

**MEASURING SPATIAL ACCESSIBILITY TO HEALTH CARE  
USING GIS**

By

Agyei – Frimpong, Seth

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## DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no materials previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

Seth Agyei-Frimpong, 20138270

Seth Agyei-Frimpong

20-09-2013

Students Name & ID

Signature

Date

Certified by

Dr. Eric K. Forkuo

(Signature)

20-09-2013

Supervisor's Name

Signature

Date

Certified by

Mr. John Ayer

(Signature)

24/09/2013

Head of Department

Signature

Date



## ABSTRACT

Public health and diseases are major concerns for developing countries, and access to health care is an important factor for ensuring a healthy population. Accessibility is one of the most important components of a health system, as it has direct impact upon the majority of diseases affecting many of these countries.

This research uses a method for demonstrating the geographic accessibility to health facilities by showing average travel time and population coverage of health facilities in the Kumasi Metropolitan Assembly. A population distribution grid was created from census data, a landcover grid was also generated from satellite imagery of the area. A Geographic Information System (GIS) was used to compile, integrate and homogenize the various data used and AccessMod<sup>®</sup> 3.0 was used to process them. The average speed of travel over each landcover type was determined and a Digital Elevation Model (DEM) was used to correct for the speed on slopes using Tobler's formula, the travel time to the health facilities was then computed over the area. The capacity of the facilities was also determined using the formulae developed by Doherty et. al., for the calculation of capacities of health facilities. The population distribution grid was then used to determine the catchment area of each health facility using its capacity and ensuring that it doesn't exceed the maximum allowed time to get to the facility.

The results obtained from the research indicate that the maximum travel time to get to a health facility is 26.44 minutes and 99.74% of the population can be served by the existing health facilities in the area.



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## LIST OF ABBREVIATIONS AND ACRONYMS

AED	Accident and Emergency Department
AIS	Analysis and Information Systems
ANOVA	Analysis of Variance
CHAG	Christian Health Association of Ghana
CICA	Composed Index of Critical Accessibility
CIESIN	Centre for International Earth Science Information Network
DEM	Digital Elevation Model
EIP	Evidence and Information for Policy Cluster
ERDAS	Earth Resource Data Analysis System
ESRI	Environmental Systems Research Institute
ETM+	Enhanced Thematic Mapper plus
GIS	Geographic Information System
GMT	Greenwich Mean Time
GPW	Gridded Population of the World
KATH	Komfo Anokye Teaching Hospital
KMA	Kumasi Metropolitan Assembly
KMHD	Kumasi Metro Health Directorate
NASA	National Aeronautics and Space Administration
PAHO	Pan-American Health Organization
SRTM	Shuttle Radar Topography Mission



TIN	Triangulated Irregular Network
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984
WHO	World Health Organization

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## CHAPTER ONE: INTRODUCTION

### 1.1 Background

Public health and diseases are major concerns for developing countries, and access to health care is an important factor for ensuring a healthy population. Accessibility is one of the most important components of a health system, as it has direct impact upon the majority of disease affecting many of these countries (Costa et. al., 2011). Measuring accessibility to health care contributes to a wider understanding of the performance of health systems within and between countries which facilitates the development of evidence based health policies (Black et. al., 2004). Accessibility to health care is concerned with the ability of a population to obtain a specified set of health care services, with the concept of “specific” having the potential to vary depending on the policy focus or impact of disease (Oliver & Mossialos, 2004).

Access to health care can be described along four dimensions:

- (1) Geographic accessibility – the physical distance or travel time from service delivery point to the user;
- (2) Availability – having the right type of care to those who need it;
- (3) Financial accessibility – the relationship between the price of services and the willingness and ability of users to pay for those services;
- (4) Acceptability – the match between how responsive health service providers are to the social and cultural expectations of individual users and communities.

Central to this framework is the concept of the quality of care and each of these dimensions has a supply and demand concept (Oliver & Mossialos, 2004).



## **1.2 Research Problems**

Access to health care is an important component of an overall health system and has a direct impact on the burden of disease that affects many countries in the developing world. Some areas in the region such as the rural areas are under-served, or served inappropriately, by existing services (Jennifer L. Pehr, 2010). Medical facilities are not evenly distributed across the region, with most rural areas lacking basic facilities such as hospitals and clinics as well as doctors and nurses.

According to the Ghana Human Development Report (GHDR, 2007), 57.7% of Ghanaians have access to a health facility within 30 minutes of their places of residence. This is also linked to the distribution of health facilities. Urban localities generally enjoy good access to health compared to rural areas as urban areas tend to have a relatively better concentration of health facilities and better road networks as well as other factors that enhance access (Aviane, 2009).

This research seeks to identify these under-served areas and determine the time needed to access a health facility.

## **1.3 Aims and Objectives**

### **1.3.1 Aim**

The aim of the research is to compute geographic coverage to health care using terrain information and population distribution using GIS models.

### **1.3.2 Objectives**

Four major types of analysis are available:

1. Determining the travel time distribution over the area.



2. Modelling geographic coverage according to the availability of services;
3. Modelling the coverage of catchment areas linked to an existing health facility network based on travel time.
4. Projecting the coverage of a scaling-up of an existing network.

#### **1.4 Benefits of the Research**

After the completion of this research the results obtained will provide a measure of physical accessibility to health care and enable us understand which parts of the city has low access to healthcare. This information will help the government know which parts need to be improved to make the health delivery system better. The results obtained will also be used for cost effectiveness analysis, population coverage estimates as well as for resource planning. If access to health care is low it will help determine the best places to locate new health facilities in order to best serve the low access areas.

#### **1.5 Structure of Thesis**

The organization of this thesis has been grouped into six chapters. The structure is given below:

- Chapter One – Introduction: This chapter described the background information of study, highlights the aims and objectives of the project, and the justification of doing this project.
- Chapter Two – Measuring accessibility to healthcare in GIS environment: This chapter describes the terms and tools used in the studies and brings out an understanding of the research topic. The chapter will further explain the



various concepts and processes that will be applied in the studies. Furthermore, it will focus on expressing the knowledge gained from the various scientific researches that have been carried out about the project. This is in terms of the theories, approaches, and data and software used in the processing.

- Chapter Three – Study Area and Data Capture: This chapter will describe the study area and step-by-step approach of capturing the data to be used for the research. A description of the study area is given to show the characteristics of the area in terms of population, area and general narrative. Then information about the data used and how they were captured is also given.
- Chapter Four – Modelling Spatial Accessibility: This chapter will describe the detailed approaches used in executing the project to attain the expected aim and objectives.
- Chapter Five – Results and Discussions: This chapter presents the results obtained from the research based on the specified objectives and these findings are also discussed or analysed.
- Chapter Six – Conclusions and Recommendations: This chapter will give the concluding statements from the research by looking at the obtained results and discussion made and whether the specified objectives were met or not. It will also discuss recommendations for future studies and also present the limitations of the project



## CHAPTER TWO: MEASURING ACCESSIBILITY TO HEALTHCARE IN GIS ENVIRONMENT

### 2.1 Accessibility

Access to health care includes at least two dimensions: economic access in terms of affordability, and geographic access in terms of proximity to providers (Gold, 1998). Accessibility is usually used to measure how easily locations or activities of importance to individuals are reached. Geographic accessibility to health care, often referred to as spatial or physical accessibility, is concerned with the relationship between the spatial separation of the population and the supply of health care facilities and thus has a strong underlying geographic component. The concept can also be extended to incorporate different types of health intervention (Shengelia et al, 2003). Although it is intuitive that the level of public health of a population may be affected negatively by the distance to health care services, there remains limited quantitative information regarding this impact (Guagliardo, 2004).

Healthcare is a significant indicator of social development. Access to facilities is an important component in the overall healthcare system and has a direct impact on the burden of diseases that encumbers health conditions in many developing countries. Therefore, measuring access to healthcare contributes to a wider understanding of health systems' performance within and between countries and facilitates the development of evidence-based health policies (Mainardi, 2007).

### 2.2 Types of Healthcare

Healthcare is the diagnosis, treatment, and prevention of disease, illness, injury, and other physical and mental impairments in humans. Healthcare is delivered by



practitioners in medicine, chiropractic, dentistry, nursing, pharmacy, allied health, and other care providers. It refers to the work done in providing primary care, secondary care and tertiary care, as well as in public health. Healthcare systems are organizations established to meet the health needs of target populations. (WHO, 1978).

### **2.2.1 Primary care**

This is the term used for the health care services that plays a role in the local community. It refers to the work of health care professionals who act as a first point of consultation for all patients within the health care system (Shoultz & Hatcher, 1997; World Health Organization [WHO], 1978). Such a professional would usually be a primary care physician, such as a general practitioner or family physician, or a non-physician primary care provider, such as a physician assistant or nurse practitioner. Depending on the nature of the health condition, patients may then be referred for secondary or tertiary care. Primary care involves the widest scope of health care, including all ages of patients, patients of all socioeconomic and geographic origins, patients seeking to maintain optimal health, and patients with all manner of acute and chronic physical, mental and social health issues, including multiple chronic diseases. (WHO, 1978).

### **2.2.2 Secondary care**

This is the short-term consultative care most often delivered by those with specialized training. It is offered to patients who have been referred from primary care providers because patients' care needs require specialized skills and and/or facilities not available in primary care (Starfield, 1998; Shah, 2003)



### 2.2.3 Tertiary care and quaternary care

Tertiary care refers to care requirements not met in secondary care which then must be provided by very specialized facilities and professional skills most often only available in university teaching hospitals (Shah, 2003). Examples of tertiary care services are cancer management, cardiac surgery, plastic surgery, treatment for severe burns and other complex medical and surgical interventions. The term quaternary care is also used sometimes as an extension of tertiary care in reference to extremely complex cases or unusual procedures that necessitate the services of quaternary health care, which is always affiliated with teaching hospitals (Shah, 2003).

### 2.3 Measuring Spatial Accessibility

The use of Geographic Information Systems (GIS) for the measurement of physical accessibility is well established and has been applied in many areas including retail site analysis, transport, emergency service and health care planning (Black et. al., 2004). GIS are well suited to measuring spatial accessibility to health care as they contain the core components needed for such analysis namely:

- Data capture storage, management and manipulation tools for both spatial and attribute (textual) data
- Core analysis algorithms such as buffering, overlay, proximity analysis, shortest path and raster cost-distance analysis
- Programming environments to customize and extend existing algorithms and create new analysis tools
- Mapping and visualization tools to communicate the results of analysis



There is a large volume of literature relating to the use of GIS for measuring physical accessibility to healthcare and a number of publications review the various methods used (Wilkinson et. al., 1998; Albert et. al., 2000; Cromley & McLafferty, 2002). Several examples of applications of these methods to different type of health care providers in developing and developed countries can be found in (Bazemore et. al., 2003; Perry & Gesler, 2000; Guagliardo, 2004; Luo, 2004; Noor et. al., 2003; Noor et. al., 2004; Mallick & Routray, 2001; Parker & Campbell, 1998).

The World Health Organization (WHO) has been involved in a number of initiatives to measure and analyse physical accessibility to health care using GIS. Within these initiatives, there has been a strong focus on providing countries with the necessary tools, guidelines and protocols that will allow them to perform reliable analysis of their capacity to provide physical access to specific health interventions (Black et. al, 2004).

#### **2.4 Previous research work on using GIS to measure access to health care**

In 1998, Parker and Campbell explored the potential use of GIS technology in defining and analysing the use of healthcare services by researching into patterns of utilization and their variance by both socio organizational and geographical aspects of accessibility. Using a survey of patients in 18 general practices in Scotland (n = 8005), this study examined patients' access to these services as well as to local Accident and Emergency Departments (AEDs). Information was obtained using a questionnaire about the patient's home postcode, means of travel to the practice, and perception of accessibility of local AED services. Travel and perception were measured using a five-point scale of estimated travel time (<15, 15– 30, 30–45, 45– 60, and >60 minutes) and a four-point scale of estimated travel distance (<1, 1–2, 2–



5, and >5 miles). They also obtained information from medical records of patients attending the local AED. Postcode data were geo-referenced using GIS software (ARC/INFO). This software was used to query and display (a) straight-line and network distances between patient homes and service centres, (b) the effect of distance on the utilization of services, (c) the overall accessibility of services, and (d) the patterns of patients' utilization and perception of health service accessibility. The results showed a distance decay effect: the use of services decreased as the patients' distance from the service increased. Furthermore, as much as a fourfold variation between the 20 postcodes surveyed was noted. The investigation of potential socioeconomic factors suggested that those with lower AED usage might be those with lower socioeconomic scores. Findings also revealed that patients appear to believe they live closer to services than they do. Several important limitations of this research were noted. The authors discussed statistical analysis and controlling for variables but did not give these statistical results. The limitations of data collection by questionnaire and the validity and reliability of GIS analysis were not discussed.

In 2004, Black et. al conducted a research to measure the access to health care in Central America, Honduras using GIS techniques. Two methods were used in this research; the two methods presented in the paper used different formats of representation of the geographic information. The method implemented in SIGEpi<sup>©</sup> uses layers in vector format while AccessMod<sup>©</sup> is based on raster layers. Such differences necessitate the manipulation of some of the source data sets in order to convert them into a suitable format for their use within both methods. It is also important to mention that the application of AccessMod<sup>©</sup> required that all the raster layers were based on the same resolution.



The data was prepared and integrated using ArcView before using the two methods to process it. At the completion of the modelling process, AccessMod<sup>©</sup> was used to determine the spatial extent of the catchment area for each Health facility. Information about the population covered by each facility and its respective catchment area was stored as a result of the model process and can be used for analysis of the existing network. The results underline a lack of health care services to cover the total population. The second mode of operation of AccessMod<sup>©</sup> was used to determine possible locations for new health facilities.

The second method implemented was using SIGEpi<sup>©</sup>. From the SIGEpi<sup>©</sup> perspective, geographical accessibility considers the relative location between population and health services taking into account specific environmental conditions.

The main processing and analysis steps followed for the application of the method implemented in preparation for the SIGEpi<sup>©</sup> analysis were:

- Standardization of databases to UTM 16 projection
- Thiessen polygon analysis to identify catchment areas based on the nearest facility
- Spider diagram analysis providing distance to the closest health facility (CESAMO)
- Distance analysis to nearest roads edges using the ArcView Extension “Nearest Feature”.
- Conversion of the Honduras DEM (USGS - GEOTOP30) into a 100m TIN and conversion to UTM16 projection based on WGS 84



- Average slope measurement and assignation to trajectories and roads was done using “Surface tools for points, lines and polygons”
- Transfer of all indicators to the Villages database
- Calculation of Composed Index of Critical Accessibility (CICA)
- Accessibility Interpolation surfaces calculation

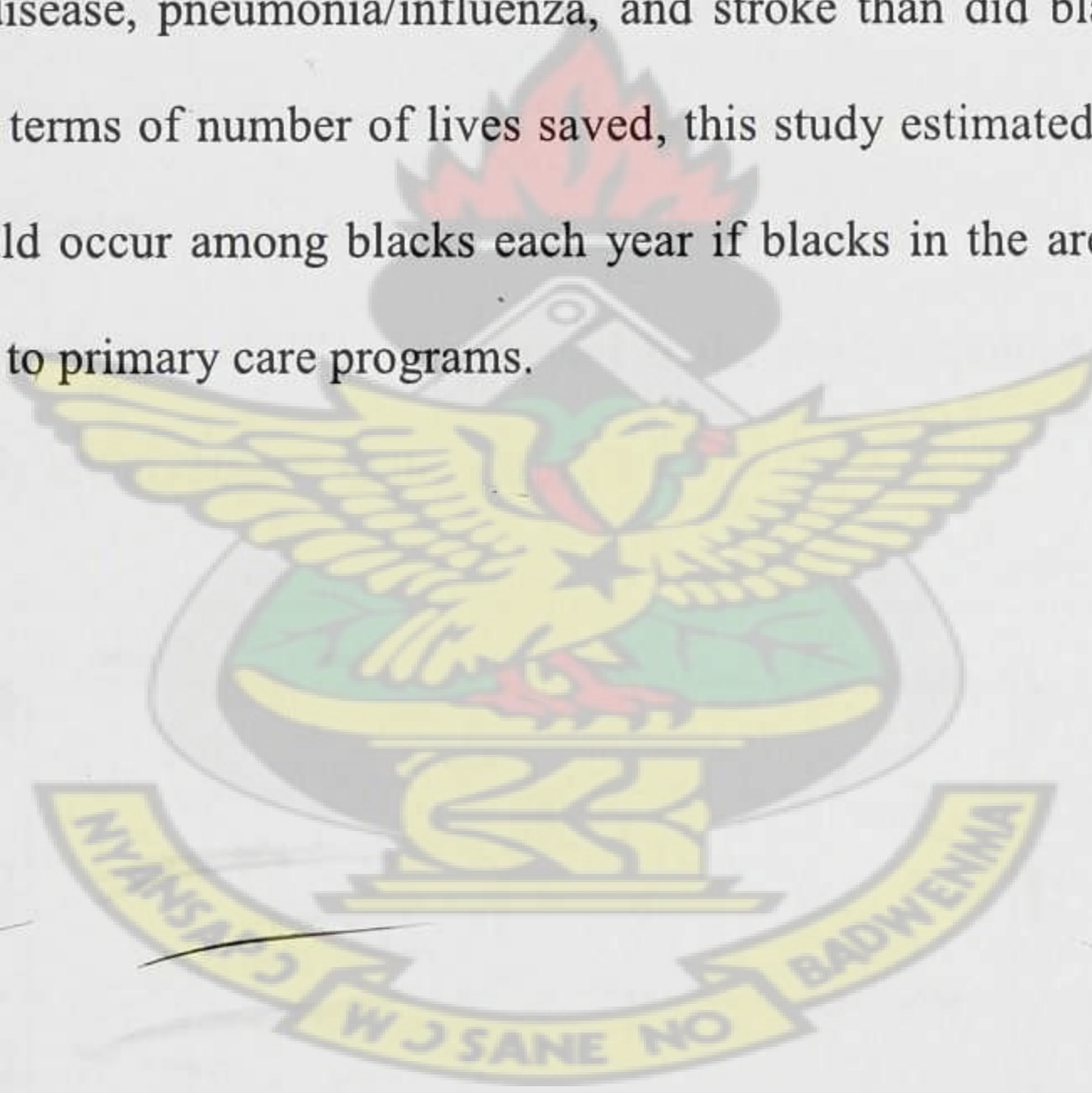
Human resources availability and other infrastructure features were calculated for each Thiessen polygon including the total population (adding up the individual values of each village), the total physicians inside each area, availability of Physicians per 10,000 inhabitants as well as the health and infrastructure resources.

After applying the procedures, it was possible to identify critical accessibility conditions for each populated place, inside the Thiessen polygons; as well as to establish the limits of areas that share the same accessibility conditions (good or bad). This classification set the opportunity to prioritize and focus health interventions over the places classified as highest risk.

Luther et. al. in 2003 studied the impact of community-based primary care clinics on health outcome disparity ( $n = 84$ ). In this study the authors sought to (1) identify geographical communities (zip codes) with high and low access to primary care clinics that serve ethnic and racial minorities, (2) describe socio demographic characteristics of high- and low-access communities, (3) compare the rates of selected health outcomes for blacks (the largest minority) between high- and low-access communities, and (4) develop a model to estimate number of lives saved by primary care clinics. Proximity was used to measure high and low access, with zip codes containing or contiguous to a clinic classified as high access and all other zip



codes as low access. ANOVA was used to compare mean values of demographic variables between high- and low-access locations for both maternal and child health and chronic disease mortality outcome measures. Linear modelling was used to compare rates between high- and low-access areas for the outcome measures. Results showed that blacks from high access areas were 50 percent more likely to receive prenatal care (OR = 0.52) than blacks from low access areas. The difference was highly significant at the  $p < .001$  level. Out of the five models used to model chronic disease mortality health outcomes, only one (diabetes) did not show a significant difference for predicted rates. Blacks from high-access areas had lower rates of all cancers, heart disease, pneumonia/influenza, and stroke than did blacks from low-access areas. In terms of number of lives saved, this study estimated that more than 130 deaths would occur among blacks each year if blacks in the area of study had only low access to primary care programs.









The metropolitan area is sub-divided into 10 sub-metropolitan areas, which are: Asawase, Asokwa, Bantama, Kwadaso, Manhyia, Nhyiaeso, Oforikrom, Suame, Subin and Tafo. These ten sub-locations are grouped into five health districts: Asokwa, Subin, Bantama, Manhyia North and Manhyia South. (Kumasi Metro Health Directorate, 2008) These areas are shown in the Figure 3.2.

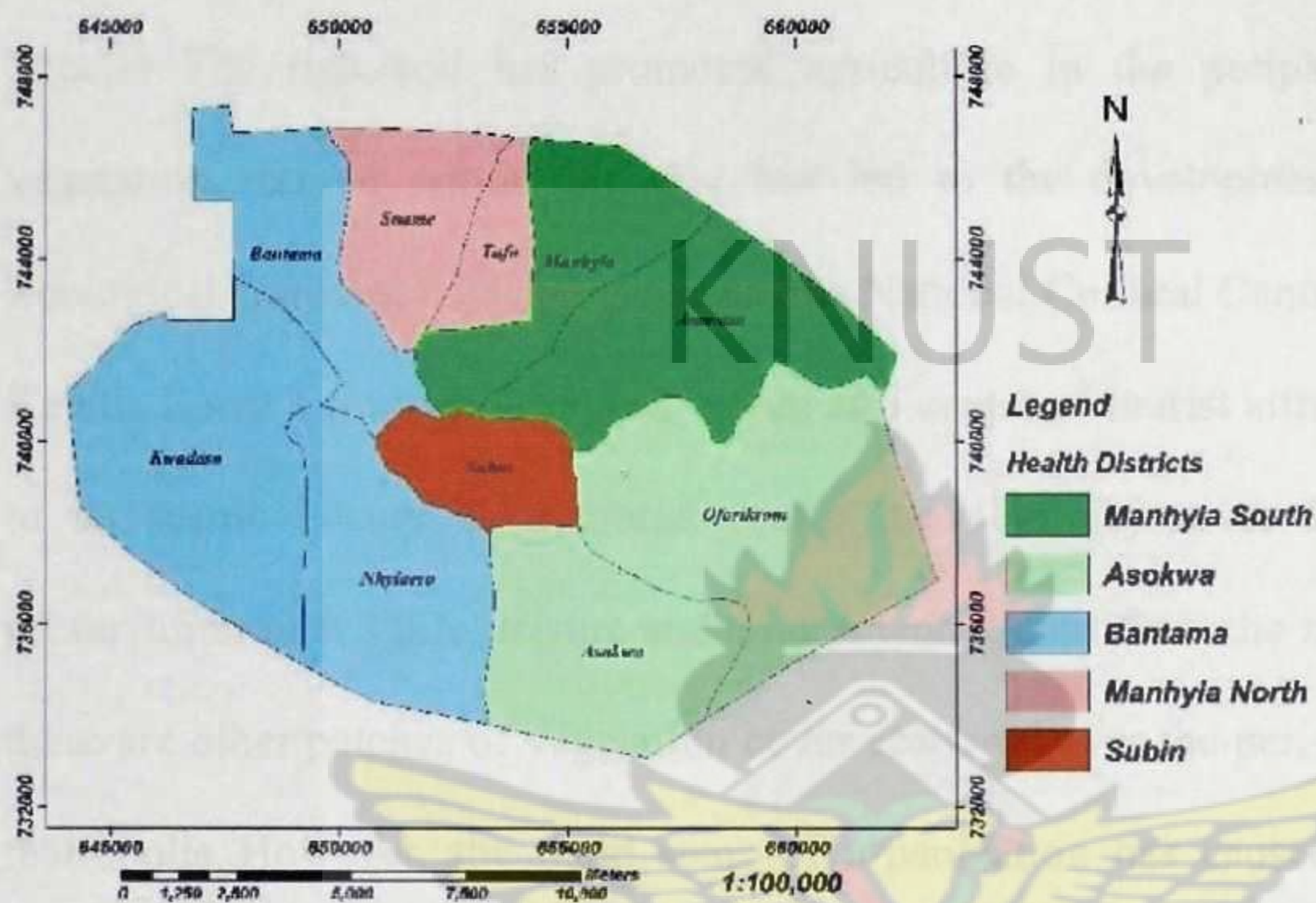


Figure 3. 2 Kumasi Metropolitan Assembly showing its sub-metropolitan areas (Source: Town and country planning department, Kumasi) and its Health districts (Source: KMHD)

### 3.1.1 Climate

The Metropolis falls within the wet sub-equatorial type. The average minimum temperature is about 21.5°C and a maximum average temperature of 30.7°C. The average humidity is about 84.16 per cent at 0900 GMT and 60 per cent at 1500 GMT. The moderate temperature and humidity and the double maxima rainfall regime (214.3mm in June and 165.2mm in September) have a direct effect on population growth and the environment as it has precipitated the influx of people from every part of the country and beyond its frontiers to the metropolis. This is



chiefly because the climatic conditions are not harsh (Ministry of Local Government Rural Development & Environment 2006).

### **3.1.2 Vegetation**

The city falls within the moist semi-deciduous South-East Ecological Zone. Predominant species of trees found are Ceiba, Triplochlon, and Celtis with Exotic Species. The rich soil has promoted agriculture in the periphery. A patch of vegetation reserve within the city has led to the development of the Kumasi Zoological Gardens, adjacent to the Ghana National Cultural Centre and opposite the Kejetia Lorry Terminal. This has served as a centre of tourist attraction. In addition to its scenic beauty as a tourist centre its other objectives include education, preservation of wildlife, leisure and amusement. Apart from the zoological gardens, there are other patches of vegetation cover scattered over the peri-urban areas of the metropolis. However, the rapid spate of urbanization has caused the depletion of most of these nature reserves (Ministry of Local Government Rural Development & Environment 2006).

### **3.2 Data and Software**

The software and data sets used in the research are described in this section.

The various software that were used to create, compile and integrate the data sets and apply the necessary models are:

- ESRI ArcGIS 10
- ERDAS IMAGINE 2010
- ESRI ArcView 3.3
- ESRI Spatial Analyst extension



- AccessMod<sup>®</sup> 3.0 ( an extension ArcView 3.x)

Different data sets were needed to perform the research. The data types had to be in the same coordinate system and cover the same extent in order for the model to work. The coordinate system that was used in this research was the UTM Zone 30N. The steps used in preparing each of the datasets are described below.

### 3.2.1 Population Distribution

This is a distribution of the population over the study area. Population data can be derived from existing global data sets such as the Gridded Population of the World (GPW) data set provided by Centre for International Earth Science Information Network (CIESIN) at Columbia University or the Landscan database or may also come from country specific census data (Black et. al., 2004). The population distribution used in this research was based on the results of the population census that was conducted by the Ghana Statistical Service in the year 2010. In Kumasi Metropolitan Area (K.M.A) the population was given with respect to the ten sub-metropolitan areas. The figures are shown in the Table 3.1.

Table 3. 1 Population of K.M.A and its sub-districts

District/Municipal	Population
<b>Kumasi Metropolitan Assembly</b>	<b>2,035,064</b>
<i>Kwadaso</i>	251,215
<i>Nhyiaeso</i>	134,488
<i>Subin</i>	174,004
<i>Asokwa (Atonso)</i>	140,161
<i>Oforikrom</i>	303,016
<i>Asawase</i>	312,258
<i>Manhyia</i>	152,225
<i>Old Tafo</i>	146,024
<i>Suame</i>	161,199
<i>Bantama</i>	260,474

Source: Ghana Statistical Service, 2012



The population distribution grid was created using the ten sub-metropolitan areas of the K.M.A and their populations derived from the results of the population census that was conducted by the Ghana Statistical Service in the year 2010.

The step by step procedure of creating the distribution grid is outlined below:

1. A shapefile of the sub-metropolitan areas was created.
2. A new field named population was added to the attribute table of the shapefile containing the sub-metropolitan areas and their populations were inputted there.
3. The areas around water bodies were considered to be unpopulated. These areas were erased from the sub-metro shapefile in order to have no data values in the produced population distribution grid.
4. The areas of the sub-metro areas was calculated.
5. The population per km<sup>2</sup> was also calculated.
6. To determine the population for each 30m grid the formulae in equations 1 to 3 were used:

$$\text{if } 1000^2m : x \dots\dots\dots$$

(1)

$$\text{then } 30^2m : \frac{x}{1000^2} * 30^2 \dots\dots\dots$$

(2)

$$: x * 0.0009 \dots\dots\dots (3)$$

The values obtained are shown in the Table 3.2.



Table 3. 2 Sub-metro areas and their population densities

Id	Name	population	Area(km <sup>2</sup> )	Pop/sqkm	Pop/sq30m
1	Nhyiaeso	134,488	19.740	6812.90	6.13
2	Asokwa	140,161	18.771	7466.72	6.72
3	Oforikrom	303,016	31.130	9733.80	8.76
4	Asawase	312,258	20.895	14943.81	13.45
5	Manhyia	152,225	13.366	11389.24	10.25
6	Subin	174,004	8.237	21125.96	19.01
7	Tafo	146,024	5.247	27828.88	25.05
8	Suame	161,199	10.977	14684.81	13.22
9	Bantama	260,474	14.455	18019.27	16.22
10	Kwadaso	251,215	27.900	9004.04	8.10

7. The sub-metro polygon shapefile was then converted into a raster grid.
8. A cell size of 30m was chosen and the pop/sq30m was chosen as the value field in order for the grid to have the same resolution as the other raster data used.
9. A grid map was created containing the population distribution of the K.M.A with a resolution of 30 meters.

### 3.2.2 Landcover grid and travelling scenario text file

The landcover grid holds information on the types of landcover (and their spatial arrangements) that characterize the area of the study and that are suspected to affect travelling time of patients differently. The landcover types in the study area were: built-up area, dense vegetation and low dense vegetation. In order to get the landcover of Kumasi, a Landsat ETM+ image with Path 194 and Row 055 which was acquired on 13<sup>th</sup> January 2007 with a resolution of 30m was used. The image was in the UTM Zone 30N coordinate system. In order to get the spatial extent of the



study area used; the boundary of K.M.A was used to subset the image using ERDAS Imagine.

After sub-setting, the image was classified into the various landcover classes. The method of unsupervised classification was used to classify the image. The number of classes selected was three (3) and a maximum of ten iterations and a convergence threshold of 0.950 were used. The three classes were then named into; built-up area, dense vegetation and low-dense vegetation. The classified image is shown in Figure 3.3.

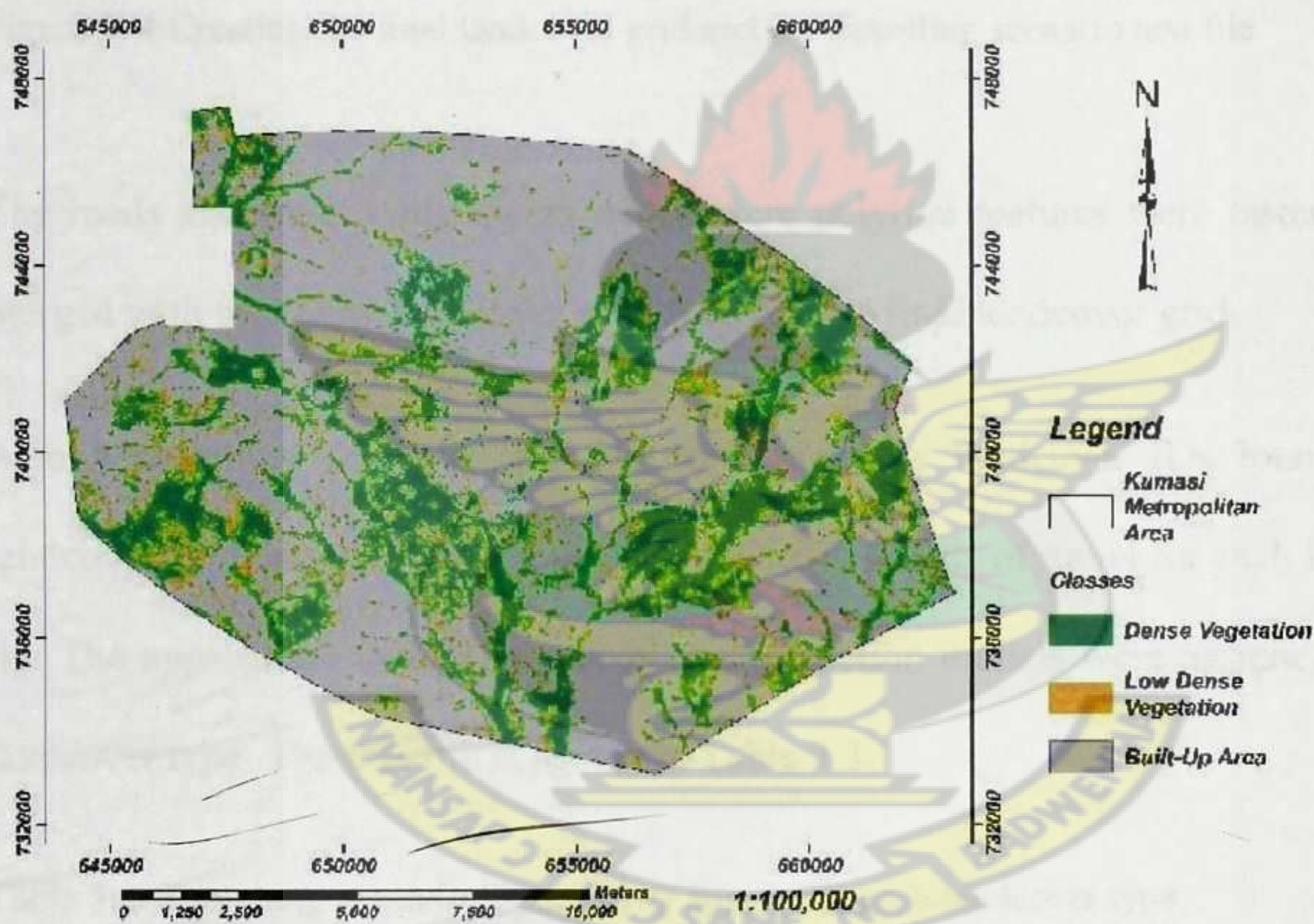


Figure 3. 3 Landcover grid of Kumasi Metropolitan Assembly

In creating the final landcover grid the roads and barriers to movement were added to the classified image. This was done using the AccessMod<sup>®</sup> extension of ArcView GIS 3.3. The interface is shown in Figure 3.4.



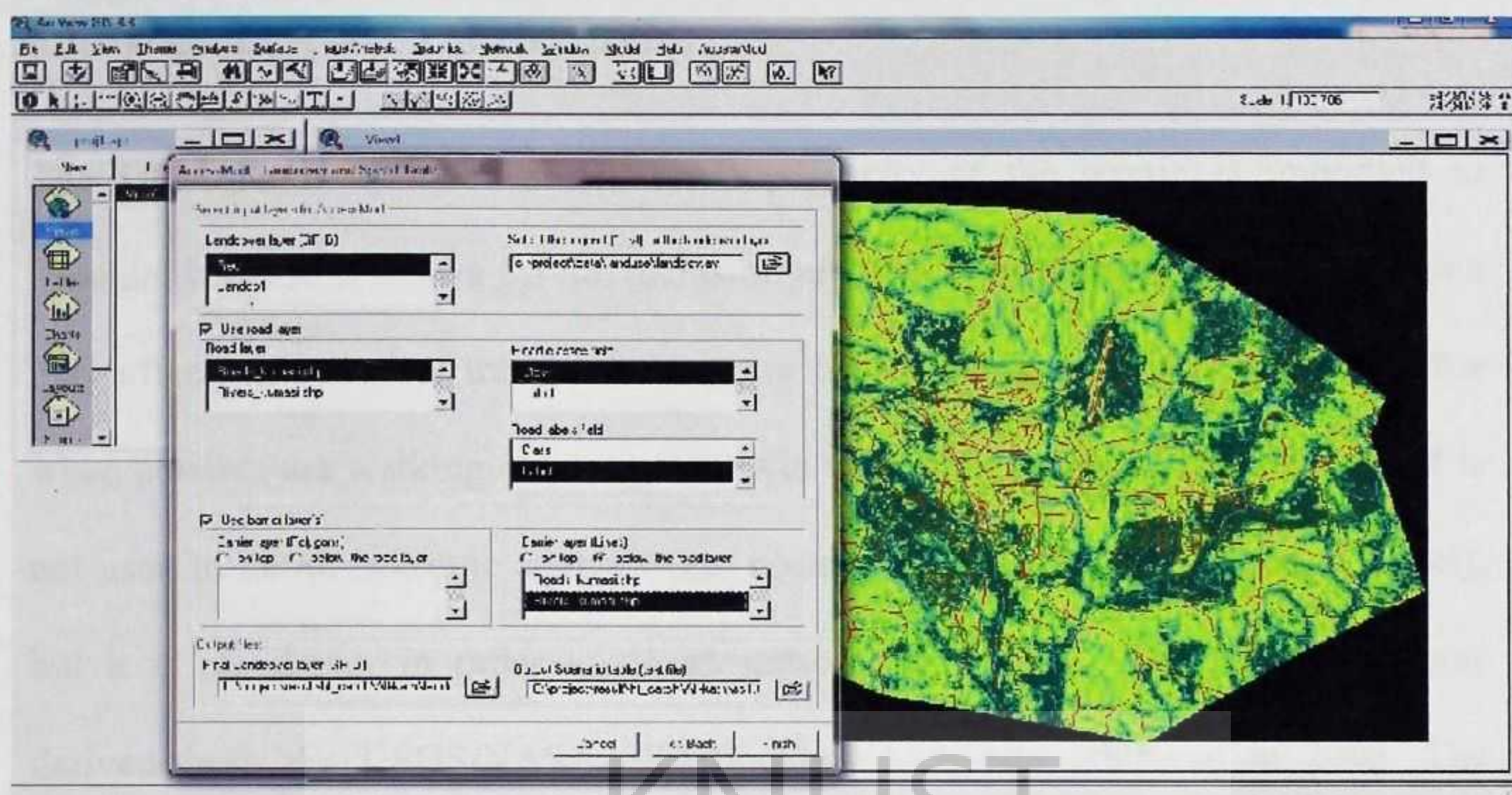


Figure 3. 4 Creating the final landcover grid and the travelling scenario text file

The roads and water body layers which were polyline features were rasterized and merged with the initial landcover grid to obtain the final landcover grid.

Also a travelling scenario text file containing the landcover IDs found in the landcover grid was also created to assign specific speeds of travel for each landcover ID. The appropriate travelling speeds and correction models were assigned to each landcover type. The text file is shown in Table 3.3.

Table 3. 3 Travelling scenario file showing speeds for each landcover type

Class	speed (km/h)	Model	Description
0	0	NONE	landuse_No Data
1	5	WALKING	landuse_Dense vegetation
2	5	WALKING	landuse_Low dense vegetation
3	20	NONE	landuse_Built-up area
4	40	NONE	road_1



### 3.2.3 Digital Elevation Model (DEM)

The DEM holds altitude values. The topography of the terrain is important to consider because it allows for the inclusion of slope as one of the parameters which may affect the speed of travel over a given landcover type. This is especially true when patients are walking or using a bicycle to reach a health facility. The DEM is not used to do an isotropic analysis (i.e. no influence of slopes on speed of travel), but it is mandatory in order to do an anisotropic analysis. The DEM used was derived from the USGS/NASA SRTM data which was produced in 2008. The altitude of point in the study area ranges from 213m to 314m and is shown in Figure 3.5.

The USGS/NASA SRTM data covered an area bigger than the study area and was in decimal degrees with WGS84 ellipsoid. The study area was clipped from it using the boundary of K.M.A. The clipped area was then projected into the UTM Zone 30N coordinate system. The SRTM data is available as 3 arc second (approx. 90m resolution) DEMs and the vertical error is reported to be less than 16m. In order for it to have the same resolution as the landcover grid it was resampled to 30m using the nearest neighbour algorithm.



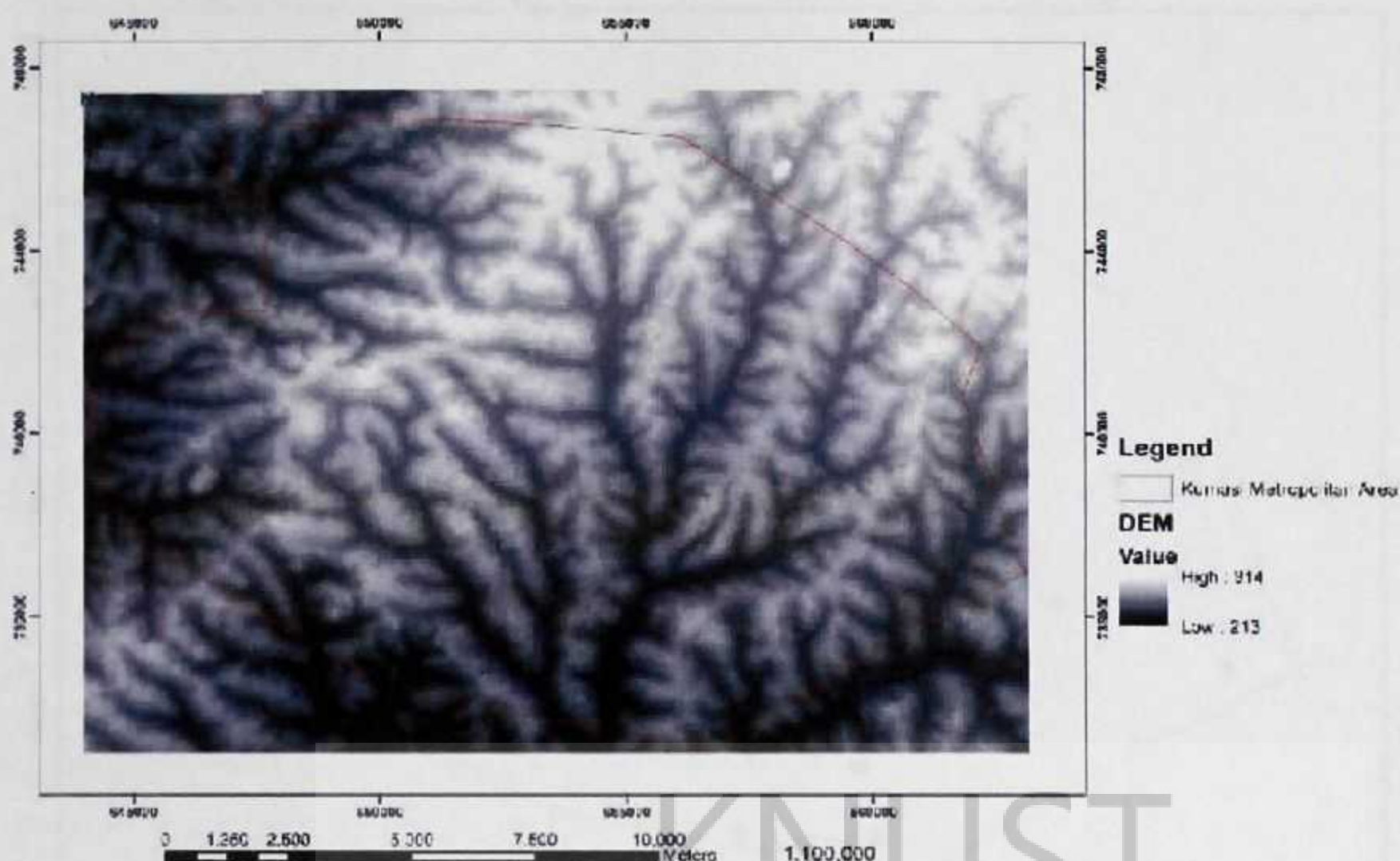


Figure 3. 5 Digital Elevation Model of Kumasi and its surroundings (Source: USGS/NASA SRTM Data, 2008)

### 3.2.4 Health Facilities

There are two broad categories of health service providers in Ghana, which are the public and private health service providers. There are 139 health facilities in the Kumasi Metropolitan Assembly, 121 of them are privately owned, 10 are owned by the government, and 3 are quasi government and 5 by the Christian Health Association of Ghana (CHAG). The data for the health facilities was obtained from the Ministry of Health. The location of the health facilities in the study area are shown in Figure 3.6.



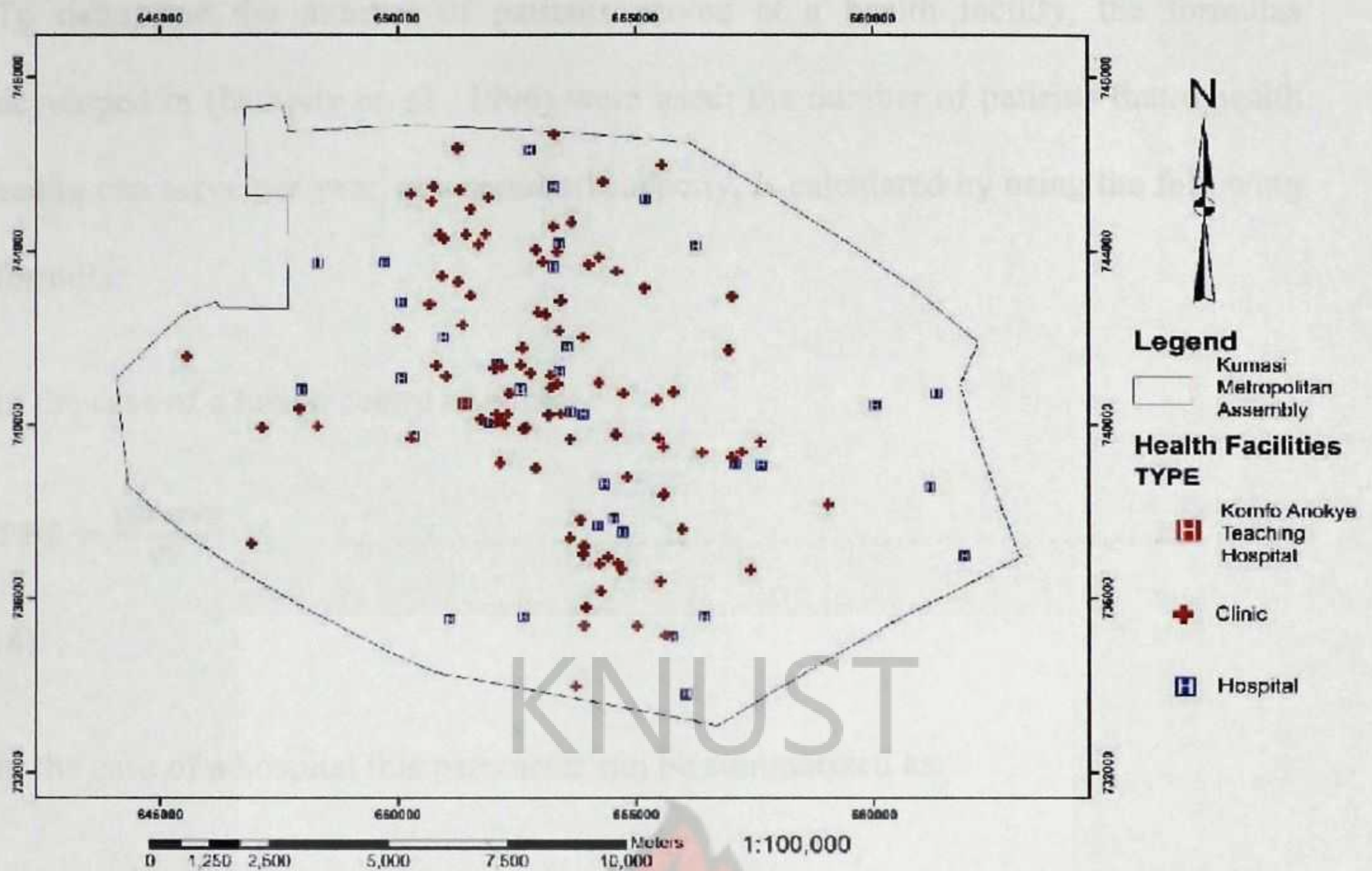


Figure 3. 6 Locations of types of Health Facilities in Kumasi Metropolitan Assembly

In addition, certain statistics like the capacity of the facilities were attached to the health facility database. These are parameters that are needed in order to estimate the population coverage capacity of the health facilities.

- For small facilities such as health centres and clinics:
  - number of patients seen in one average day
  - number of days worked per year
  - average number of outpatient visits per capita per year
- For larger facilities such as hospitals:
  - number of beds
  - average occupancy rate
  - number of working days in the year
  - average number of inpatient admittances per capita per year
  - average length of stay



To determine the number of patients served at a health facility, the formulas developed in (Doherty et. al., 1996) were used; the number of patients that a health centre can serve per year, at a standard capacity, is calculated by using the following formula:

In the case of a health centre or clinic:

$$TPS = \frac{HW * P * D}{OV} \dots\dots\dots$$

(4)

In the case of a hospital this parameter can be summarized as:

$$TPS = \frac{B * OR * D}{IA * LS} \dots\dots\dots$$

(5)

Where

- TPS is Total population served
- HW is number of health workers
- P is number of patients seen in one average day
- D is number of days worked per year
- B is Number of beds
- OR is occupancy rate
- IA is Average number of inpatient admittances per capita per year
- LS is the average length of stay
- OV is average number of outpatient visits per capita per year.

The health facilities dataset was in decimal degrees WGS84 ellipsoid so it was projected into the UTM Zone 30N coordinate system.

In the case of a health centre or clinic:

$$Total\ population\ served = \frac{(120 * 236)}{1.75}$$



$$= 16183$$

In the case of a hospital this parameter can be summarized as:

$$\begin{aligned} \text{Total population served} &= \frac{(40 \times 70\% \times 365)}{(0.11 \times 60\% \times 4)} \\ &= 38712 \end{aligned}$$

The computed capacities were then added to the attributes of the health facilities depending on their type.

### 3.2.5 Road Network

The road network shapefile is a key information layer for an accessibility analysis, because the speed of travel is usually higher on roads. Hence, for a given maximum time of travel, roads allow a catchment area to extend much further outward a health facility and may allow patients far away from this health facility to access it. The road network is shown in Figure 3.7.

This data were acquired from the topographic sheet 0602A. The data was in the Ghana Grid (foot) coordinate system and it was transformed into the UTM Zone 30N coordinate system. The sheet covered more than the study area so the K.M.A boundary shapefile was used to clip the road network located within the area.

### 3.2.6 Barriers to Movement

These barriers may be various components of the landscape for which one knows that patients cannot travel through, such as water bodies, military and airport zones, industrial etc. In the study area the features that were seen as barriers to movement are water bodies. They are shown in Figure 3.7.



The data for water bodies were acquired from the topographic sheet 0602A. The same process for the road network was used to change the data into the UTM Zone 30N coordinate system.

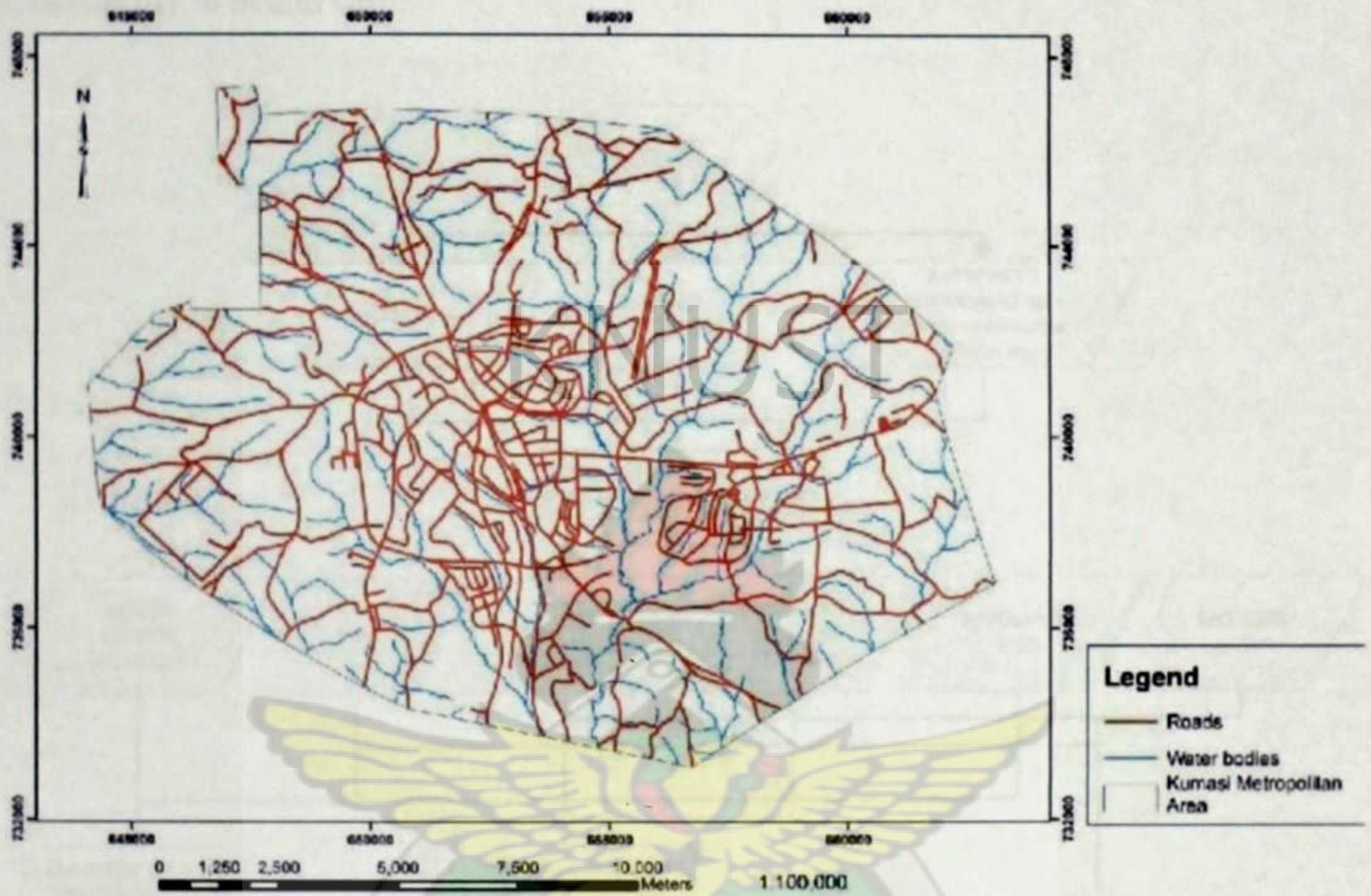


Figure 3. 7 Roads and water bodies in K.M.A



## CHAPTER FOUR: MODELLING SPATIAL ACCESSIBILITY

### 4.1 Introduction

This chapter describes the steps by step procedure for modelling physical accessibility to health care.

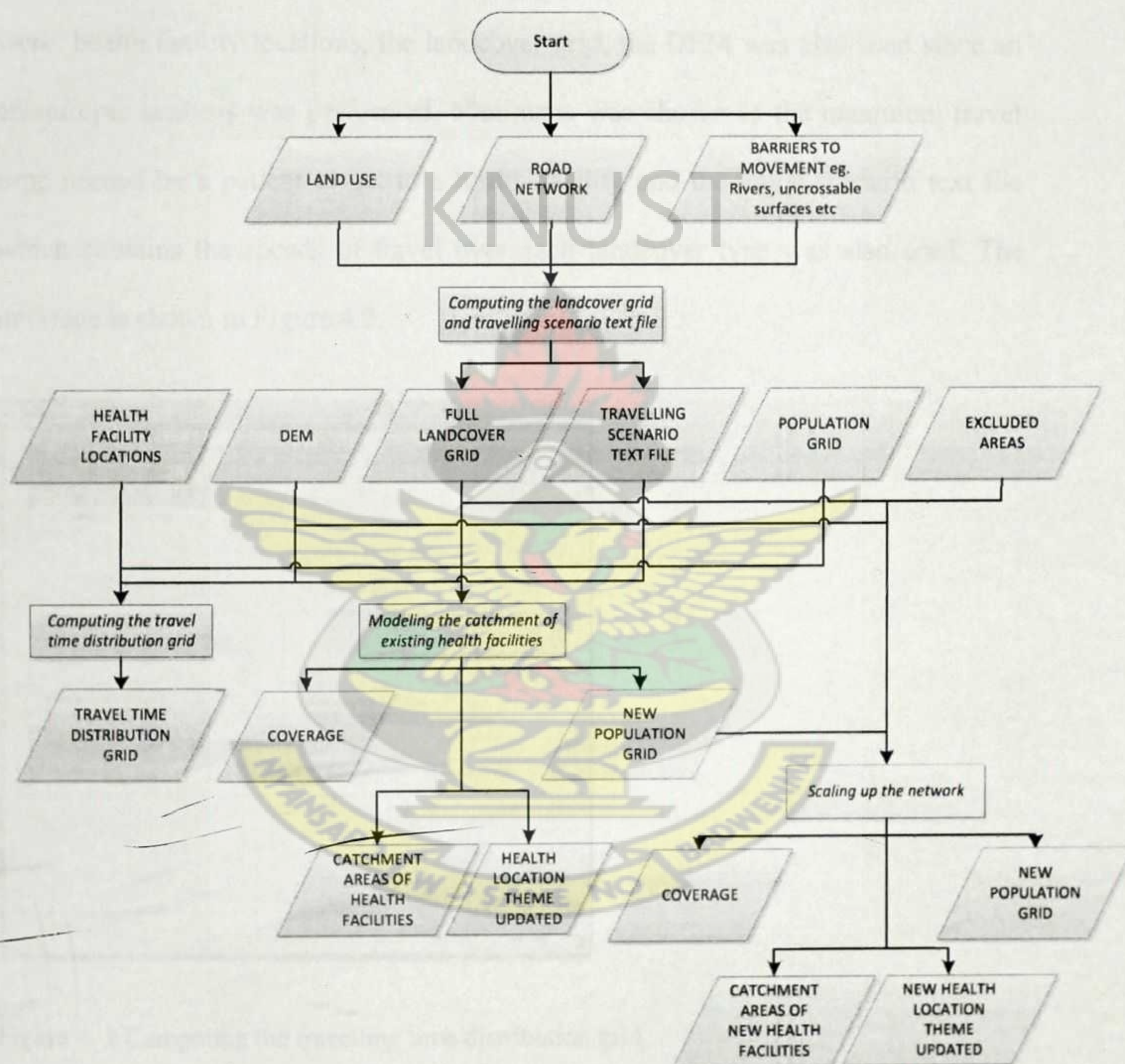


Figure 4. 1 Flowchart of method of measuring physical accessibility to health care



## 4.2 Computing the travelling time distribution grid

The first analysis that was performed after the preparation of the data sets was the creation of the travel time distribution grid. This was done using the AccessMod<sup>®</sup> extension of ArcView GIS 3.3. This was done to determine the travel time to the nearest health facility from any point in the district. The data sets used in this process were: health facility locations, the landcover grid, the DEM was also used since an anisotropic analysis was performed, 60minutes was chosen as the maximum travel time needed by a patient to get to a health facility and the travel scenario text file which contains the speeds of travel over each landcover type was also used. The interface is shown in Figure 4.2.

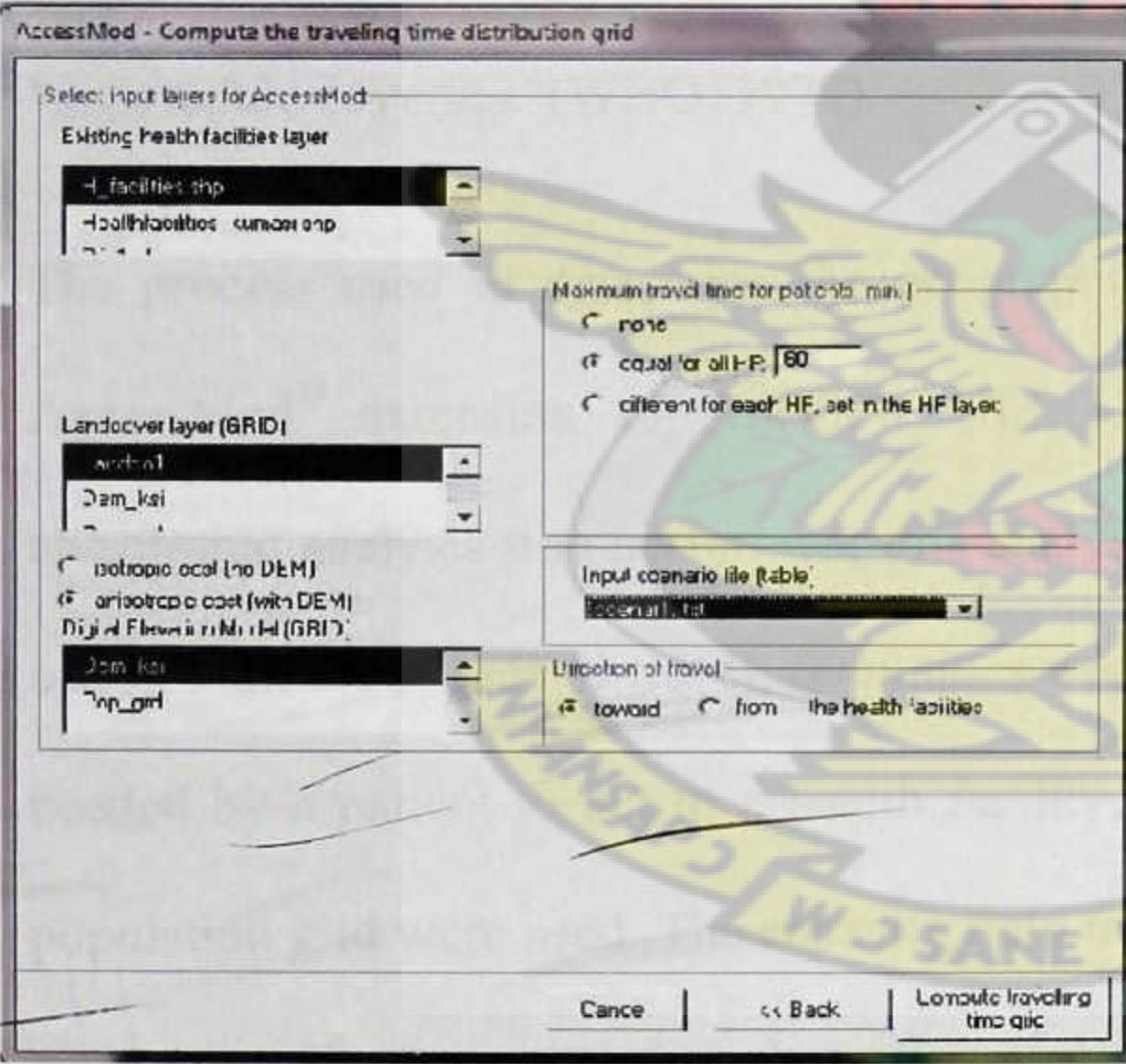


Figure 4. 2 Computing the travelling time distribution grid

The correction applied to the speed over the landcover types uses Tobler's formula which links walking speed with the slope of the terrain through the following formula:



$$V = 6 * e^{-3.5 * \text{abs}(S + 0.05)} \dots\dots\dots (6)$$

Where V is the walking speed in km/h and S is the slope in hundredth of percent.

#### 4.3 Measuring the geographic coverage of an existing health facility network

Availability coverage looks at how the supply of services is spatially distributed without considering if this supply is physically accessible. Accessibility coverage looks at how physically accessible a service is to the population without considering if the offer would be enough to cover the demand. This is addressing the demand side of the equation. Understanding the performance of the health system from a geographic perspective requires the ability to look at both the supply and the demand at the same time. The measure resulting from this type of analysis is referred to as "geographic coverage"(WHO, 1978).

The process used to determine the geographic coverage involved the use of the AccessMod<sup>®</sup> extension of ArcView GIS 3.3. The DEM was used since an anisotropic analysis was performed; this analysis takes into consideration the effect of slope on the speeds of travel, 60minutes was chosen as the maximum travel time needed by a patient to get to a health facility, the travel scenario text file and the population grid were used. The capacity field in the health facility attribute table was also selected to ensure that the catchment area do not exceed the maximum population that can be served and the time needed to get to a facility within its catchment area does not exceed the specified maximum. The AccessMod<sup>®</sup> interface is shown in Figure 4.3.



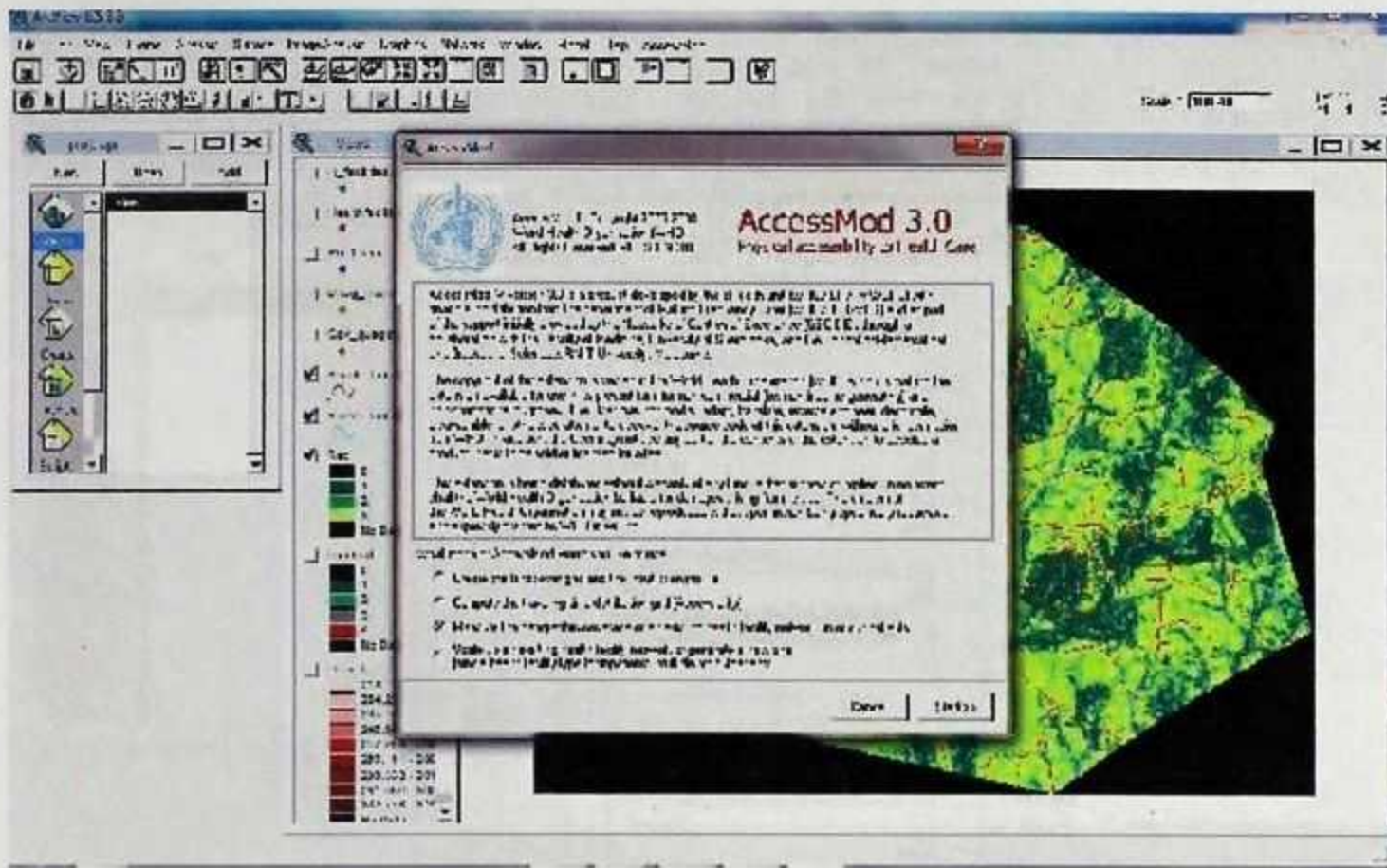


Figure 4. 3 ArcView GIS 3.3 interface with the AccessMod<sup>®</sup> extension

The travel time to each health facility was determined using the DEM and the travelling scenario text file to determine the speed over any landcover type in order to get the time it takes a patient to travel from any part of the district to a health facility. The capacity of each health facility is then used to determine its catchment area using the population grid and the travel time to make sure that the catchment area does not exceed an area whose travel time is more than the specified maximum and does not cover a population that is more than the capacity of the health facility. The catchment areas were then drawn around their respective health facilities and shown on the map. Figures 4.4 to 4.7 show the interface of AccessMod<sup>®</sup> during the processing of the data.



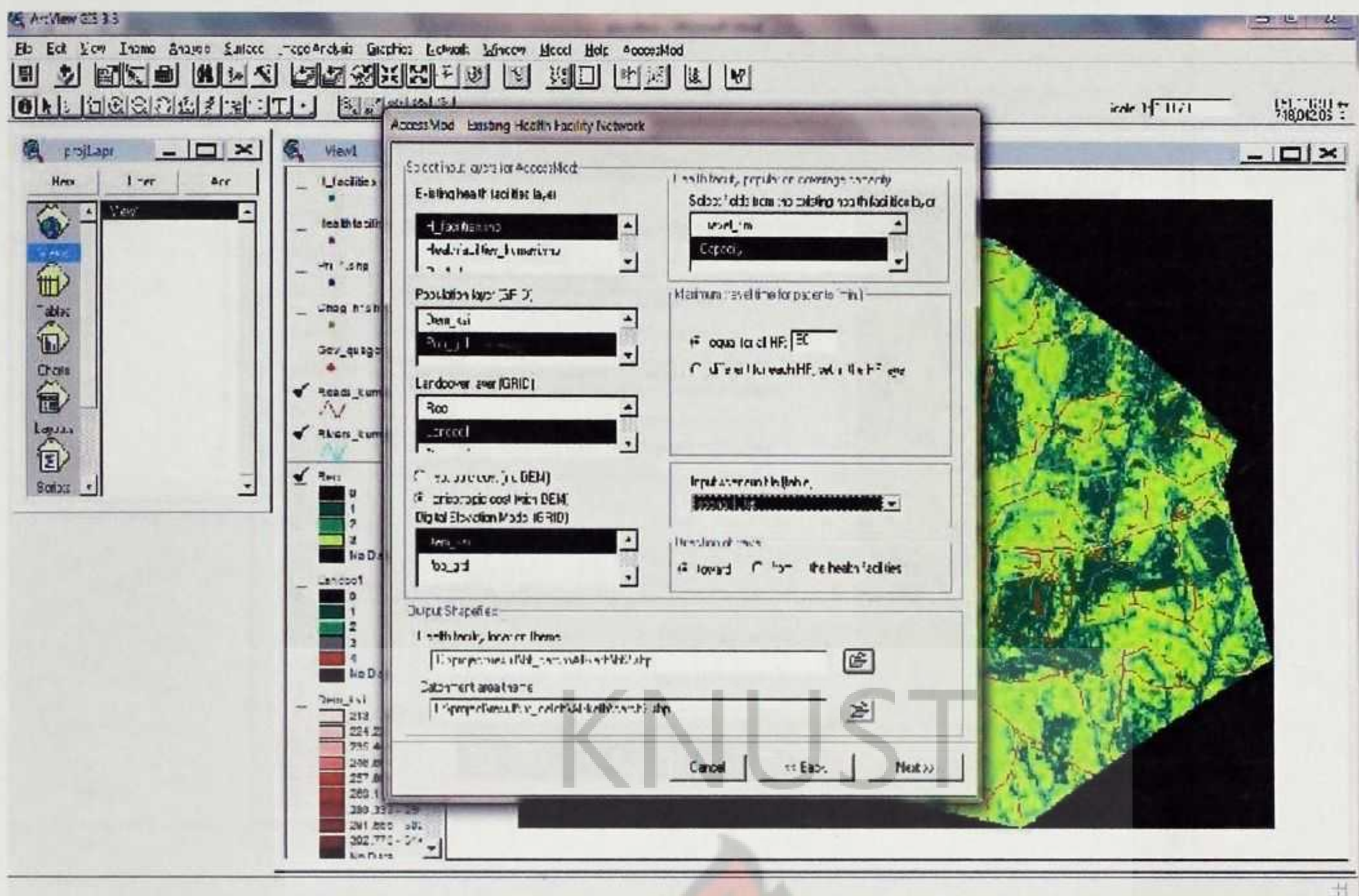


Figure 4. 4 AccessMod<sup>®</sup> dialog for analysing an existing health facility network

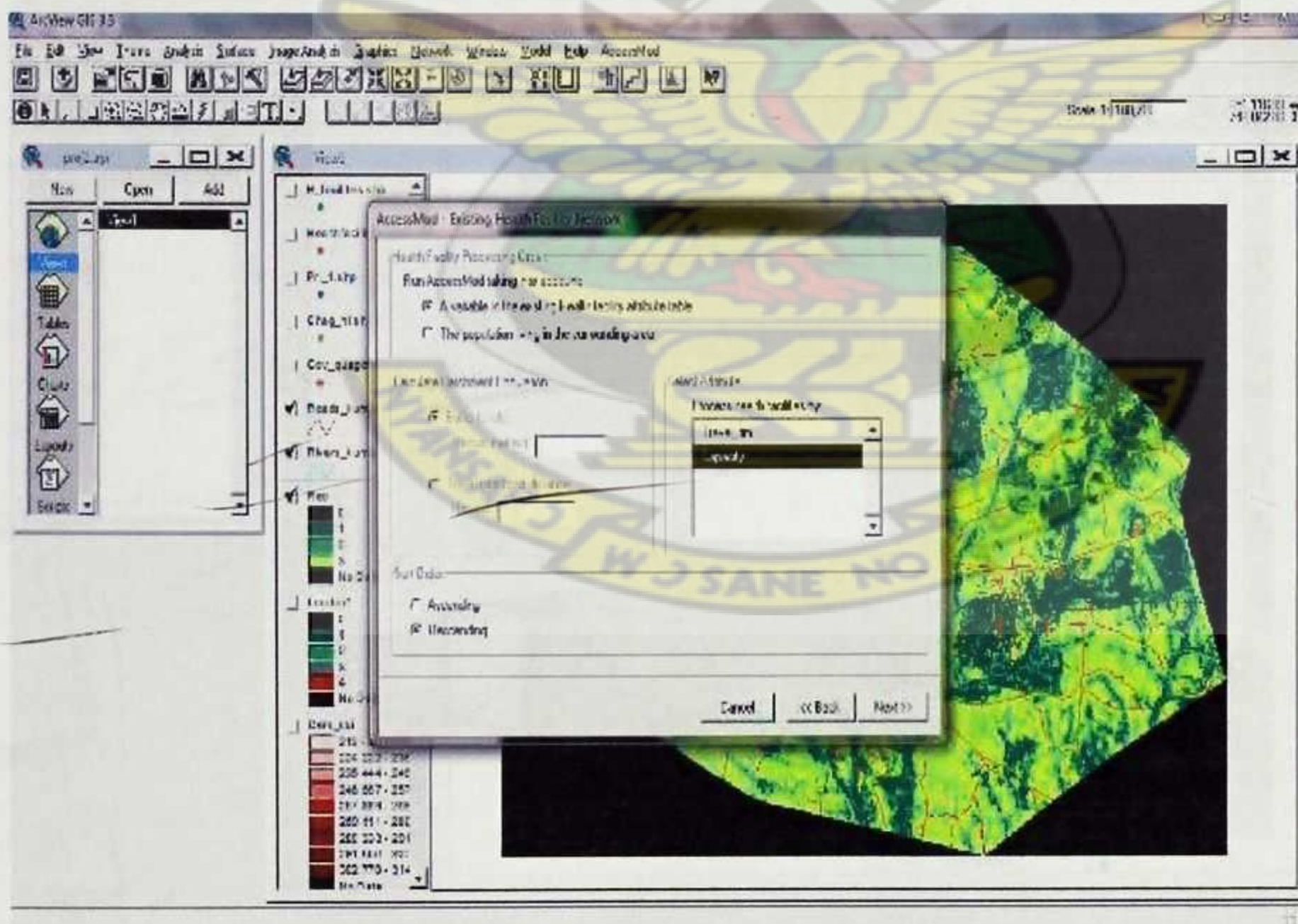


Figure 4. 5 Follow-up dialog for setting health facility processing order



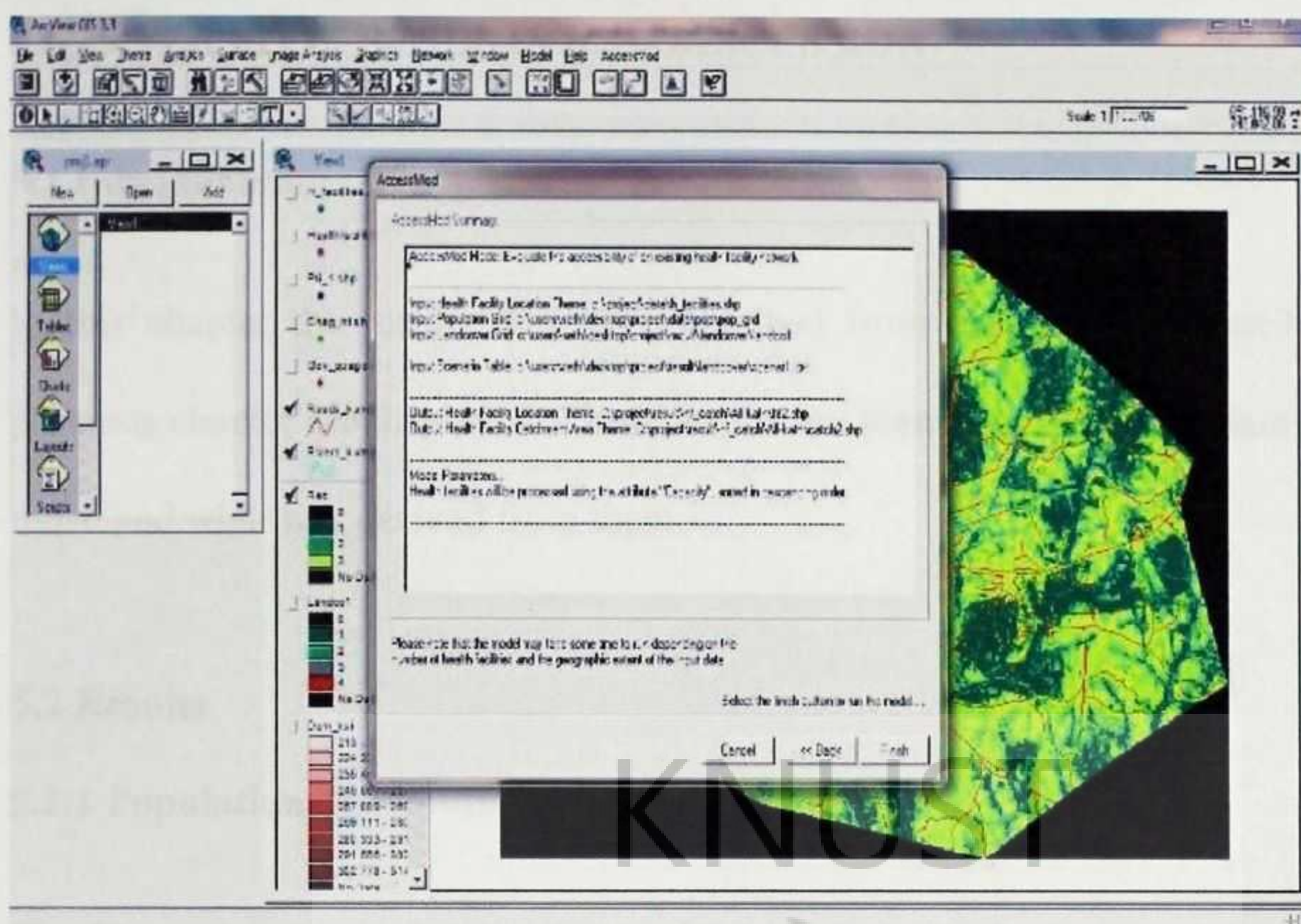


Figure 4. 6 AccessMod<sup>®</sup> Summary Screen

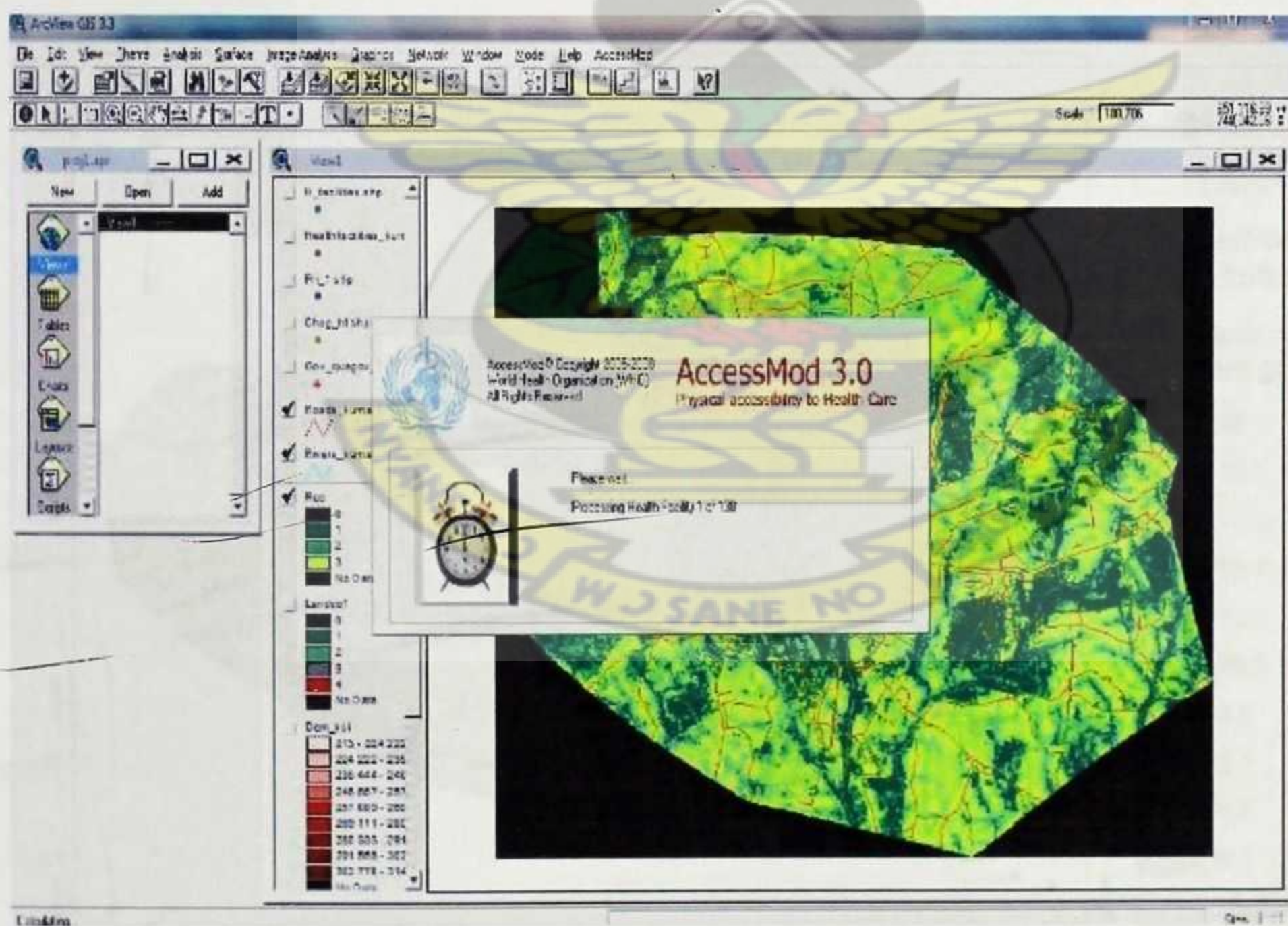


Figure 4. 7 AccessMod<sup>®</sup> Processing Status Screen



CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 Introduction

In this chapter the results that were obtained from the methods described in the previous chapter are displayed. These results are then discussed to explain what they mean and what was derived from them.

5.2 Results

5.2.1 Population distribution grid

The Figure 5.1 shows the distribution of the population in the Kumasi Metropolitan Assembly.

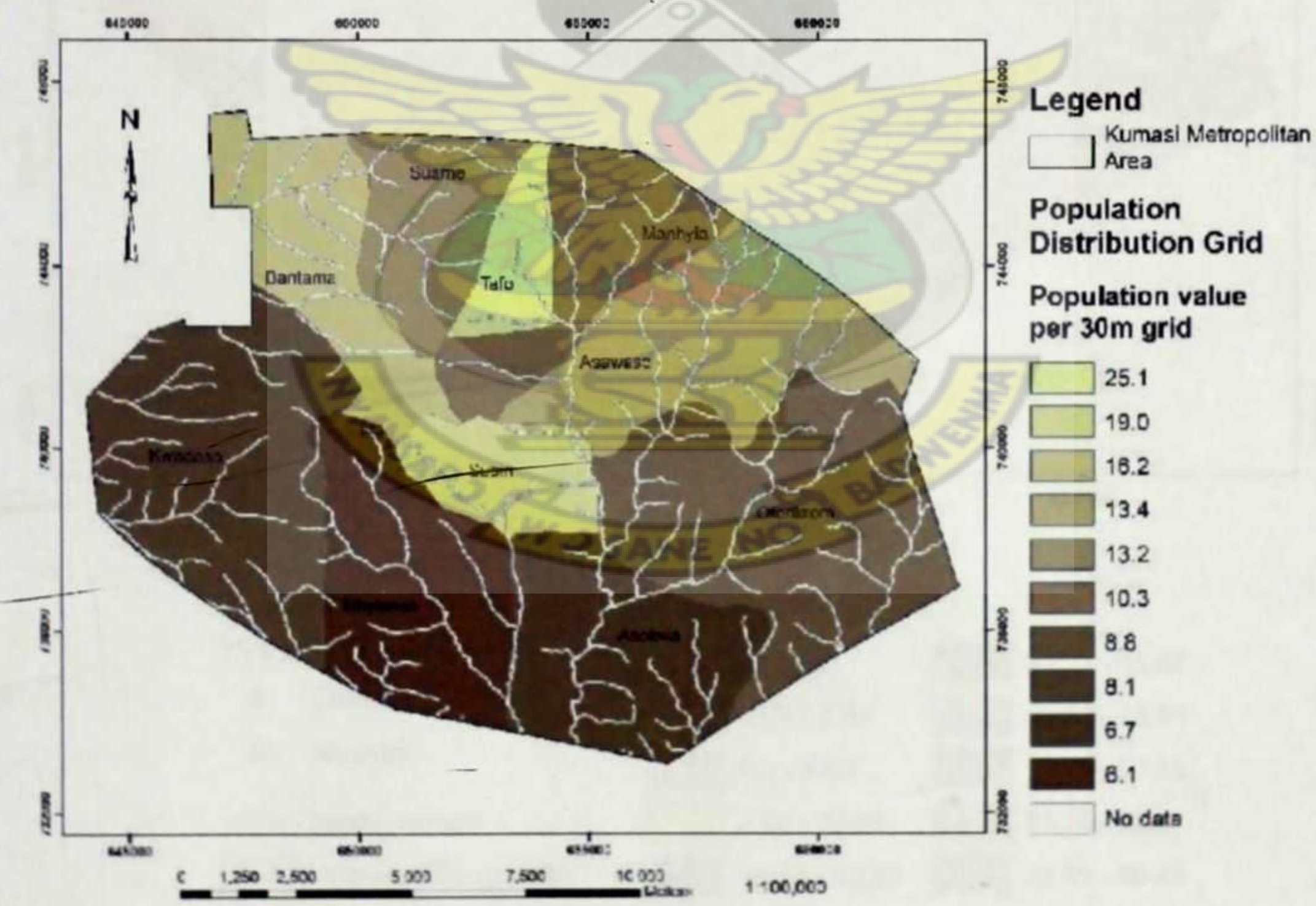


Figure 5. 1 Population distribution grid of K.M.A



5.2.2 Travel time distribution grid

The Figure 5.2 shows the map of Kumasi Metropolitan Assembly showing the health facilities, the road network and a grid showing the time of travel to a health facility.

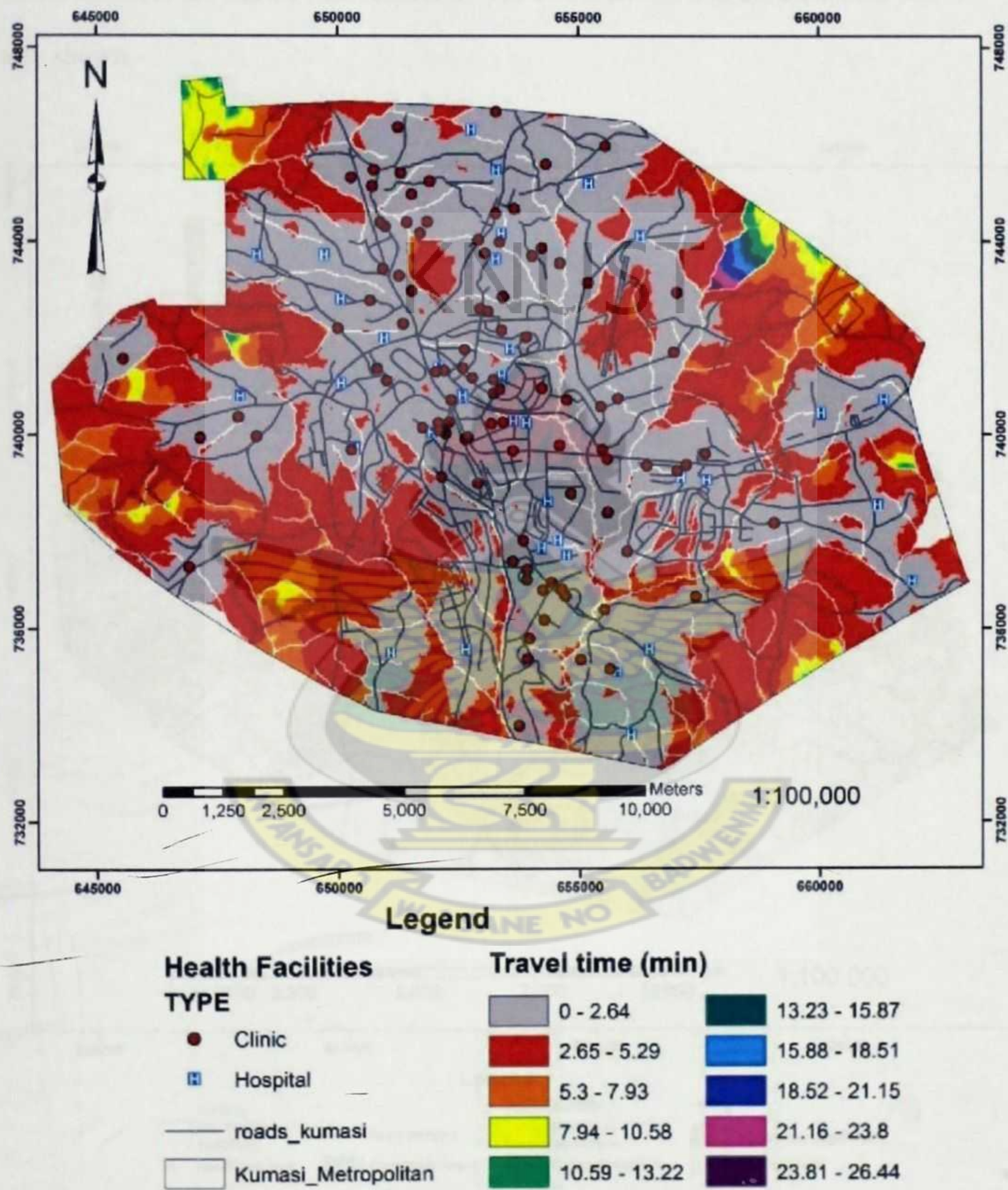


Figure 5. 2 Travelling time distribution grid analysis



### 5.2.3 Results of measuring the geographic coverage of existing health facilities

The Figures 5.3 to 5.8 show the health facilities and their catchment areas and Tables 5.1 to 5.10 shows some attributes and statistics that are associated with them. The health facilities are shown with respect to type of ownership and the combined one is also shown.

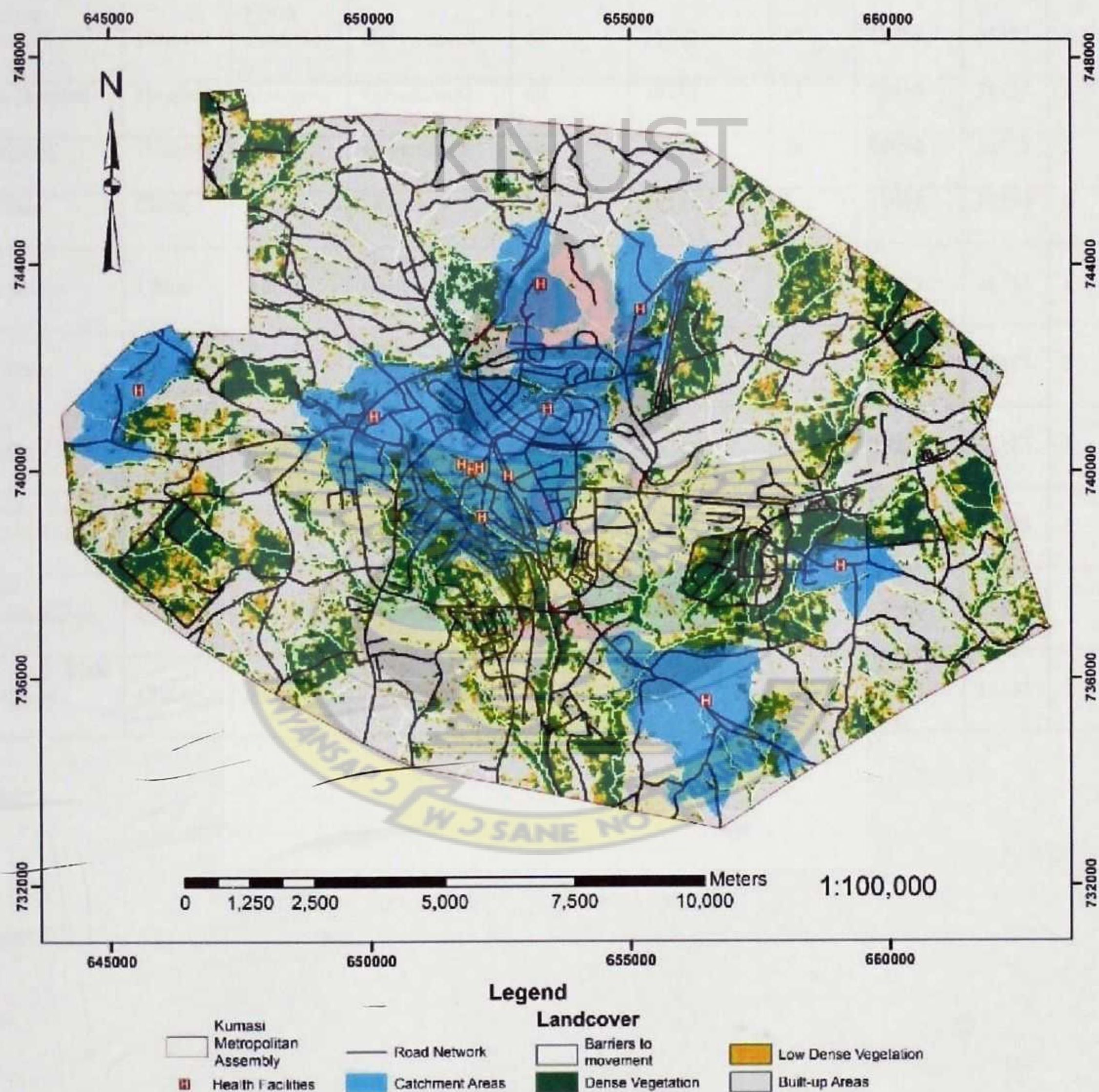


Figure 5. 3 Government and Quasi-Government owned health facilities and their catchment areas



Table 5. 1 Attributes of government and quasi-government owned facilities with their catchment areas

FACILITYNAME	TYPE	TOWN	OWNERSHIP	TRAVEL TIME	CAPACITY	CELL POP	CATCH POP	COEF POP	CALC TT
Kumasi South Hospital	Hospital	Atonsua-Agogo	Government	60	38712	7	49442	38712	3
Maternal and Child Health Hospital	Hospital	Adum	Government	60	38712	19	47855	38712	1
Suntreso Government Hospital	Hospital	North Suntreso	Government	60	38712	17	62783	38712	2
Manhyia Hospital	Hospital	Manhyia	Government	60	38712	11	74954	38712	2
Tafo Hospital	Hospital	Tafo	Government	60	38712	26	68094	38712	2
KMA Clinic	Clinic	Adum	Government	60	16183	0	17078	16183	1
Railway Clinic	Clinic	Railways Adum	Quasi Government	60	16183	0	20222	16183	1
Police Clinic	Clinic	Adum	Quasi Government	60	16183	0	26015	16183	2
Apatrapa Community Clinic	Clinic	Apatrapa	Government	60	16183	8	26221	16183	3
Sepe-Buokrom Community Clinic	Clinic	Buokrom	Government	60	16183	11	39952	16183	2
Ayeduase Community Clinic	Clinic	Ayeduase	Government	60	16183	9	17960	5394	1
Central Male Prisons Clinic	Clinic	Adum	Quasi Government	60	16183	0	52791	16183	3



Table 5. 2 Some other statistics for government and quasi-government owned facilities

Total Population	2,034,960
Total Population Covered	296,052
Percentage Population Covered (%)	14.55
Total Surface area (km <sup>2</sup> )	166.08
Total surface area covered by catchment areas (km <sup>2</sup> )	28.44
Percentage of surface area covered (%)	17.13
Mean realized travel time (minutes)	1.92
Minimum realized travel time (minutes)	1
Maximum realized travel time (minutes)	3
Number of facilities that realized maximum allowed travel time	0
Percentage of facilities that realized maximum allowed travel time (%)	0
Number of facilities that did not realize maximum allowed travel time	12
Percentage of facilities that did not realize maximum allowed travel time (%)	100



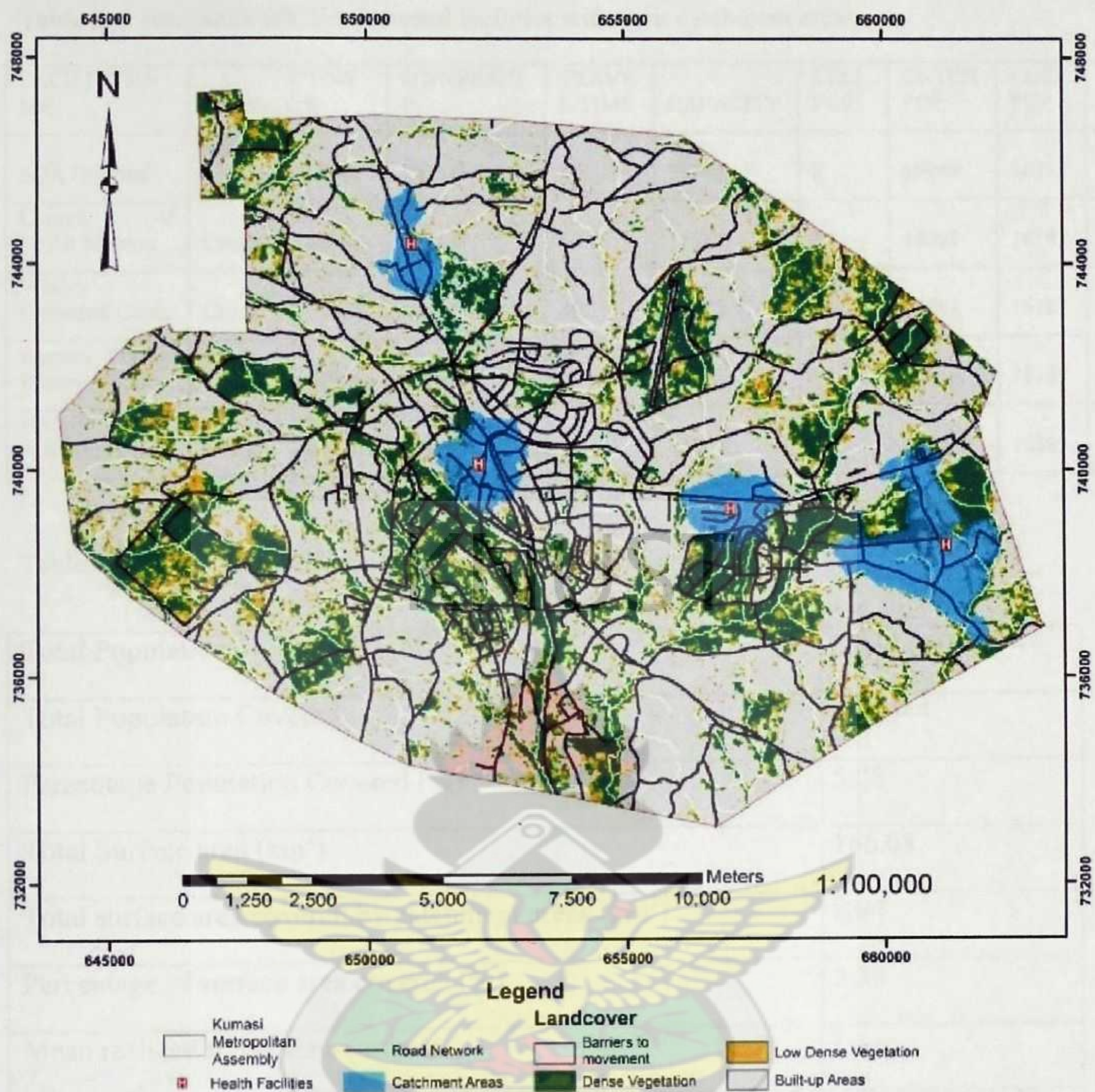


Figure 5. 4 CHAG owned facilities with their catchment areas



Table 5. 3 Attributes of CHAG owned facilities with their catchment areas

FACILITY NAME	TYPE	TOWN	OWNERSHIP	TRAVEL TIME	CAPACITY	CELL POP	CATCH POP	COEF POP	CALC TT
SDA Hospital	Hospital	Onwe	CHAG	60	38712	9	49940	38712	3
Church of Christ Mission	Clinic	Bomso	CHAG	60	16183	9	19090	16183	1
Wesley Cathedral Clinic	Clinic	Adum	CHAG	60	16183	19	44792	16183	1
Kumasi Female Prisons Clinic	Clinic	Adum	CHAG	60	16183	0	27130	16183	1
Histolic Adventist Clinic	Clinic	Maakro	CHAG	60	16183	14	20543	16183	1

Table 5. 4 Some other statistics for CHAG owned facilities

Total Population	2,034,960
Total Population Covered	103,444
Percentage Population Covered (%)	5.08
Total Surface area (km <sup>2</sup> )	166.08
Total surface area covered by catchment areas (km <sup>2</sup> )	8.94
Percentage of surface area covered (%)	5.38
Mean realized travel time (minutes)	1.4
Minimum realized travel time (minutes)	1
Maximum realized travel time (minutes)	3
Number of facilities that realized maximum allowed travel time	0
Percentage of facilities that realized maximum allowed travel time (%)	0
Number of facilities that did not realize maximum allowed travel time	5
Percentage of facilities that did not realize maximum allowed travel time (%)	100



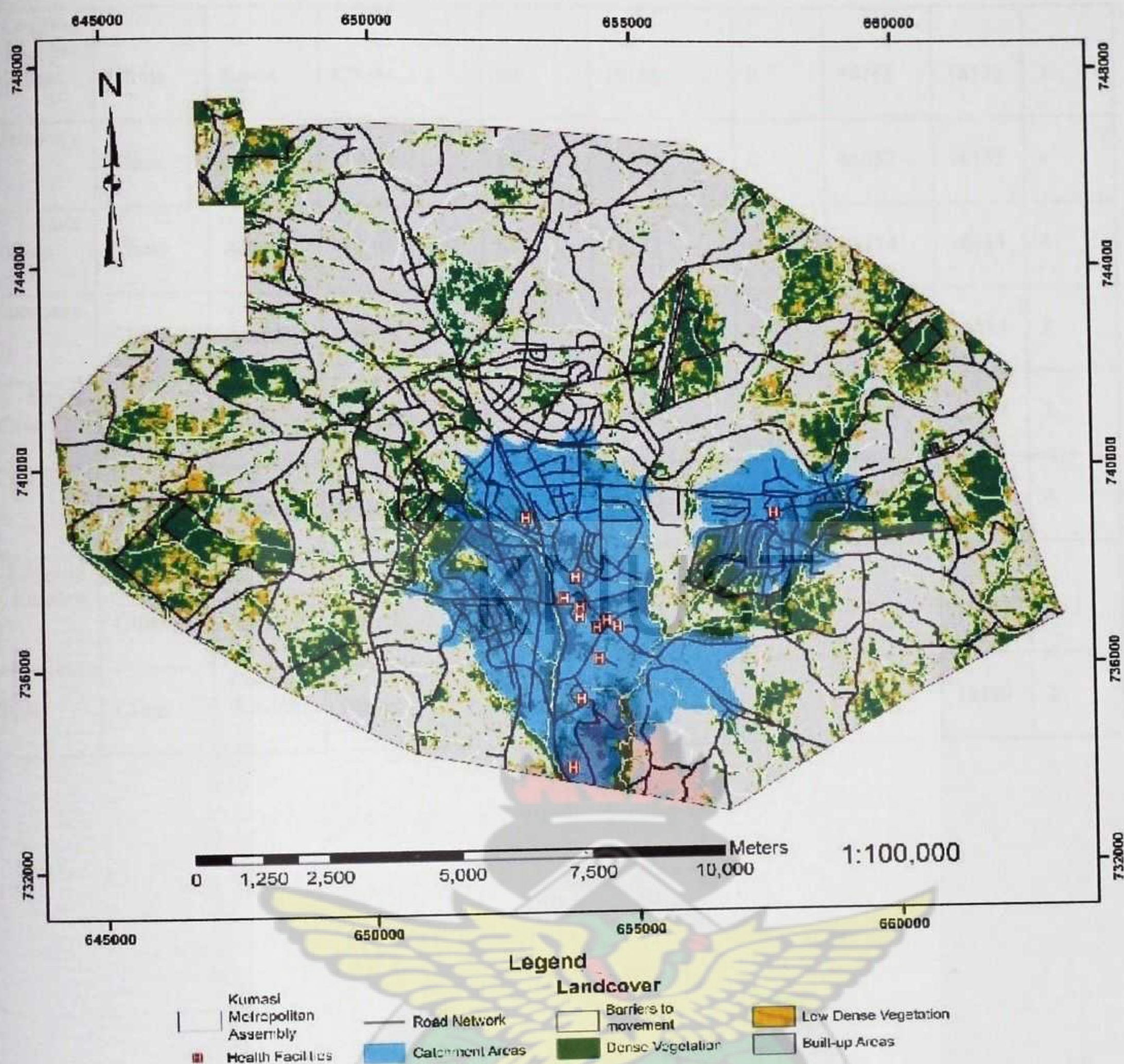


Figure 5. 5 Health facilities owned by other institutions and their catchment areas

Table 5. 5 Attributes of health facilities owned by other institutions with their catchment areas

FACILITYNAME	TYPE	TOWN	OWNERSHIP	TRAVEL TIME	CAPACITY	CELL POP	CATCH POP	COEF POP	CALC TT
KNUST Hospital	Hospital	Ayigya	Others	60	38712	9	50871	38712	2
Habitat Sawmill Clinic	Clinic	Kaase	Others	60	16183	7	23002	16183	4
Ghana Guinness Breweries Group Clinic	Clinic	Ahinsan	Others	60	16183	0	24157	16183	3
Omega Sawmill Clinic	Clinic	Kaase	Others	60	16183	0	20815	16183	3



Bibiani Logging and Lumber Company Clinic	Clinic	Kaase	Others	60	16183	0	34168	16183	3
Ghana Brewery Clinic	Clinic	Ahinsan	Others	60	16183	0	66557	16183	4
Coca Cola Bottling Clinic	Clinic	Ahinsan	Others	60	16183	0	74114	16183	4
JCM Company Clinic	Clinic	Asokwa	Others	60	16183	0	23857	16183	3
Paul Sagoe Sawmill Clinic	Clinic	Asokwa	Others	60	16183	0	18358	16183	3
Atwima Timbers Clinic	Clinic	Asokwa	Others	60	16183	0	68540	16183	4
Logs and Logging Lumber Clinic	Clinic	Asokwa	Others	60	16183	0	71241	16183	4
Cocoa Clinic	Clinic	Cocobo d-Adum	Others	60	16183	0	19134	16183	2

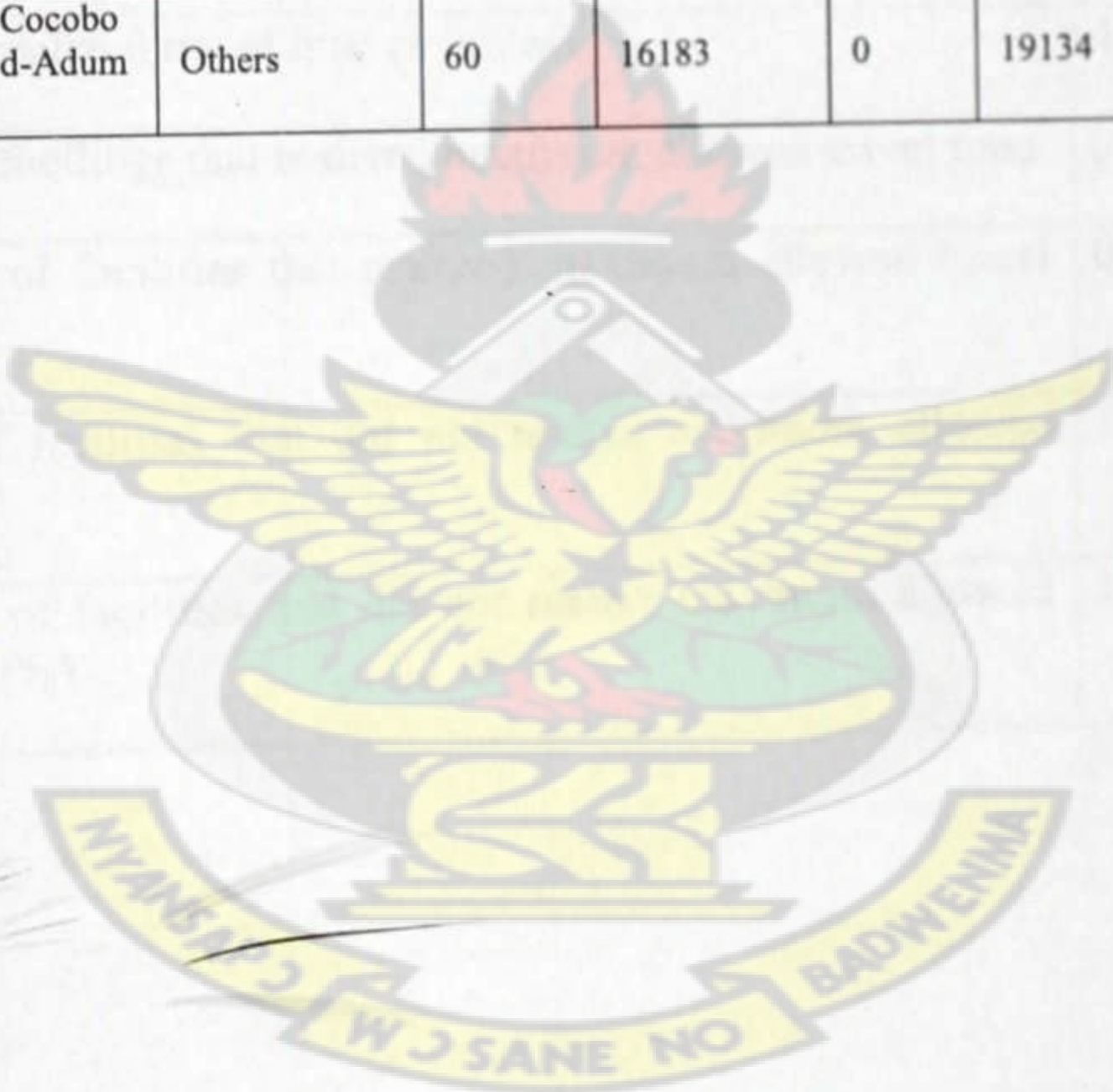




Table 5. 6 Some other statistics for facilities owned by other industries

Total Population	2,034,960
Total Population Covered	216,725
Percentage Population Covered (%)	10.65
Total Surface area (km <sup>2</sup> )	166.08
Total surface area covered by catchment areas (km <sup>2</sup> )	24.22
Percentage of surface area covered (%)	14.58
Mean realized travel time (minutes)	3.25
Minimum realized travel time (minutes)	2
Maximum realized travel time (minutes)	4
Number of facilities that realized maximum allowed travel time	0
Percentage of facilities that realized maximum allowed travel time (%)	0
Number of facilities that did not realize maximum allowed travel time	12
Percentage of facilities that did not realize maximum allowed travel time (%)	100



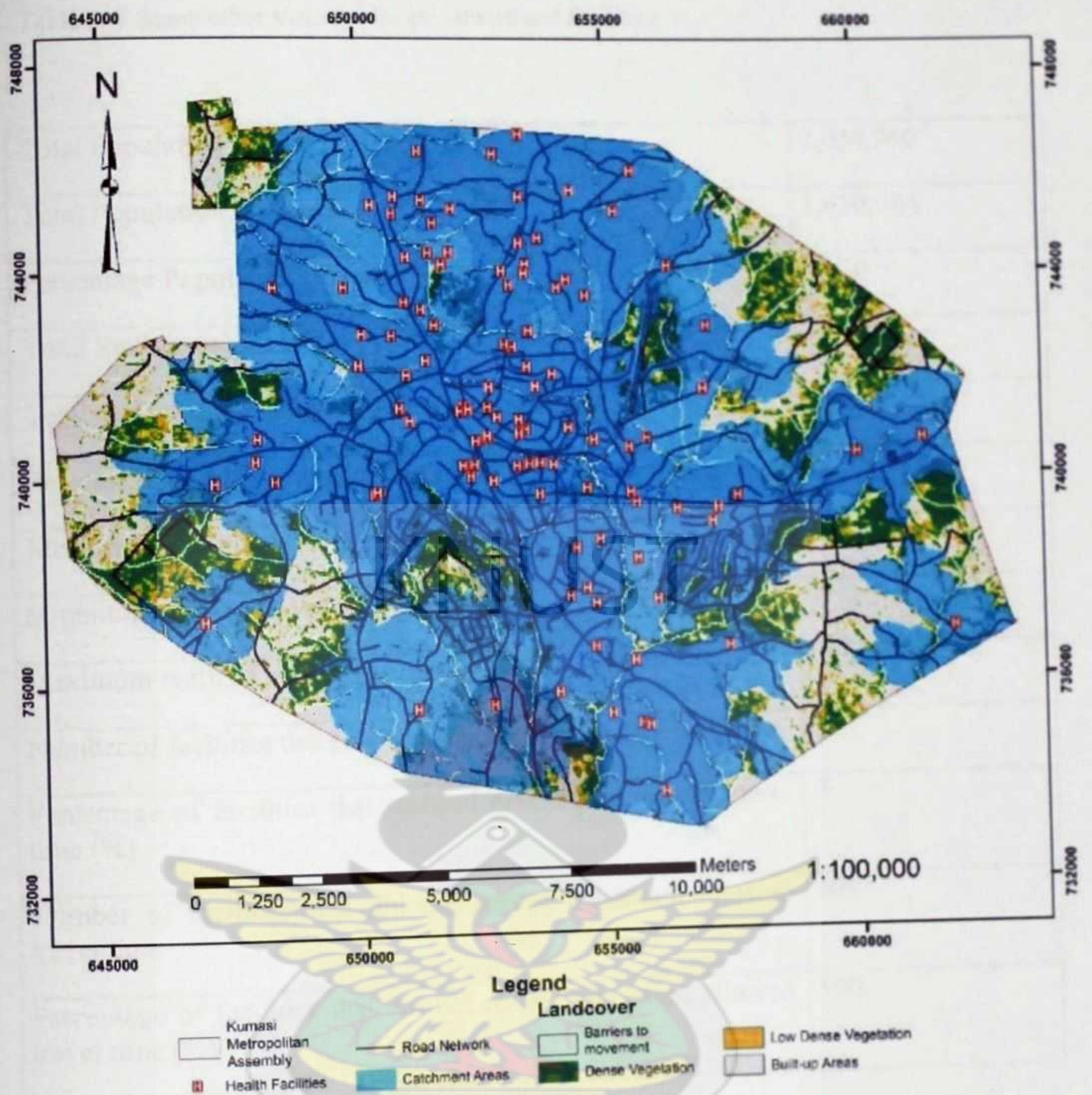


Figure 5. 6 Privately owned health facilities with their catchment areas

The attributes of the privately owned health facilities and their catchment areas are shown Appendix 2.



Table 5. 7 Some other statistics for private owned facilities

Total Population	2,034,960
Total Population Covered	1,630,084
Percentage Population Covered (%)	80.10
Total Surface area (km <sup>2</sup> )	166.08
Total surface area covered by catchment areas (km <sup>2</sup> )	132.61
Percentage of surface area covered (%)	79.85
Mean realized travel time (minutes)	3
Minimum realized travel time (minutes)	1
Maximum realized travel time (minutes)	9
Number of facilities that realized maximum allowed travel time	0
Percentage of facilities that realized maximum allowed travel time (%)	0
Number of facilities that did not realize maximum allowed travel time	109
Percentage of facilities that did not realize maximum allowed travel time (%)	100



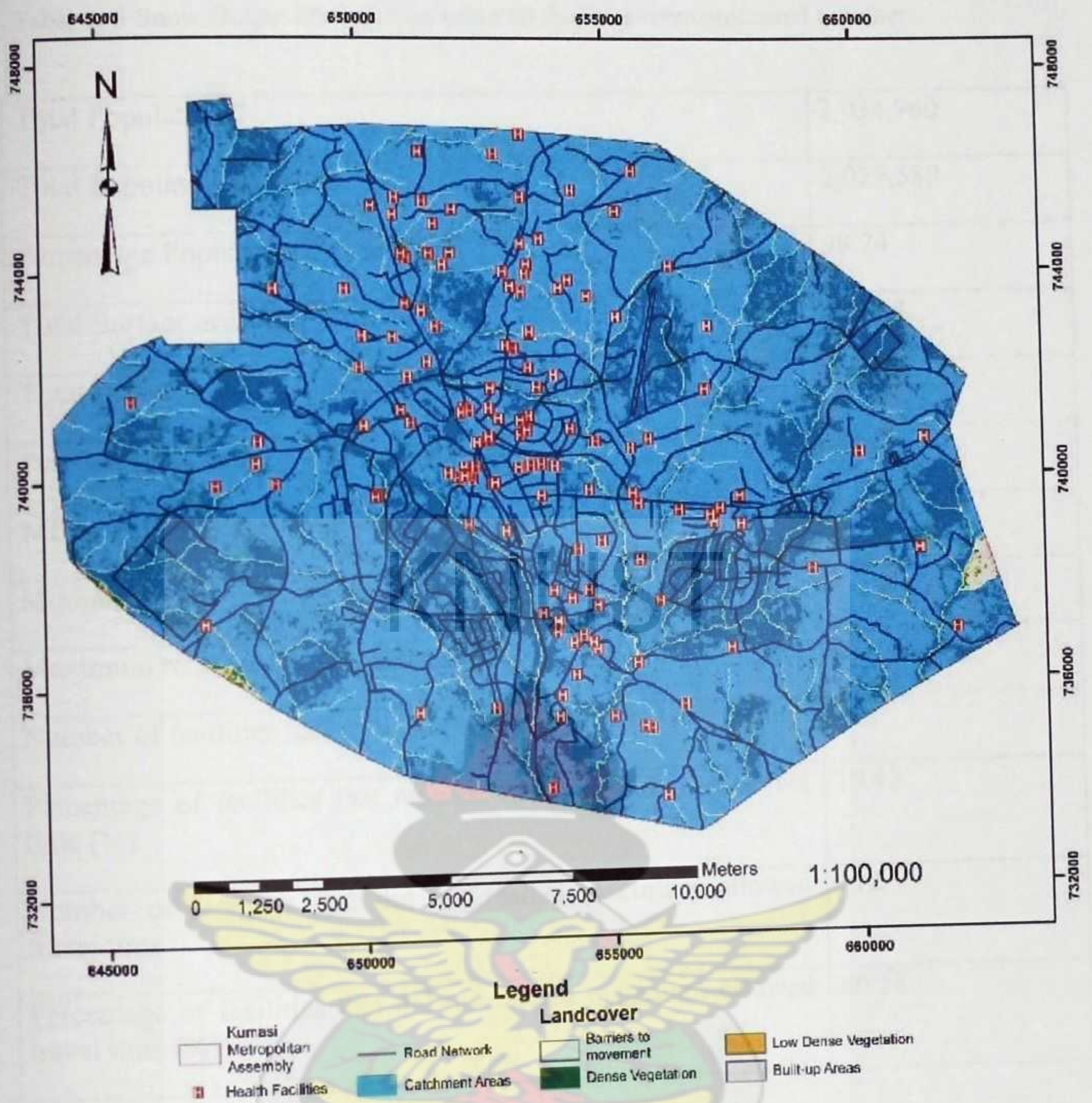


Figure 5. 7 All health facilities and their catchment areas

The attribute table for all the health facilities and the catchment areas will be shown Appendix 3.



Table 5. 8 Some Output Statistics for when all facilities were processed together

Total Population	2,034,960
Total Population Covered	2,029,580
Percentage Population Covered (%)	99.74
Total Surface area (km <sup>2</sup> )	166.08
Total surface area covered by catchment areas (km <sup>2</sup> )	165.53
Percentage of surface area covered (%)	99.67
Mean realized travel time (minutes)	17.23
Minimum realized travel time (minutes)	1
Maximum realized travel time (minutes)	60
Number of facilities that realized maximum allowed travel time	26
Percentage of facilities that realized maximum allowed travel time (%)	19.42
Number of facilities that did not realize maximum allowed travel time	112
Percentage of facilities that did not realize maximum allowed travel time (%)	80.58





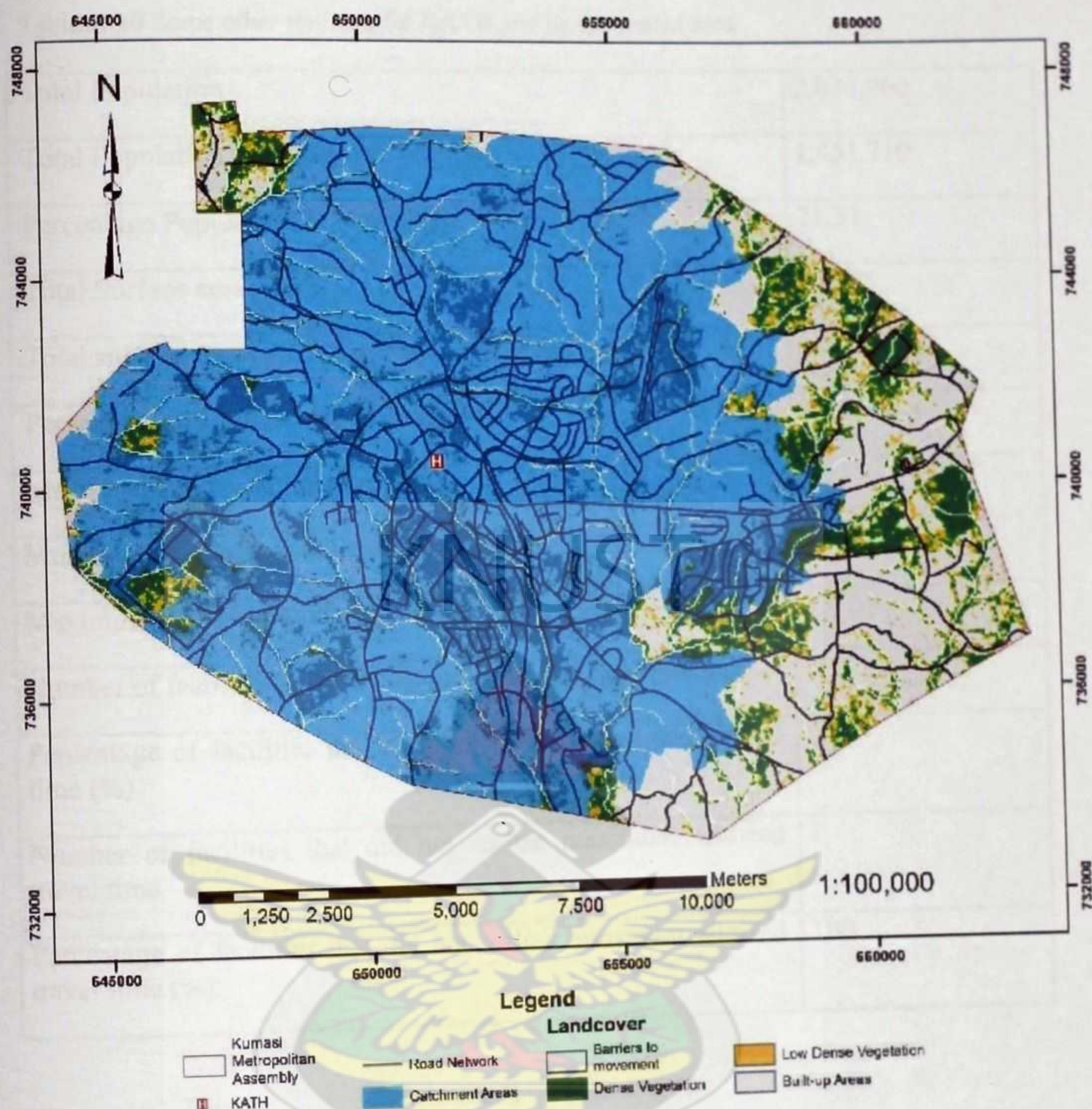


Figure 5. 8 Komfo Anokye Teaching Hospital (KATH) and its catchment area

Table 5. 9 Attributes of KATH and its catchment area

FACILITY NAME	TYPE	TOWN	OWNERSHIP	TRAVEL TIME	CAPACITY	CELL POP	CATCH POP	COEF POP	CALC TT
Komfo Anokye Teaching Hospital	Teaching Hospital	Bantama	Government	60	1451705	19	1520160	1451705	13



Table 5. 10 Some other statistics for KATH and its catchment area

Total Population	2,034,960
Total Population Covered	1,451,710
Percentage Population Covered (%)	71.34
Total Surface area (km <sup>2</sup> )	166.08
Total surface area covered by catchment areas (km <sup>2</sup> )	113.44
Percentage of surface area covered (%)	68.31
Mean realized travel time (minutes)	13
Minimum realized travel time (minutes)	13
Maximum realized travel time (minutes)	13
Number of facilities that realized maximum allowed travel time	0
Percentage of facilities that realized maximum allowed travel time (%)	0
Number of facilities that did not realize maximum allowed travel time	1
Percentage of facilities that did not realize maximum allowed travel time (%)	100





## 5.3 Discussion

### 5.3.1 Population distribution grid

The Figure 5.1 shows the distribution of the population over the metropolitan area. It is shown in a gridded form with a grid size of 30 meters. The grid values range from 6 to 25 people per 30 meter square grid. The populations are evenly distributed within each sub-metropolitan area. Nhyiaeso has the least population per grid with 6 people whilst Tafo is the most densely populated with 25 people per each grid. The areas around water bodies are assumed to have no people living there so they are shown as no data areas in the distribution grid.

### 5.3.2 Travel time distribution grid

The amount of time needed to get to a health facility in the Kumasi Metropolitan Assembly is shown in Figure 5.2. It shows the locations of the different types of health facilities and the road network in the metropolitan area. The travel time distribution is shown in different colours. The shortest time is shown in ash and violet being the longest time. The longest time it takes to get to a health facility was found to be about 26.44 minutes. The travel time has been divided into 10 classes with each class having a range of 2.64 minutes. It can be seen that areas around the roads are able to get to a health facility faster than areas that are not close to any roads. This is because the speed of travel along the roads is higher than that over the other landcover types. This therefore enables patients moving along the roads to get to the health facilities faster than those who have to move over the other landcover types. The barriers to movement also increases the travel time to a facility because patients cannot move across them and have to move around them to get to their



destinations. The parts with the longest travel time was the area which is bounded by the barriers to the movement and has no roads.

### 5.3.3 Measuring the geographic coverage of existing health facilities

In showing the geographic coverage of the existing health facilities, the coverage was shown first with each type of ownership before all the facilities were shown together.

Figure 5.3 shows the government and quasi-government owned facilities in the metropolitan area. The catchment areas are shown in blue around the health facility points on the map and it is overlaid on the landcover map of the Kumasi Metropolitan Assembly. The attributes of the health facilities and the catchment areas are shown in Table 5.1. The table contains the name of the health facility, the type, the town in which it is located, the kind of ownership, the maximum allowed travel time to get there, the capacity of the facility, the CellPop: which is the population found in the cell in which the facility is located, the CatchPop: the total population located within the catchment area drawn using the Health Facility Population Coverage Capacity and the maximum travel time as the limits, the CoeffPop: the adjusted total population in case the CatchPop value is larger than the Health Facility Population Coverage Capacity, the CalcTT: this the travel time in minutes at the limits of the catchment areas. The other statistics show the total population of the study area which is 2034960, the total population covered by all the catchment areas which was 296052 representing 14.55% of the total population. It also showed the total surface area covered by the population as 166.08 sq. km and the surface area covered by the catchment areas was 28.44 sq. km representing 17.13% of the total surface area. The average amount of time needed by people in



the catchment areas to get to the health facilities was determined to be 1.92 minutes, and the minimum time was 1 minute with the maximum being 3 minutes.

Figure 5.4 shows health facilities owned by CHAG and their catchment areas. The attributes for the facilities and their catchment areas is shown in Table 5.2. The table contains the same fields as discussed for Table 5.1. From the other statistics it is found that the catchment areas of the CHAG owned facilities covers a total population of 103444 which is 5.08% of the total population. And these catchment areas cover a total surface area of 8.94 sq. km which is 5.38% of the total surface area. The maximum amount of time used by people in the catchment area to get to the health facilities is 3 minutes and the minimum is 1 minute, the average amount of time used was 1.4 minutes.

Figure 5.5 shows health facilities owned by other institutions and their catchment areas. The attributes for the facilities and their catchment areas is shown in Table 5.3. The table contains the same fields as discussed for Table 5.1. From the other statistics it is found that the catchment areas of these facilities covers a total population of 216725 representing 10.65% of the total population. The surface area covered by the catchment areas is 24.23 sq. km which is 14.58% of the total. The maximum amount of time used by people in the catchment area to get to the health facilities is 4 minutes and the minimum is 2 minutes, the average amount of time used was 3.25 minutes.

Figure 5.6 shows privately owned health facilities and their catchment areas. The attributes for these facilities and their catchment areas is shown in Table 5.4. The table contains the same fields as discussed for Table 5.1. From the other statistics it is found that the catchment areas of these facilities covers a total population of



1,630,084 which is 80.10% of the total population. The catchment areas cover a total surface area of 132.61 sq.km which is 79.85% of the total populated surface area. The maximum amount of time used by people in the catchment area to get to the health facilities is 9 minutes and the minimum is 1 minute, the average amount of time used was 3 minutes.

Figure 5.7 shows the results of when all the health facilities apart from Komfo Anokye Teaching hospital were processed together. The health facilities are shown with their catchment areas. The attributes which contain the same fields as table 5.1 will be shown in the appendix. The catchment areas of all the facilities covers a population of 2,029,580 which is 99.74% of the total population in the study area. The catchments cover a combined surface area of 165.53 sq. km which is 99.67% of the total populated surface area.

Figure 5.8 shows the results of processing KATH alone. KATH is shown with its catchment area around it and the attributes is shown in Table 5.5. The catchment area of KATH covers a population of 1,451,710 which is 71.34% of the population of the KMA. Its catchment area covers a surface area of 113.44 sq. km which is 68.31% of the total surface area. The time needed to travel from the limits of the catchment area to the facility is 13 minutes.



## CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

The aim of the research was to determine the geographic coverage to health care using terrain information and population distribution using GIS models. This was measured in two ways; the time of travel to a health facility and determining the catchment area of each facility which depended on the capacity of the facility, the population living around and the time needed to get to the facility.

In the research the maximum time allowed to get to a health facility was 60 minutes but from the obtained travel time distribution grid it was found that the maximum time that a patient will use to get to a health facility in the Kumasi Metropolitan Assembly was 26.44 minutes which was less than half of the maximum required time.

The research also helped determine the catchment areas and the population that the facilities can serve. This was done first based on the type of ownership before all the facilities were processed together. After processing all the facilities together it was determined that the health facilities in the study area could serve 99.74% of the total population and the catchment areas covered 99.67% of the total populated surface area.

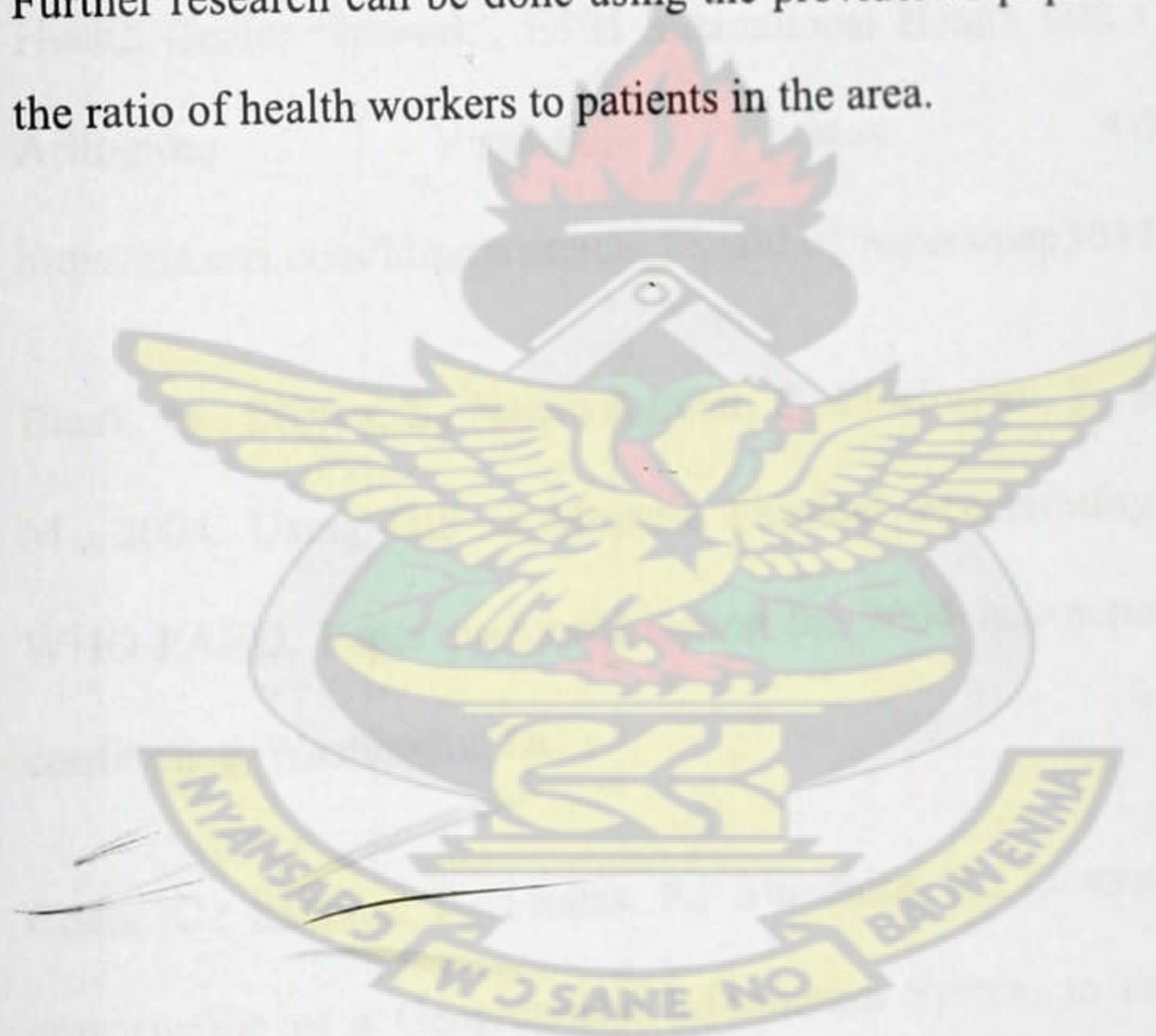
Due to the high coverage of the existing facilities the scaling up of the facilities was not performed in the research.



## 6.2 Recommendations

In order to get a better measure of the access to health care the following recommendations are proposed:

- A population distribution grid of the country should be created using the enumeration areas used for the census and their populations. This will help get a better representation of the population distribution in the country.
- More research must be done to determine the effect of the road network on the catchment areas of the health facilities.
- Further research can be done using the provider-to-population ratio to check the ratio of health workers to patients in the area.





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## APPENDIX

**Appendix 1: Attribute information of the health facility data**

FACILITY NAME	TYPE	TOWN	OWNERSHIP	Northing	Easting
Queens Hospital	Hospital	Dompoase	Private	733795.504	656069.975
New Era Millennium Hospital	Hospital	Bokro-Atonsu	Private	735105.038	655780.983
Atasemanso Hospital	Hospital	Atasemanso	Private	735500.482	651089.767
Kumasi South Hospital	Hospital	Atonsu-Agogo	Government	735560.317	656448.601
Washie Hospital	Hospital	Ahodwo Kumasi	Private	735561.696	652639.145
Animwaa Medical Centre	Hospital	Amena	Private	736976.203	661917.414
St. Markus Hospital	Hospital	Asokwa	Private	737512.682	654733.165
Twumasi Memorial Hospital	Hospital	Asokwa	Private	737660.470	654211.482
Poku Transport Hospital	Hospital	Asokwa	Private	737811.396	654551.589
City Hospital	Hospital	Stadium	Private	738620.697	654349.250
SDA Hospital	Hospital	Onwe	CHAG	738544.011	661204.958
KNUST Hospital	Hospital	Ayigya	Others	739054.754	657646.973
Bomso Specialist Hospital	Hospital	Bomso	Private	739101.778	657107.991
Trust Care Specialist Hospital	Hospital	South Suntreso	Private	739734.039	650347.258
Maternal and Child Health Hospital	Hospital	Adum	Government	740041.470	651947.219
Gloria Memorial Hospital	Hospital	Akwatiline	Private	740237.193	653911.210
Kyei Memorial Hospital	Hospital	Akwatiline	Private	740281.753	653636.910
Quality Health Care Ltd.	Hospital	Kentinkrono	Private	740438.451	660033.176
Komfo Anokye Teaching Hospital	Teaching Hospital	Bantama	Government	740481.175	651410.914
Peace and Love Hospital	Hospital	Oduom	Private	740718.746	661331.384
New Town Hospital	Hospital	Dr. Mensah-Ash Town	Private	740763.202	652600.147
Siloam Hospital	Hospital	Kwadaso	Private	740795.710	647982.952
Wilben Dental Clinic	Hospital	Dr. Mensah - Ash Town	Private	740813.986	652586.260
Suntreso Government Hospital	Hospital	North Suntreso	Government	741061.306	650073.839
Manhyia Hospital	Hospital	Manhyia	Government	741214.865	653405.255
Mbrom Hospital	Hospital	Mbrom Dichemso	Private	741388.721	652097.113
Wisdom Hospital	Hospital	Dichemso	Private	741769.951	653572.998
Hebrona Hospital	Hospital	Abrepo Junction	Private	741999.154	650962.213
Charity Hospital	Hospital	Kropo	Private	742802.878	650071.227
Tafo Hospital	Hospital	Tafo	Government	743625.721	653279.206
St. Anthony Hospital	Hospital	Asuogya	Private	743713.071	649726.011
County Hospital	Hospital	Abrepo	Private	743719.167	648327.601
Naka and St. Ama Hospital	Hospital	Buokrom	Private	744100.951	656278.092
Rophi Hospital	Hospital	Old Tafo	Private	744147.999	653402.641
Keffam Hospital	Hospital	Buokrom Estate	Private	745176.032	655215.961
Siaw Larbi Hospital	Hospital	Mile 4 – Tafo	Private	745461.437	653288.422
Atsyyor Hospital Complex	Hospital	Atafoa-Pankrono	Private	746301.388	652777.486



Habitat Sawmill Clinic	Clinic	Kaase	Others	733986.658	653739.668
St. Anne's Clinic	Clinic	Atonsua	Private	735153.273	655633.794
Animah Clinic	Clinic	S-line Atonsua	Private	735352.803	655027.332
Ghana Guinness Breweries Group Clinic	Clinic	Ahinsan	Others	735368.478	653921.645
Kaase Maternity Home	Clinic	Kaase	Private	735787.686	653963.584
Omega Sawmill Clinic	Clinic	Kaase	Others	736173.358	654268.755
Lake Road Clinic	Clinic	Atonsua	Private	736385.893	655517.509
Complementary Clinic	Clinic	Gyinaase	Private	736650.077	657411.797
Christ the King Clinic	Clinic	Ahinsan	Private	736666.678	654709.608
Bibiani Logging and Lumber Company Clinic	Clinic	Kaase	Others	736792.508	654238.260
Ghana Brewery Clinic	Clinic	Ahinsan	Others	736807.988	654628.497
Coca Cola Bottling Clinic	Clinic	Ahinsan	Others	736946.736	654423.566
JCM Company Clinic	Clinic	Asokwa	Others	737011.623	653907.064
Paul Sagoe Sawmill Clinic	Clinic	Asokwa	Others	737214.013	653918.654
Peace Homoeo Medical Clinic	Clinic	Agric Nzema	Private	737273.210	646916.811
Atwima Timbers Clinic	Clinic	Asokwa	Others	737387.883	653619.652
Bilsons Allens Clinic	Clinic	Ahinsan	Private	737589.237	655991.699
Logs Logging and Lumber Clinic	Clinic	Asokwa	Others	737809.862	653842.926
Sunkwa Clinic	Clinic	Anloga	Private	738377.605	655584.797
Ebenezer Clinic	Clinic	Anloga	Private	738401.967	655596.889
Bimpeh Hill Clinic	Clinic	New Amakom	Private	738779.067	654830.752
Cocoa Clinic	Clinic	Cocobod-Adum	Others	738995.883	652905.345
KMA Clinic	Clinic	Adum	Government	739126.449	652146.566
Church of Christ Mission	Clinic	Bomso	CHAG	739245.389	657033.931
Yentumi Boitey Memorial Clinic	Clinic	Susanso	Private	739355.260	656404.544
Manukure Clinic	Clinic	Bomso	Private	739368.703	657231.472
PPAG Teen's Centre	Clinic	Oforikrom	Private	739486.713	655586.048
New Era Clinic	Clinic	Ayigya	Private	739599.843	657623.281
St. Edward Clinic	Clinic	Amakom	Private	739665.818	653630.913
Oforikrom Clinic	Clinic	Oforikrom	Private	739686.548	655477.131
Peace Land Clinic	Clinic	South Suntreso	Private	739689.625	650281.049
Anwiam Clinic	Clinic	Afful Nkwanta	Private	739778.020	654593.531
Railway Clinic	Clinic	Railways Adum	Quasi Government	739910.653	652641.437
Dunkirk Clinic	Clinic	Bompata	Private	739932.995	652697.079
Asuoyeboa Clinic	Clinic	Asuoyeboa	Private	739936.486	647149.520
Emahata Clinic	Clinic	Kwadaso	Private	739965.098	648319.083
Rabito Clinic	Clinic	Adum	Private	740022.384	652239.134
Wesley Cathedral Clinic	Clinic	Adum	CHAG	740092.973	652174.816
Kumasi Female Prisons Clinic	Clinic	Adum	CHAG	740127.196	652154.820
Police Clinic	Clinic	Adum	Quasi Government	740136.037	651757.908



Girbrines Health Services and Clinic	Clinic	Akwatialine Zongo	Private	740222.954	653177.172
Faith Clinic	Clinic	Adum	Private	740244.196	652079.316
Rophii Hospital	Clinic	Akwatialine	Private	740253.512	653425.832
Kufour Clinic	Clinic	Adum	Private	740253.656	652311.205
Maranatha Maternity Clinic	Clinic	Asuoyeboa	Private	740362.148	647944.335
Assalam Clinic	Clinic	Akrome	Private	740567.360	655454.299
Prince of Peace Clinic	Clinic	Aboabo	Private	740711.721	654741.226
Dr. Osei Clinic	Clinic	Akrome	Private	740741.375	655810.095
Zongo Hill Clinic	Clinic	Manhyia Zongo	Private	740848.966	653227.366
VAG Clinic	Clinic	Manhyia	Private	740935.597	653361.995
Sir Gibrine Memorial Health Centre	Clinic	Asawase	Private	740956.845	654231.456
Sedom Clinic	Clinic	Bantama	Private	741111.461	651013.383
Safo Adu Clinic	Clinic	Manhyia	Private	741134.254	653226.560
Enec Dental Clinic	Clinic	Ash Town	Private	741173.930	652787.557
Kumasi Medical Centre	Clinic	Mbrom Dichemso	Private	741300.086	652035.453
Brainok Salvation Clinic	Clinic	Ash Town	Private	741328.204	652204.518
Bantama Clinic	Clinic	Bantama	Private	741364.132	650815.899
Clinic Ash Town Ltd.	Clinic	Ash Town	Private	741372.423	652593.534
Apatrapa Community Clinic	Clinic	Apatrapa	Government	741566.504	645563.156
Sir Gibrinnes Clinic	Clinic	Akrome	Private	741694.519	656963.833
Sir Gilbrenes Memorial Health Centre	Clinic	Sepe-Tinpom	Private	741694.519	656963.833
Bimpeh Hill Hospital Annex	Clinic	Ash Town	Private	741760.021	652627.776
Dr. Okyere Piese Clinic	Clinic	Dichemso	Private	742009.754	653909.497
Asihene's Clinic	Clinic	Krofrom	Private	742155.376	653399.448
Dr. Quaye Clinic	Clinic	Asuogya	Private	742198.945	650004.361
SOS Home Clinic	Clinic	New Suame	Private	742291.182	651361.641
St. Joseph Clinic	Clinic	Krofrom	Private	742538.265	653110.936
Kwesamkof New Tafo Clinic	Clinic	New Tafo	Private	742595.402	652952.537
PPAG Clinic	Clinic	New Suame	Private	742772.491	650676.005
New Tafo Clinic	Clinic	Tafo Nhyiaso	Private	742832.173	653420.746
Tafo Nhyiaeso Homeopatic Clinic	Clinic	Tafo Nhyiaeso	Private	742849.916	653438.383
Sepe Dote Clinic	Clinic	Sepe Dote	Private	742928.806	657039.852
God First Clinic	Clinic	Zone 3 Suame	Private	742970.615	651536.617
Sepe-Buokrom Community Clinic	Clinic	Buokrom	Government	743134.039	655196.409
Zion Hill Clinic	Clinic	Zone 5 - Suame	Private	743282.793	651271.328
Joy Maternity Home Clinic	Clinic	Maakro	Private	743421.199	650937.299
Matty Memorial Clinic	Clinic	Moshie Zongo	Private	743533.302	654608.247
Russia Clinic	Clinic	Moshie Zongo	Private	743688.688	654035.168
Dr. Brown Clinic	Clinic	Mile 3 Old Tafo	Private	743736.771	653055.587
Moshie Zongo Clinic	Clinic	Moshie Zongo	Private	743847.384	654234.806
Washington Clinic	Clinic	Old Tafo	Private	743973.184	653366.657
St. John's Clinic	Clinic	Old Tafo	Private	744020.566	652917.706



Cosmos Clinic	Clinic	Bremang - Azar Junction	Private	744157.592	651709.057
Mavelil Homoe Mission	Clinic	New Suame	Private	744294.911	650982.342
Histolic Adventist Clinic	Clinic	Maakro	CHAG	744380.851	650881.557
Medical Centre - ANNEX	Clinic	Osborn Junction - Suame	Private	744381.302	651437.594
Nkontwima Clinic	Clinic	Nkontwima-Bremang	Private	744392.430	651856.527
Suame Hospital	Clinic	Old Tafo	Private	744563.417	653277.651
St. Paul's Clinic	Clinic	Tafo Zongo	Private	744655.187	653663.192
Levenuel Clinic	Clinic	Nkontwima-Bremang	Private	744961.010	651538.774
Kumasi Medical Centre ANNEX	Clinic	Bremang	Private	745135.647	650722.477
Gansmen's Medical Centre	Clinic	Bremang North	Private	745232.976	651912.750
Yeji Medical Clinic	Clinic	Bremang	Private	745310.241	650284.241
Bremang Clinic	Clinic	Bremang	Private	745402.694	651316.448
Graceland Clinic	Clinic	Bremang	Private	745470.794	650758.019
Islamic Homoeopathic Clinic	Clinic	Pankrono Estate	Private(Islamic )	745588.142	654323.794
Pima Clinic	Clinic	Buokrom Estate	Private	745962.152	655566.330
Mintah Clinic	Clinic	UGC - Bremang	Private	746353.492	651257.403
Vincent Clinic	Clinic	Abed-Pankrono	Private	746678.829	653297.062
Ayeduasi Health Centre	Clinic	Ayeduase	Government	738167.009	659049.381
Kama Clinic	Clinic	Ash Town	Private	740716.929	652349.172
Central Male Prisons Clinic	Clinic	Adum	Quasi Government	740074.955	652093.471

## Appendix 2: Attributes of privately owned health facilities with their catchment areas

FACILITYNAME	TYPE	TOWN	OWNERSHIP	TRAVEL TIME	CAPACITY	CELL POP	CATCH POP	COEF POP	CALC TT
New Era Millennium Hospital	Hospital	Bokro-Atonsu	Private	60	38712	7	53241	38712	4
Animwaa Medical Centre	Hospital	Amena	Private	60	38712	9	42040	38712	3
Twumasi Memorial Hospital	Hospital	Asokwa	Private	60	38712	7	62163	38712	2
Trust Care Specialist Hospital	Hospital	South Suntreso	Private	60	38712	6	61884	38712	3
Peace and Love Hospital	Hospital	Oduom	Private	60	38712	9	52024	38712	3
Hebrona Hospital	Hospital	Abrepo-Junction	Private	60	38712	0	80557	38712	6
St. Anthony Hospital	Hospital	Asuogya	Private	60	38712	0	39517	38712	6
Oforikrom Clinic	Clinic	Oforikrom	Private	60	16183	9	24026	16183	1
Dunkirk Clinic	Clinic	Bompata	Private	60	16183	19	54124	16183	1
Rabito Clinic	Clinic	Adum	Private	60	16183	0	30083	16183	1
Rophii Hospital	Clinic	Akwatiline	Private	60	16183	0	23724	16183	1



Kufour Clinic	Clinic	Adum	Private	60	16183	0	74062	16183	2
Maranatha Maternity Clinic	Clinic	Asuoyeboa	Private	60	16183	8	26524	16183	2
Assalam Clinic	Clinic	Akrome	Private	60	16183	0	21074	16183	1
Prince of Peace Clinic	Clinic	Aboabo	Private	60	16183	0	35701	16183	2
Dr. Osei Clinic	Clinic	Akrome	Private	60	16183	0	18552	16183	2
Zongo Hill Clinic	Clinic	Manhyia Zongo	Private	60	16183	0	44707	16183	2
Sir Gibrine Memorial Health Centre	Clinic	Asawase	Private	60	16183	0	23724	16183	2
Sedom Clinic	Clinic	Bantama	Private	60	16183	0	30175	16183	1
Safo Adu Clinic	Clinic	Manhyia	Private	60	16183	0	60146	16183	3
Enec Dental Clinic	Clinic	Ash Town	Private	60	16183	0	53644	16183	3
Kumasi Medical Centre	Clinic	Mbrom Dichemso	Private	60	16183	0	45092	16183	3
Brainok Salvation Clinic	Clinic	Ash Town	Private	60	16183	0	39942	16183	3
Clinic Ash Town Ltd.	Clinic	Ash Town	Private	60	16183	0	26805	16183	3
Sir Gibrinnes Clinic	Clinic	Akrome	Private	60	16183	14	29413	16183	2
Sir Gilbrenes Memorial Health Centre	Clinic	Sepe-Tinpom	Private	60	16183	0	41997	16183	3
Bimpeh Hill Hospital Annex	Clinic	Ash Town	Private	60	16183	0	22104	16183	3
Dr. Okyere Piese Clinic	Clinic	Dichemso	Private	60	16183	0	19153	16183	3
Asihene's Clinic	Clinic	Krofrom	Private	60	16183	0	36738	16183	4
Dr. Quaye Clinic	Clinic	Asuogya	Private	60	16183	17	20175	16183	1
SOS Home Clinic	Clinic	New Suame	Private	60	16183	0	36594	16183	3
Kwesamkof New Tafo Clinic	Clinic	New Tafo	Private	60	16183	0	38691	16183	4
PPAG Clinic	Clinic	New Suame	Private	60	16183	0	34427	16183	3
New Tafo Clinic	Clinic	Tafo Nhyiaso	Private	60	16183	0	29148	16183	5
Tafo Nhyiaeso Homeopathic Clinic	Clinic	Tafo Nhyiaeso	Private	60	16183	0	64628	16183	6
God First Clinic	Clinic	Zone 3 Suame	Private	60	16183	0	18812	16183	3
Zion Hill Clinic	Clinic	Zone 5 Suame	Private	60	16183	0	18165	16183	3
Joy Maternity Home Clinic	Clinic	Maakro	Private	60	16183	0	17089	16183	3
Dr. Brown Clinic	Clinic	Mile 3 Old Tafo	Private	60	16183	0	60884	16183	4
Moshie Zongo Clinic	Clinic	Moshie Zongo	Private	60	16183	26	19825	16183	3
Washington Clinic	Clinic	Old Tafo	Private	60	16183	0	19528	16183	3
St. John's Clinic	Clinic	Old Tafo	Private	60	16183	0	52427	16183	4
Cosmos Clinic	Clinic	Bremang Azar Junction	Private	60	16183	0	17669	16183	6
Medical Centre - ANNEX	Clinic	Osborn Junction Suame	Private	60	16183	0	36288	16183	8
Nkontwima Clinic	Clinic	Nkontwima-Bremang	Private	60	16183	0	28237	16183	7



Suame Hospital	Clinic	Old Tafo	Private	60	16183	0	26512	16183	4
St. Paul's Clinic	Clinic	Tafo Zongo	Private	60	16183	0	42028	16183	5
Levenuel Clinic	Clinic	Nkontwima-Bremang	Private	60	16183	0	19219	16183	4
Gansmen's Medical Centre	Clinic	Bremang North	Private	60	16183	0	27763	16183	5
Yeji Medical Clinic	Clinic	Bremang	Private	60	16183	0	30042	16183	4
Graceland Clinic	Clinic	Bremang	Private	60	16183	0	35130	16183	5
Islamic Homoeopathic Clinic	Clinic	Pankrono Estate	Private(Islamic )	60	16183	0	30776	16183	5
Pima Clinic	Clinic	Buokrom Estate	Private	60	16183	0	16938	16183	5
Vincent Clinic	Clinic	Abed-Pankrono	Private	60	16183	0	24232	16183	9
Kama Clinic	Clinic	Ash Town	Private	60	16183	0	48432	16183	3
Queens Hospital	Hospital	Dompoase	Private	60	38712	7	39513	38712	5
Atasemanso Hospital	Hospital	Atasemanso	Private	60	38712	6	55046	38712	4
Washie Hospital	Hospital	Ahodwo Kumasi	Private	60	38712	6	43209	38712	4
St. Marku's Hospital	Hospital	Asokwa	Private	60	38712	7	46758	38712	3
City Hospital	Hospital	Stadium	Private	60	38712	0	43123	38712	2
Bomso Specialist Hospital	Hospital	Bomso	Private	60	38712	9	43128	38712	2
Kyei Memorial Hospital	Hospital	Akwatiline	Private	60	38712	19	64010	38712	2
Quality Health Care Ltd.	Hospital	Kentinkrono	Private	60	38712	9	46238	38712	3
Siloam Hospital	Hospital	Kwadaso	Private	60	38712	8	55100	38712	3
Wilben Dental Clinic	Hospital	Dr. Mensah - Ash Town	Private	60	38712	0	66089	38712	2
Mbrom Hospital	Hospital	Mbrom Dichemso	Private	60	38712	0	42581	38712	2
Wisdom Hospital	Hospital	Dichemso	Private	60	38712	11	72271	38712	3
County Hospital	Hospital	Abrepo	Private	60	38712	17	59762	38712	2
Naka and St. Ama Hospital	Hospital	Buokrom	Private	60	38712	11	41543	38712	2
Rophi Hospital	Hospital	Old Tafo	Private	60	38712	26	72403	38712	2
Keffam Hospital	Hospital	Buokrom Estate	Private	60	38712	11	45359	38712	3
Siaw Larbi Hospital	Hospital	Mile 4 - Tafo	Private	60	38712	98	70821	38712	2
Atsyor Hospital Complex	Hospital	Atafoa-Pankrono	Private	60	38712	14	63317	38712	6
Animah Clinic	Clinic	S-line Atonsus	Private	60	16183	7	32953	16183	3
Kaase Maternity Home	Clinic	Kaase	Private	60	16183	7	23425	16183	2
Lake Road Clinic	Clinic	Atonsus	Private	60	16183	0	27862	16183	3
Peace Homoeo Medical Clinic	Clinic	Agric Nzema	Private	60	16183	8	23167	16183	2
PPAG Teen's Centre	Clinic	Oforikrom	Private	60	16183	9	22568	16183	1
Sepe Dote Clinic	Clinic	Sepe Dote	Private	60	16183	14	25153	16183	2
Mavelil Homoe Mission	Clinic	New Suame	Private	60	16183	14	20679	16183	1
Bremang Clinic	Clinic	Bremang	Private	60	16183	14	25397	16183	1
Poku Transport Hospital	Hospital	Asokwa	Private	60	38712	7	54869	38712	2



Gloria Memorial Hospital	Hospital	Akwatiline	Private	60	38712	19	49147	38712	1
New Town Hospital	Hospital	Dr. Mensah-Ash Town	Private	60	38712	11	39519	38712	1
Charity Hospital	Hospital	Kropo	Private	60	38712	17	49163	38712	2
St. Anne's Clinic	Clinic	Atonsu	Private	60	16183	7	16452	16183	2
Complementary Clinic	Clinic	Gyinase	Private	60	16183	9	25520	16183	2
Christ the King Clinic	Clinic	Ahinsan	Private	60	16183	7	19347	16183	2
Bilsons Allens Clinic	Clinic	Ahinsan	Private	60	16183	9	23117	16183	2
Sunkwa Clinic	Clinic	Anloga	Private	60	16183	9	23580	16183	3
Ebenezer Clinic	Clinic	Anloga	Private	60	16183	0	32500	16183	4
Bimpeh Hill Clinic	Clinic	New Amakom	Private	60	16183	0	31347	16183	3
Yentumi Boitey Memorial Clinic	Clinic	Susanso	Private	60	16183	0	22484	16183	2
Manukure Clinic	Clinic	Bomso	Private	60	16183	0	22394	16183	2
New Era Clinic	Clinic	Ayigya	Private	60	16183	0	34434	16183	3
St. Edward Clinic	Clinic	Amakom	Private	60	16183	0	28577	16183	2
Peace Land Clinic	Clinic	South Suntreso	Private	60	16183	6	47643	16183	2
Anwiam Clinic	Clinic	Afful Nkwanta	Private	60	16183	0	22452	16183	3
Asuoyeboa Clinic	Clinic	Asuoyeboa	Private	60	16183	8	30419	16183	3
Emahata Clinic	Clinic	Kwadaso	Private	60	16183	8	27270	16183	2
Girbrines Health Services and Clinic	Clinic	Akwatiline Zongo	Private	60	16183	0	46185	16183	3
Faith Clinic	Clinic	Adum	Private	60	16183	0	25845	16183	2
VAG Clinic	Clinic	Manhyia	Private	60	16183	0	43717	16183	3
Bantama Clinic	Clinic	Bantama	Private	60	16183	17	28984	16183	1
St. Joseph Clinic	Clinic	Krofrom	Private	60	16183	26	21301	16183	1
Matty Memorial Clinic	Clinic	Moshie Zongo	Private	60	16183	11	25921	16183	2
Russia Clinic	Clinic	Moshie Zongo	Private	60	16183	0	27814	16183	2
Kumasi Medical Centre ANNEX	Clinic	Bremang	Private	60	16183	14	25092	16183	1
Mintah Clinic	Clinic	UGC Bremang	Private	60	16183	14	25468	16183	2

**Appendix 3: Attributes of all health facilities and their catchment areas**

FACILITY NAME	TYPE	TOWN	OWNERSHIP	TRAVEL TIME	CAPACITY	CELL POP	CATCH POP	COEF POP	CALC TT
Queens Hospital	Hospital	Dompoase	Private	60	38712	7	46739	38712	4
New Era Millennium Hospital	Hospital	Bokro-Atonsu	Private	60	38712	0	54976	38712	6
Atasemanso Hospital	Hospital	Atasemanso	Private	60	38712	6	55046	38712	4
Kumasi South Hospital	Hospital	Atonsu-Agogo	Government	60	38712	0	56709	38712	6
Washie Hospital	Hospital	Ahodwo Kumasi	Private	60	38712	6	44448	38712	4
Animwaa Medical Centre	Hospital	Amena	Private	60	38712	9	42040	38712	3
St. Marku's Hospital	Hospital	Asokwa	Private	60	38712	0	68962	38712	4



Twumasi Memorial Hospital	Hospital	Asokwa	Private	60	38712	0	81606	38712	4
Poku Transport Hospital	Hospital	Asokwa	Private	60	38712	0	94823	38712	5
City Hospital	Hospital	Stadium	Private	60	38712	0	60214	38712	4
SDA Hospital	Hospital	Onwe	CHAG	60	38712	5	59374	38712	4
KNUST Hospital	Hospital	Ayigya	Others	60	38712	9	47881	38712	2
Bomso Specialist Hospital	Hospital	Bomso	Private	60	38712	0	53651	38712	4
Trust Care Specialist Hospital	Hospital	South Suntreso	Private	60	38712	6	48853	38712	2
Maternal and Child Health Hospital	Hospital	Adum	Government	60	38712	19	44429	38712	2
Gloria Memorial Hospital	Hospital	Akwatiale	Private	60	38712	0	40385	38712	3
Kyei Memorial Hospital	Hospital	Akwatiale	Private	60	38712	0	78006	38712	5
Quality Health Care Ltd.	Hospital	Kentinkrono	Private	60	38712	21	39830	38712	4
Peace and Love Hospital	Hospital	Oduom	Private	60	38712	0	48371	38712	6
New Town Hospital	Hospital	Dr. Mensah-Ash Town	Private	60	38712	0	69117	38712	4
Siloam Hospital	Hospital	Kwadaso	Private	60	38712	8	52687	38712	3
Wilben Dental Clinic	Hospital	Dr. Mensah - Ash Town	Private	60	38712	0	100152	38712	5
Suntreso Government Hospital	Hospital	North Suntreso	Government	60	38712	0	49875	38712	4
Manhyia Hospital	Hospital	Manhyia	Government	60	38712	0	52666	38712	5
Mbrom Hospital	Hospital	Mbrom Dichemso	Private	60	38712	0	58116	38712	5
Wisdom Hospital	Hospital	Dichemso	Private	60	38712	0	76287	38712	6
Hebrona Hospital	Hospital	Abrepo Junction	Private	60	38712	0	63129	38712	6
Charity Hospital	Hospital	Kropo	Private	60	38712	0	47463	38712	5
Tafo Hospital	Hospital	Tafo	Government	60	38712	0	71284	38712	4
St. Anthony Hospital	Hospital	Asuogya	Private	60	38712	0	61046	38712	5
County Hospital	Hospital	Abrepo	Private	60	38712	0	42331	38712	6
Naka and St. Ama Hospital	Hospital	Buokrom	Private	60	38712	0	56157	38712	3
Rophi Hospital	Hospital	Old Tafo	Private	60	38712	0	82859	38712	4
Keffam Hospital	Hospital	Buokrom Estate	Private	60	38712	11	50972	38712	4
Siaw Larbi Hospital	Hospital	Mile 4 - Tafo	Private	60	38712	0	41385	38712	3
Atsior Hospital Complex	Hospital	Atafoa-Pankrono	Private	60	38712	2	57479	38712	9
Habitat Sawmill Clinic	Clinic	Kaase	Others	60	16183	7	23967	16183	8
St. Anne's Clinic	Clinic	Atonsus	Private	60	16183	0	19962	16183	8
Animah Clinic	Clinic	S-line Atonsus	Private	60	16183	0	18186	16183	8
Ghana Guinness Breweries Group Clinic	Clinic	Ahinsan	Others	60	16183	0	21805	16183	9
Kaase Maternity Home	Clinic	Kaase	Private	60	16183	0	23566	16183	10
Omega Sawmill	Clinic	Kaase	Others	60	16183	0	28641	16183	10



Lake Road Clinic	Clinic	Atonsua	Private	60	16183	0	24699	16183	8
Complementary Clinic	Clinic	Gyinaase	Private	60	16183	0	17311	16183	6
Christ the King Clinic	Clinic	Ahinsan	Private	60	16183	0	21689	16183	10
Bibiani Logging and Lumber Company Clinic	Clinic	Kaase	Others	60	16183	0	40535	16183	11
Ghana Brewery Clinic	Clinic	Ahinsan	Others	60	16183	0	18658	16183	11
Coca Cola Bottling Clinic	Clinic	Ahinsan	Others	60	16183	0	19147	16183	11
JCM Company Clinic	Clinic	Asokwa	Others	60	16183	0	17526	16183	11
Paul Sagoe Sawmill Clinic	Clinic	Asokwa	Others	60	16183	0	19255	16183	11
Peace Homoeo Medical Clinic	Clinic	Agric Nzema	Private	60	16183	8	18534	16183	3
Atwima Timbers Clinic	Clinic	Asokwa	Others	60	16183	0	30111	16183	12
Bilsons Allens Clinic	Clinic	Ahinsan	Private	60	16183	0	22506	16183	10
Logs Logging and Lumber Clinic	Clinic	Asokwa	Others	60	16183	0	36168	16183	12
Sunkwa Clinic	Clinic	Anloga	Private	60	16183	0	27293	16183	11
Ebenezer Clinic	Clinic	Anloga	Private	60	16183	0	32374	16183	12
Bimpeh Hill Clinic	Clinic	New Amakom	Private	60	16183	0	24143	16183	12
Cocoa Clinic	Clinic	Cocobod-Adum	Others	60	16183	0	19940	16183	12
KMA Clinic	Clinic	Adum	Government	60	16183	0	22604	16183	12
Church of Christ Mission	Clinic	Bomso	CHAG	60	16183	0	30279	16183	11
Yentumi Boitey Memorial Clinic	Clinic	Susanso	Private	60	16183	0	19026	16183	12
Manukure Clinic	Clinic	Bomso	Private	60	16183	0	19978	16183	12
PPAG Teen's Centre	Clinic	Oforikrom	Private	60	16183	0	18314	16183	13
New Era Clinic	Clinic	Ayigya	Private	60	16183	0	18328	16183	14
St. Edward Clinic	Clinic	Amakom	Private	60	16183	0	23834	16183	14
Oforikrom Clinic	Clinic	Oforikrom	Private	60	16183	0	24690	16183	17
Peace Land Clinic	Clinic	South Suntreso	Private	60	16183	0	28595	16183	10
Anwiam Clinic	Clinic	Afful Nkwanta	Private	60	16183	0	17011	16183	17
Railway Clinic	Clinic	Railways Adum	Quasi Government	60	16183	0	41888	16183	15
Dunkirk Clinic	Clinic	Bompata	Private	60	16183	0	24040	16183	15
Asuoyeboa Clinic	Clinic	Asuoyeboa	Private	60	16183	0	17751	16183	8
Emahata Clinic	Clinic	Kwadaso	Private	60	16183	0	22570	16183	19
Rabito Clinic	Clinic	Adum	Private	60	16183	0	18350	16183	17
Wesley Cathedral Clinic	Clinic	Adum	CHAG	60	16183	0	17461	16183	18
Kumasi Female Prisons Clinic	Clinic	Adum	CHAG	60	16183	0	16826	16183	27
Police Clinic	Clinic	Adum	Quasi Government	60	16183	0	4810	4810	60
Girbrines Health Services and Clinic	Clinic	Akwatiline Zongo	Private	60	16183	0	0	0	60



Faith Clinic	Clinic	Adum	Private	60	16183	0	0	0	60
Rophii Hospital	Clinic	Akwatiline	Private	60	16183	0	0	0	60
Kufour Clinic	Clinic	Adum	Private	60	16183	0	0	0	60
Maranatha Maternity Clinic	Clinic	Asuoyeboa	Private	60	16183	0	0	0	60
Assalam Clinic	Clinic	Akrome	Private	60	16183	0	0	0	60
Prince of Peace Clinic	Clinic	Aboabo	Private	60	16183	0	0	0	60
Dr. Osei Clinic	Clinic	Akrome	Private	60	16183	0	0	0	60
Zongo Hill Clinic	Clinic	Manhyia Zongo	Private	60	16183	0	0	0	60
VAG Clinic	Clinic	Manhyia	Private	60	16183	0	0	0	60
Sir Gibrine Memorial Health Centre	Clinic	Asawase	Private	60	16183	0	0	0	60
Sedom Clinic	Clinic	Bantama	Private	60	16183	0	0	0	60
Safo Adu Clinic	Clinic	Manhyia	Private	60	16183	0	0	0	60
Enec Dental Clinic	Clinic	Ash Town	Private	60	16183	0	0	0	60
Kumasi Medical Centre	Clinic	Mbrom Dichemso	Private	60	16183	0	0	0	60
Brainok Salvation Clinic	Clinic	Ash Town	Private	60	16183	0	0	0	60
Bantama Clinic	Clinic	Bantama	Private	60	16183	0	0	0	60
Clinic Ash Town Ltd.	Clinic	Ash Town	Private	60	16183	0	0	0	60
Apatrapa Community Clinic	Clinic	Apatrapa	Government	60	16183	0	0	0	60
Sir Gibrinnes Clinic	Clinic	Akrome	Private	60	16183	0	0	0	60
Sir Gilbrenes Memorial Health Centre	Clinic	Sepe-Tinpom	Private	60	16183	0	0	0	60
Bimpeh Hill Hospital Annex	Clinic	Ash Town	Private	60	16183	0	0	0	60
Dr. Okyere Piese Clinic	Clinic	Dichemso	Private	60	16183	0	0	0	60
Asihene's Clinic	Clinic	Krofrom	Private	60	16183	0	0	0	60
Dr. Quayee Clinic	Clinic	Asuogya	Private	60	16183	0	0	0	60
SOS Home Clinic	Clinic	New Suame	Private	60	16183	0	0	0	60
St. Joseph Clinic	Clinic	Krofrom	Private	60	16183	0	0	0	60
Kwesamkof New Tafo Clinic	Clinic	New Tafo	Private	60	16183	0	0	0	60
PPAG Clinic	Clinic	New Suame	Private	60	16183	0	0	0	60
New Tafo Clinic	Clinic	Tafo Nhyiaso	Private	60	16183	0	0	0	60
Tafo Nhyiaeso Homeopathic Clinic	Clinic	Tafo Nhyiaeso	Private	60	16183	0	0	0	60
Sepe Dote Clinic	Clinic	Sepe Dote	Private	60	16183	0	0	0	60
God First Clinic	Clinic	Zone 3 Suame	Private	60	16183	0	0	0	60
Sepe-Buokrom Community Clinic	Clinic	Buokrom	Government	60	16183	0	0	0	60
Zion Hill Clinic	Clinic	Zone 5 - Suame	Private	60	16183	0	0	0	60
Joy Maternity Home Clinic	Clinic	Maakro	Private	60	16183	0	0	0	60
Matty Memorial Clinic	Clinic	Moshie Zongo	Private	60	16183	0	0	0	60



Russia Clinic	Clinic	Moshie Zongo	Private	60	16183	0	0	0	60
Dr. Brown Clinic	Clinic	Mile 3 Old Tafo	Private	60	16183	0	0	0	60
Moshie Zongo Clinic	Clinic	Moshie Zongo	Private	60	16183	0	0	0	60
Washington Clinic	Clinic	Old Tafo	Private	60	16183	0	0	0	60
St. John's Clinic	Clinic	Old Tafo	Private	60	16183	0	0	0	60
Cosmos Clinic	Clinic	Bremang - Azar Junction	Private	60	16183	0	0	0	60
Mavelil Homoe Mission	Clinic	New Suame	Private	60	16183	0	0	0	60
Histolic Adventist Clinic	Clinic	Maakro	CHAG	60	16183	0	0	0	60
Medical Centre - ANNEX	Clinic	Osborn Junction - Suame	Private	60	16183	0	0	0	60
Nkontwima Clinic	Clinic	Nkontwima-Bremang	Private	60	16183	0	0	0	60
Suame Hospital	Clinic	Old Tafo	Private	60	16183	0	0	0	60
St. Paul's Clinic	Clinic	Tafo Zongo	Private	60	16183	0	0	0	60
Levenuel Clinic	Clinic	Nkontwima-Bremang	Private	60	16183	0	0	0	60
Kumasi Medical Centre ANNEX	Clinic	Bremang	Private	60	16183	0	0	0	60
Gansmen's Medical Centre	Clinic	Bremang North	Private	60	16183	0	0	0	60
Yeji Medical Clinic	Clinic	Bremang	Private	60	16183	0	0	0	60
Bremang Clinic	Clinic	Bremang	Private	60	16183	0	0	0	60
Graceland Clinic	Clinic	Bremang	Private	60	16183	0	0	0	60
Islamic Homoeopathic Clinic	Clinic	Pankrono Estate	Private(Islamic )	60	16183	0	0	0	60
Pima Clinic	Clinic	Buokrom Estate	Private	60	16183	0	0	0	60
Mintah Clinic	Clinic	UGC - Bremang	Private	60	16183	0	0	0	60
Vincent Clinic	Clinic	Abed-Pankrono	Private	60	16183	0	0	0	60
Ayeduasi Health Centre	Clinic	Ayeduase	Government	60	5394	0	0	0	60
Kama Clinic	Clinic	Ash Town	Private	60	16183	0	0	0	60
Central Male Prisons Clinic	Clinic	Adum	Quasi Government	60	16183	0	0	0	60