LOCATION-ALLOCATION ANALYSIS OF PUBLIC HEALTH SITE SELECTION USING P-CENTRE MODEL: (CASE STUDY OF CHANCHAGA LOCAL GOVERNMENT AREA, MINNA, NIGER STATE)

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Healthcare planning is a challenging field that depends on spatial data such as location and characteristics of health center demand. Chanchaga Local Government Area lack adequate healthcare facilities. So, the need to locate new public healthcare facilities is necessary if distance with population is considered. Garmin 76CSx handheld GPS receiver was used to mapped the existing health facilities and overlaid it on a high resolution Satellite image of 0.5m (GeoEye-1))of the study area. Base on the analysis it was discovered that inadequate healthcare facilities have been the problem of the people in Chanchaga Local Government Area. Thus, there is need to site more new public healthcare facilities in other to solve the problem of uncovered areas in the study area by considering proximity (distance) to the demand (Potential users) using P-Centre algorithm in determining optimal location of public health facilities within study area with the primary goal of minimizing the maximum response time (i.e. Time between a demand site and nearest service location using a given number of service locations).Twenty healthcare facilities were found in the study area which actually shown that the facilities are randomly distributed using Nearest Neighbourhood Analysis in ArcGIS 9.3 Software. Thus, Factor and Constraint maps were produced and overlaid on the buffered of the existing public health facilities using ArcGIS 9.3 software. The study shows that, the health facilities were randomly distributed in the locality with four of them not suitably located affected by the factor criteria which need to be relocated to the proposed suitable site. Similarly, the research showed that the city heart's centre is enjoying more presence of public health facilities than the extreme North-West of the Local Government Council with fewer facilities.

Keywords: Geographical Information System, P-center, Facility, Wards, and Service Area

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Background of the study

Public health facilities are social amenities provided by government for good health care delivery for its citizen. The importance of health care to human can never be over-emphasized. Ogundare (1982) linked health to food based on its importance to individual existence and opined that the concern and attention that any government pays to health could lead to the well-being of the people. Adequate supply and optimal allocation of public health facility is important for improving health care delivery system; meanwhile the presence of public health facility is not adequate except when access to these facilities is ascertained.

At the regional scale, the relative location of major population and employment centres in a region influences travel behaviour by making certain modes of travel more or less convenient or 'costly' than the others, and has been shown to be strongly correlated with travel. The location and size of a region's centres is influenced by numerous factors such as housing availability and affordability, school district and neighbourhood quality, private investment and jobs growth, transportation investments and access to other centres. Commute distances are a function of regional growth patterns and associated with per capita sedentary time spent in cars which has been shown to be a predictor of obesity and vehicle emissions. Development that is located within already established urban or suburban areas of a region, preferably in areas well-served by transit, is more likely to become more compact over time and support transit use and reduced auto dependence. Many positive public health outcomes can result from a more compact urban form.

Residential density, land use mix, and street connectivity have all been consistently associated with multiple outcomes related to health: per capita vehicle miles, per capita air pollution emissions, physical activity rates, and obesity and body weights. Climate change impacts such as temperature increase and changes in the frequency, intensity, and duration of extreme events such as floods, high winds, and tropical storms could affect healthcare facilities and practices for managing medical wastes. Health posts, clinics, and hospitals designed to last for decades need to plan for exposure to an altered climate. Plans to build new facilities need to consider projected impacts within the timeframe that the facility is intended to be operational, and ensure that the appropriate materials and locations are selected to reduce vulnerability. This is especially important because health facilities are often key community spaces used as safe havens during and after storms and other emergencies, and need to be fully operational and able to provide services. Health care facilities may also need to be prepared to handle increased visitors as a result of changing disease vectors or injuries from extreme weather events. It is particularly important for healthcare facilities to consider the vulnerability of their electricity source, and build resilient systems that can withstand the projected impacts of climate change.

In designing, building, and operating healthcare facilities and managing medical wastes, steps should be taken, where feasible, to reduce greenhouse gas emissions that contribute to climate change. The activity should aim not only to reduce emissions immediately, but also to support sustained low-emissions development through investments that will lead to reduced emissions in the future.

This study is aimed to solve the problem of location-allocation of site selection of public health facility using P-centre model. A P-center model minimizes the maximum distance (or travel-time) between the demand nodes and the facilities (Hongzhong, et al., 2005). They're often used to optimize the locations of facilities in the public sector such as hospitals, post-offices and fire station etc. The study addressed the following problems:

(i) Investigation of physical accessibility to public health care

(ii) Utilization of health care services

(iii) Analysis of the extent of service areas and identification of gaps in provision

(iv) Modeling of optimal facility locations

(v) Examination of issues of equity and efficiency in health care provision, among others.

The study is necessitated on the fact that Chanchaga Local Government Area of Niger state is one of the highly populated areas among the Local Governments in Niger State. The Local Government Council under study is both residential and commercial in nature in respect to the Land Use with population of more than 57% of people who leave in the heart-center of the metropolitan city of Minna (Census, 2006). Based on Land Mass, Bosso Local Government Area covers 1584.5km² i.e. approximately 96% of the entire area of Minna city (Fig. 1.0). Geographical Information System (GIS) uses various methods in the site selection which includes Network Analysis, Spatial Analysis, Proximity Analysis, Multi-Criteria Analysis (MCA), Analytical Hierarchy Process (AHP), Rank Order Method (ROM), P-centre (minimax), P-median (minisum), etc. The P-center model of location-allocation will be used in this study to address the problem in Chanchaga Local Government Area.

Statement of the Problem

The major challenged people in study area is facing is the problem of inadequate health facilities. Twenty healthcare facilities were found in the study area which actually shown that the facilities are haphazardly distributed. Base on this; it was discovered that inadequate healthcare facilities and accessibility have been the problem of the people in Chanchaga Local Government Area (i.e. in the study area some areas enjoying this service (facility) more than other). Thus, there is need to site more new public healthcare facilities in other to solve the problem of uncovered areas in the study area by considering proximity (distance) to the demand (Potential users) using P-Centre algorithm in determining optimal location of public health facilities within study area with the primary goal of minimizing the maximum response time (i.e. Time between a demand site and nearest service location using a given number of service locations).

The Study Area

The study was carried out in Chanchaga Local Government Area, Minna, Niger State located approximately on Latitude 09^0 36'50'' North of the equator and Longitude 06^0 33' 25'' East of the Greenwich Meridian, covering approximately 72km². The administrative areas of Chanchaga Local Government Area composed of Ten (10) wards. According to the 2006 census, it has a total population of 201,429, which comprises of 105,803 male and 95,626 female.

The land use comprises of both residential and commercial. The major inhabitants of Chanchaga Local Government Area are the Gwari, Nupe and Hausa. Chanchaga Local Government Area possesses a great many world famed places of interest like the Shiroro Palace and the Tunga fall, which attract countless tourists. Besides, Chanchaga is Local Government Area where Innumerable society elites assemble here for school and career, making it matches the name "city centre". Figure 3.0 shows the map of the study area.

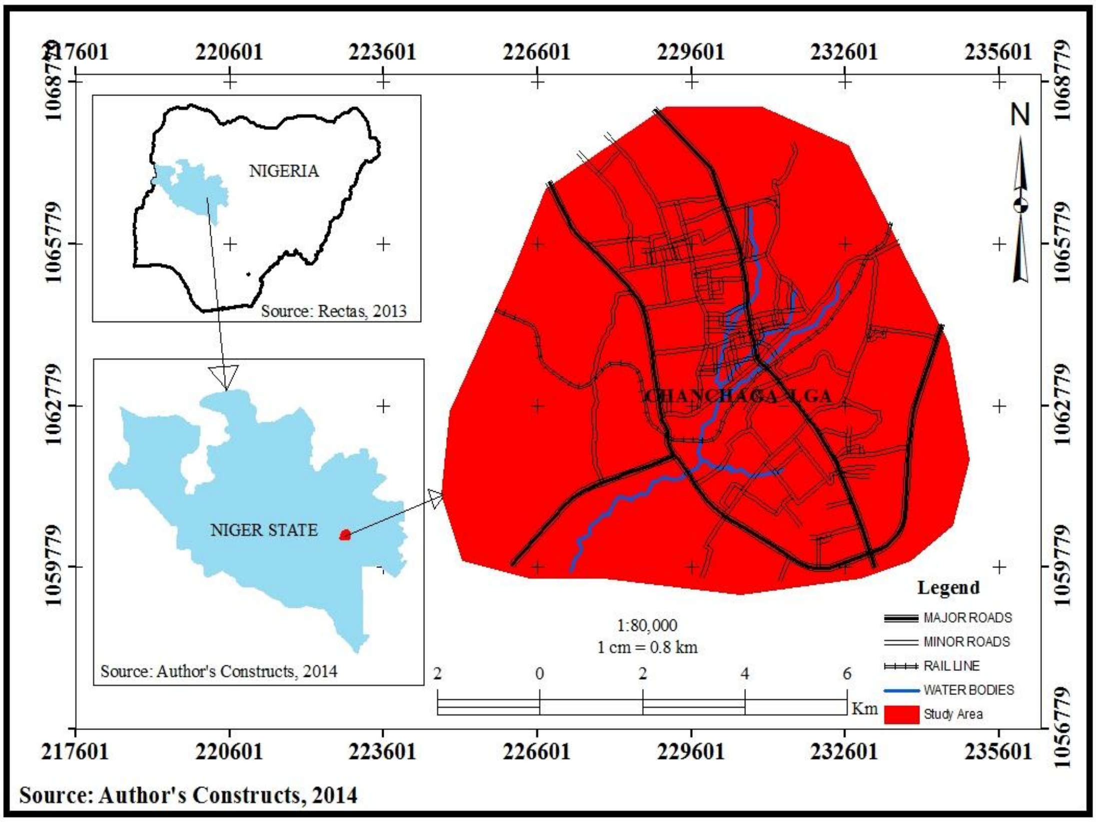

Figure 3.0: Shows the map of the study area

Relevant Conceptual issues and related literature

The location-allocation of equitable distribution of health facilities had been widely studied by researchers over the years. Some of the researchers who had contributed immensely and their findings are highlighted below:

World Bank (2004 and 2006) in its annual development report, gave the following explanation on the need for equity; When personal and property rights are enforced only selectively, when budgetary allocations benefit mainly the politically influential, and when the distribution of public services favours the wealthy, both middle and poorer groups end up with unexploited talent. Society, as a whole, is then likely to be more inefficient and to miss out on opportunities for innovation and investment. Thus, achieving equity in resource allocation and having an equitable development of a society make nations stronger in all ramifications (Tegeret, 2011).

Bagheri et al (2005) also measured accessibility to primary health care services in New Zealand based on World Health Organization (2000) acceptable levels of minimum travel time and distance of 4km for third world countries to the closest facility via a road Network. He used the mean centre of population distribution within each unit and road networks, the best route (shortest path) from residential areas to facilities as well as areas poorly covered was obtained.

Robert (1997) also in his thesis examined the problem of evaluating and improving the potential accessibility of a target population to primary health care services in Central Valley of Costa Rica. Toward this end, he developed a generic mode1 of potential accessibility. He also examined how spatial aggregation of the target population can lead to errors in the evaluation of accessibility, and discussion methods of disaggregating population counts to a grid to reduce this spatial aggregation error. Also, he developed a generic Accessibility Optimization Problem (AOP) that takes a facility-oriented approach to improving accessibility. Two sub-problem formulations are also discussed for the AOP. The Facility Location Sub-problem (FLS) adjusts the facility configuration to improve the efficiency and equity in the distribution of accessibility among the target population while the Resource Allocation Sub-problem (RAS) modifies the allocation of resources to existing facilities. Specific accessibility optimization models for the minimum distance accessibility measure and the Joseph and Bantock (1982) accessibility measure are developed from the generic formulations. These accessibility measures are used to evaluate the current accessibility, and the optimization models are applied in two specific planning scenarios to examine potential strategy of improving accessibility to family planning services in the Central Valley of Costa Rica.

Gustavo (nd) examined case study related to the spatial analysis of Primary Health Care Centers (PHCC) in the city of Lujan, Argentina. In his research, the aptitude of the location-allocation models was exemplified based on the calculus of coverage, mainly applied in the search of efficiency and spatial equity of the Primary Health Care Centers (PHCC) in the city of Lujan. His research answers the question: is there any correspondence between the real localization of the supply points and the ideal localization based on the spatial distribution of the demand population? Which way the spatial efficiency and the spatial equity is modified in accordance to the reallocation of these points and finally where should new installations be settled in order to satisfy the distributed demand?

Oda et al (1987) in his paper used a modeling approach to the problems of the equity-efficiency trade-off relation in the spatial provision of health care in Hokkaido Japan, that is, the relationship between the equalization of access opportunity to health care services and the effective provision of the services in a free-entry and fee-for-service market system was attempted from the perspective of location-allocation analysis. The location-allocation models developed in their paper are composed of a spatial interaction model of demand allocation and another is a resource location model when service provider is private sector. In the resource location model, the amount of potential demand in each region and its capacity (work load) of a human as well as a physical resource are internalized. The demand allocation model consists of a space discount function, attractiveness of the service and potential demand for the service in the region. In the resource location model, revenue maximization was adopted as a criterion of efficiency for private sector as service provider, which is different from the criterion of efficiency usually adopted when public sector is regarded as service provider, that is, minimization of construction and operation costs of public facilities.

Ayoade (2014) in her paper looked into the potential accessibility of women ranged from 15-49 years of age to public maternal health care services by examining the service areas and distributional pattern of public maternal health care facilities in Ibadan, Nigeria. Her findings of the locations of these facilities were collected from the Oyo State Ministry of Health. The distributional pattern was assessed using nearest neighbor analysis and Moran's I statistic. Her research on walking and driving service areas were modeled using the circular buffer method i.e. at a given or defined radius around the supply (Public health facility). Her results showed that facilities are randomly distributed in Ibadan. Thus, there is a need to improve the supply and distribution of facilities to meet present and future needs.

Health care facilities

Health care facilities are hospitals, primary health-care centers, isolation camps, burn patient unit, feeding centers and others (WHO, 2014). In case of emergency situations, health-care facilities are often faced with an exceptionally high number of patients, some of whom may require specific medical care (e.g. treatment of chemical poisoning).

The responsibility of health care is a concurrent in nature among the three tiers of government in Nigeria. However, because Nigeria is a mixed economy, private providers of medical health care have a visible role to play in health care delivery. The federal government is mostly limited to coordinating the affairs of the University teaching hospitals and Federal medical centers which are known as Tertiary Health Care centers whereas the State Government manages various General hospitals i.e. Secondary Health Care centers while the Local Government is responsible for the dispensaries known as Primary Health Care centers (Abbas et al., 2012).

The World Health Organization (1997) specified criteria for health care planning for third world countries and indicated that each service area should cover a 4km catchment area with a population of 60,000 for primary health care in order to have adequate and equity of access to health centers.

Many factors affect a population's ability to access appropriate levels of health care. Oliver and Mossialos (2004) group these factors into three categories:

i. Availability: How suitable or ready for use are those facilities? It is also the degree to which a facility is in a specified operable and committable state at the start of operation. In most cases the facilities are not available for use, even if available they are not suitable for use.

ii. Acceptability and Affordability (Socio-economic)

a) Ethnicity, Religious: How do the people accept the health facilities? In some places their religious beliefs do not allow them to visit hospital. They believe in the traditional ways and self-medication,
b) Gender, Age: Female and young children have more access to health facilities. Even with the status of the facilities they visit those facilities for treatment.
c) Cost: It involves money, which is always a challenge in health. People are not able to fund those facilities.

iii. Geographical Location: The location and terrain in which the facility is located. In areas with rough terrain the geography of the place need to be visited to know where to locate the facility for easy access.

One of the imperatives of the primary health care approach, which is widely adopted in Sub-Saharan Africa, is a concern for social justice. In health terms this means population coverage irrespective of social position. "One main problem with urban health care is not simply that it lacks quality and comprehensiveness but that, because of mal-distribution of facilities, it is not easily accessible to those in need" (WHO, 1993).

Site Selection of Health Care Facilities

Site selection of healthcare facilities have considerable impact on the population of any given area because of the almost universal demand for the services they provide, but there is no definite theory for the location and distribution of healthcare facilities as in the case with other public facilities (Nasri, 2014). World Health Organization (1997) said health facility should be located within 4km of the demand node for the third world countries. Siting a facility into the best place is a decision making problem. Arifin (2010) said the best place depends on criteria such as the optimal distance, the capacity of the facility, population density, optimal cost etc. The term facility is used in location-allocation problem to define an object whose spatial position is optimized through model or algorithm considering interaction with other pre-existing objects (Scapama and Scutella, 2009).

The process of site selection typically involves two main phases: screening in which the identification of a limited number of candidate sites from a broad geographical area given a range of selection factors and the evaluation in-depth examination of alternatives to determine the most suitable site (Chang et al., 2008).

P-Centre Location-Allocation Models

In location literature, the P-center model is referred to as the minima model since it minimizes the maximum distance between any demand point and it nearest facility. The P-center model considers a demand point is served by its nearest facility and therefore full coverage to all demand points is always achieved. However, unlike the full coverage in the set covering models, which may lead to excessive number of facilities, the full coverage in the P-center model requires only a limited number (P) of facilities. The P-center problem was first posed by Sylvester (1857) more than one hundred years ago. The problem asks for the center of a circle that has the smallest radius to cover all desired destinations. In the last several decades, the P-center model and its extensions have been investigated and applied in the context of locating facilities such as Petro Stations, hospitals, fire station, and other public facilities.

Criteria for site selection of public health facility

The factors criteria in table 4.1 were used in this study after due consultations with experts in the health ministry, those responsible for decision making in the health sector and urban regional planners.

Table 4.1: Factor Criteria Siting Health Centre in Chanchaga Local Government Area, Minna, Niger State.

s/n	**Factor**	**Siting (m)**
1	Major Road	70
2	Minor Road	30
3	Market	50
4	Motor Park	50
5	Cemetery	200
6	Industrial Areas	100
7	Water Bodies	50
8	Rail Line	150

Source: Authors' study, (2014).

MATERIALS AND METHODOLOGY

The preliminary stage was organized into two aspects: the first involved a reconnaissance visit to the study area for on-the-spot evaluation of the selected existing public health facilities. The second involved the acquisition of the Satellite image (Geo-eye 1) of Minna metropolis for year 2010, the high resolution image and hospitals location information which was obtained from the Ministry of Lands and Survey and Ministry of Health Minna, Niger State. The Shape files (States and Local Government boundaries) shown administrative map of Nigeria was also obtained from Regional Centre for Training in Aerospace Surveys Ile- Ife Osun State, Nigeria. Population data for the Local Government was obtained for both 1991 and 2006 population census (NPC, 2014). Two methods for collecting geometric and attribute data, required for this study are the primary and secondary sources. The primary source of data collection involves direct collection of information, using Garmin *76CSx* Hand Held GPS receiver, oral interview and observations. On screen digitization was also carried out in order to extract the criteria from a high resolution image (0.5m). Various layers were created in order to achieve set objectives. The positions of the existing health facilities mapped by Garmin *76CSx* handheld GPS receiver were modeled into vector during the conceptual designs; a relational database was adopted for the logical modeling and ArcGIS 9.3 software was used in the physical design. Spatial analyses were then carried out on the geodatabase built in ArcGIS 9.3 software.

Workflow Diagram

Figure 5.1 shows the workflow diagram used in achieving the aim of the study Healthcare facilities considerable impact on the population of any given area because of the high demand of the facilities and services provided by the facility, but yet no definite theory for the location and distribution of health facilities as in the case with other public facilities (Oyewo, 2013).

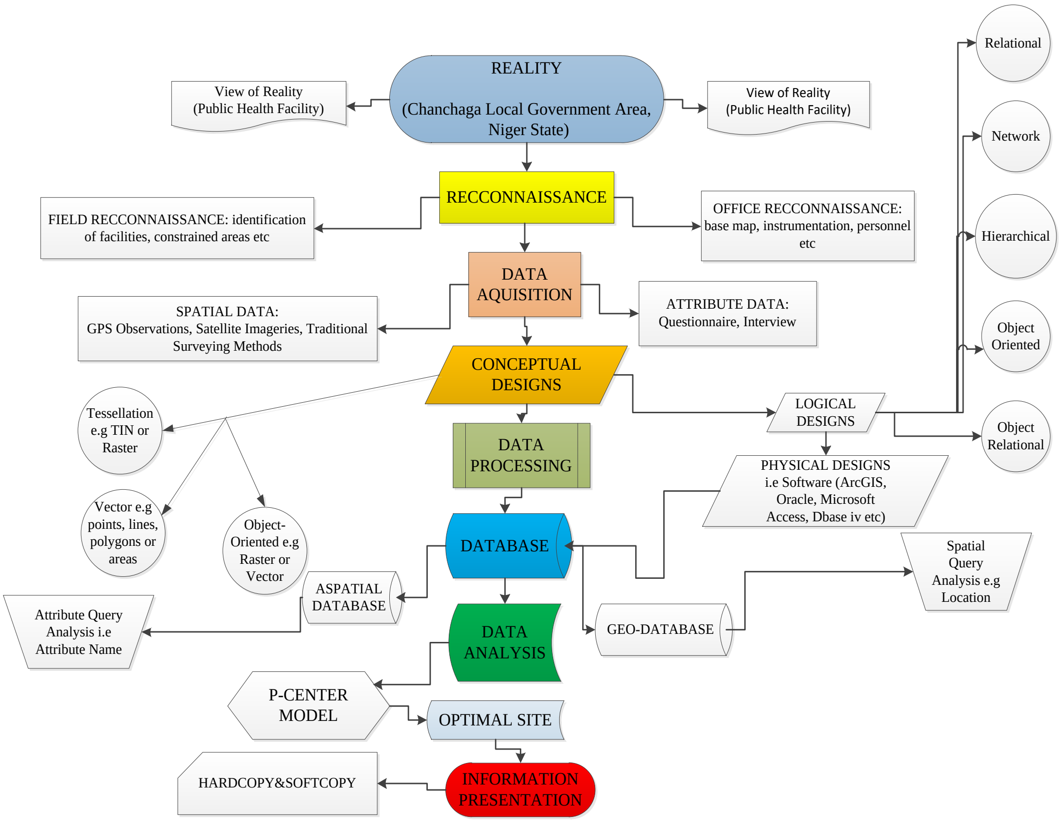

Figure 5.1: Workflow Diagram (Authors', 2014)

Research factor criteria for site selection of public health facility in Chanchaga Local Government Area Niger State

GIS uses various methods in the site selection which includes P-centre model, P-median model, network analysis, spatial analysis, proximity analysis, multi-criteria analysis (MCA), rank order method (ROM), Analytical Hierarchy Process (AHP). Abdullahi et al (2014) used GIS-based network analysis to locate areas of green spaces and also of the deprived socio-economic groups of people of urban green spaces in the city of Leicester, UK.GIS-based P-centre model (PCM) is adopted in this research.In order to carry out site selection successfully, Criteria are needed for the study. The Local Government Area Council has four majorly land-uses: Residential, Commercial, Agricultural and Industrial land-uses. The authors' criteria in table 4.1 section 4.1.3 were used in this study based on the consultations made by the author to experts in the ministry of health, SURE-P and those responsible for decision making in the health sector. Only population density among the criteria is not used based on the fact that; population figures of each ward and household was not given from the National Population Commission (NPC).

In the process of achieving the first objective, criteria were identified and evaluated. Below are the criteria identified for use in this study.

a) **Road networks**: Theoretically, hospitals should be located near the roads, especially the major roads. The noise from motor vehicles passing-by influences the patients in the hospital. Therefore, the roads where categorized into two types i.e. major roads with a quiet distance of 70 meters is set and minor road also with a distance of 30 meters was set beyond the buffer zone, the nearer the better is the hospital being sited.
b) **Existing public health facilities**: New hospital constructions should take this criterion seriously. Keeping the distance from other existing hospitals as well as anticipating impact from each other, is not only relevant to rational resource allocation, but also does matter to the fair competition in the market economy. No set standard for distance from existing healthcare facilities, but after consultation with some experts in the healthcare planning unit, a distance of 300m buffer was agreed and 500m for both optimal and tolerable distances.
c) **Market area:** Hospital is the source of infection, to protect the general public, keep a distance from the market areas. A buffer zone of 50 meters was used.
d) **Water body**: Hospitals cannot be built around the water body, in case the water has been polluted by construction or drainage discharged. A buffer zone of 50 meters was made.
e) **Cemetery**: Hospitals are hardly built inside the cemetery, it is better to protect those areas where dead bodies are disposed from air pollution. A buffer zone of 200 meters was made.
f) **Motor Park**: Siting hospitals close to the motor park is not too good because the volume of noise generated in the park influences the patients in the hospitals. A buffer zone of 50 meters was used.
g) **Industrial Areas**: These areas were also restricted and buffered at 100 meters.
h) **Rail Line**: This factor must also be taken seriously as the noise being generated and vibrations from the train is too high, hospital should not be sited close to it. A buffer of 150 meters was chosen.

Constrained Areas

Constrained areas were also considered. These areas are like Banks, Paramilitary formations, Recreational centers, Religion centers. These areas were considered not because they have adverse effects but their importance to people and as such hospitals cannot be located in such areas.

Database Creation

A database is a large computerized collection of structured data. There are two basic categories of database. These are attribute database (A spatial) and geo-database (spatial). In order to achieve the third objective, a geo-database was created in ArcGIS 9.3 in other to store the acquired existing public health data, factor data and constrained data.

Digitizing the Factor criteria and Constrained Areas

All the shape files created for both factor criteria and constrained areas were digitized in ArcMap. Also, attributes were added in other to perform some queries analysis on the digitized features which have been converted to shape files. Digitizing the features convert it automatically to shape files and as such query by location or attribute can be done on any of the feature class.

Buffering the Factor Criteria and Existing Public Health Facilities

The operation was done based on the set criteria earlier mentioned. All criteria that was set, was buffered so as to know where hospitals can be located. Also, the existing health care was also buffered (300m and 500m for optimal and tolerable distance respectively). This was done in Arc tools box (where analyses are done). Fields were also created to insert the name and type of each facility for easy identification. Two types of facilities were identified: primary healthcare (Clinics) and secondary healthcare (i.e. General hospital) in the study area.

Finally, a map was visualized in ArcMap to show the spatial distribution of existing health facilities in the study area. Average nearest neighbour analysis tool was used to analysis the distribution within the study area.

Wrongly cited public health facilities

Having carried out buffering on the factor criteria and existing health facilities in the study areas, it was shown that four (4) hospitals were wrongly located or sited (Figure 5.2). They were affected by factor criteria chosen. The hospitals that were affected are: Kutilko Clinic in Limawa 'B' Ward which is affected by rail-line, Angwa-kaje in Sabon-Gari Ward is also affected by river, School Clinic in Limawa 'A'- affected by major road and Asibitin in T/Wada South is also affected by minor road.

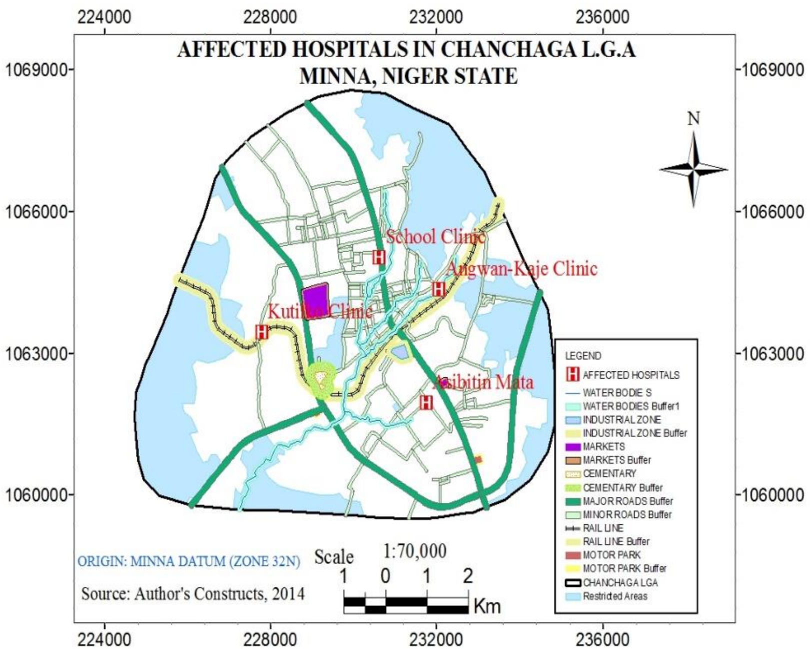

Figure 5.2: Affected hospitals in Chanchaga Local Government Area

Propose Model for the suitable Site Selection of a New Site

This was achieved using model builder, an extension in ArcMap 9.3. Buffer analysis, conversion of feature to raster, union, reclassify, con and plus analysis were done in the model builder through Arc-toolbox. The model builder was used to propose a model that can be used to select all suitable sites for public healthcare facility.

Factor maps are represented as spatial distributions to display the opportunity criteria and the quality of achieving an objective. Constraint maps are limitations or restrictions which prohibit certain elements to be taken into account during the analysis (Malczewski, 1999). The GIS-based P-Centre model uses summations of the factor criteria, criteria for existing facilities and the constrained areas (Yassine and Adel, 2011).

As for the summations procedures, the linear combination of all factors considered is shown as Equation (3.1) and Equation (3.2):

$$\mathbf{U = \Sigma\, fi + ci} \qquad 3.1$$

fi = Factor Criteria

ci = Constrained Areas

ei = Existing facilities Criteria

U = 'Unsuitable Area'

$$\mathbf{S.S = S - U} \qquad 3.2$$

Where S.S = Site Selection (Suitable Area)

S = Study Area Map

U = 'Unsuitable Area'

After the factor criteria, constraint criteria and existing facilities have been selected separately, the GIS-based P-centre process integrates them together by subtracting the Unsuitable site (U) from the entire area under study (S) and gets the final result of site selection (S.S). Using the two equations above, the site selection areas was generated.

Figure 5.3 is the composition of the models in order to faction out areas where new hospitals are to be sited.

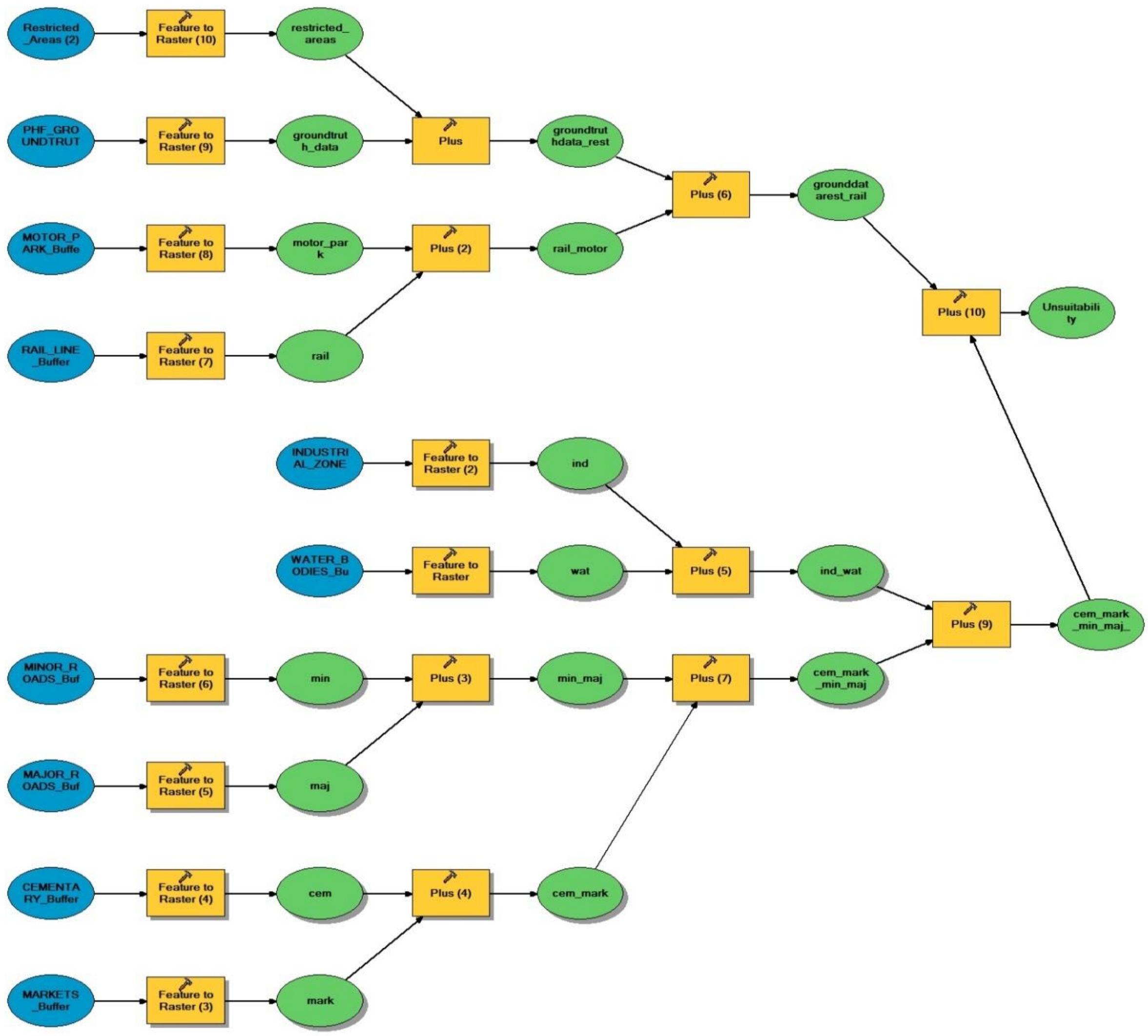

Figure 5.3: Factor model, constrained model with Existing Model used to generate the suitable site selection.

Results and Analysis

Spatial Distribution of Existing Public Health Facility

Figure 6.1 shows the spatial distribution of healthcare facilities in the study area. Twenty (20) healthcare facilities were found in the study area. Only one (1) secondary healthcare facility (General hospital) was found in the study area and nineteen primary healthcare were found.

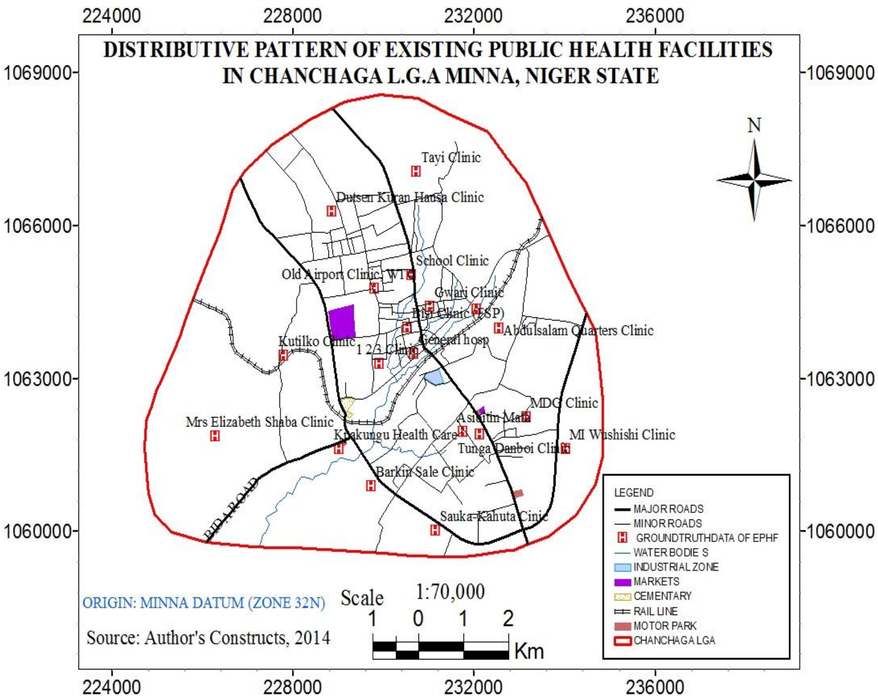

Figure 6.1: Distributive Pattern of Public Health Facilities in Chanchaga L.G.A. Niger State

Further analysis was carried out in the study area to know the distributive pattern of the facilities in the study areas. The nearest neighbourhood analysis was carried out and it was found that the facilities are randomly distributed in the study area (figure 6.2).

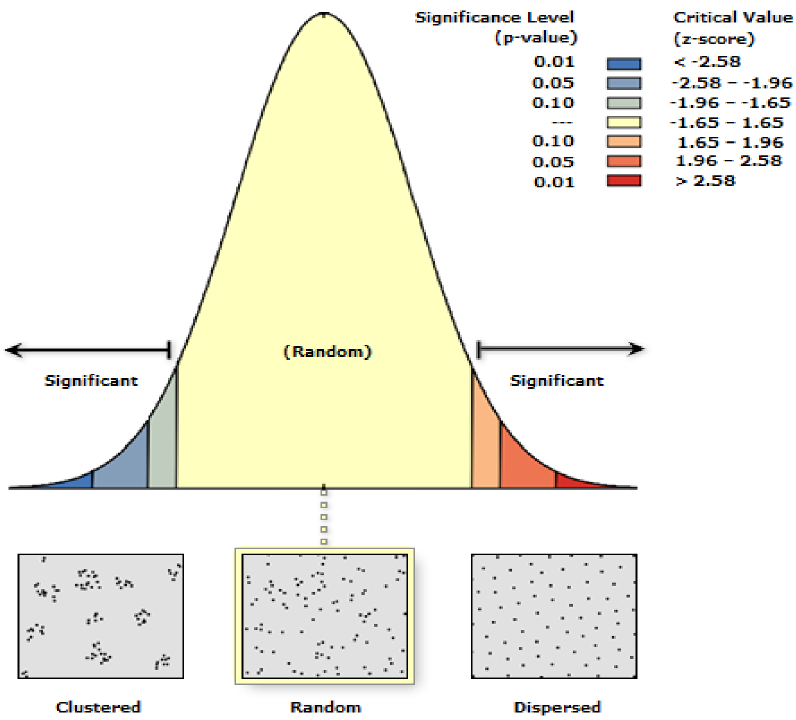

Figure 6.2: Nearest Neighbourhood Analysis. Source: Authors' constructs, 2014

EVALUATION AND MAP PRODUCTION OF CRITERIA

Factor maps were produced; the maps were initially extracted from the high resolution image; constraint maps were also generated from the extracted features.

Factor Maps

They are also referred to as the criteria maps. These maps have been defined in the criteria to be adopted. They are maps that show where hospitals should not be located within a certain distance (figure 6.3). The factors that were considered are: Cemetery, Water Bodies, Major Roads, Minor Roads, Rail-Line, Markets, Motor-Parks, and Industrial Zone.

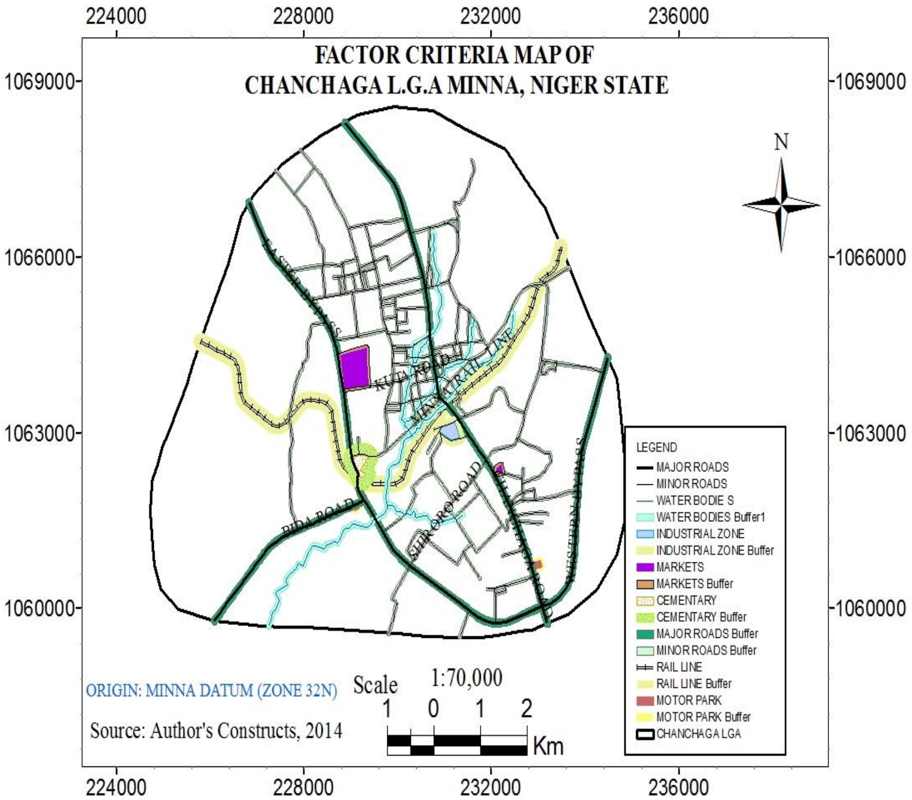

Figure 6.3: Factor Criteria of Chanchaga Local Government Area Minna, Niger State

Constrained/Restricted Areas

These are areas that hospitals should not be located because of some factors which may in the opinion of the people and government are important areas. These areas include but not limited to the following: Banks Areas, Paramilitary Formations, Recreational Centres, Religion Centres, Media Houses, Farmland (Agricultural Land use) and Judiciary Locations. Boolean map was created showing restricted and non-restricted areas (figure 6.4).

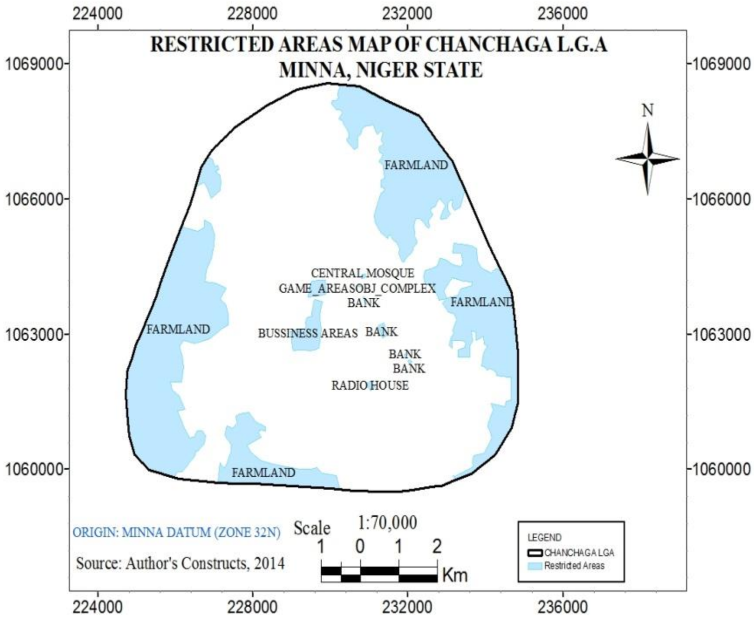

Figure 6.4: Constrained or Restricted Areas of Chanchaga L.G.A. Minna, Niger State

Proposed Site Selection

In the final stage, a suitable site was created by overlaying the factor maps and constrained maps on the buffered existing public health facility map in ArcGIS 9.3 using arithmetic function in ArcGIS 9.3. Based on this, areas that are deprived of the existing public health facilities by author's criteria can be easily identified because of their locations (distance). See figure 6.5a &6.5b.

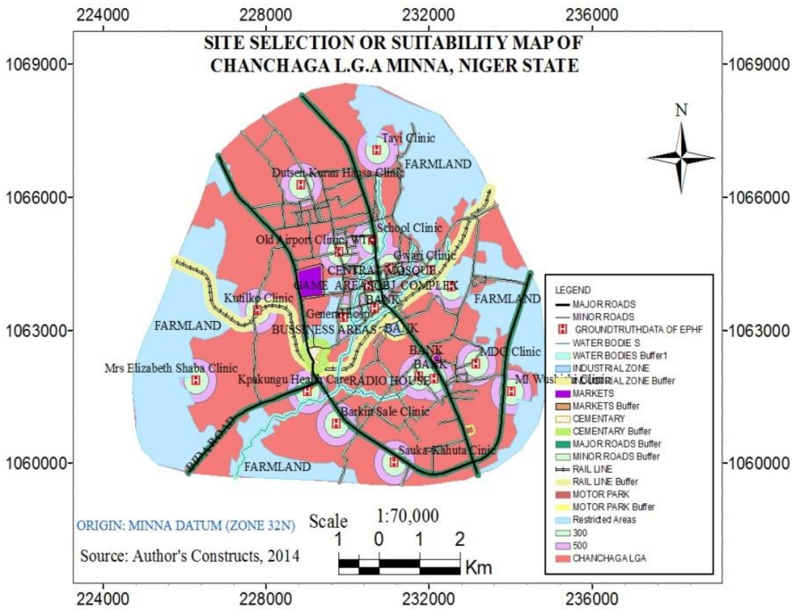

Figure 6.5a: Site Selection of Proposed Public Health Facility

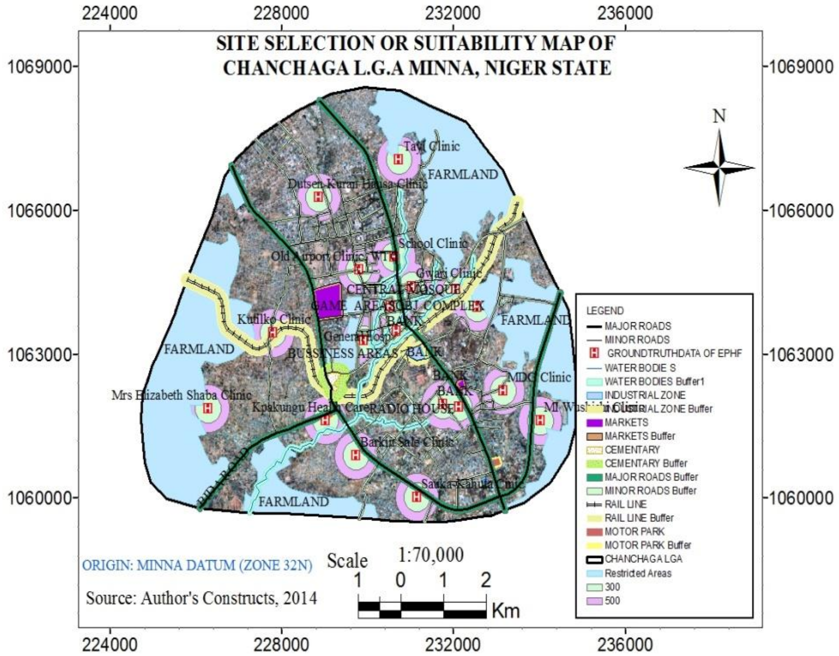

Figure 6.5b: Site Selection of Proposed Public Health Facility

From the results obtained, it can be seen that, the Council's centre enjoys more of the presence of facilities than any other parts. This may be due to the population density in the area. Also, the North-East part of the Council is the areas with low presence of public health facility.

Discussion of Results

Having carried out successful buffering on the factor and existing health facilities in the study areas, it was shown in figure 5.2 that four (4) hospitals were wrongly located or sited. They were affected by factor criteria chosen. The hospitals that were affected are: Kutilko Clinic in Limawa 'B' Ward which is affected by rail-line, Angwa-kaje in Sabon-Gari Ward is affected by river, School Clinic in Limawa 'A'- affected by major road and Asibitin in T/Wada South is affected by minor road. Hence, the health sector needs to be carefully accessed and managed its resources for sustainable development. Health management board may involve in policy making on health. The public (individuals and corporate bodies) also needs information in the distribution, and locating a standard site for public health facilities. Therefore, as a result of the above mentioned issues, the results obtained from this study provide a background for planning and implementation of good management technique and location of public health facilities in Chanchaga Local Government Area, Minna, Niger State. The Niger State Ministry of health can fast run the management and establishment of public health facilities in Minna metropolis based on this study to attend to the areas that are uncovered in the study area. Also, decisions which are related to resource allocation to public health facilities can easily be taken and quick updates could easily be made by the Ministry of Health, Niger State.

Conclusion

The paper presented an experiment based on a real case, in the field of healthcare, where actual positions of basic health units were compared with locations proposed by optimization models. The results showed the effectiveness of the model used, in all criteria considered: P-Centre model. It also revealed that as the population of the study area grows there seems to be a trend of increasing the proportional advantage of the model, when compared to empirical decisions. Further study should be developed in this field to validate this apparent trend, but this may be an indication of the importance of using this model in the health area. In fact, modeling this tendency may represent a powerful tool to support investments decisions. For future studies it would be important to consider other instances of the problem. A new experiment to validate the apparent tendency mentioned above is also, a study that should be done. Moreover, it would be important to consider other types of models, in order to compare their performances. Expanding the study a little more, it could be interesting to explore the field of metaheuristics in order to compare results obtained by different strategies.

Recommendations

For the decision makers of hospital site selection, when making GIS-based P-centre model, reliable and up to date data should be used. For this study, 2010 satellite imagery was used because recent image of the study area could not be accessed and also population figures of wards and if possible that of household should be provided by national population commission.

Also factor criteria should be taken seriously. The need to have defined criteria for hospitals site locations is necessary by those concerned. GIS experts and latest equipment should be acquired by both the Niger State and the Niger State health board in other to enhance the efficiency of GIS. From the study, four hospitals need to be relocated because these hospitals are affected by the chosen criteria of the study.

Finally, GIS technology has the potential to revolutionize health surveillance. It gives health professionals quick and easy access to large volume of data. Moreover, this system provides analytical support for the planning, programming, and evaluation of activities and interventions in the health sector.

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