Application of Remote Sensing and Geographic Information Systems Techniques in Health Care Distribution and Accessibility in the Upper West Region of Ghana

Albert Angzenaa[*1]

International Fertilizer Development Center(IFDC)-Tamale, Ghana
Monitoring and Evaluation Unit
December 1, 2016

Summary

This paper seeks to provide an insight on how accessibility can be improved using a combination of GIS, remote sensing and programming techniques. Data obtain from both primary and secondary source were properly analysed to provide recommendations to tackle the inaccessibility problem in the study area. Satellite image of the study area was classified to isolate settlements, population data was redistributed over the classified areas in R programming by using "pynco" function to create a demand area- Pycnophylactic Interpolation and Network analysis tool was employed using the health facilities as the supply area to determine the population will access to health facilities.

KEYWORDS: GIS, Remote Sensing, Health, Image Classification, Network Analysis, Pycnophylactic Interpolation, R Programming.

1. Introduction

Ghana's population, which was estimated at 18.83 million in the 2000 population and Housing Census, experienced a 22.35% increase in the 2010 population and housing census. With a population growth rate of 2.1%, and the limited resources at the disposal of the country, it is highly necessary to address the needs of the country prudently.

The health of a nation is said to be the wealth of the nation. Developing countries are widely known for their abundance of physical labour both skilled and non-skilled. However, government agencies in third world countries face a common problem of limited resources.

The application and uses of Geographic Information Science/System (GIS) has provided more pragmatic alternatives to solving the world's problems from a spatial and geographical perspective.

Spatial analyst fall into the temptation of using centroids of census areas for analysis when analysing accessibility. The ideal that the population is not focused in one location provides the rational to consider some Remote Sensing techniques to evaluating the accessibility situation.

Remote sensing techniques and principles such as dasymeteric mapping has made population disaggregation very useful in studying how various groups of people have access to public facilities such as public health (Tapp, 2010). This technique has not only helped to reduce the margin of error but also has been useful in resisting a fallacy of generalisation that location is centred in one place (as observed in the used of population centroids).

This process and Pycnophylactic (an areal interpolation technique which reassigns population densities to where they are needed, since population does not occur in places other than residential areas) is a very useful approach to addressing access from demand to supply areas (Mohammed, Comber and Brunsdon, 2012). The technique, which makes a practical combination of judicious skills and principles, is being projected as an accurate approach to estimating population of smaller areas mapping and analysing accessibility (Qiu and Cromley, 2013).

Accessibility is one challenge in the health sector. Rural dwellers are the hardest hit in this case

[*] albertangzenaa@yahoo.com

scenario. In some cases, people have to walk over 20km to access health care.

2. Background

The purpose of this research is to evaluate the accessibility situation of health care facilities to the people in the Upper West Region, Ghana, using remote sensing and Geographic Information System Techniques. Using remote sensing techniques, demand areas would be created based on a classification of residential and non-residential areas. This paper seeks to investigate whether health facilities are accessible within planning guidelines and to find out if the health facilities serve their capacity at their current location. It will also investigate which health facilities are easily accessible and how many people access them.

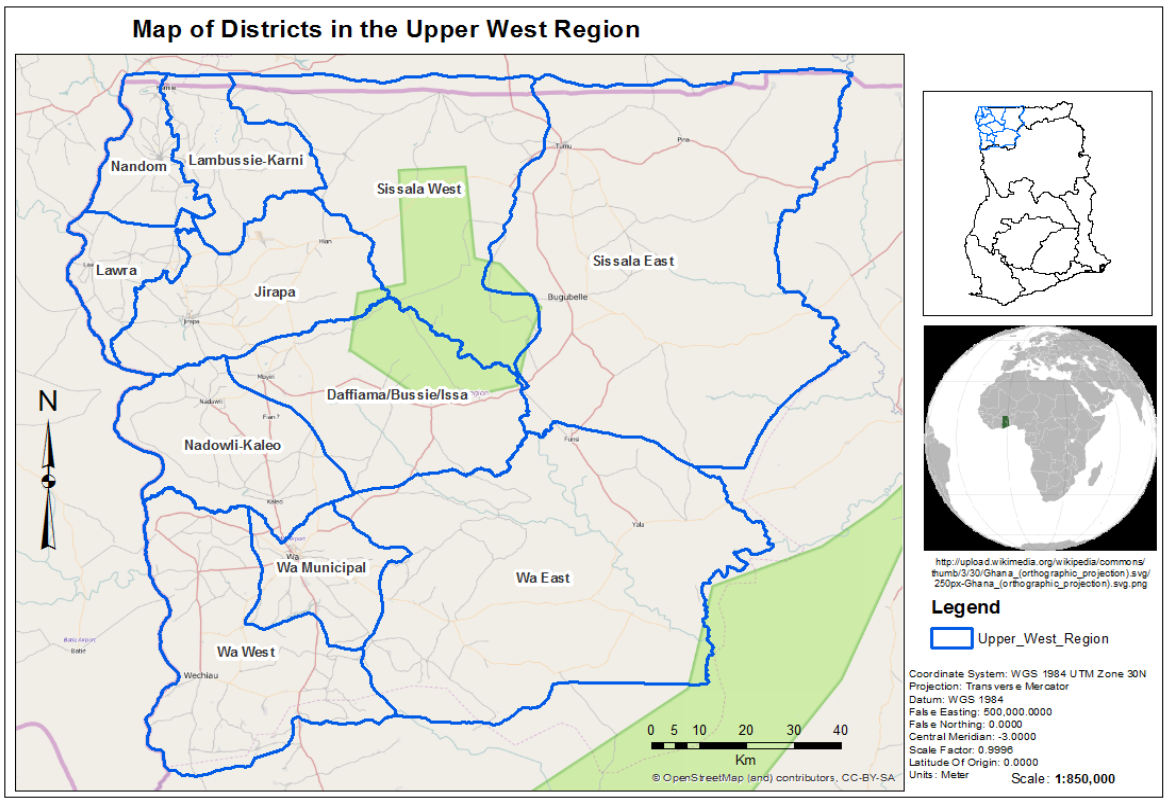

Figure 1District Map of the Upper West Region

2.1 Upper West Region

The Upper West Region is situated in the North-Western part of Ghana. It lies between longitudes 1º25'' W and 2º 45'' and latitudes 9º 30'' N and 11ºN. It is bordered to the south by the Northern region, to the North and West by Burkina Faso, and to the east by the Upper East region (UER). It has one municipality and 10 districts and has a land area which is 12.7 % (about 18,476 square kilometres) of the entire land area of Ghana, making the region the 7th largely ranked region of Ghana. The Upper West Region has a population size of about 702,110 people (Ghana Census, 2010) and is one of the lesser populated regions. There are 175 health facilities in the region, which provide a variety of health care services to the population and are either privately or government owned. Also across the region are a good number of trained and certified traditional healers, who treat their patients with natural and raw materials.

3. Data and Method

Remote Sensing (Image Classification)- A Landsat 8 image was downloaded from http://landsat.usgs.gov/ for this process. The image was proposed and subset using the shapefile of the study area which was converted to an aoi file. It went through an image classification process using coordinates obtained from the field and Google Earth. Five classes were created and the class

labelled “Settlement” was selected as the built-up areas. Image pre-processing makes it possible for the provision of dataset, which can be useful for extracting accurate spatial information (Chang, 2012). It is useful because the remote sensing techniques used require a digital image data which is in an accessible file format with relevant and accurate meta-data (Teillet, 1986).

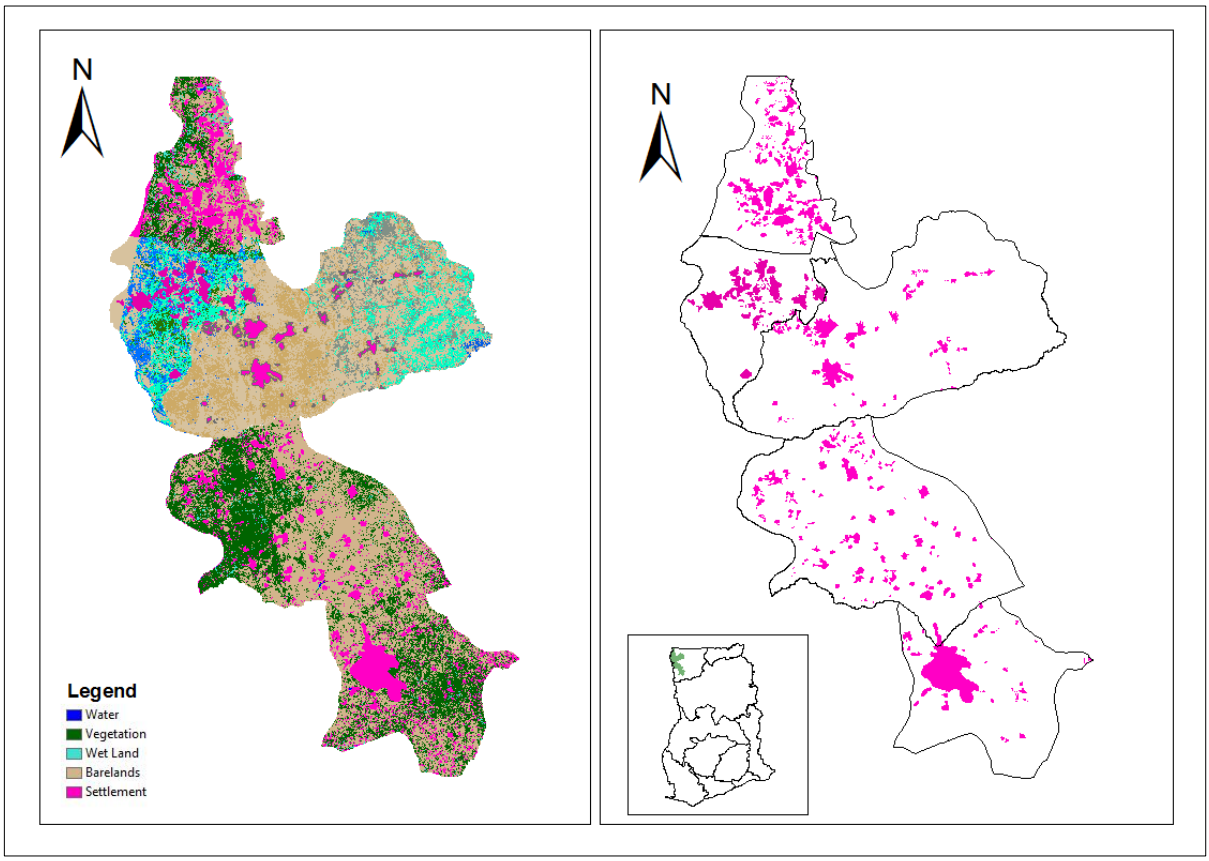

Figure 2 Map of Settlement areas (Demand Area)

R Programming (Pycnophylactic Interpolation)- The process of Pycnophylactic interpolation is a technique which produces a spatial grid data frame by using Tolber’s interpolation algorithm, to compute the population density estimates of area given a set of census of data of the area. This is derived by allocating values to each pixel over the census area which adds up to the initial population of the population census area.

A pycno function designed by Chris Brundson (Brunsdon, 2014) to the dataset (polygon shapefile and population data of the study area) in R programming language. The method of Pycnophylactic interpolation requires the user to pre-install the “Pycno” and “GISTool” packages in the R programming language (Brunsdon, 2014). This process produced population density estimates for the study area

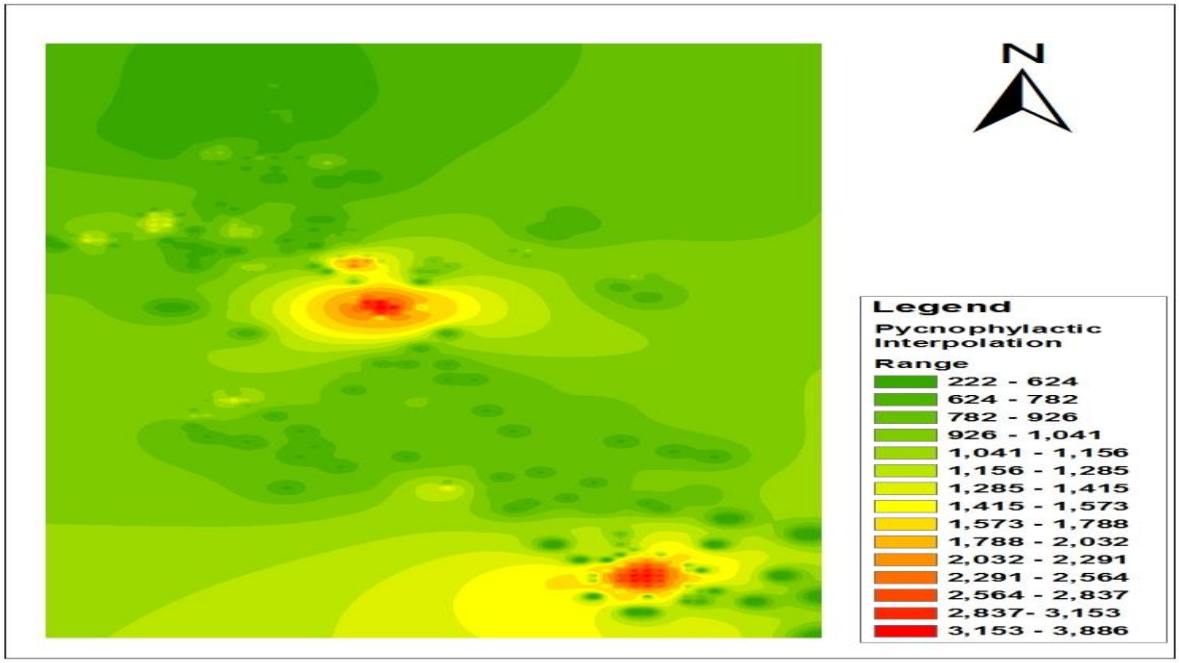

Figure 3 Results of Pycnophylactic interpolation

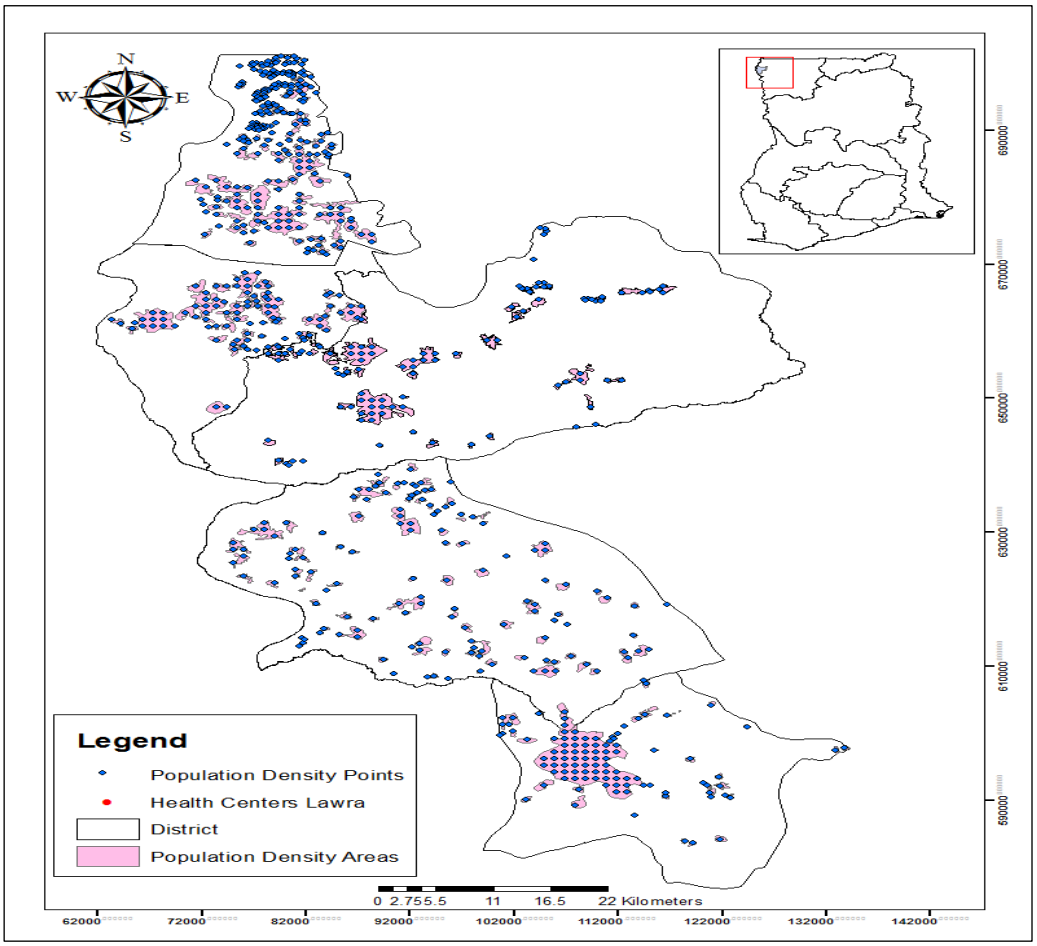

Figure 4 Map of Population Density Points

GIS (Network Analysis)- Network analysis is used in solving transportation analysis problems using

dataset which represents the real-live datasets. It uses algorithms to find best routes to and from demand areas or points and service facilities. Network analyses in ArcGIS enable users to find the closest services facilities to the demand areas. In order to study the accessibility situation for the study area, it was important to use the Location-Allocation tool in the Network analysis. The fifty-five (55) health care facilities across the five districts represent the supply areas for the purposes of this analysis in the research.

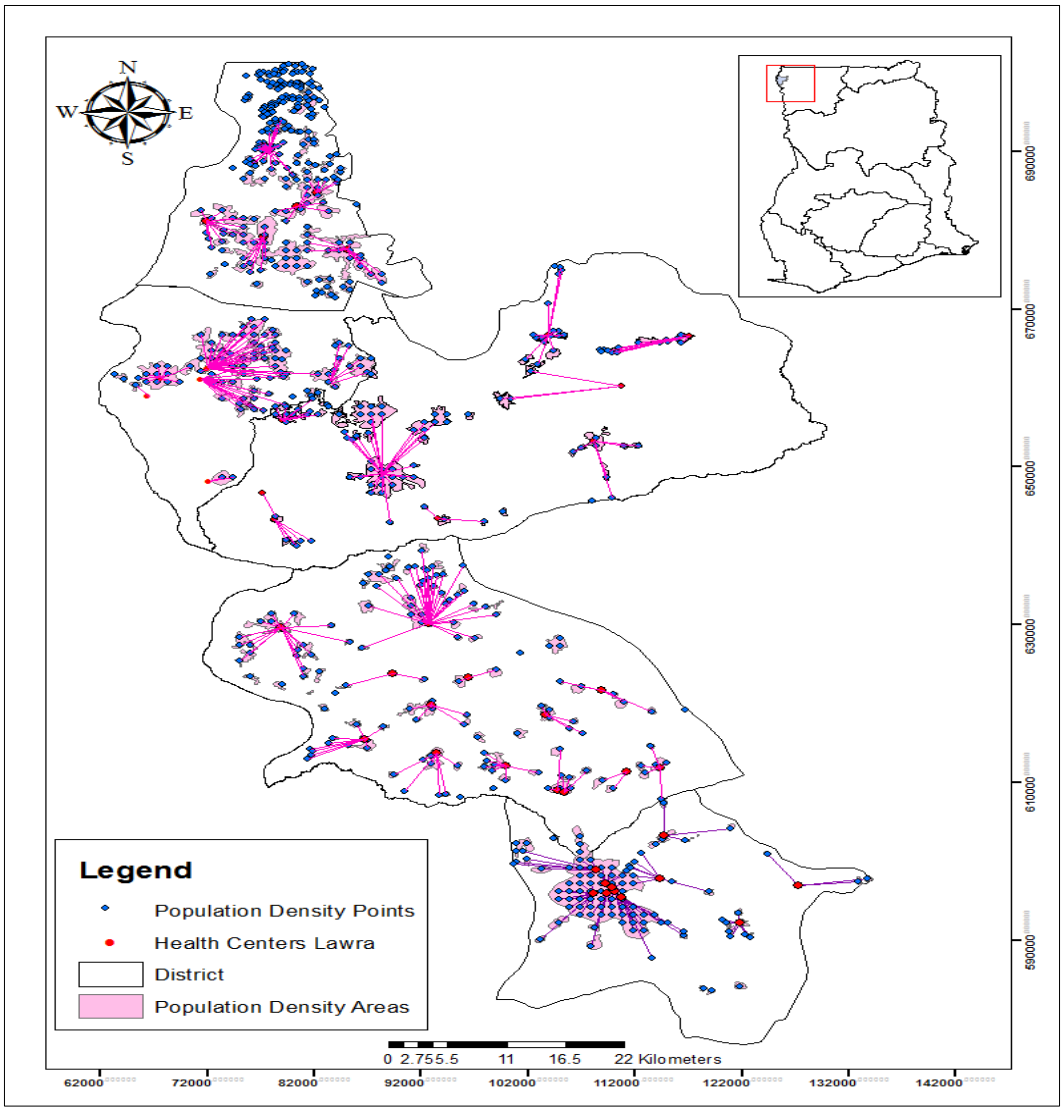

Figure 5 Map of Health facilities to Demand Areas pink lines denotes lines of service or access created using Location-Allocation analysis in the Network Analyst Tools.

District	Hospital	Health Centre	CHPS	Clinic	RCH	Maternity Home	Total
Wa Municipality	3	3	2	4	1	1	14
Nandom	1	4	0	0	1	1	7
Lawra	1	4	2	0	1	0	8
Kalea/Nadowli	2	6	7	0	1	0	16
Jirapa	1	6	3	0	0	0	10
Total							55

Figure 6 Distribution of Health Care Facilities in Districts of Study Area

Population of Upper West Region (2010)	
District	All localities Total
Wa West	81,348
Wa Municipality	107,214
Wa East	72,074
Sissala East	56,528
Kaleo/Nadowli	94,388
Jirapa	88,402
Sissala West	49,573
Lambussie Karni	51,654
Lawra	100,929
Total	702,110

Figure 7 Population of Upper West Region (2010)

4. Analysis

The total land area of the Upper West Region is 18476 kilometres squared and the total land area of the study area is 7320 kilometres squared. The results shown above indicated a populated land area of an estimated 355.60 kilometres squared which represents 5% of the study area and 2% off the entire Upper West Region. It means that the population of the research area (702,110) is distributed over an area of 355.60 kilometres squared. The remaining 95% of the study area is made up of water bodies, wet lands, bare lands, vegetative areas among others.

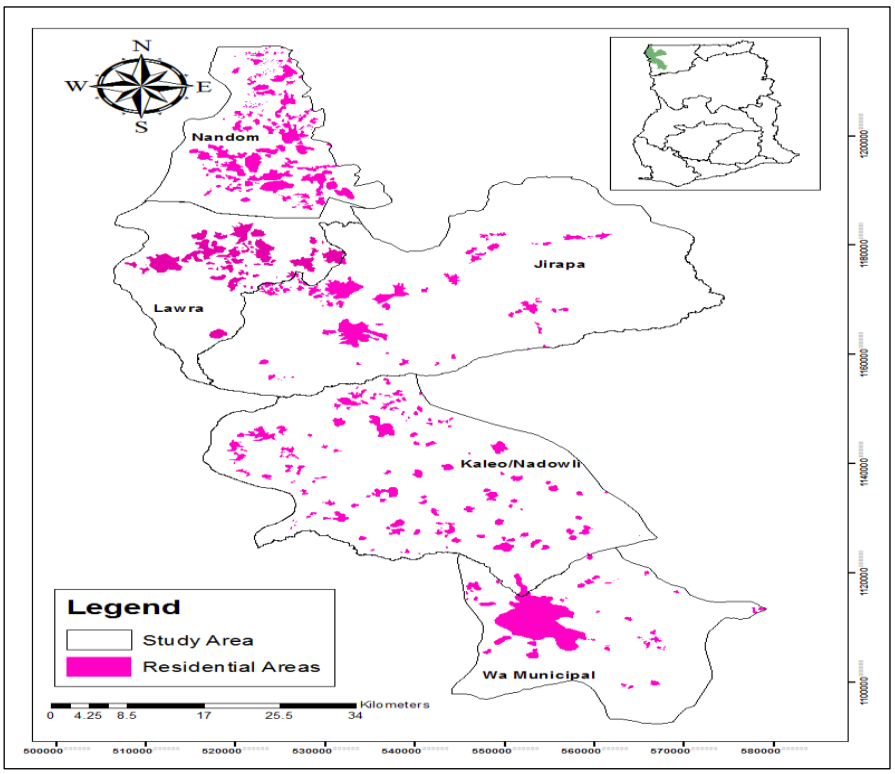

Figure 8 Map of Settlement Areas

Wa Municipality has a large proportion of its population concentrated towards the north-Western part of the district, which could be explained by the fact that it is the home of the regional capital and the central business district of the region. The Kaleo/Nadowli district has scattered settlement patterns with areas of spacing in-between the settlement areas. The district has most of the settlement areas in the Western part of the district. It also has decent road network systems which connect the inhabited areas for easy access to and from the health facilities. The settlement areas are centrally located but with a rather poor road network system (typical of the younger districts).

In map 3, it can be seen that some population density points do not have access to the health care facilities, representing a total of 52677. In the Nandom district, 14136 out of 46040 people (30.70% of the population) do not have access to the health facilities. In the Wa Municipality, 99781 people of a population of 107214 have access to the 14 health care facilities in the district which represents 93% of the entire population.
Jirapa, Lawra and Kaleo/Nadowli district have 14.11%, 15.11% and 16.79% of their population respectively, lacking access to health care services. These represent 12476, 8298 and 10334 people respectively.

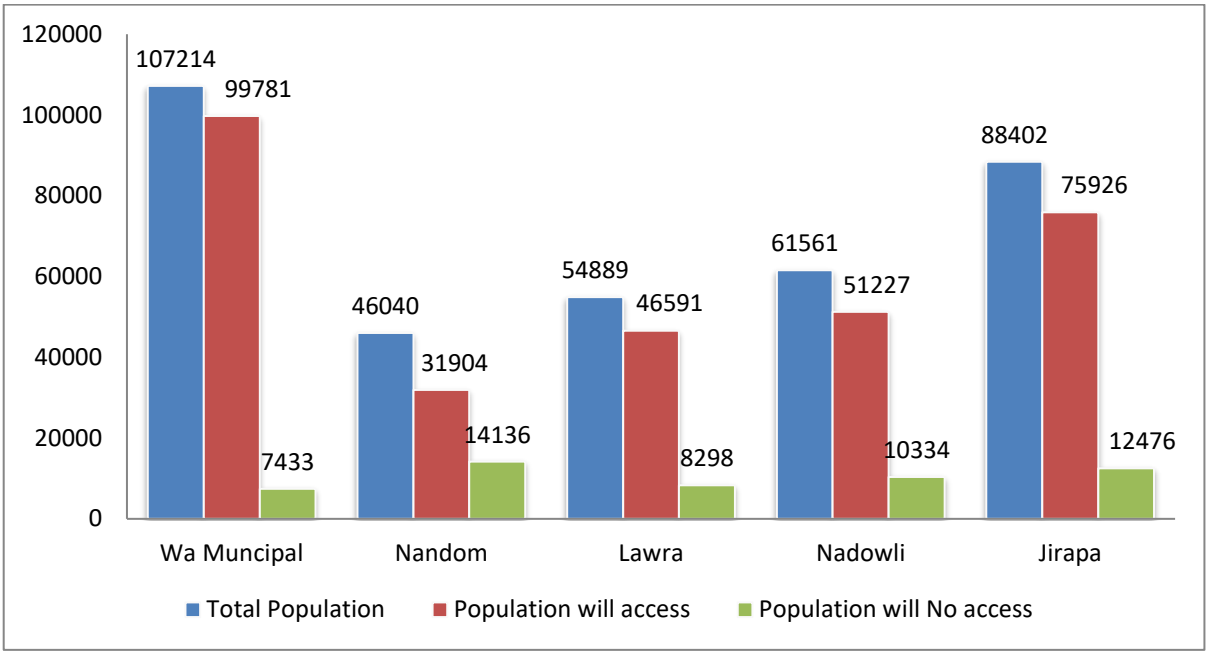

Figure 9 A Graph showing the population of the district who have access to HealthCare Facilities.

5. Discussion and Future work

An important objective of this research was to investigate if these standards were followed in the siting of the health facilities and whether they are accessible by the population. A basic assumption used in this research was travel by car to provide a uniformity of analysis. The results obtained from the research in the study area reveal that there's over 80% access in most of the districts in the study area. The population in the Wa Municipality have 93% to health care facilities; people in the Kaleo/Nadowli have 83% access to health care facilities and populace in the Jirapa and Lawra district having 86% and 85% access respectively. The research also revealed that the population in the Nandom had the worst case of accessibility with only 70% access to health care facilities. The guidelines as provided by the Town and Country Planning Department in the Zoning guidelines and planning standard which are stated in Table 2 have not been violated as shown in the resultant tabulated information in results (Caley, 2004). This emphasises the point that lack of access in this case can be attributed to the travel time to the health care facilities. The results of the network analysis show the principal health care facilities in the districts and Municipality are more accessible by the population. There are number of reason that determine access which ranges from the type of health care available and patients' personal preference. This leave a gap to investigate the other factors that affect accessibility to health facilities and how GIS can help solve this problem.

6. Acknowledgement

My profound gratitude goes to the Ghana Statistical Service for providing me the data to conduct this preliminary investigation.

7. Biography

Albert Angzenaa is the currently the Data Manager/GIS Specialist for the International Fertilizer Development Center. He is a graduate of the University of Leicester-UK with the ambition to purse in GIS both academically and on a professional level.

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