV/AIDS IN ETHIOPIA

The HIV/AIDS epidemic is one of the most destructive health crises of modern times, ravaging families and communities throughout the world. By 2005, more than 25 million people had died and an estimated 39 million were living with HIV/AIDS. An estimated four million people were newly infected with HIV/AIDS in 2005—95 percent of them in sub-Saharan Africa, Eastern Europe, or Asia. While sub-Saharan Africa has been hardest hit, other regions also face serious HIV/AIDS epidemics. During the past two decades HIV/AIDS has had a devastating impact on the health and social and economic well-being of populations in many parts of the developing world. The number of people afflicted with HIV/AIDS in Africa, particularly in sub-Saharan Africa, is truly daunting. Experts expect that the total number of deaths due to the disease will reach 55 million by 2020 unless aggressive measures are taken to prevent and treat the disease (UNAIDS, 2005)

The first HIV infections in Ethiopia were identified in 1984, and the first AIDS cases reported in 1986. In 1987, the government established an HIV/AIDS department within the Ministry of Health, and in 1988, an HIV surveillance system was established. HIV/AIDS increased rapidly during the 1990s. By 1989, HIV prevalence among the general adult population was estimated at 2.7 percent, increasing to 7.1 percent in 1997 and to 7.3 percent in 2000. There are many factors that promote the spread of the disease including the presence of sexually transmitted infections, gender inequality, multiple sexual partner, prostitution, men with disposable, income, alcohol, unsafe blood transfusion, and transmission from infected mother to her fetus/child during pregnancy and breast feeding (Lisa, 2003). The HIV/AIDS epidemic had already spread to all the administrative provinces of Ethiopia. However, the prevalence levels were different, suggesting a difference in the times when the epidemic started in the provinces.

According to the sixths report of the Federal Ministry of Health about HIV/AIDS in Ethiopia the most recent estimates state that the HIV prevalence was 3.5 % (4% in females and 3% in males) in 2005. The HIV Prevalence among the urban populations was estimated at 10.5 % (11.9 % in females and 9.1 % in males). The corresponding estimate among the rural population was 1.9 % (2.2 % in females and 1.7 % in males).

A total of 1,319,795 persons were estimated to be living with HIV/AIDS in the year 2005. The corresponding figures for estimated numbers of new HIV infections was 128,922 while the number of new AIDS cases and AIDS deaths were 137,499 and 134,450 respectively the estimated number of persons requiring ART for 2005 was 277,757. There were 105,675 HIV-positive pregnancies and 30,338 HIV positive births in the country in 2005. The number of HIV positive births will decline in the coming five years with the coverage of and access to PMTCT program being improved (MOH, 2006)

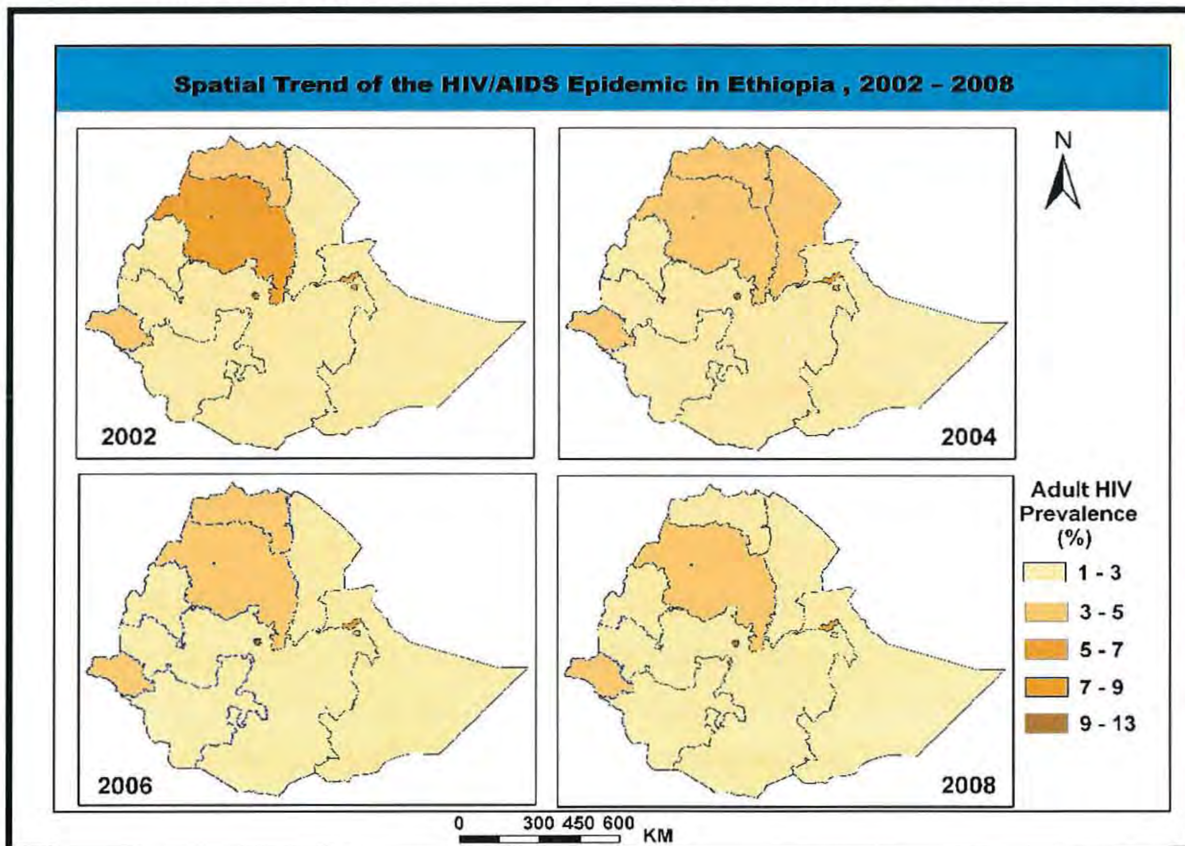


Figure 3.1: Map of the spatial trend of Adult HIV prevalence (%) in Ethiopia; 2002 – 2008.

There are few data on the impact of HIV/AIDS in Ethiopia. HIV/AIDS is now recognized as the leading cause of adult morbidity and mortality in the country. Ethiopia's population will be up to 16 percent smaller than it would have been in a "no-AIDS" scenario. HIV/AIDS will reduce life expectancy by 9 to 13 percent through 2050. HIV/AIDS has already increased the number of deaths in Ethiopia by 6 percent. Between 2000 and 2015, it will increase the number of deaths in Ethiopia by 27 percent. By the end of 2002, 1.7 million Ethiopians had died because of HIV/AIDS. By 2014, there will be a cumulative total of 5.3 million HIV/AIDS deaths (Lisa, 2004).

3.2 SIZE, STRUCTURE AND DISTRIBUTION OF POPULATION IN ETHIOPIA

The Ethiopian population is estimated at 75 million in mid July 2006 with a growth rate of 2.62 percent per annum (approximately additional 2 million people per year). From the total population, 50.1 percent are males and 49.9 percent are females. Considering the age structure of the population, 43 percent is under the age of fifteen which shows high level of dependency burden and elevated potential for rapid population growth. The share of working age (15-64 years) population is 54.2 and that of the old age population (>65 years) is estimated at 2.8 percent (MOFED, 2006).

In Ethiopia, population distribution is highly uneven. The overwhelming majority (84 percent) resides in rural areas where agriculture is a predominant economic activity, infrastructure and social services are not well developed. Only 16% of the population is urban dwellers. In addition, there is a great disparity in regional distribution. The overwhelming majority of the country's population lives in Oromiya (35.4%), Amhara (25.5%) and SNNPR (19.9%). On the other hand, Harari (0.26%), Gambella (0.33%) and Dire Dawa (0.53%) have the smallest share from the country's total population (MOFED, 2006).

Regarding density, Addis Ababa has the highest (5,608 persons per km^2), followed by Harari and Dire Dawa. Gambela, Beneshangul-Gumuz, Afar and Somali are sparsely populated regions (Table 3.1).

Table 3.1: Ethiopian Population by Region, Percentage Share and Density (July 1, 2006).

Region	Population	% share from total population	Population density (persons/km^2)
Tigray	4,334,996	5.78	87
Afar	1,389,004	1.85	16
Amhara	19,120,005	25.47	120
Oromiya	26,553,000	35.37	75
Somali	4,329,001	5.77	17
Benishangul-Gumuz	625,000	0.84	13
SNNPR	14,901,990	19.85	133
Gambella	247,000	0.33	10
Harari	196,000	0.26	630
Addis Ababa	2,973,004	3.96	5608
Dire Dawa	398,000	0.53	328
Ethiopia	75,067,000	100	68

Source: Report of Population Department Ministry of Finance and Economic Development (MOFED, April 2007)

3.3. POPULATION AND HEALTH IN ETHIOPIA

Health care is one of the crucial components of basic social services that have a direct linkage to the growth and development of a country as well as to the welfare of a society. Ethiopia has shown encouraging results in health service coverage. The potential health service coverage in the last decade has gone up from 45 to 92 percent. Between 2000/01-2005/06 the number of hospitals, health centers, and health posts increased from 115 to

138, 412 to 635 and 1311 to 5955, respectively. In addition, the ratio of physicians to population, health officers to population and nurses to population has improved from 1:47,836 to 1:35,493, 1:220,756 to 1:104,988 and 1:8,461 to 1:4,207, respectively (Table.3.2). Health Services Extension Programme (HSEP) that focuses on preventive and promotive aspects of health care has contributed significantly for the improvement of health service coverage particularly at community level (MOFED, 2006).

Table 3.2: Health Related Indicators in Ethiopia 2005/2006.

Physician/Population Ratio	1:35,493
Nurse/Population Ratio	1:4,207
Health Officers/Population Ratio	**1:15,638**
Health assistant/Population Ratio	1:15,638
Environmental health workers /Population Ratio	1:60,587
Health extension workers /Population Ratio	1:8,434
Potential health service coverage (%)	92
Anti natal care coverage in %	50.4
Post natal care coverage in %	15.5
Percentage of deliveries at health care facilities %	15.1
Access to safe water in % (2004/05)	47
Access to sanitation in % (2004/05)	30

Source: Report of Population Department Ministry of Finance and Economic Development (MOFED, April 2007)

3.4 URBANIZATION LEVELS AND MIGRATION

Ethiopia was under-urbanized, even by African standards. In Ethiopia, the proportion of population living in the urban areas is quite low in comparison to that living in the rural areas. Based on figures from the Central Statistical Agency of Ethiopia (CSA), only 16% of the population was living in urban areas in 2005. Nonetheless, the urban population has been increasing steadily from time to time. Addis Ababa, both a province and a city, has had the highest proportion of the urban population among the administrative provinces.

Rural to Urban migration is the main contributor to population increase in the urban areas (Meheret, 1999). Though natural increase in population is contributing to the growth of the urban population, migration is still the predominant contributor. In Ethiopia, migratory movements have been going on for ages. The movements may be short distance or long distance, short-term or long term. They may be confined within the rural areas or rural to urban or urban to rural. They may either be influenced by socioeconomic or political factors. Moreover, these migratory movements have also created the currently observed uneven distribution of population in the country. Among the different types of population movements, rural to urban migration continues to be the key causes for the emergence, growth and development of urban centers (Meheret, 1999)

Levels of urbanization and interaction between urban and rural areas are factors that also contribute to the differential patterns and diffusion of HIV/AIDS (Dyson, 2003). In and out-migration of infected and susceptible persons to the urban areas, and higher concentration of vulnerable populations are important variables contributing to the dynamics of the epidemic. Throughout sub Saharan Africa in general, urban areas have been the HIV/AIDS pandemic in comparison to the rural areas (Ngigi, 2005). Through population movements, HIV/AIDS has reached areas previously unaffected by the disease (Agyei, 2005). Six groups of migrants identified to have influenced the spread of

the HIV/AIDS epidemic in sub-Saharan Africa include migrant laborers, female itinerant traders, truck drivers, commercial sex workers, refugee populations and military personnel. Studies have shown the contribution of long distant truck driving in the spread of HIV/AIDS in Africa, India and South America. In addition, studies have identified the importance of migrant labor in the creation of markets for prostitution. Migration acts to increase the extent of sexual networking, and has heightened HIV risk as encounters with casual partners increase (Mosses, 2006).

CHAPTER FOUR

GIS: A TOOL FOR ANALYSIS, MONITORING AND MANAGEMENT OF HIV/AIDS EPIDEMIC AND ITS APPLICATION IN HEALTH

INTRODUCTION

In order to properly plan, manage and monitor any public health programme, it is vital that up-to-date, relevant information is available to decision-makers at all levels of the public health system. As every disease problem or health event requires a different response and policy decision, information must be available that reflects a realistic assessment of the situation at local, national and global levels. This must be done with best available data and taking into consideration disease transmission dynamics, demographics, availability of and accessibility to existing health and social services as well as other geographic and environmental features.

Geographic information systems (GIS) provide ideal platforms for the convergence of disease-specific information and their analyses in relation to population settlements, surrounding social and health services and the natural environment. They are highly suitable for analyzing epidemiological data, revealing trends and interrelationships that would be more difficult to discover in tabular format. Moreover GIS allows policy makers to easily visualize problems in relation to existing health and social services and the natural environment and so more effectively target resources. The basic consideration in analysis of the data is the geographic location. A GIS can therefore provide managers with graphical, digital and statistical information as well as maps, which are essential in decision making and dissemination of information.

4.1 BASIC DATABASE MANAGEMENT

4.1.1 DATA MANAGEMENT

GIS can be used to capture, store, handle and geographically integrate large amounts of information from different sources, programmes and sectors; including epidemiological surveillance, census, environment and others. Surveillance of diseases requires continuous and systematic collection and analysis of data. GIS serves as a common platform for convergence of multi-disease surveillance activities. Each data record has to be georefenced to a desired level of accuracy. Standardized geo-referencing of epidemiological data facilitates structured approaches to data management.

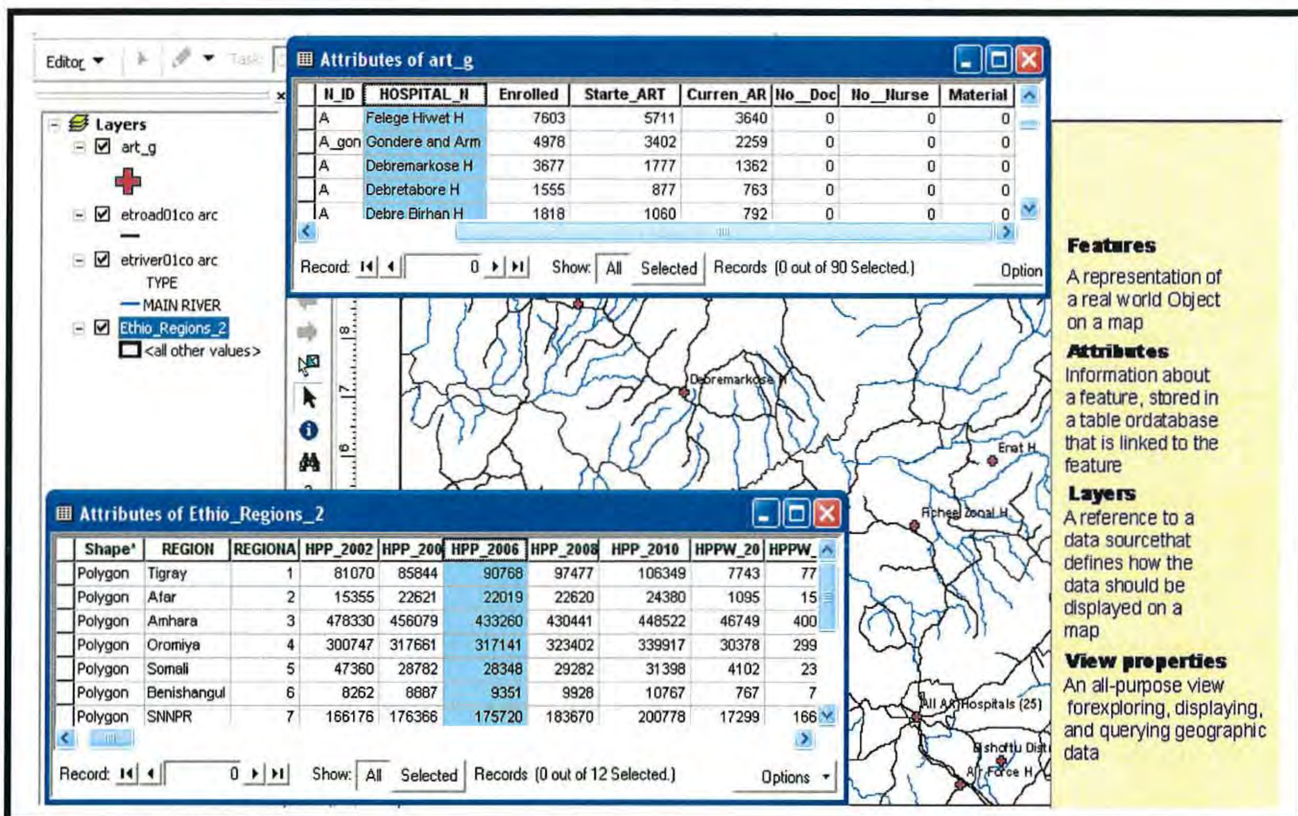


Figure 4.1. Visualization of attribute data

Generally, the objectives of a GIS are the management (acquisition, storage and maintenance), analysis (statistical and spatial modeling), and display (graphics and mapping) of geographic data.

4.1.2 UPDATING ATTRIBUTES

Another common task is updating or editing the database. Since no user can foresee all future data needs and applications, a GIS must provide ways to easily modify, refine, or correct the database. Attribute data are seldom static. Therefore, maintaining the up to date of the data depends on updating capability. For a GIS to accurately represent occurrences on the earth's surface, data must be reliable, accurate, and pertinent. Because the success of the GIS and all decisions that are based on it ultimately rest on the integrity of the data therefore GIS is capable of updating and maintaining its data.

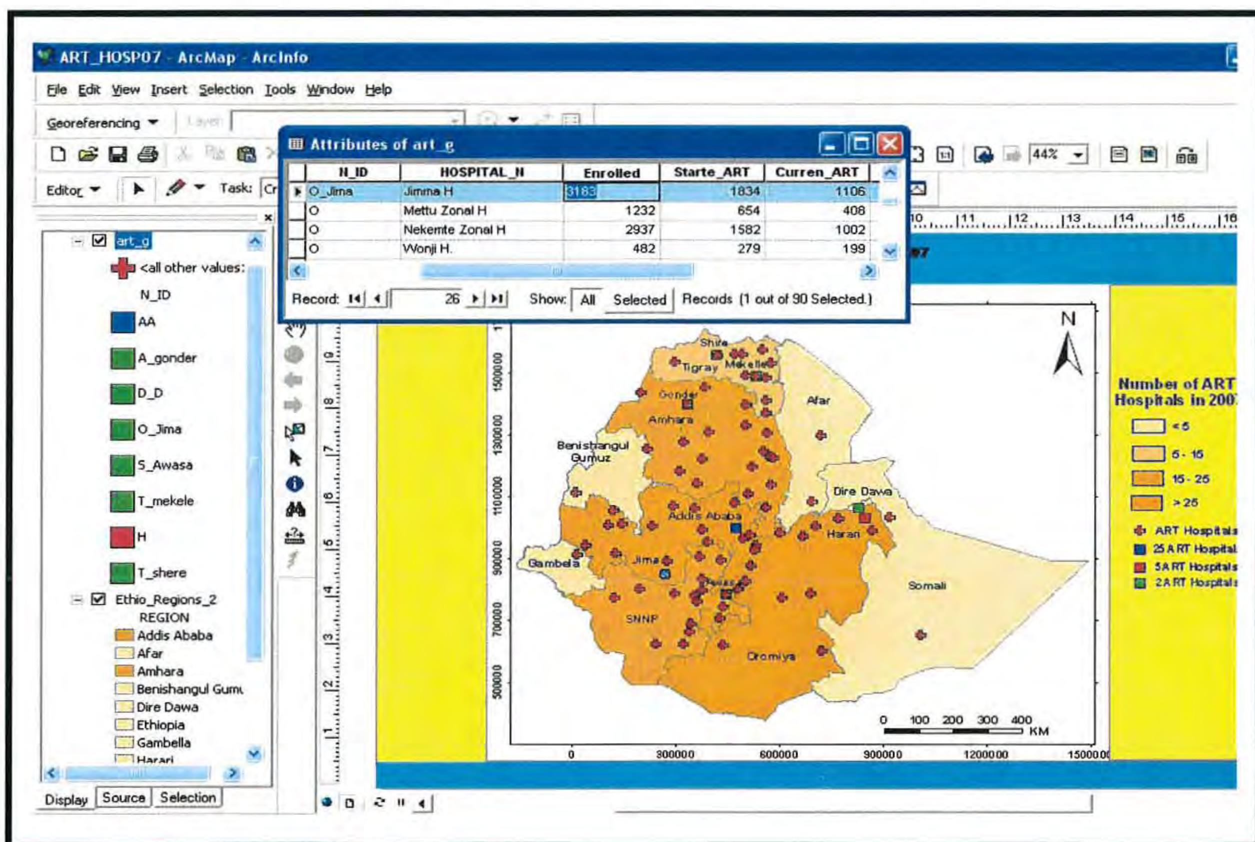


Figure 4.2. Updating or editing the database

4.1.3 IMPORTING AND EXPORTING THE DATABASE

A GIS may also be capable of importing data files that are in other formats. Another method of expanding the database is to manually enter data. Every DBMS has the capacity to create new geographical objects of interest or records. This technique is commonly used to add a relatively small amount of new objects (a few printed pages) to the database. However, care must be taken when collecting, automating, and changing the database. A GIS must also provide the ability to create data files that can be exported to other systems. During the exporting process, data files are written in a common format to a file that can then be imported by other systems (ESRI, 1999).

4.2 GEOGRAPHIC (MAP) ANALYSIS

The phrase "GIS analysis" encompasses a wide variety of operations that you can do with a geographic information system. These range from simple display of features to complex, multistep analytical models. The analysis of HIV/AIDS database comprises of tools and operations that use the spatial and non-spatial data to answer questions about the real world.

GIS is great for making maps. Using a computer to combine layers of detailed information on a single map so you can see what's in a place is indeed powerful. But the true power of GIS lies in analysis. GIS analysis shows you patterns, relationships, and trends in your geographic data that help you understand how the world works, make the best choice from among options, or plan for the future.

Perhaps the simplest form of GIS analysis is presenting the geographic distribution of data. This is conceptually the same as sticking pins in a wall map, a simple but powerful method of detecting patterns (chapter five). Here, the map is the analysis. A Health department might analyze the occurrence of HIV/AIDS patterns by mapping the spatial distribution of health facilities and the incidence of HIV/AIDS. The department could make the map more informative by displaying the incidents with different symbols in combination with a comprehensive health facility database, demographic and population data, health information systems, and summary statistics to enhance facility utilization,

improve distribution of preventive and curative care, and provide evidence-based rationale for targeted assistance and service delivery (ESRI White Paper, 1999).

Map data used by GIS are collected from existing maps, aerial photos, satellites, and other sources. A digitizer or similar device is used to convert compiled map data to a digital form in order to make it computer compatible. This transformation allows the storage, retrieval, and analysis of the mapped data to be performed by the computer. Maps produced by a GIS are typically displayed on computer monitors or are printed on paper. GIS, however, is more than a mapping system. What sets it apart from even the most sophisticated mapping system is its power to analyze data and to present the results of that analysis as useful information to assist decision makers. The analysis of HIV/AIDS database comprises three broad categories:

4.2.1 DATABASE QUERY FUNCTIONS

Manipulating the database to answer specific data-related questions is accomplished through a process known as database analysis. Tabular output is the result of a database analysis query. To query the database, logical expressions that impose limits or conditions on the database search are defined. These logical expressions specify which geographical objects are to be included in the analysis and/or how that data is to be analyzed. A subset of the database is produced. Some logical expressions are simple and require only one condition while others are very complex and contain multiple conditions.

Another logical expression requires that mathematical analysis be performed. These prompt the DBMS to perform such functions as calculating population density and generating descriptive statistical summaries. These types of operations are common when the database contains numeric data and a statistical analysis of the data is required.

Queries let you identify and focus on a specific set of features. There are two types of GIS queries, attribute and location queries. Attribute queries, or aspatial queries, find features based on their attributes. GIS allows interactive queries for extracting information contained within the map, table or graph.

SELECT BY ATTRIBUTE

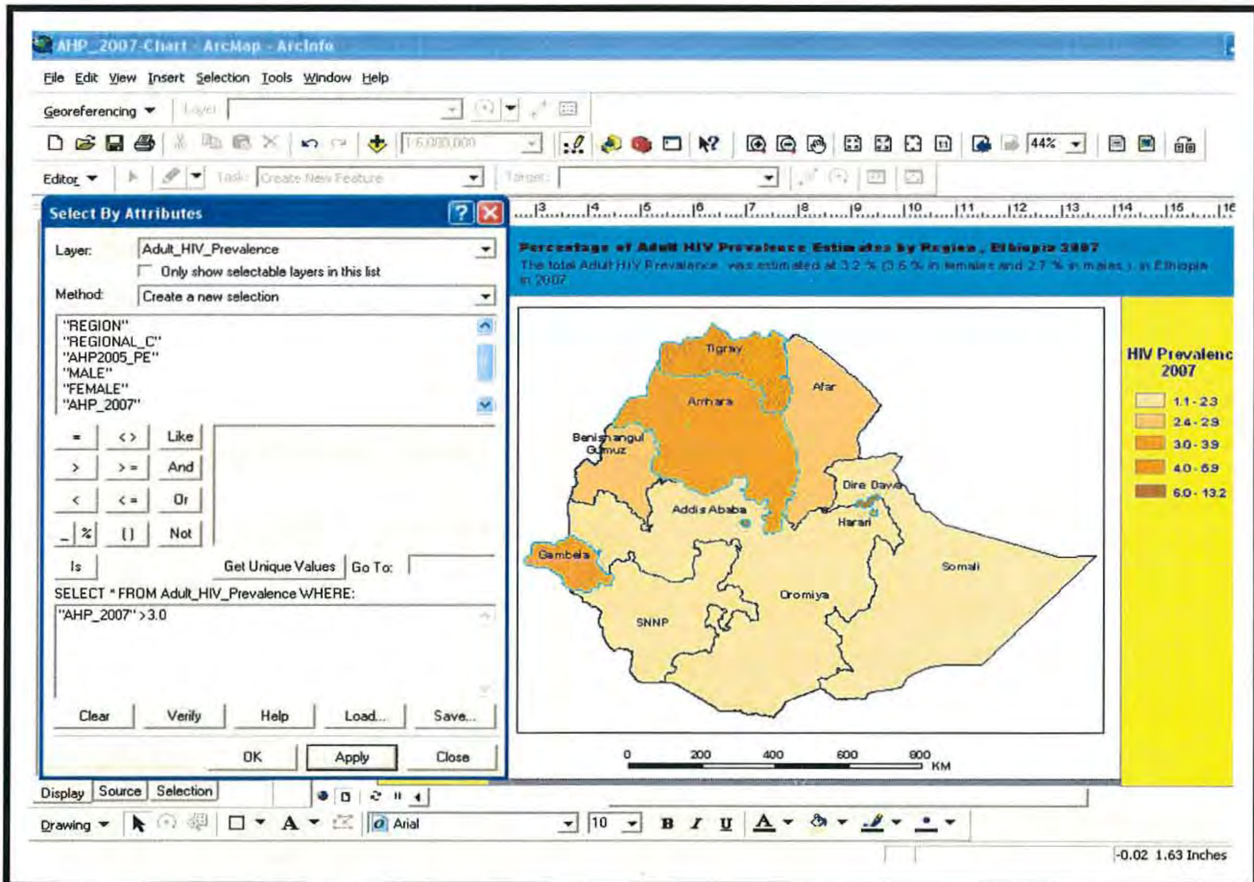


Figure 4.3 Adult HIV prevalence and the use of query

Frequently a GIS user wants to discover whether the mapped data will meet certain conditions. Suppose someone wants to know where the highest adult HIV prevalence is in Ethiopia in 2007. Select by attribute can situate easy identification of the result; For example, figure 4.4 shows selected regions (Addis Ababa, Dire Dawa, Harari, Tigray, Amhara and Gambella) with green out line are Areas with highest HIV prevalence in 2007 that is greater than 3.0 %.

SELECT BY LOCATION

The Select by Location dialog box, lets you select features based on their location relative to other features. For instance, if you want to know how many hospitals are located within a distance of 500m from any type of road you could select all the hospitals that are within this distance. Answering this type of question is known as a spatial and this could help decision makers to convey the priorities (figure 4.4).

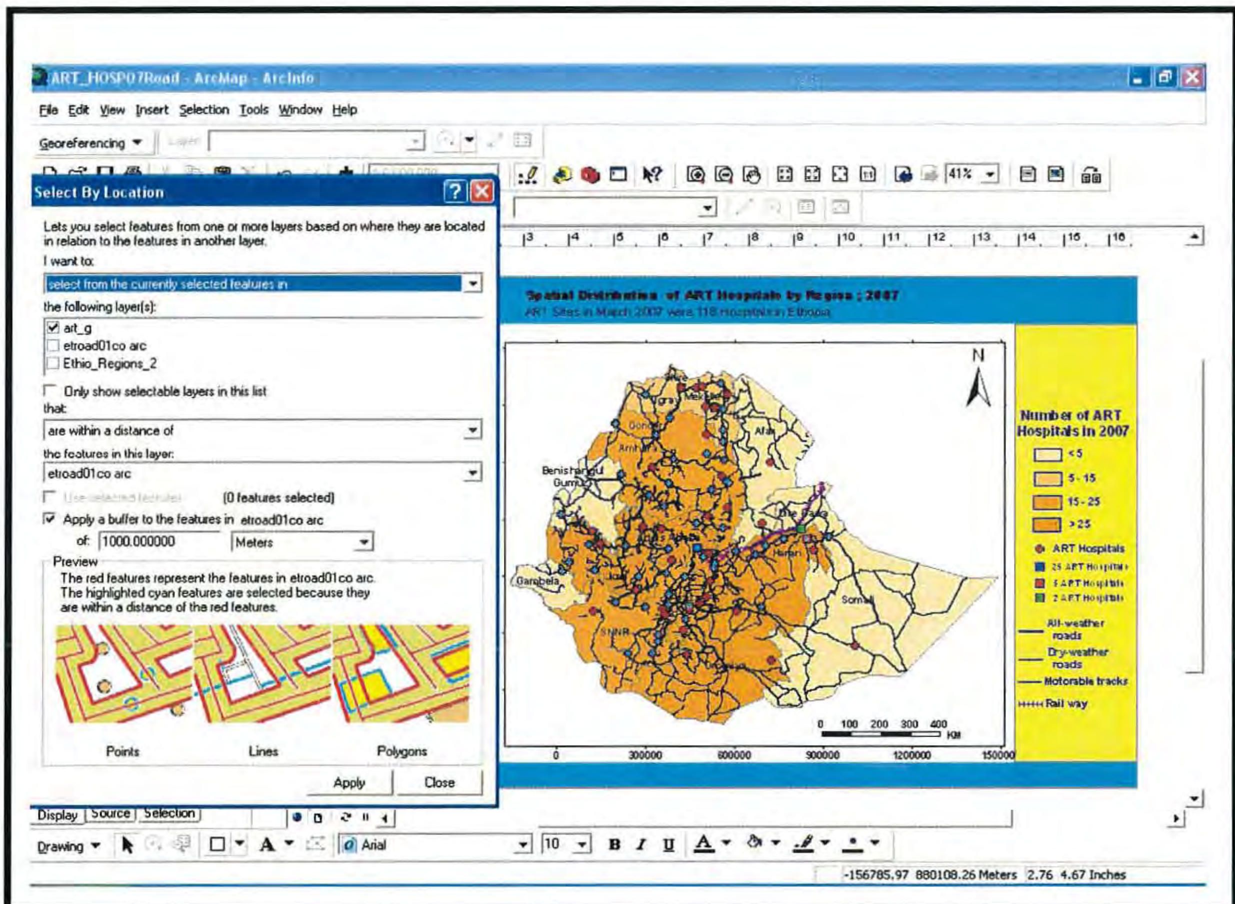


Figure 4.4. Spatial distribution of ART hospitals and road net work.

4.2.2 PROXIMITY AND NETWORK FUNCTIONS

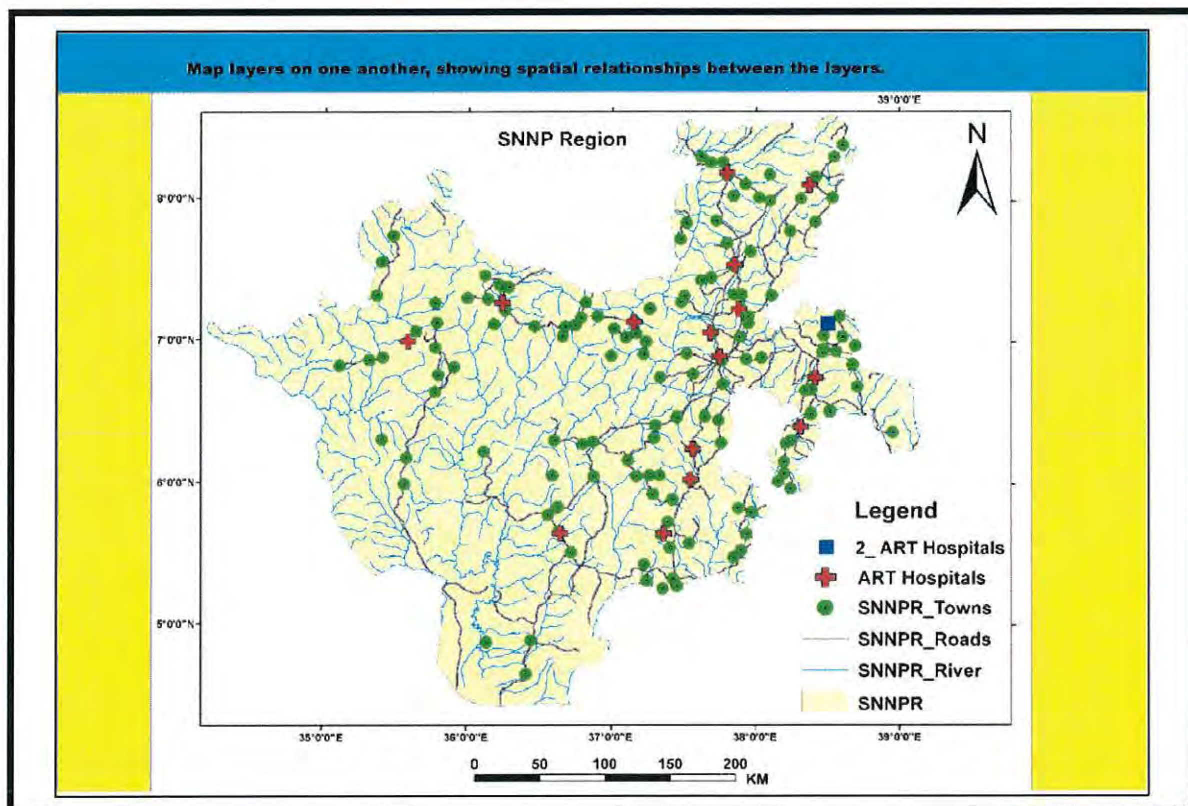
Buffer is one of the Analysis tools used in calculating proximity. This tool creates a new feature class of buffer polygons around polygon, line, or point features. These types of analyses consider predefined areas around a geographical object or the connectivity of phenomena. Another type of proximity analysis involves the network function of a GIS. Networks are commonly established to evaluate options for the purpose of route optimization and resource allocation. Specifically, this means locating the best route between two points or the selection of service zones in a network (e.g., drug delivery areas, service zones, mail routes).

GIS provides the ability to quickly access the geodemographic dynamics of an organization's existing service area in contrast to the likely demand for services at a new location (ESRI White Paper, 1999). It can identify catchment areas of health centers and also locate suitable site for a new health facility. Health services delivered at home can be scheduled in a more efficient manner by analyzing transportation factors and street patterns, and by recommending the most efficient route. GIS Provides accurate and timely information about where health services are located and instructions and maps on how to get there.

Figure 4.5. The buffer function examines an area which surrounds an object of interest. This function is used to create zones and to determine routes within zones. For example, a zone can be created based on specified distances from map features (e.g., the area within five miles of a road). Network functions examine the movement of objects along an interconnected pathway (e.g., traffic flow along a map of highway segments).

4.2.3 OVERLAY ANALYSIS

GIS can overlay different pieces of information. This helps in decision making and medical research through multicriteria modeling (for example, in understanding the association between Distribution of Health Centers and specific geographic features).



Prepared by the Author

Figure 4.6. Map of SSNP and overlay analysis with different geographical information

GIS involves the overlaying of a number of layers of information. It is important to realize that there are few limits in terms of the amount and type of information that can be included. In the HIV/AIDS case the layers of information can include distributions of all the elements thought to influence the spread of the disease such as: Location of roads, Location of health centers, Cultural attributes of the population, Migration patterns, Incidence of prostitution, Population density, and . Maps can be produced showing all of these things. More useful analyses, however, would involve more detailed mapping

down to the local level. GIS has the ability to 'zoom in' to very local or regional scales of visualization.

4.3 GIS APPLICATION IN HEALTH SYSTEMS

In a developing country like Ethiopia where 84 % of the populations reside in rural area and 16 % in urban areas, we need a very structured planning procedure such that the development activities and infrastructure facilities are available at both urban and rural area. However, in such a condition where majority of people leave in rural area and are provided with the least infrastructure facilities, creates a regional imbalance in development, causing shift in population from rural to urban areas. Hence administrators or decision-makers require an efficient GIS based tool which will assist them to get the updated scenario of the region. The present study emphasizes the power of GIS technology which will help MOH to better understand and evaluate spatial data by creating maps and graphic displays using information stored in the database .As GIS does more than just display the data; it enables the user to dynamically analyze and update the information linked to those locations spatially and can further strengthen the management of data.

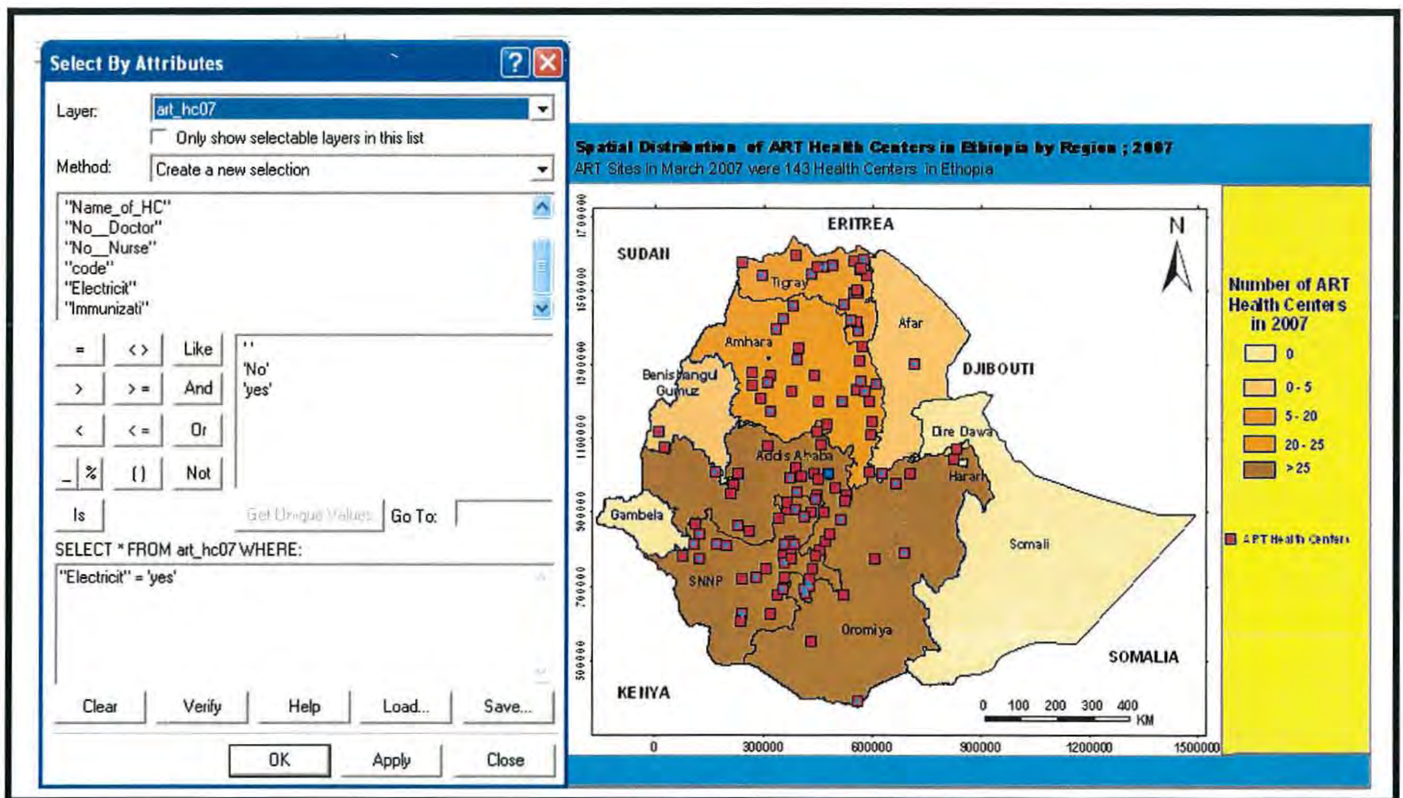
GIS is a valuable tool to assist in health research, in health education, and in the planning, monitoring and evaluation of health programmes and health systems.

Public health management needs information on various aspects like the prevalence of diseases, facilities that are available in order to take decisions on either creating infrastructure facilities or for taking immediate action to handle the situation and so on. These decisions need to be taken based on the observations made and available data. As the data relates to Public health covering the whole state and the entire population the data is voluminous, and hence it is extremely difficult to understand the real content. The data needs to be presented in a way that the temporal and spatial nature of the problem can be brought out in a focused way. Spatial variations in health related data is well known, and its study is a fundamental aspect of epidemiology.

Geographic Information System (GIS) is an innovative technology, ideal for generating data suitable for analysis both with respect to space and time. GIS-driven applications are being developed for a variety of end users. The aim is to bring the benefits of GIS to as wide an audience as possible. On the basic level, the GIS can provide map-based ("point and click") access to view information about a particular feature, such as a district or facility, while more advanced users can employ spatial analysis techniques to answer questions related to their health sector concerns. Some initial applications are described below.

4.3.1 FACILITY TARGETING

By incorporating information into a GIS, decision makers can not only see where all facilities are located, but also focus in on a subset of facilities that meet a certain criteria (e.g., facilities that offer immunization services, or have an electricity source available to run equipment). This "filtering" approach helps decision makers better understand how populations are currently being served .For example, if a donor organization is able to provide new equipment to several health facilities, the GIS can help them quickly identify which facilities are optimal candidates for this support by locating only those facilities that have electricity (see Fig 4.7) and serve the largest population catchments. The filtering approach helps decision makers target specific health centers or populated regions for interventions, improvements, or new programs. Mapping the spatial distribution of particular facilities relative to populated areas provides analysts with an easy way to visualize and target areas of need.



Prepared by the Author

Figure 4.7 spatial distributions of ART health centers that meet certain criteria

4.3.2 HEALTH CARE ACCESSIBILITY

Ensuring adequate access health care is an important goal of health systems strengthening the development of a country. Integrating the GPS-enabled Health Facility Survey into a GIS gives decision makers instant access to critical information. Facility locations can be displayed along with the existing road network, the complexity of the terrain, and other geographic features that may assist or prohibit access to a particular location. In Ethiopia rural areas, most people travel by foot, thus pedestrian access to health facilities is the first accessibility tier. The second accessibility tier is equal to the spatial extent to which health care workers based at a facility can reach the surrounding population and the third accessibility tier is based on the reasonable travel time to the health facility using motorized transportation.

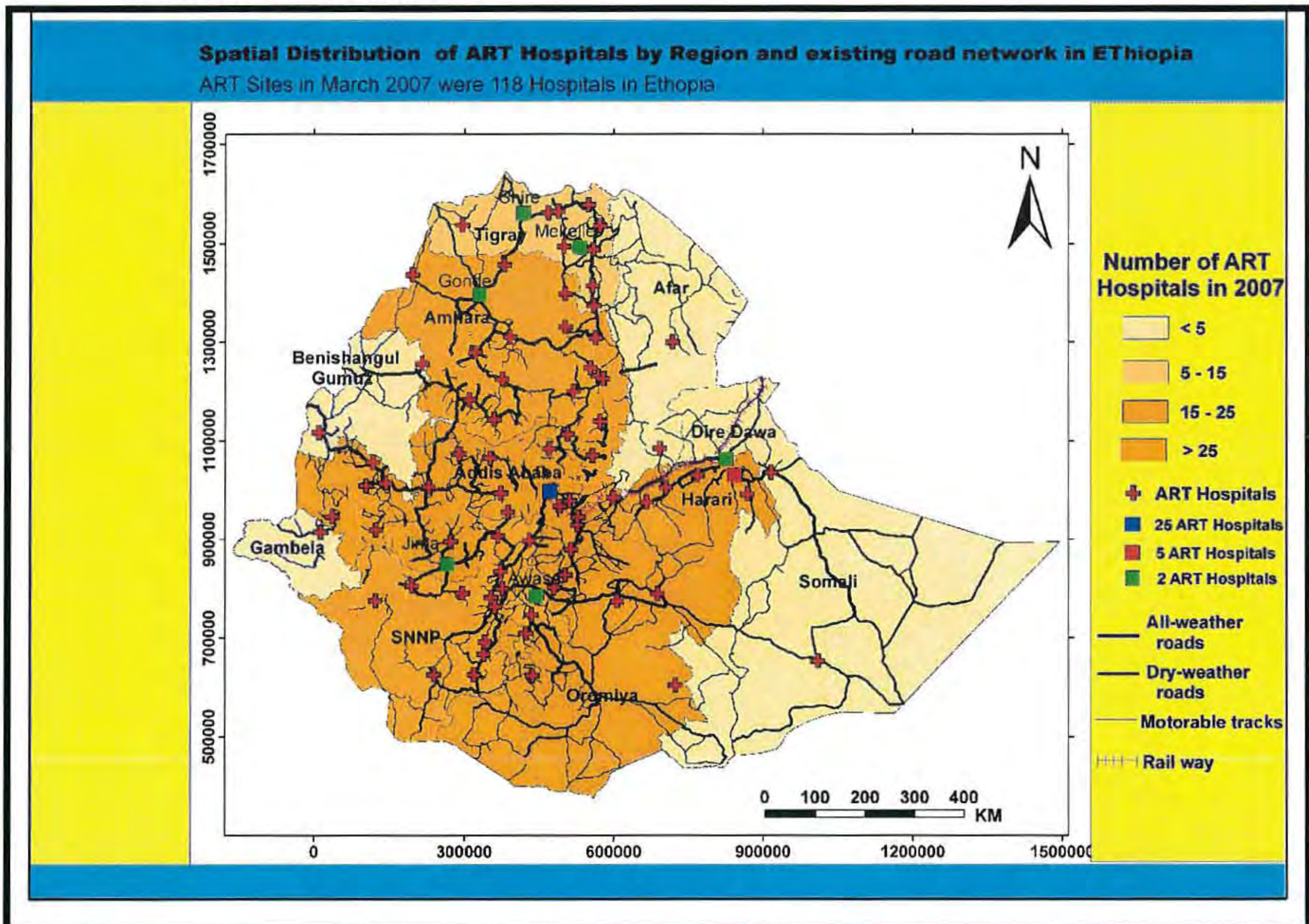


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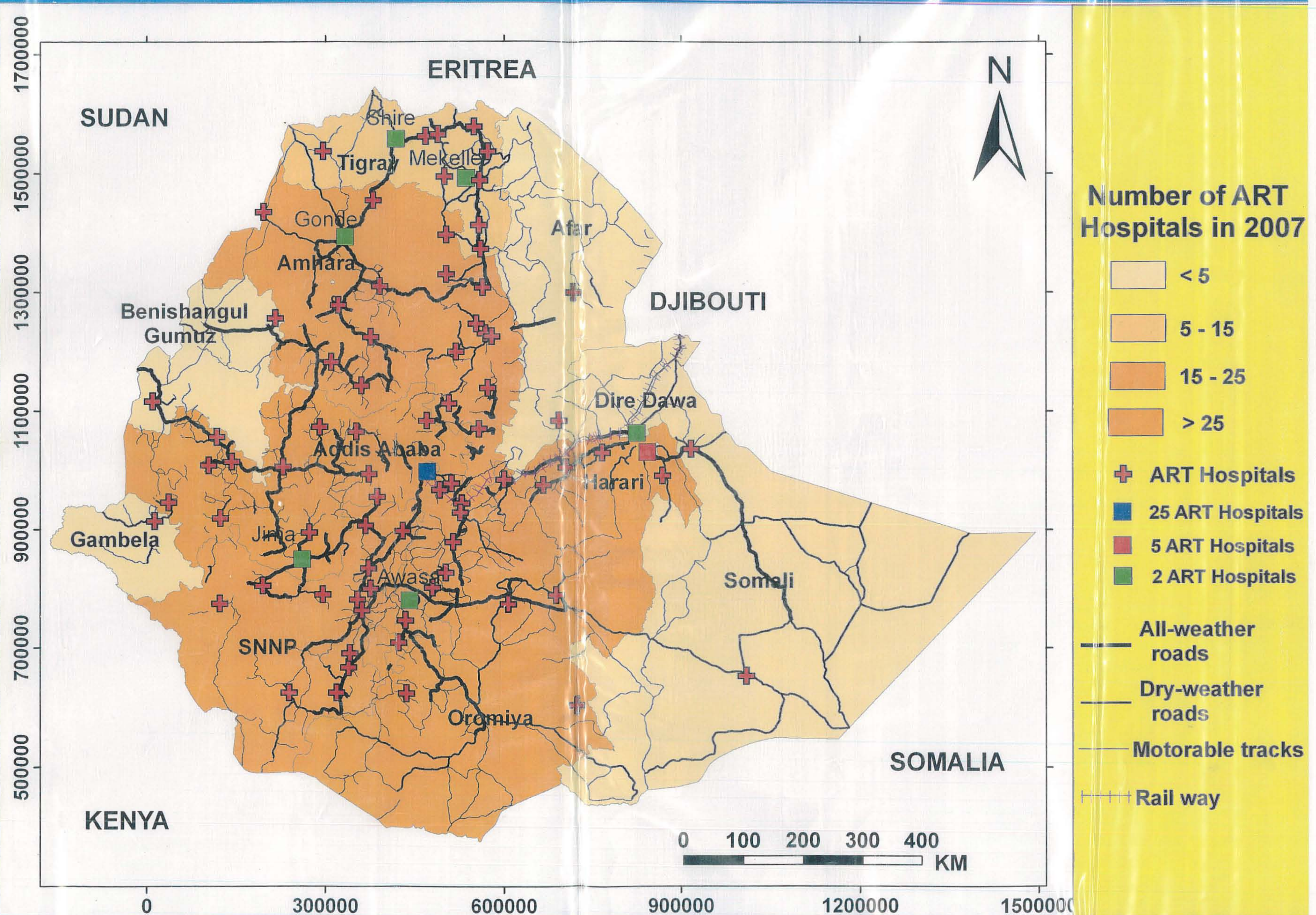
Figure 4.8. Spatial Distribution of ART hospital and existing road net work in Ethiopia

Spatial Distribution of ART Hospitals by Region ; 2007

ART Sites in March 2007 were 118 Hospitals in Ethiopia



4.4 MONITORING AND EVALUATION WITH GIS SYSTEM

HIV/AIDS is the largest health crisis facing the world today. To combat the pandemic, international agencies and governments have devoted large sums of money over the past two decades. Monitoring and evaluating are key components of social development programs. Each year more than $300 billion is spent by developing countries, international agencies, and developed nations on these programs. While social development programs have clear goals, evidence documenting their progress, impact, and outcomes is lacking (Xiaomei, 2006).

With such huge investments, monitoring and evaluating seem especially important to understand if money is being well spent. The first step in evaluating these programs is to understand the distribution of PLWHA in the area of interest. GIS enables analysts to create maps that demonstrate where high concentrations of people with HIV/AIDS are living in Ethiopia.

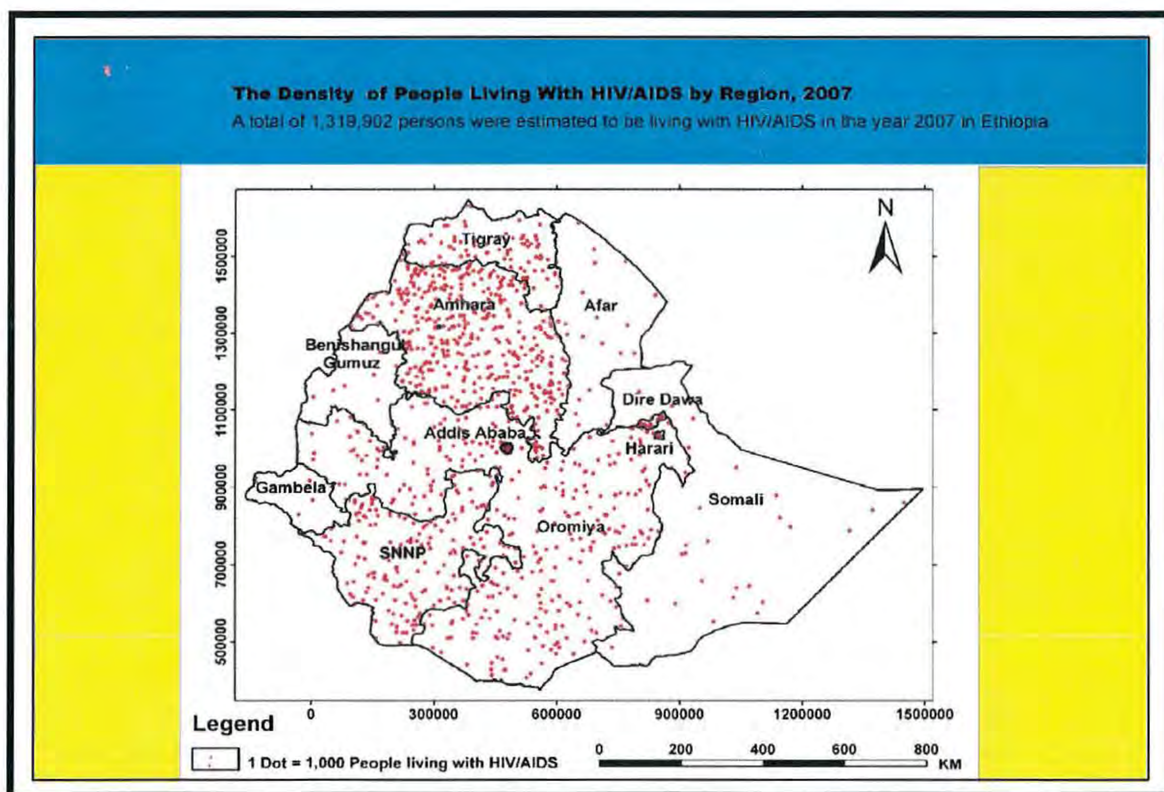


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Figure 4.9 .Density map of people living with HIV/AIDS in Ethiopia

Using data provided by MOH, figure 4.9 reveals the density of population living with HIV/AIDS. Each dot represents 1000 People living with HIV/AIDS. Amhara, Addis Ababa, Oromia, SNNP, Dire Dawa and Harari have much higher densities. In addition to revealing the distribution of people living with HIV/AIDS, GIS can also present demographic information about these Regions. Knowing demographic characteristics helps donors target different groups effectively. GIS analysis was also used to reveal the changes caused by interventions. Overall, the analysis provides insight into the effectiveness of current HIV/AIDS programs, identifies the focus of program actions, and improves decision making.

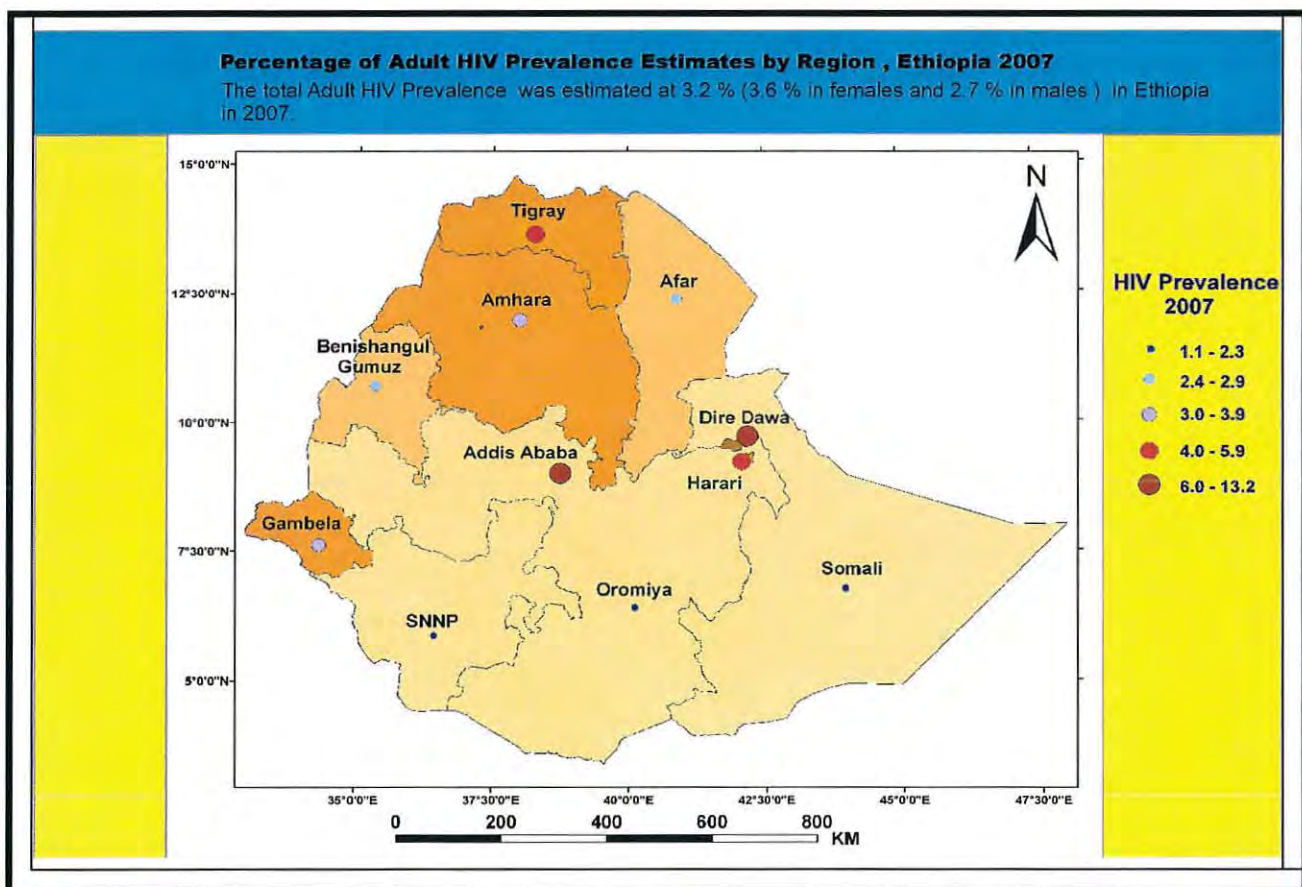

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Figure 4.10.Map of adult HIV prevalence Estimates percentage by Region

Consistent with the density distribution, Addis Ababa, Dire Dawa, Harari and Tigray also have the highest HIV prevalence. On figure 4.10, the smallest circles represent an HIV infection rate of 1.1 percent to 2.3 percent and the largest circles represent an HIV prevalence rate of more than 6.0 percent. Addis Ababa, Dire Dawa, and Harari have HIV prevalence rates of 11, 6.2, and 4.7 percent, respectively in 2007 according to the 2006 MOH report.

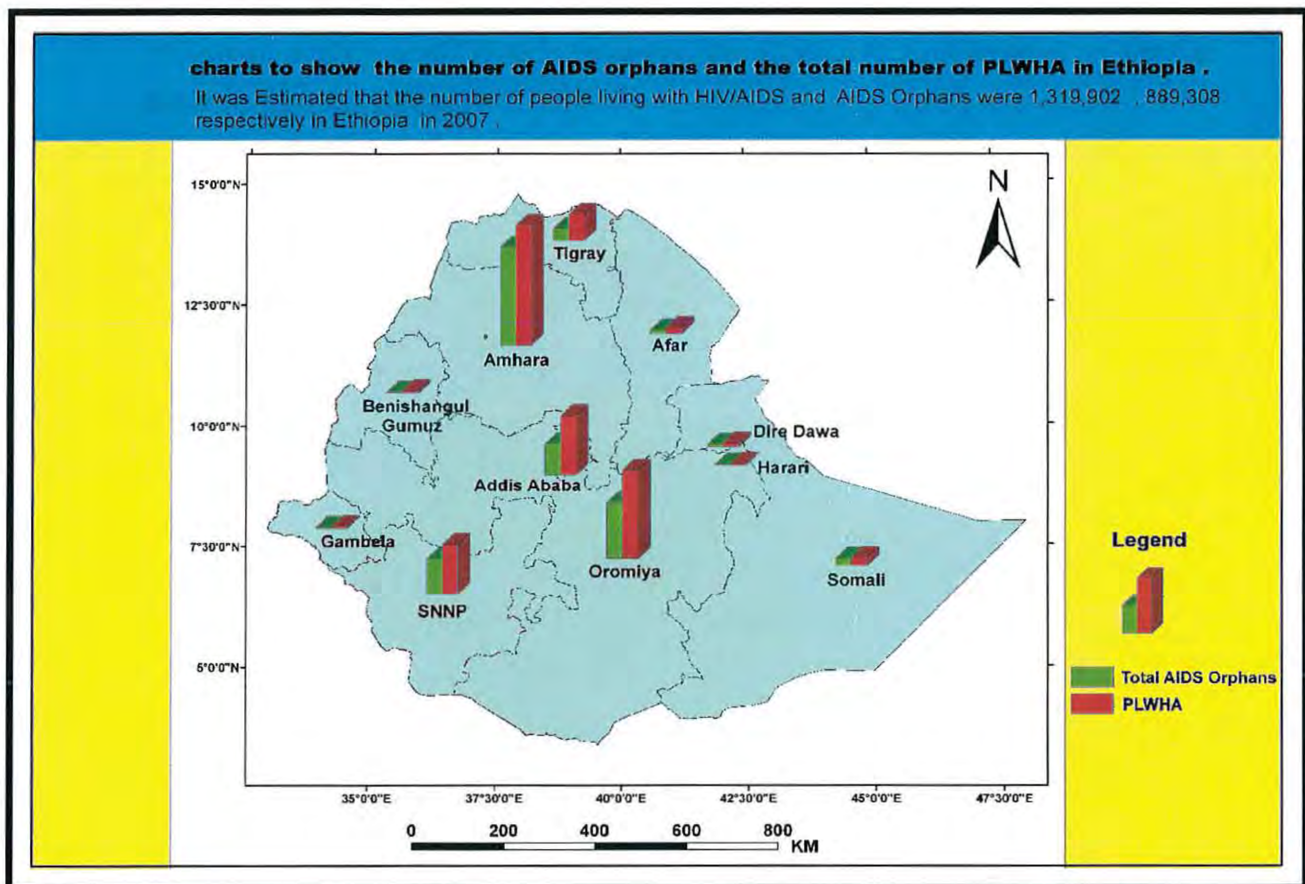

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Figure 4.11. Map that show the number of AIDS orphans and the total number of PLWHA by region; 2007.

Figure 4.11 uses bar charts to shows the number of AIDS orphans (green bar) and the total number of people living with HIV/AIDS (red bar) in Ethiopia in 2007. Amhara region had the largest number of AIDS orphans (352,950) followed by Oromiya with 199,748 orphans. In Harari, Dire Dawa, Gambella, Benishangul Gumuz and Somali

regions the gap between total number of AIDS orphans and the total number of people living with HIV/AIDS is not very large. As the information presented HIV/AIDS in figure 4.12 shows, although regions in Ethiopia face the same threat from the HIV/AIDS pandemic, each region may have different priorities in mitigating the crisis. For Harari, Dire Dawa ,Gambella, Benishangul Gumuz and Somali regions where the number of AIDS orphans matches or a little lower than the total number of people living with HIV/AIDS, providing livelihood, education, and health care opportunities for the orphans should be considered the priority. In regions like Amhara Addis Ababa, Oromiya, SNNP and Tigray prevention and treatment could be the highest priorities.

Maps and final outputs produced by a GIS can be used by health officials as a monitoring and evaluation tool for better planning, showing the spatial distribution and differential evolution of diseases, thereby reducing the monitoring and implementation costs of the health sector programmes. GIS is becoming an effective tool for monitoring and evaluating social development programs. As the maps accompanying this article illustrate, GIS analysis can demonstrate the input, output to help effective allocation of resources to combat HIV/AIDS so that can easily target highest priorities. GIS can demonstrate how and where things move over time; analysts can gain insight into the progress of programs. The benefits of mapping changes are twofold. Mapping identifies program impacts by comparing conditions before and after an intervention. Mapping also helps anticipate needs based on the impact of these changes. Another important that a GIS offer is its ability to analyze massive amounts of spatial data very quickly. Hence the monitoring can be constant, weekly, fortnightly etc. as well as annually. This allows fine tuning of policy and programme interventions to be undertaken continually rather than waiting until the end of a fixed period. Overall, the analysis provides insight into the effectiveness of current global HIV/AIDS programs, identifies the focus of program actions, and improves decision making.

CHAPTER FIVE

MAPPING OF THE SPATIAL DISTRIBUTION OF HOSPITALS AND HEALTH CENTERS PROVIDING ART AND HIV/AIDS INDICATORS IN ETHIOPIA

INTRODUCTION

The final set of tools we consider here provide the ability to create output such as maps, geographical summaries or reports, and geographical base files (files containing both the digital map and attribute data). Output can be either hard copy, digital files, or displayed on a computer monitor. The sophistication of the GIS software and the output capabilities of the hardware/software system dictate the quality and variety of options available to the operator. In most cases, the GIS allows maps, summaries, and base files to be written in a number of different digital export formats so that they may be used by another GIS. Most systems have the ability to translate or directly import and export these files. Generating graphic output, commonly in the form of maps, requires that a GIS have a wide variety of symbols and format options. Most offer numerous line, polygon, and point symbols to represent geographical phenomena as well as text options for labeling and annotating output. Since these utilities allow maps to be produced at various page sizes and map scales, output can be custom-designed to a format that is most appropriate for the situation.

Geographical and tabular summaries are common types of GIS output. Such summaries differ from those created by a traditional database query because they are based on map analysis. Use of reference maps is an important part of the output (mapping) process. It is common for a GIS to contain a library of basic, often-used map and attribute data of the study area for creating these simple reference maps. Such base files could include county, section, parcel, or zip code boundaries, major transportation routes, or hydrological features. When included in output maps, these cartographic features provide a useful frame of reference for the map user.

5.1 POPULATION DISTRIBUTION

In Ethiopia, population distribution is highly uneven. The overwhelming majority (84 percent) resides in rural areas where agriculture is a predominant economic activity, infrastructure and social services are not well developed. Only 16% of the population is urban dwellers. In addition, there is a great disparity in regional distribution. The overwhelming majority of the country's population lives in Oromiya (35.4%), Amhara (25.5%) and SNNPR (19.9%). On the other hand, Harari (0.26%), Gambella (0.33%) and Dire Dawa (0.53%) have the smallest share from the country's total population.

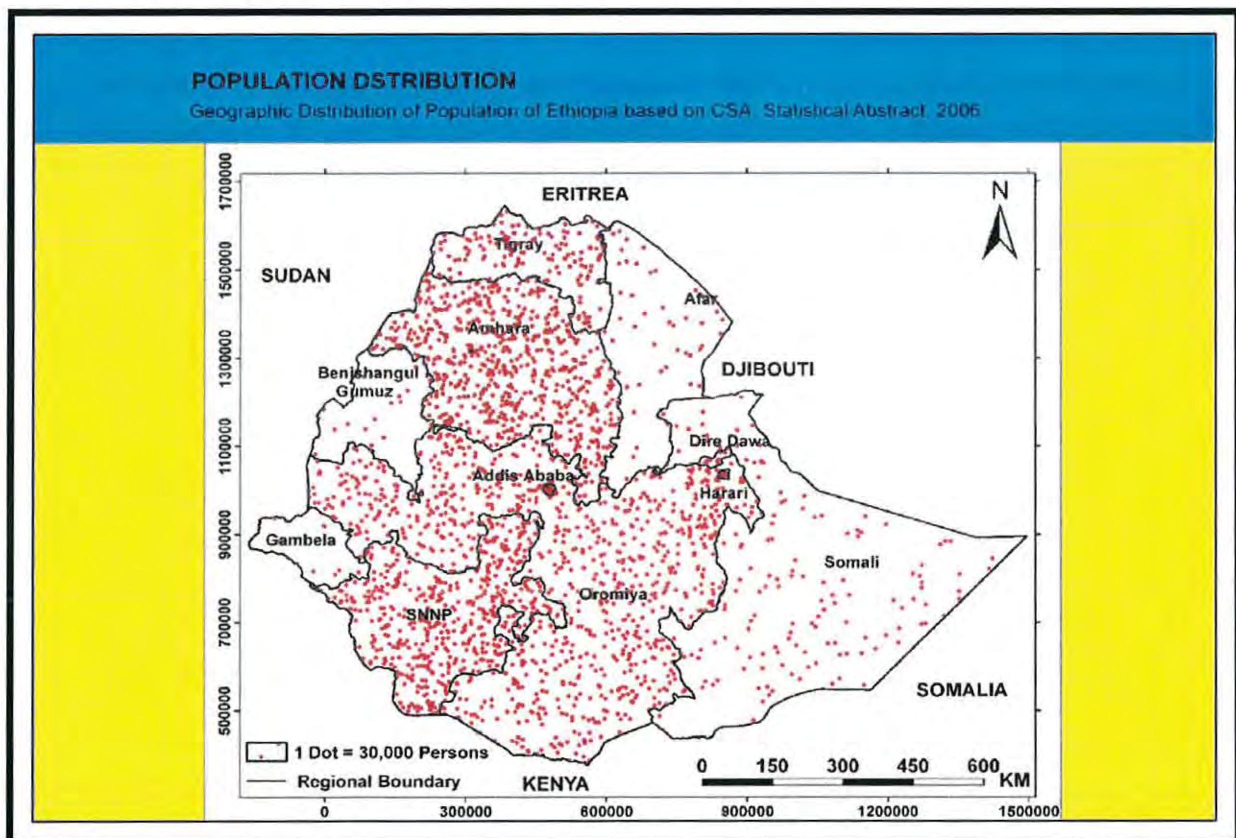

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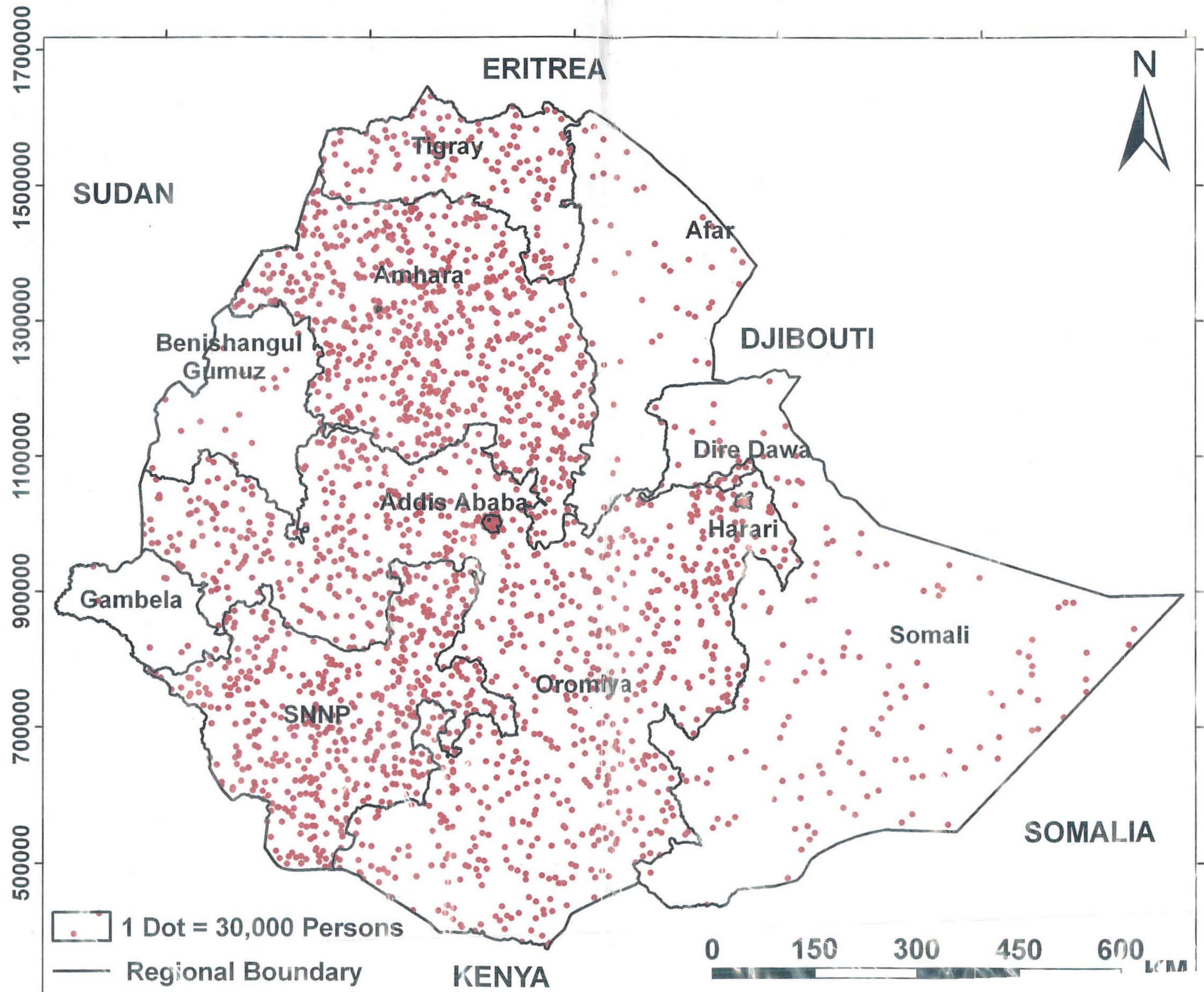
Figure 5.1.Density Map of the Ethiopian population

Figure 5.1 shows the distribution of people throughout the country, with each red dot representing 30,000 persons. The Ethiopia population is expected to increase from the current 75 million to 83 million in 2010. Addis Ababa has the highest density (5,608 persons per km^2), followed by Harari and Dire Dawa. However Gambela, Beneshangul-Gumuz, Afar and Somali are sparsely populated regions

POPULATION DSTRIBUTION

Geographic Distribution of Population of Ethiopia based on CSA, Statistical Abstract, 2006



5.2 ART PROVIDING HEALTH FACILITIES

With increasing access to ART and recognition of its impact in improving the lives of PLWHA, the Ethiopian government through the MOH endorsed a policy on supply and provision of antiretroviral drugs in 2002 (HAPCO, 1998 E.C). Since then there has been an increase in the number of sites providing ART. The estimated number of persons requiring ART is increasing from time to time for example The estimated number of persons requiring ART for 2007 were 287,881 in the country and to ensure timely delivery of required resources there should be a rapid scale up in the number of sites providing ART.

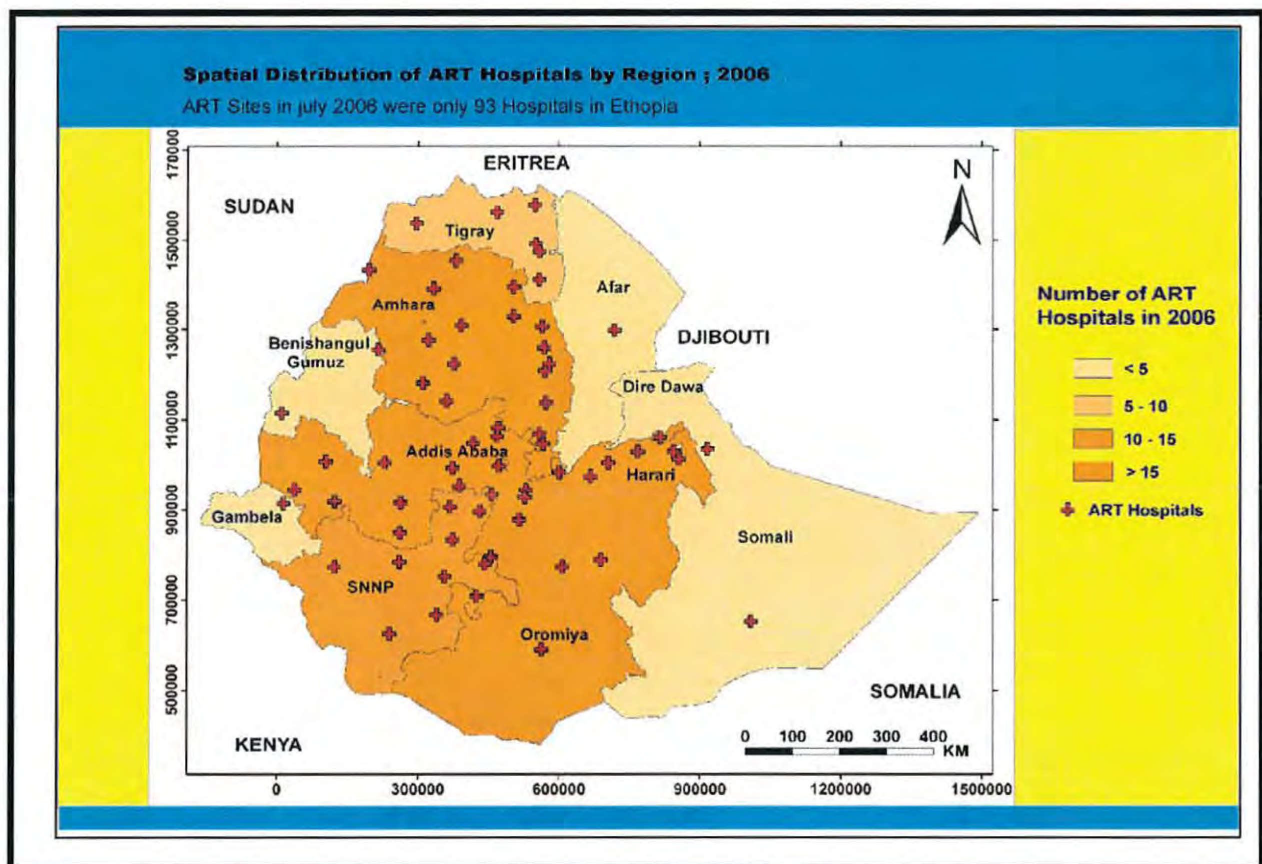


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Figure 5.2.Map of ART hospitals by region; MOH -2006

Integrating the GPS-enabled Health Facility Survey into a GIS gives decision makers instant access to critical information and Facility locations can be displayed.

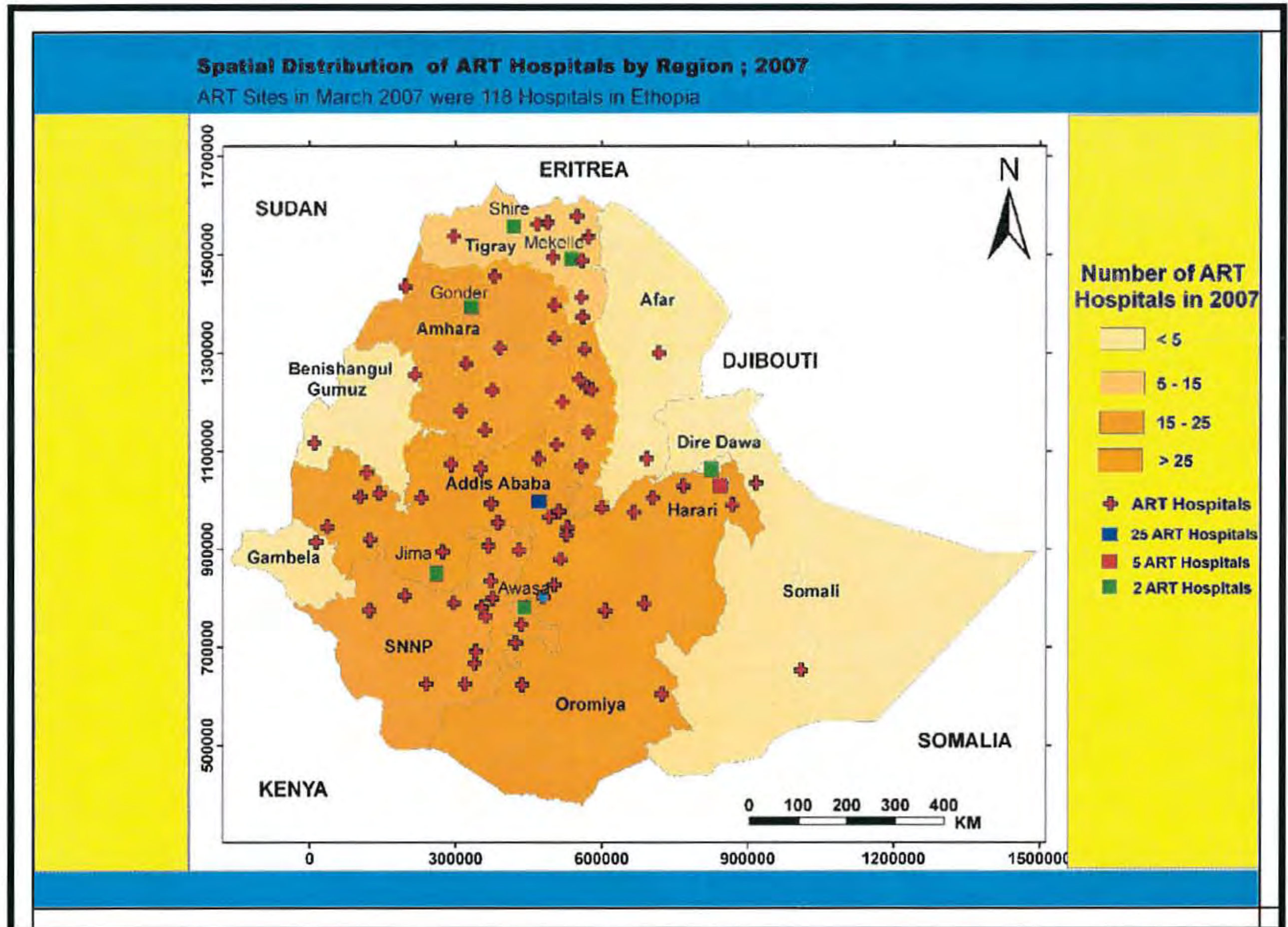

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Figure 5.3.Map of ART hospitals by region; MOH 2007

Ensuring adequate access of rural and urban populations to health care is an important goal of health systems. ART sites in 2006 were only 93 Hospitals in Ethiopia and this number increased to 118 Hospitals in 2007; while the number of Health centers was 143 in March 2007 (MOH, 2007). Mapping the spatial distribution of particular facilities relative to populated areas provides analysts with an easy way to visualize and target areas of need.

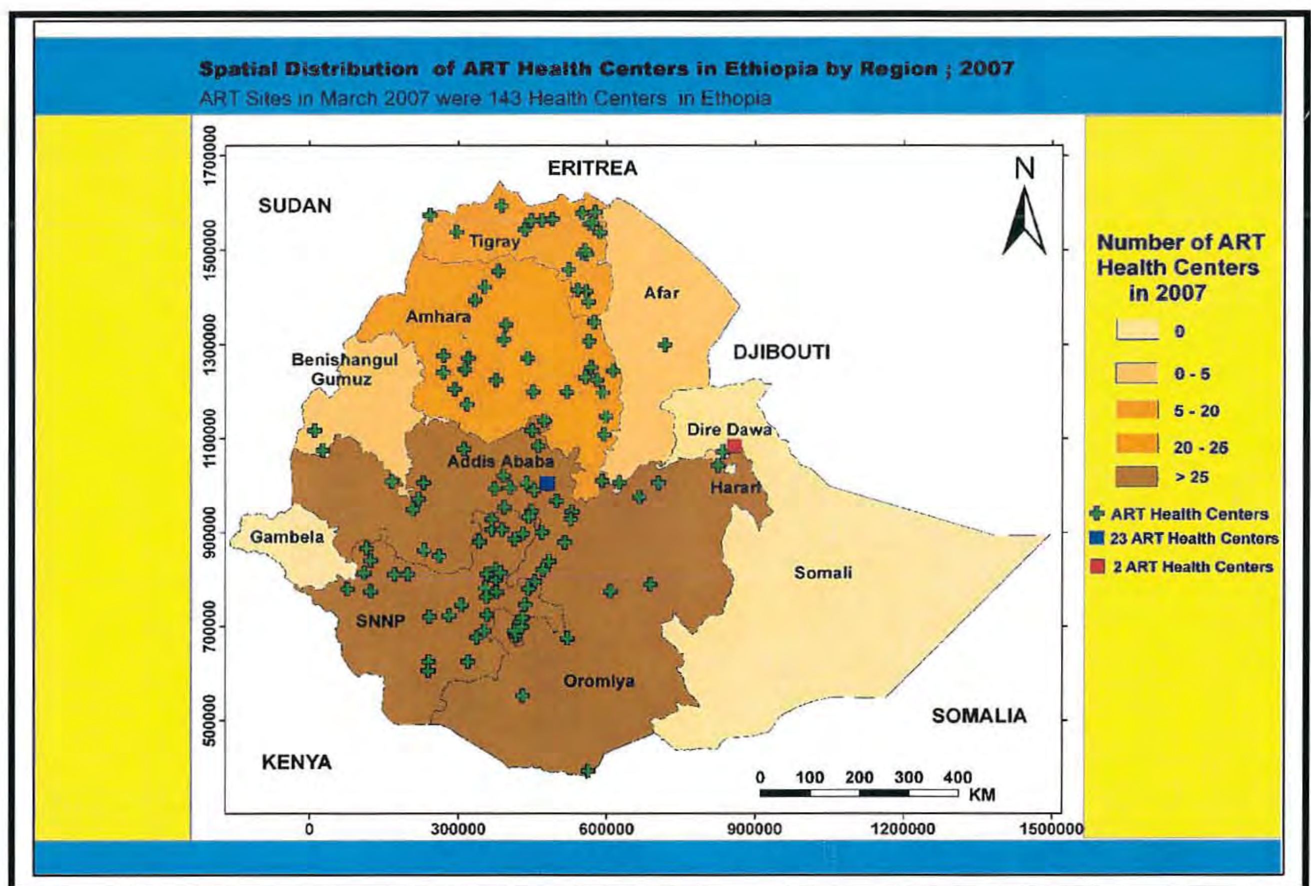

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Figure 5.4.Map of ART Health centers by region; MOH 2007

5.2 ART PROVIDING HEALTH FACILITIES

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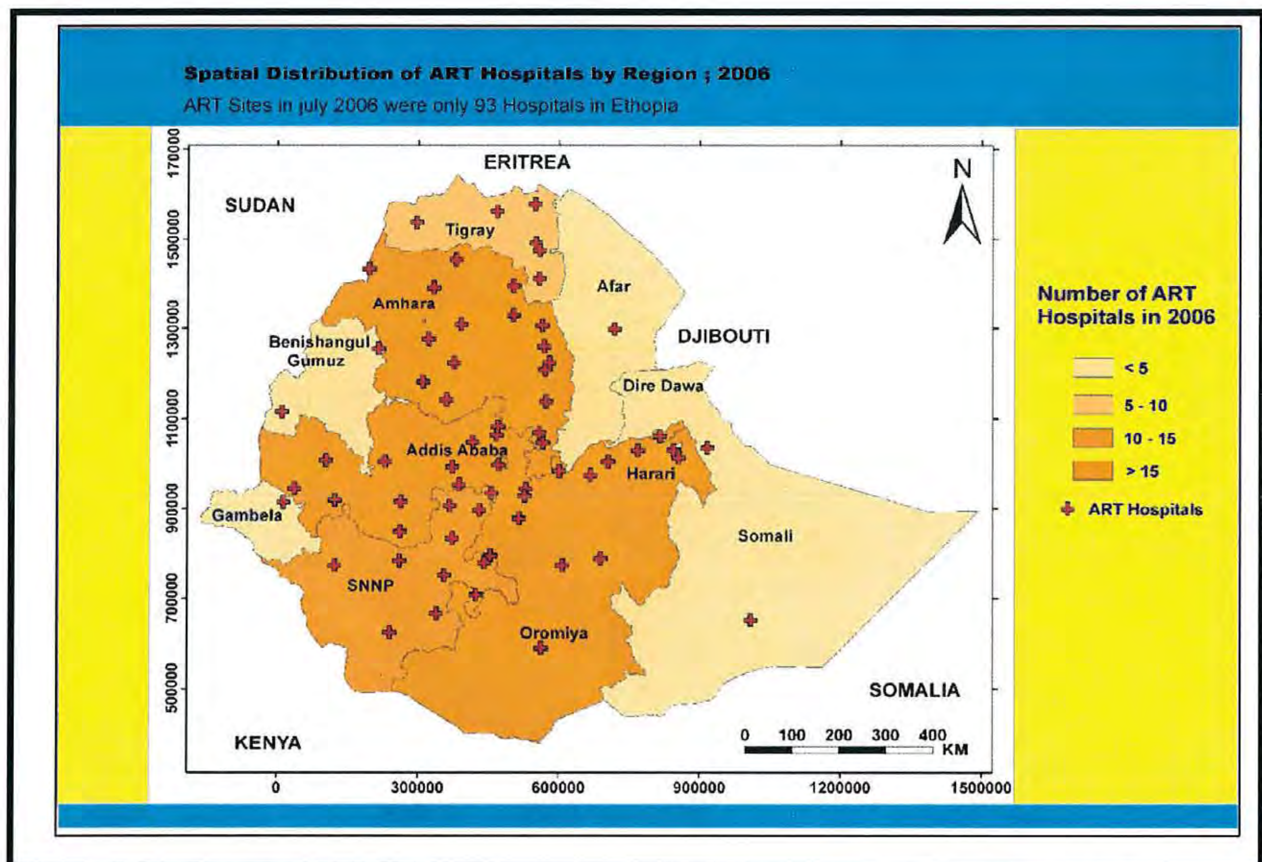

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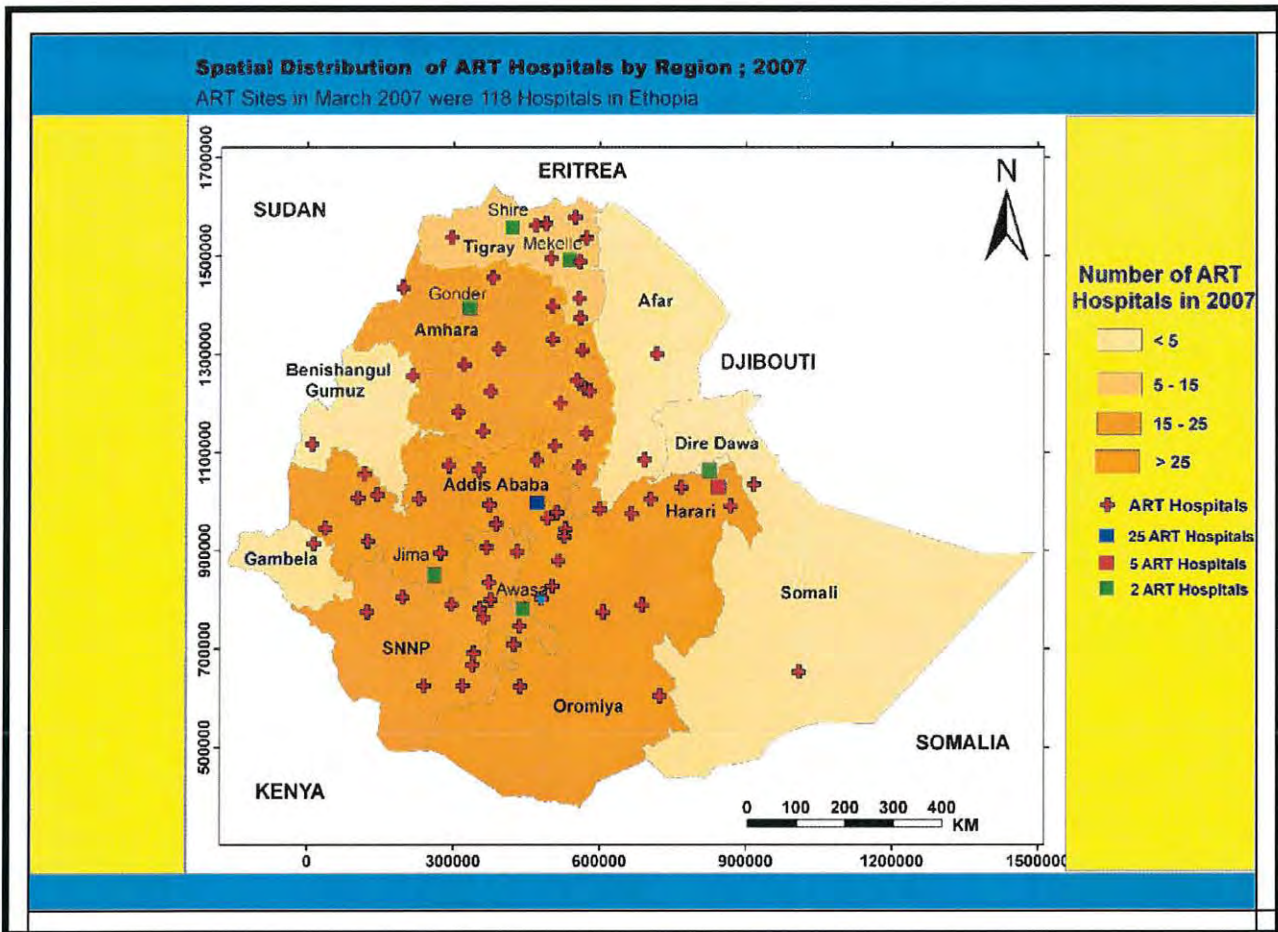

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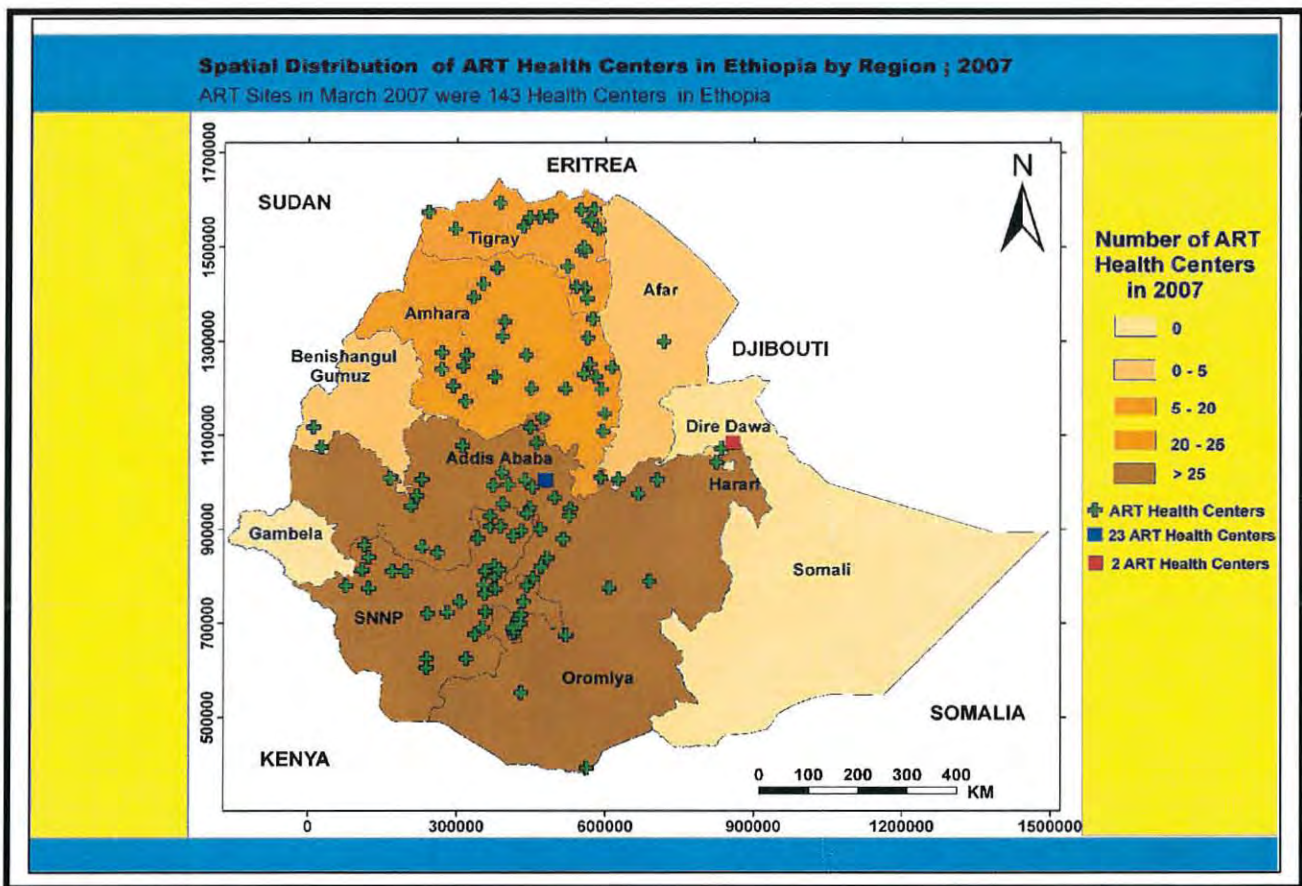

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Figure 5.4.Map of ART Health centers by region; MOH 2007

The identify viewer (see Fig 5.5) is an informational tool that is available to users with no specific GIS knowledge. It provides a user-friendly interface for viewing the results of the Health Facility in Ethiopia through map-based navigation. The user can zoom into a district of interest, and then use the map to select a facility (hospital or health center). This pulls up to flip through the set of facility, as well as tables of information and statistics about the particular facility. At any time, the user can step back to select a different facility within the district, or view a new district. This provides a baseline assessment of each facility and provides evidence-based rationale for future facility-based health care service availability; equipment, staffing, and other decisions (figure 5.5).

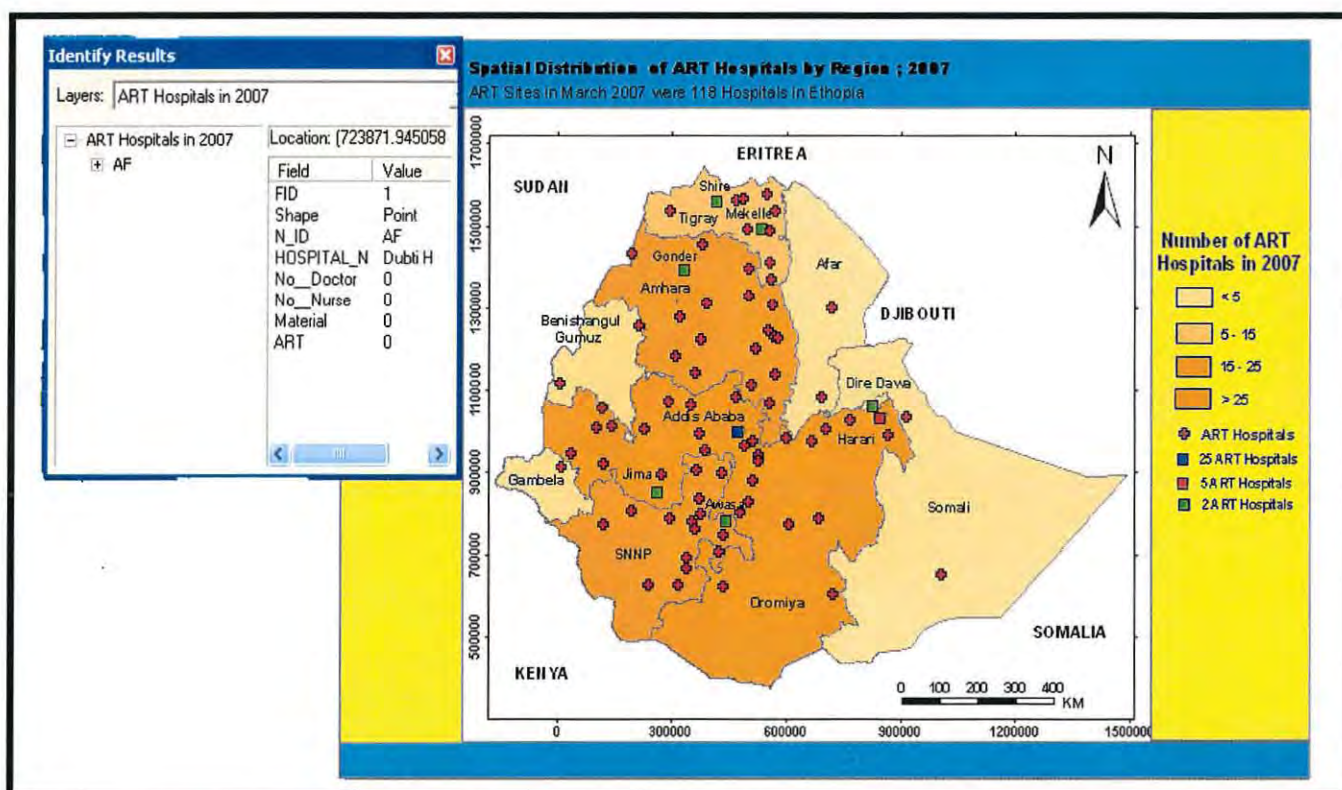

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Figure 5.5.Spatial distribution of ART hospitals and Identifier results in Arc Map

5.3 ATLAS OF HIV/AIDS INDICATORS IN ETHIOPIA BASED ON EDHS AND MOH REPORTS

5.3.1 KNOWLEDGE OF HIV/AIDS PREVENTION METHODS

Knowledge of condoms and the role that they can play in preventing transmission of the AIDS virus is much less common, particularly among women. Around four in ten women and six in ten men are aware that using a condom during sexual encounters can reduce HIV/AIDS transmission. Even fewer women and men are aware that using condoms and limiting sex to one uninfected partner can reduce the risk of getting the AIDS virus (35 percent and 57 percent, respectively).

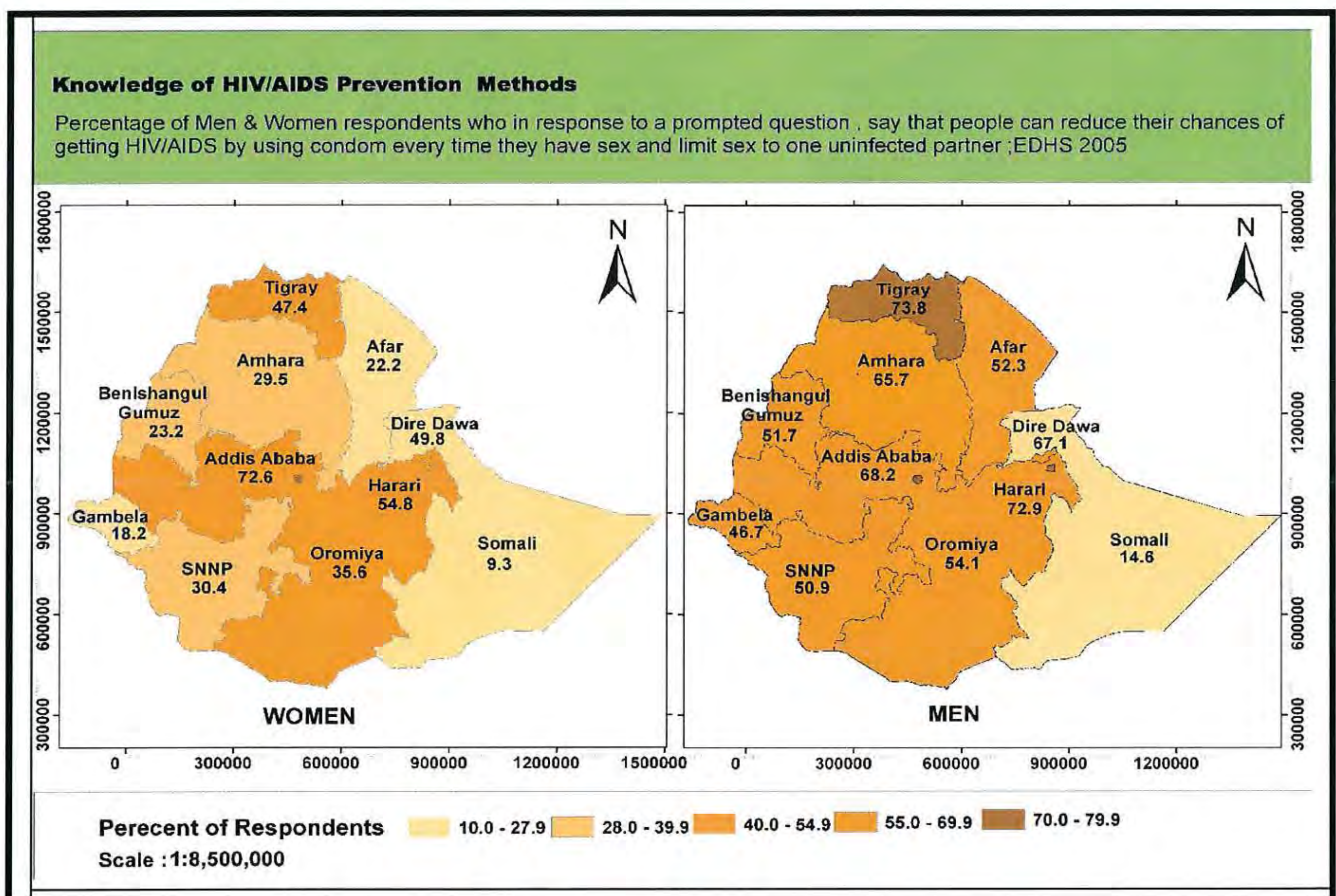

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Figure 5.6 Map of knowledge of HIV prevention Methods among men and women (Condom use) EDHS, 2005

There is considerable variability across regions in knowledge of prevention methods (using condom every time they have sex and limit sex to one uninfected partner). Among women, knowledge levels for the various methods are highest in Addis Ababa (72.6 %) and lowest in the Somali Region (9.3 %). Among men, knowledge levels tend to be higher in Tigray (73.8), Harari (72.9 %), Addis Ababa (68.2 %), and Dire Dawa (67.1 %) than in other regions and lowest in the Somali Region (14.6); (figure 5.6).

5.3.2 KNOWLEDGE OF MOTHER – TO – CHILD TRANSMISSION

Increasing knowledge of ways in which HIV can be transmitted from mother to child and the fact that the risk of transmission can be reduced by using antiretroviral drugs is critical to reducing mother-to-child transmission (MTCT). To obtain information on these issues, respondents in the 2005 EDHS were asked if the virus that causes AIDS can be transmitted from a mother to a child during breastfeeding and whether a mother with HIV can reduce the risk of transmission to the baby by taking certain drugs (antiretroviral) during pregnancy (see Fig 5.7).

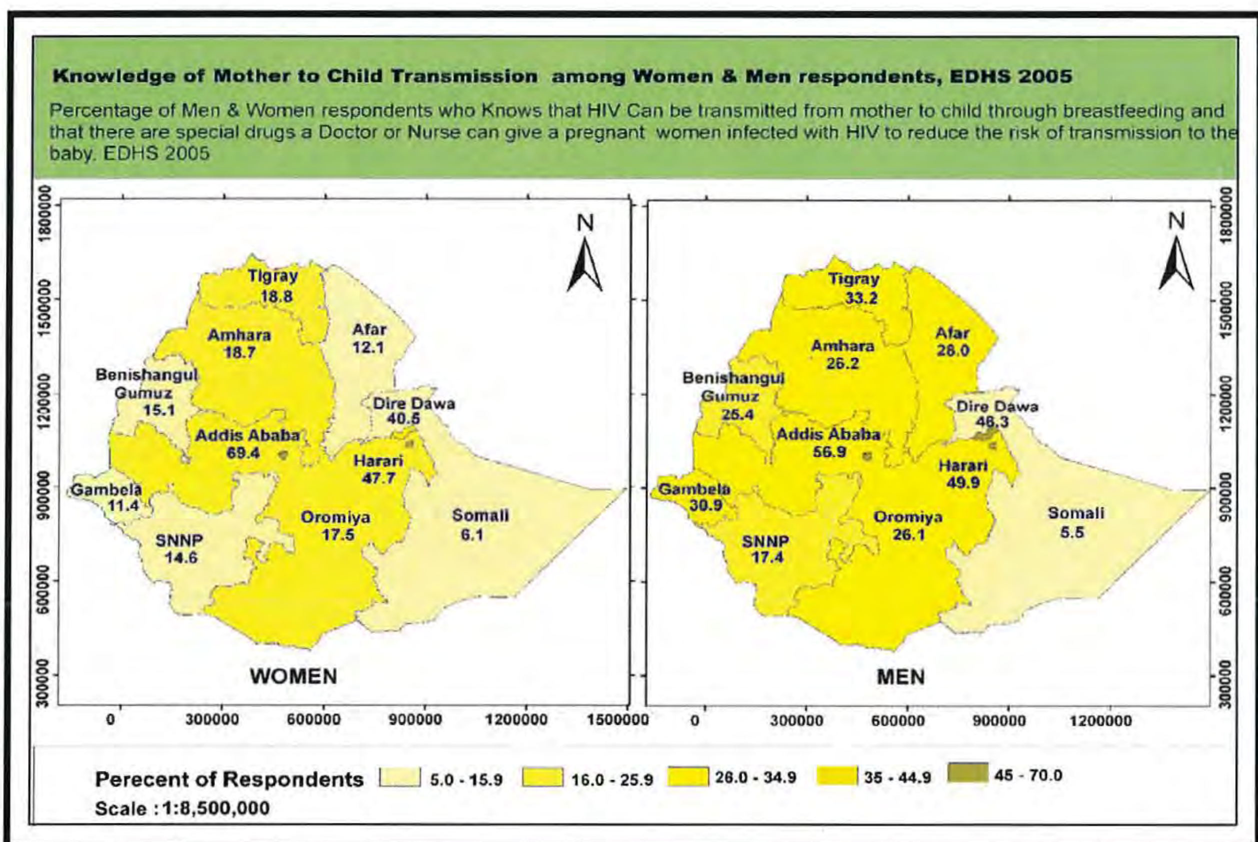

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Figure 5.7 Map of knowledge of MTCT of HIV among women and men, EDHS 2005

There are marked differences in MTCT knowledge among women and men by age, marital status, residence, education, and wealth. Knowledge about mother-to-child transmission is highest among men and women living in Addis Ababa (69.4 % Women and 56.9 % Men). Knowledge levels are lowest among women and men in the Somali Region (6.1 % and 5.5 %) ;(figure 5.7).

5.3.3 COMPREHENSIVE KNOWLEDGE OF HIV/AIDS

Knowledge of how HIV is transmitted is crucial to enabling young people to avoid AIDS. Young people are often at greater risk because they may have shorter relationships with more partners or engage in other risky behaviors. Comprehensive knowledge is defined as knowing that: 1) people can reduce their chances of getting the AIDS virus by having sex with only one uninfected, faithful partner and by using condoms consistently; 2) a healthy-looking person can have the AIDS virus; and 3) HIV cannot be transmitted by mosquito bites or by sharing food with a person who has AIDS.

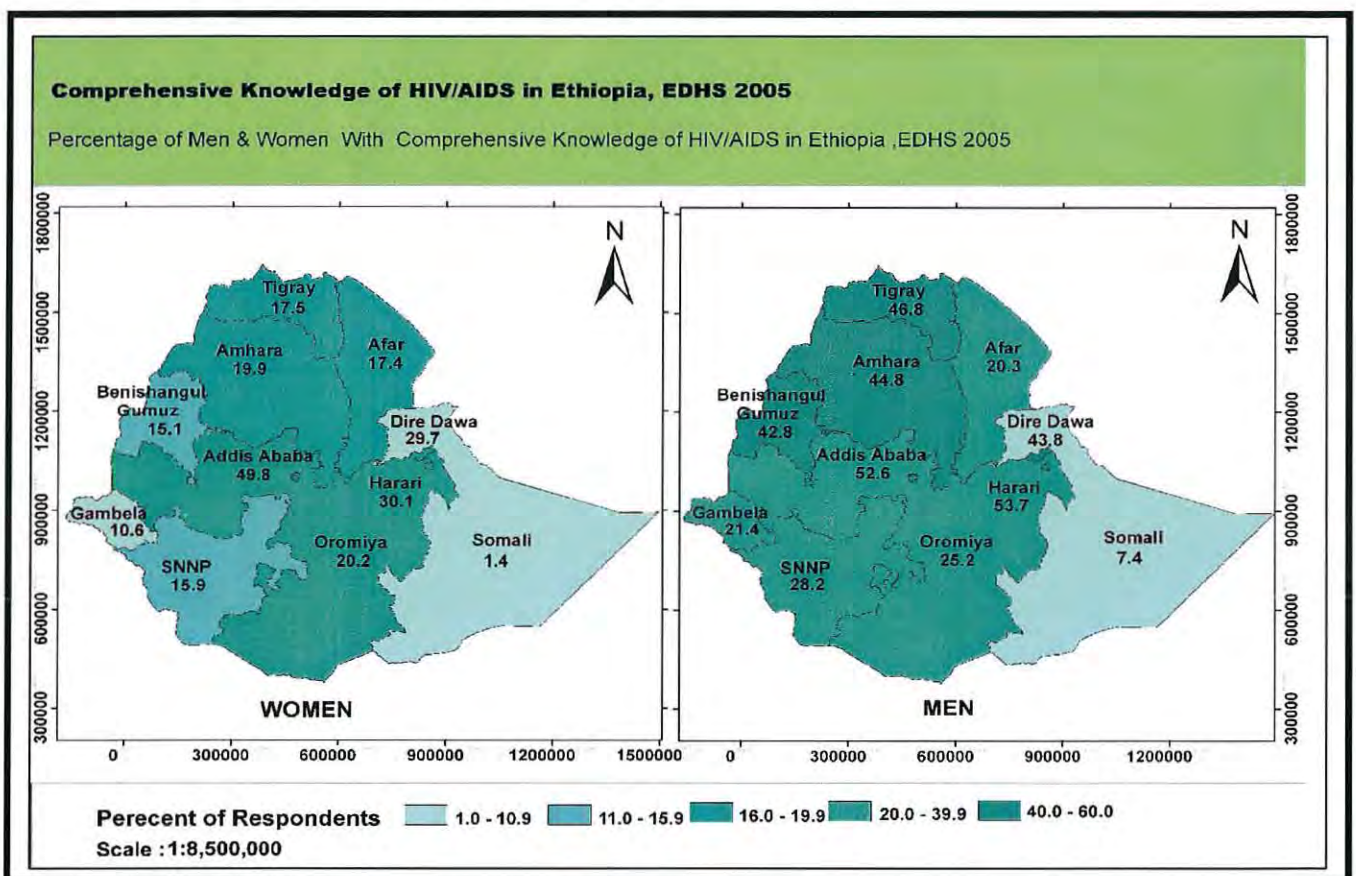

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Figure 5.8 Map of Comprehensive knowledge of HIV/AIDS among men and women in Ethiopia, EDHS 2005

According to the 2005 EDHS results, 16 percent of women and 30 percent of men in Ethiopia have comprehensive knowledge of HIV/AIDS prevention and transmission.

Knowledge varies greatly by region and sex.In Addis Ababa more men (52.6 percent) than women (49.8 percent) have comprehensive knowledge of HIV/AIDS, but the differences are larger in some regions. For example, in Tigray 46.8 percent of men but only 17.5 percent of women have comprehensive knowledge, and in Amhara region, 44.8 percent of men and 19.9 percent of women have such knowledge. Such difference is also large in Benishangul Gumuz 42.8 percent of men but only 15.1 percent of women have comprehensive knowledge (figure 5.8).

5.4 MAJOR HIV/AIDS INDICATORS IN ETHIOPIA

5.4.1 ADULT HIV PREVALENCE

According to the 2006 report of the Federal Ministry of Health; the total Adult HIV Prevalence in Ethiopia was estimated at 3.2 % (3.6 % in females and 2.7 % in males) in 2007. Like in a number of other countries in sub-Saharan Africa adult HIV prevalence in women is higher than for men (MOH, 2006).

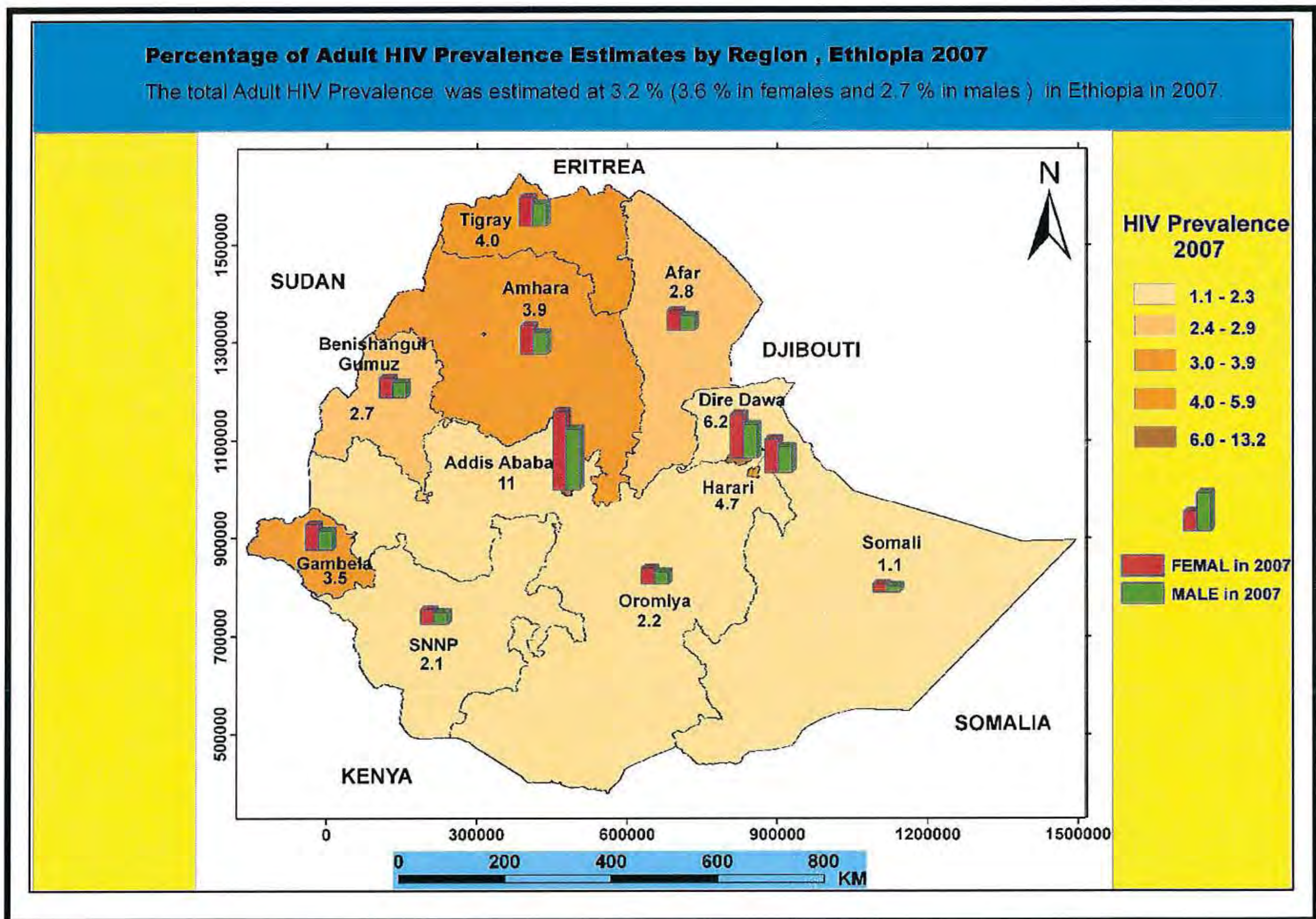

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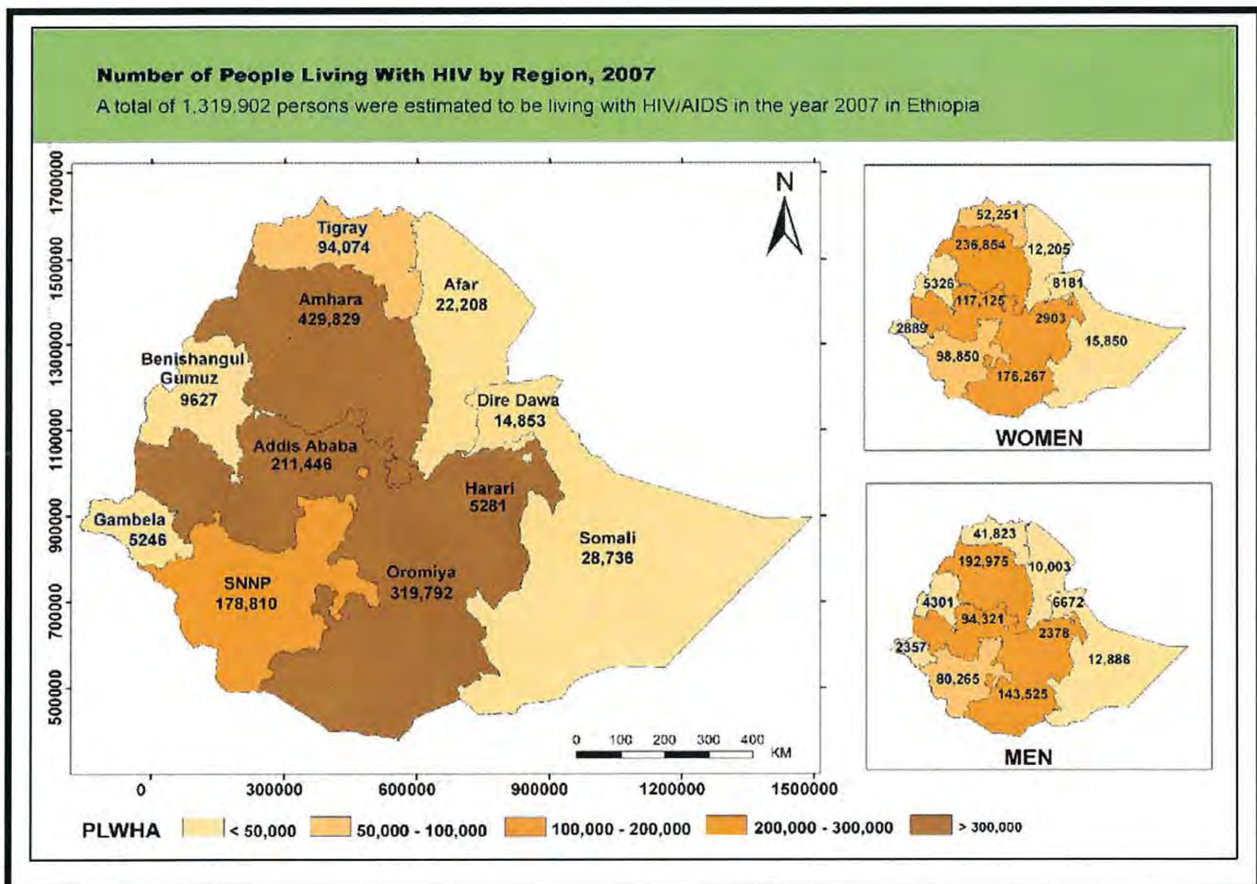
Figure 5.9 Map of percentage of adult HIV prevalence by region in 2007 in Ethiopia,

Adult HIV prevalence is highest in Addis Ababa, Dire Dawa and Harari regions (over 4.5 percent), and lowest in Somali, SNNP and Oromiya regions (below 2.3 percent). Overall, more women (3.6 %) than men (2.7 %) have the virus, a common pattern in sub-Saharan

Africa. In Addis Ababa, 12.4 percent of women are positive compared with 9.6 percent of men. Similarly, in Dire Dawa, 7.0 percent of women and 5.3 percent of men have the virus. Men and women in Somali region are least likely to be HIV positive (1 percent and 1.3 percent, respectively) ;(figure 5.9).

5.4.2 NUMBER OF PEOPLE LIVING WITH HIV/AIDS IN ETHIOPIA

It is now two decades since the first AIDS case was reported in Ethiopia .since then HIV/AIDS has become the biggest public health problem facing the country. According to the MOH at the end of 2007 A total of 1,319,902 persons were estimated to be living with HIV/AIDS in Ethiopia and below is estimated number of persons living with HIV/AIDS by region in 2007 (MOH, 2006).



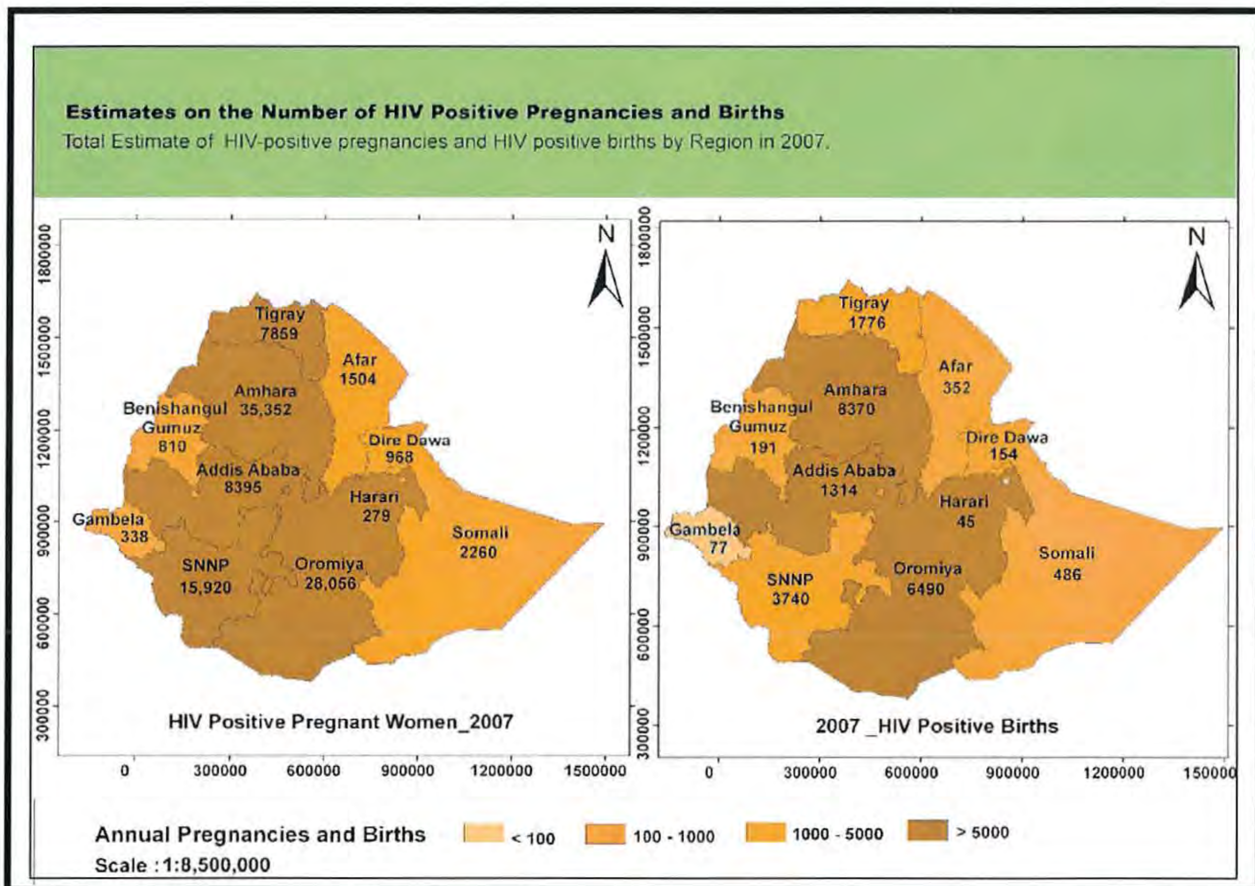
Prepared by the Author

Figure 5.10 Map of the number of people living with HIV/AIDS by Region, 2007

There is considerable difference across regions in the number of people living with HIV/AIDS. Highest in Amhara and Oromiya regions and lowest in Gambella, Harari and Benishangul Gumuz (figure 5.10).

5.4.3 HIV POSITIVE PREGNANCIES AND BIRTHS

There were 101,741 HIV-positive pregnancies and 23,003 HIV positive births in the country in 2007. The number of HIV positive births will decline in the coming five years with the coverage of and access to PMTCT program being improved (MOH, 2006).



Prepared by the Author

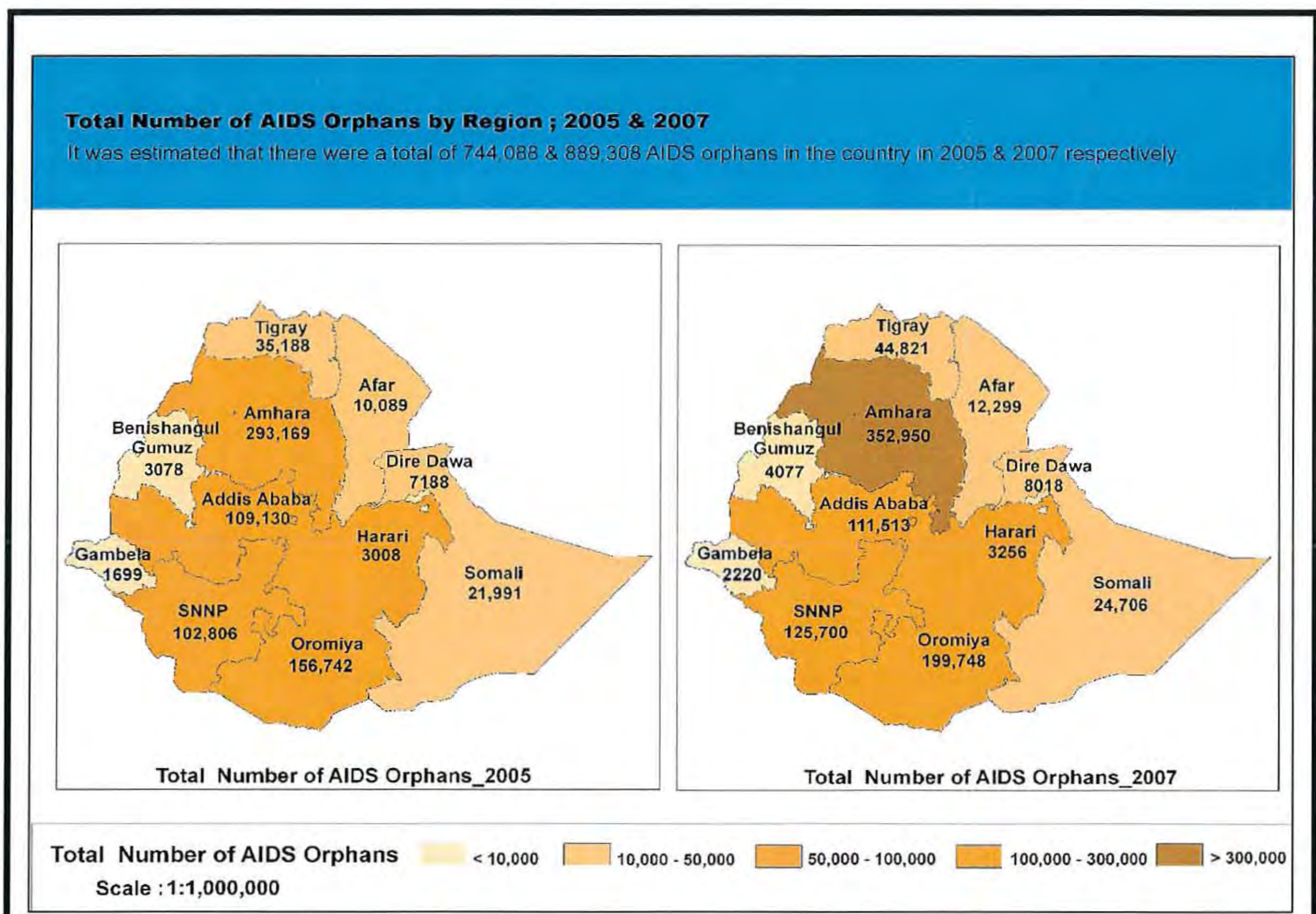
Figure 5.11 Map of HIV positive pregnancies and births in 2007 in Ethiopia,

At the end of 2007 the number of a HIV positive pregnancy and birth is high in Amhara and Oromiya regions and low in Harari and Gambella regions (see figure 5.11). Great risk attached with pregnancy is the spread of infection from the mother to the baby. The virus can be transmitted to her baby during pregnancy, labor, delivery and breastfeeding.

If the HIV positive woman takes the correct treatment during pregnancy then the chances of passing the virus to the baby are quite low.

5.4.4 TOTAL AIDS ORPHANS

The number of orphans has increased over time. It was estimated that there were a total of 744,088 AIDS orphans in Ethiopia in 2005 and it increased to 889,308 AIDS orphans in 2007.According to the MOH report the total number of AIDS orphans at the end of 2005 and 2007 by Region is given below.

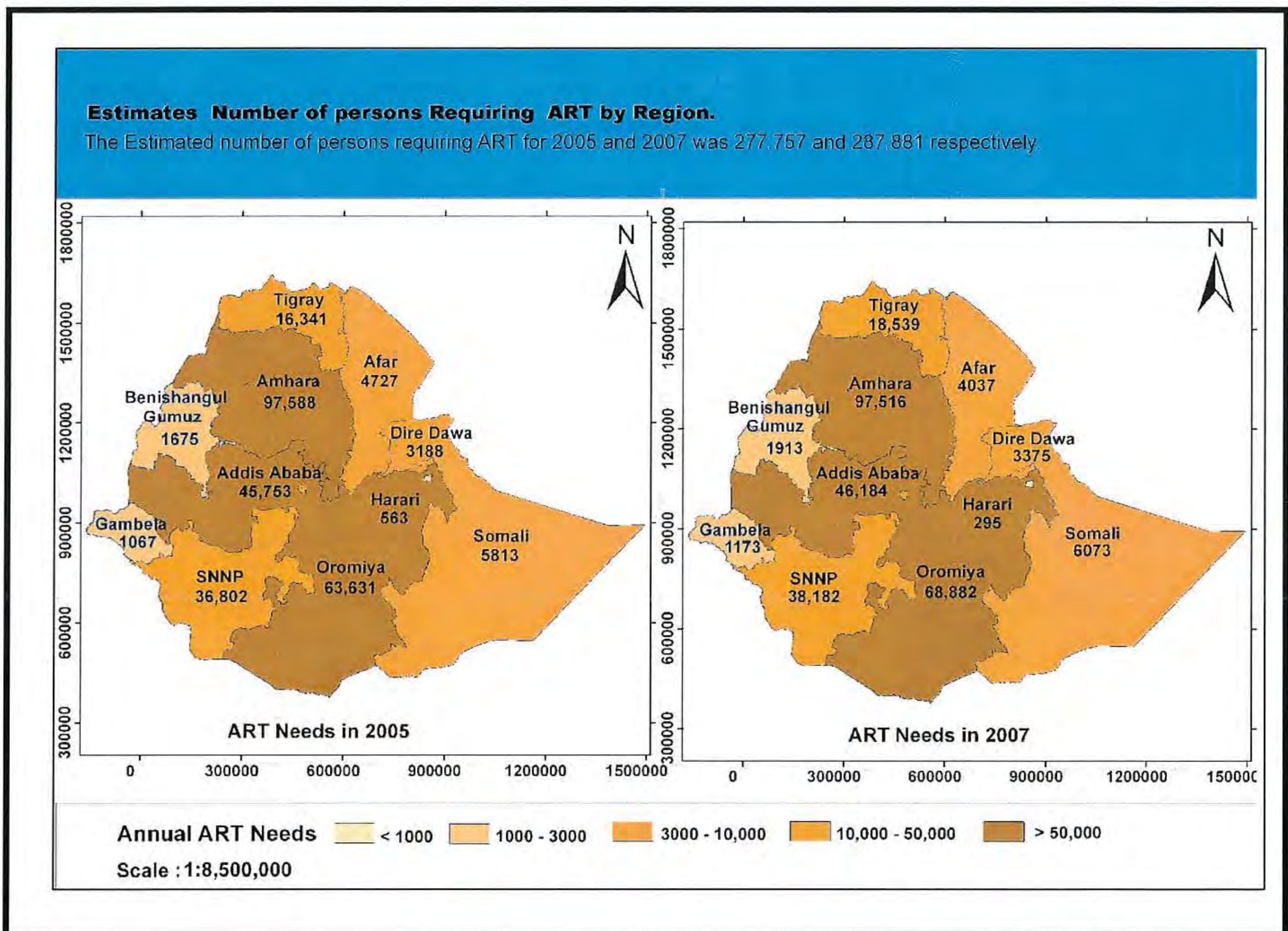


Prepared by the Author

Figure 5.12 Map of total number of AIDS orphans in 2005 & 2007 in Ethiopia,

5.4.5 NUMBER OF PERSONS NEEDING ART

The Estimated number of persons requiring ART for 2005 and 2007 was 277,757 and 287,881 respectively in Ethiopia. Considerable variation in the number of patients who started on ART was noted by region and According to the MOH report the estimated number of persons requiring ART for 2005 and 2007 show high in Amhara, Oromiya, Addis Ababa and SNNP and lowest in Harari, Gambella and Benishangul Gumuz (Figure 5.13).



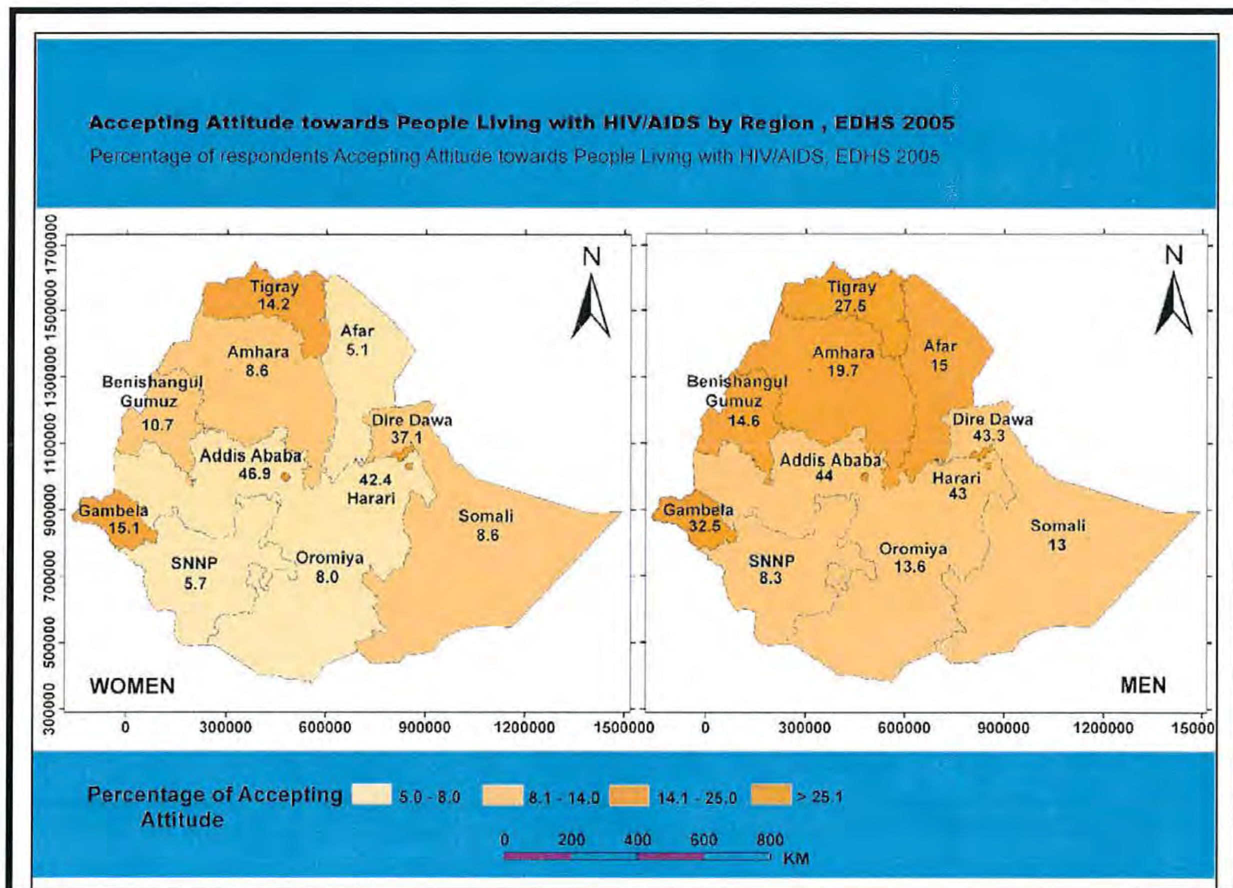
Prepared by the Author

Figure 5.13 Map of total number of persons requiring ART in 2005 & 2007 in Ethiopia,

5.5 ATTITUDE AND PERCEPTIONS ABOUT HIV/AIDS

5.5.1 ACCEPTING ATTITUDE TOWARDS PEOPLE LIVING WITH HIV/AIDS

Knowledge and beliefs about HIV/AIDS affect how people treat those they know to be living with HIV. In the 2005 EDHS, a number of questions were posed to respondents to measure their attitudes towards HIV-infected people including questions about their willingness to buy vegetables from an infected vegetable seller, to let others know the HIV status of family members, and to take care of relatives who have the AIDS virus in their own household. They were also asked whether an HIV positive female who is not sick should be allowed to continue teaching. Figure 5.14 shows the percentages who express positive attitudes towards people with HIV/AIDS among women and men who have heard about HIV/AIDS.



Prepared by the Author

Figure 5.14 Map of percentage of population with positive attitude towards people living with HIV/AIDS in Ethiopia, EDHS 2005.

The rates of accepting attitudes were highest in Addis Ababa and Harari Regions and the lowest rates of accepting attitudes were found in the Afar and SNNP regions, where only 5.1 percent and 5.7 percent respectively of women reported accepting attitudes towards PLWHA. Men were more likely than women to have accepting attitudes. Overall, people in the Addis Ababa, are more likely to have accepting attitudes towards PLWHA than those in other regions, with 46.9 percent of women and 44 percent of men reporting accepting attitudes (figure 5.14).

Since mapping is an excellent means of communicating a message clearly even to those who are not necessarily familiar with the methodology, GIS can be used effectively with leadership at various levels to convey the priorities, the problems and provide an analysis and evidence based menu of options for programme implementation. Such maps can help in discussion, assessment, analysis and decision making. These maps when posted in public places and if updated provide a mirror for review and continuous updating of decisions at the community level. GIS can be used as a management support tool through integrated data base management to prepare combined maps for state, Zone,Wereda , or maps down to block / village levels.

Maps are very easy to understand, and they don't require a lot of explanation to attract someone's attention. The decision makers and policymakers we work with are busy and often don't have a lot of time to read data. So, we can use these maps to present data to them in a different, more interesting way. We can also share them with people we work with at the community level, and they are easy to follow.

Maps have the advantage of presenting data in an easily accessible, readily visible and eye-catching manner. The resulting maps combine information from different sectors to provide an immediately comprehensive picture of the geographical distribution of exposed groups at national level. By providing a visual overview of the major issues, the maps highlight gaps and shortfalls in information and thus areas needing attention.

5.6 BARRIERS TO BETTER USE OF GIS IN COMBATING HIV/AIDS

In considering all of the developments and possibilities for GIS to increase effectiveness and efficiency in prevention and treatment of HIV/AIDS it is relevant to recognize that there are a number of important issues which prevent that full potential being realized. Some of these will be briefly addressed here...

- The first issue relates to the lack of understanding about the potential of GIS. The concepts underlying GIS are not easy to understand and many of the senior people in relevant areas did not receive exposure to GIS when undertaking their final education. Hence there is a considerable evangelical task that needs to be undertaken in this area to the relevant health decision makers and planners that GIS has much to offer them in their day-to-day work as well as in the policy development area.

- Of considerable importance, too, is the fact that for data to be included in a GIS it needs to be spatially referenced. Hence ensuring that all data relating to HIV/AIDS is appropriately spatially referenced is important. Clearly the failure to do this is an important barrier to it's under use. Similarly the lack of spatially referenced information relating to the variables associated with high risk of contracting HIV/AIDS is a problem.

- A critical barrier to the industry remains in the area of trained personnel. There is a pressing need for specialists trained in the area as well as for people being trained in other areas to gain some knowledge of GIS and its capabilities. This not only involves producing more GIS specialists but also making sure that graduates in such areas as public health have a knowledge of what GIS can do.

CHAPTER SIX
CONCLUSIONS AND RECOMMEDATIONS

6.1 CONCLUSIONS

The fight against HIV/AIDS has to be waged on many fronts. GIS provides one weapon which can be employed in the battle. It can assist in targeting where resources for prevention and treatment of HIV/AIDS can be deployed to have maximum impact. GIS has developed so that we can undertake analyses of spatially referenced information on a scale and speed. We must harness this technology in the important battle against the spread of HIV/AIDS.

The digital maps produced have the benefit of easier revision and spatial analysis, besides a clear representation of geographically referenced information. GIS techniques are therefore highly suitable for analysis of HIV/AIDS occurrence patterns and planning of punctual preventive measures to mitigate it. GIS aids in faster and better health mapping and analysis than the conventional methods. It gives health professionals quick and easy access to large volumes of data. It provides a variety of dynamic analysis tools and display techniques for monitoring and management of epidemics.

We live in a society where the resources that we use to address the multitude of problems we face are limited. It is necessary therefore that we explore all the possibilities information technology can offer us in enabling us to use our resources in an efficient and sustainable manner. As an information technology, The World Health Organization describes GIS as, "an excellent means of analyzing epidemiological data, revealing trends, dependencies and inter-relationships that would be more difficult to discover..." using traditional tabular approaches). Moreover, it is "a powerful tool for monitoring and management of disease and other public health programmes" (Sigodi, 2005). Its optimized implementation can only be of tremendous good to our society.

6.2 RECOMMEDATIONS

As it has been put forward in this study, the use of GIS in mapping, analysis, management and monitoring of HIV/AIDS occurrence patterns has greater potential of being the first step towards achieving an integrated analysis of HIV/AIDS in Ethiopia but there are certain issues that could be investigated and developed further .Based on the study the author recommend the following points.

- Enough resources should be projected towards this technique and make it a reality that is health institutions and research organizations should have the hardware, software or trained staff that would enable them to apply GIS technology.

- A broader database that will be able to incorporate Ethiopia and the whole world can also be created. Since HIV/AIDS is a global disaster, the database created should be shared and be made available to different organizations and individuals across the world through the Internet. This should include designing of software that can enable people who are not specialists in GIS or who do not understand the GIS software to be able to access this information easily on the web.

- Regular Training should be given to Health administrators, professionals and researchers in order to use GIS properly and effectively.

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Declaration

The thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

Solomon Tesfay — Student | Signature | 06/07/08 — Date

I confirm that this thesis has been submitted with my approval as the supervisor of the same.

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