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## Spatial distribution and challenges in accessing HIV drugs centers in Oyo, Nigeria

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### ABSTRACT

There is no complete cure for HIV infection, but highly active antiretroviral therapy (HAART) has been applied to reduce the morbidity and mortality of HIV worldwide. Still, the ease of accessing these medications poses a serious concern. This work was carried out to understand the effectiveness and efficiency of area coverage of HIV drug centers. Google Earth Pro was employed to capture imagery of the study area and GPS instrumentation was used to pick the coordinates of the HCT and HIV Drugs centres within the study area. A questionnaire was then used to collect the attribute information of the facilities that exist. Subsequently, ArcGIS software was applied to import imagery to bring out the spatial entities of the area. Herein, GIS operations like network analysis, nearest neighborhood and Query were accessed. Average Nearest Neighbor Index (Rn) for HIV Drugs centres within Oyo metropolis was then calculated based on average straight line distance from each facility to its nearest neighboring facility. Herein, the Rn was 28.8. The Rn value indicates that spatial pattern of HIV Drugs centres in Oyo metropolis are dispersed. The Z-score (74.813624) and P-value (0.00000) reveals that the pattern of HIV Drugs centres in Oyo metropolis also exhibits significant dispersion. This means that the pattern of HIV Drugs centre location in the study area was significantly different from a random pattern. Network operation was then applied to determine best route from one HCT centre to HIV Drugs centre and to find if alternative routes were possible. The study shows that the spatial distribution of HIV Drugs centres is uneven - with 35 existing HCT (HIV Counselling and Testing) centres in 3 local governments, as well as 2 HIV Drugs centres. The service area calculation result shows other areas are in need of HIV Drugs.

**Keywords:** Antiretroviral Therapy, database design, database creation, GIS, maps, queries, spatial analysis

## **1. INTRODUCTION**

Human Immunodeficiency Virus (HIV) is a virus that causes AIDS (Acquired Immune Deficiency Syndrome). AIDS can be identified when the amount of immune system cells known as CD4 cells in the blood of an infected person falls below a certain level. Although there is no cure for AIDS, HIV infection is preventable and those living with HIV condition can take antiretroviral drugs to delay the onset of AIDS. Effective treatment with antiretroviral drugs can control the virus so that people with HIV can enjoy healthy lives and reduce the risk of transmitting the virus to others. Almost all nations have been affected by the HIV/AIDS pandemic but Africa has been the worst hit. It was estimated in 2013 by the Joint United Nations Programme on HIV and AIDS (UNAIDS) global report that 35 million people were living with HIV; 2.1 million people had become infected with HIV that year. Sub-Saharan Africa accounted for almost 70% of all new infections and more than two-thirds of all HIV-related deaths globally. In 2015, National Agency for the Control of AIDS (NACA), pointed out that Nigeria has the second highest number of people living with HIV in the world after South Africa.

HIV prevalence is widely reported in literature. The National Agency for the Control of AIDS (NACA), Nigeria, claimed that HIV prevalence is highest in Nigeria's southern states and stands at 5.5% and lowest in the southeast with 1.8%. NACA also claimed that there are higher rates of HIV in rural areas than in urban ones. A study conducted by Esan [1], correlates well with the national study. Among 312 emergency department patients in Lagos, they reported a prevalence rate of 5.77%. This group of patients is a fair representation of the general population, and has been used to determine the HIV prevalence in some countries. Also Sagay [2] showed a prevalence rate of 8.2% among 2,657 pregnant women attending antenatal clinic in Jos. Among some people regarded as high-risk groups, high prevalence rates were encountered in different parts of the country.

Kehinde [3] reported a prevalence of 21.9% among 210 patients attending special treatment clinic in Ibadan. In Port Harcourt, a study among intending couples reported a rate of 20.8% [4], while among infertile couples, a prevalence of 6.82% was reported in 2002 in Nnewi [5]. A prevalence rate of 60% was found among Kaposi's sarcoma patients in Jos [6] and of 69.2% among patients with herpes zoster, in Benin City [7]. However, only a rate of 4.2% was recorded by Campbell [8] among patients with cancer of the cervix receiving radiotherapy in Ibadan. An overwhelming ten out of 11 children aged from four weeks to 11 months with acquired rectal fistulae were found to be HIV-positive in Jos. All their mothers were HIV-positive. In Ile Ife, Adejuyigbe screened 401 paediatric patients aged between three days and 17 years, presenting features of immunosuppression, and reported a prevalence rate of 20%.

Although, no complete cure exists for HIV infection, highly active antiretroviral therapy (HAART) has been used to reduce the morbidity and mortality of HIV worldwide. Antiretroviral Therapy (ART) are medications that treat HIV. It is treatment for AIDS that helps the body's immune system recover from the damage caused by infection with HIV. Although the drugs do not kill or cure the virus; however, when taken in combination they can prevent the growth of the virus. The concerned individual may remain well for many years but must continue to take Antiretroviral (ARVs) for the rest of their lives. Antiretroviral drugs are referred to as ARV and that makes ART an important component of the global response to AIDS [9, 10]. Keiser [11] looked at antiretroviral therapy as a treatment for AIDS to enable them to live productive lives. Antiretroviral Therapy (ART) has effectively decreased HIV/AIDS related Morbidity and mortality and improved the quality of life of people living

with HIV/AIDS (PLWHA). Nigeria has adopted the use of Lamivudine, Nevirapine and Stavudine as first line drugs, and they have been showed to be very effective. The government has been involved in the provision of free ARV to infected patients, as well as other donor agencies like the AIDS Prevention Initiative in Nigeria (APIN), President's Emergency Plan for AIDS Relief (PEPFAR) and others in Nigeria. Their activities however have been limited to a few centres, especially in the urban areas, with only a small percentage of those infected having access to these drugs. The use of these drugs in 50 patients followed up for the period of 12 months showed viral decrease by 1.79 log<sub>10</sub> cells/mL, CD4 increase of 186 cells/uL, opportunistic infection decreasing in 82%, and weight gain of 4.8 Kg/m<sup>2</sup>. Adherence was over 85% in this group Idigbe [12]. Idoko [13], conducted a clinical trial on the effectiveness of Nelfinavir, Zalcitabine and Zidovudine on 40 patients.

There were viral load reductions of 1 log (25%), 2 log (17%), and 8% had undetected viral load in 24 weeks. An average of 27 cells/uL of CD4 increase was observed in 80% of them, with appreciable weight gain. However, 21% showed increase in their viral load, while 15% experienced decrease in their CD4 count and 5% withdrew due to adverse reaction. This combination was adjudged to be effective and relatively safe in treating patients with HIV. There is however the increasing need for adequate monitoring of these patients using viral load and drug resistance tests, which currently have been lacking in the current treatment programmes in the country. Mariam et al [14] reported that distance and economic constraints where major challenges to accessing and adhering to ART schedules and regimes. They also identified other barriers to ART access and adherence.

The study of Chiegil [15] studied the perceptions of the end user of antiretroviral therapy across the six geopolitical zones of Nigeria. The study shows that the end users were satisfied with uninterrupted antiretroviral drug supplies, courtesy treatment and quality counseling services but identified gaps in ART services provision, weak health leadership, non-attractive ART services infrastructure, frequently interrupted laboratory services, inadequate health care workers, and long waiting time. This study did not have a database that showed the number of health personnel in the hospitals and the number of people enrolled for the programme. Omenka [16, 17] studied the factors influencing access to ART drugs centres in Benue State. The study discussed some of the barriers preventing people living with HIV/AIDs from accessing treatment in Benue State. The results showed that factors influencing access are free cost and increased number of sites, beneficial effects of ART, membership in a group and having a treatment partner while factors considered to be barriers are stigma and discrimination, hunger, poverty and transportation cost. Tamen [18] examined antiretroviral drugs therapy in Benue State. The study looked at the age range of people receiving antiretroviral drugs at private hospitals in Gboko Local Government Area of the State. The result revealed that most people receiving drugs at the centres are aged between 11 and 40 years.

Mapping case locations at the individual or population level are vital to public health research since their spatial distributions provide insights into the environment where potential exposures of health risks may be encountered. The application of GIS in public health and health sciences abound in literatures [19]. In Africa, the application of GIS in health care system has been focused on mapping the distribution and control of vector borne disease using climatic data only of recent development that expanded the use of the software for other health application. To address the challenge of providing treatment to HIV/AIDS in Tanzania, PEPFAR [20] uses GIS as an information management and analytical tool to improve HIV/AIDS programme delivery by facilitating the integration and analysis of spatially

referenced data by mapping. GIS help PEPFAR answer essential questions such as where are the highest HIV prevalence districts in the country. What is the geographic distribution of counseling and testing service delivery points? Where should PEPFAR expand its services in order to maximize coverage of equity? How many people live within the catchment areas of facilities that currently offer ARVS? In recent years, there has been a growing interest among the ministries of health and other health sector institutions in the use of Geographical Information System (GIS) as a tool to strengthen the analytical, management, monitoring and decision-making capacity in public health, as well as a tool for advocacy and communication between technical personnel, policy makers and the general public [21]. Recognizing the power of this tool (GIS) has led to a growing number of health studies and projects being developed by academic teams and health service professionals that include its use as a tool for analysis and decision making [22].

This research shows that there are 35 facilities offering HIV Counselling and Testing (HCT) in Oyo metropolis, Private and Government facilities. Only 2 of these facilities are providing ART, Oyo state hospital (government facility) and Shekina hospital (private facility), both located in Oyo east local government. The aim of the research was to use Geographic Information System (GIS) to understand the effectiveness and efficiency of distribution of HIV Drugs centres and the inherent challenges in Oyo, Nigeria. It is expected that the database design and the output maps from spatial analysis result will aid decision-makers to make right choice in siting HIV Drugs centres, this can further be applied at nationwide scale to enhance the sustainability and development of HCT centres.

## **2. MATERIALS AND METHODS**

This study was carried out in Oyo town in Oyo State, Nigeria. The geographical location of the Oyo town lies within latitudes 7°44'59.53" and 8°00'00.00" north of equator and longitude 3°52'31.35" and 4°05'00.00" east of Greenwich meridians. Oyo covers the total area of 2,427 km<sup>2</sup> and has the total population of 442,899, density of 180 km<sup>2</sup>. Oyo comprises three local governments namely: Oyo West, Oyo East and Atiba. It is located in the south-western geo-political zone of Nigeria.

The objectives used to realize the aim of the research included the design of a spatial database of Distribution of HIV Drugs centre in the study area, examination of existing HIV Drugs centre in Oyo, spatial queries and analysis. Thus, the method used include a database design, data capture, map scanning, georeferencing and digitizing and attribute data acquisition, database creation and information presentation. All the phases of a database design (conceptual and logical) were implored in this work. The effective implementation of any geospatial work lies on the proper planning and designing of geospatial database, regarded as the heart of a GIS. The process of designing such a database is called data modeling.

Data modeling is well defined in literature [23] and refers to the process by which the real world and their interrelationships are analyzed and modeled in such a way that maximum benefits are derived while utilizing a minimum amount of data. Improper design often leads to implementation problems. Obtaining a GIS database requires two main phases; the design phase and the construction or implementation phase. The design phase (data modeling) consists of three levels, namely: Conceptual Design phase, Logical Design phase, Physical design phase. Definitions and the general Principle of Data Modeling in the real world system [24] were

adopted in this research work. The view of reality, an important part of the design phase is a mental abstraction of reality for a particular application or group of applications. They include all aspect of things in space in their different location that may not be perceived by individuals, their spatial relationships and attributes that could be man-made in their various sizes and themes. For the purpose of this project these includes HIV Drugs centres, boundary, road network and people. We used the vector data model in this research. For this study, the entities of reality were to access the accessibility of the existing HIV Drugs center which were identified as Points, Lines and Area object, the relationship between entities and the attributes of each entity were also identified. The entity classes were Boundary (polygon), HIV Drugs centre (points) and Road (line). The conceptual data model developed in this research work translated into a data structure in the following manner: Node, Arc and Area.

**Conceptual design:** This is the conceptualization of human reality and how the view of reality will be represented in a simplified manner but still satisfy the information requirement of the organization concerned. The conceptual database design is the representation of human conceptualization of the reality using a high-level conceptual data model. The conceptual model is a human-oriented, often partially structured, model of selected objects and processes that are thought relevant to a particular problem domain [25, 26]. It describes how to represent and present the database and gives a concise description of the data requirements of the users. Furthermore, it also includes detailed descriptions of the relationships and constraints expressed using the concepts provided by the high-level data model. One of the most effective ways of developing a conceptual data model in a relational data model is the Entity-Relationship data modeling. The entity-relationship diagrams constitute a very useful framework for creating and manipulating databases. An ER diagram is a pictorial representation of the information that can be captured by a database. It allows database professionals to describe an overall design concisely yet accurately. The steps used in conceptual design of the database are: Careful identification of basic entities in the application; identification of the attributes of each entity; definition of the topological relationships which exists among the attributes and definition of the enterprise rule that governs the creation and connection between entities.

**Logical Design:** This is the second phase in database design. It is the representation of the data model designed to reflect the recoding of the data into computerized system using a family of Relationship Database Management System (RDBMS). Logical design translates a conceptual data model into a simple structured form of relational tables. In this case road, facilities, boundary, and attributes of their relationship are represented in a single uniform manner in forms of relation. Since data were intended to be shared using relational database format, data were structured as simple records known as Tuples or row contain a set attribute that are grouped together in two dimensioned table known as RELATION.

### **Data Acquisition**

The datasets are primary data from field and the secondary data are some HCT centres records. The Primary data acquisitions were as follows: location specificity data (coordinates) was achieved with the use of Handheld GPS; while the secondary data was: HCT center data.

### **Physical Design: This phase involves**

Deciding which attributes belong together and in which relationship; choosing appropriate names for the relations and attributes. Specifying sensible domains for the various

attributes; identifying the candidate keys and choosing primary key for each relation; Specify all foreign keys.

The procedure above was achieved in the project through interactive user interface of DBMS (database management system). This is the representation of data structure in the format applicable to the implementing of software. For this project, the attribute for each of the Road, Boundary, Facilities and Building were translated into appropriate data type in ArcGIS 10.1, the implementation software, the software uses number, text, string and date for data declaration.

### **Database implementation**

This is the actual creation of database in the system. It involves the following steps: Hardware and software selection based on data storage requirement and storage format; Physical database creation; the graphic of the spatial data content of the database

### **Database Creation**

A Spatial primary HIV drugs center database was created at the construction phase, after the three levels of the design phase. The creation of the database allows for easy management, storage, manipulation and analysis.

### **Database Management**

This is the use of chosen software (ArcGIS10.1) to organize information in a database. It is the collection of software for the creation, storing and manipulating, retrieving, organizing and querying of information in a database. To ensure that data stored in a database are correct, consistent and secured, a number of measures against unauthorized access, user errors and hardware failure amongst others are necessary. This involves database security which can involve either having a back-up for finished works or having a password to deny unauthorized persons; data integrity which involves ensuring that inconsistency between two entities representing the same fact does not occur which is ensuring that the data in database is accurate and finally database maintenance which can involve a database administrator to man the database. A Database Management System (DBMS) is a software package that allows us to work with a database. It is not the database itself but rather a batch of tools that help to ensure that the integrity and security of the database is maintained. This ensures proper management, data security, integrity and adequate maintenance of the database.

## **3. RESULTS AND DISCUSSIONS**

The spatial analysis in this research work presented system design and implementation of a generic system that is fully compatible with assessing the facilities that exist within the existing HCT centres and HIV drugs centres in the study area. The operation in this stage use a number of analytical commands/queries and spatial analysis including query operation, network analysis and service area.

The analytical power of Geographical Information System (GIS) used in this research work encircles the combination of spatial and non-spatial data especially in a single and multi-criterion situation.

We considered criteria recommended by WHO for the siting of HIV Counseling and Testing Services Centres (HCT) for easy accessibility. These criteria are: A Population threshold of one Heart to Heart centre to 40,000 people, by which we can determine whether the population falling within a catchment area has access to or are being underserved by the existing Heart to Heart centres and access distance of 15 minutes in vehicle travel time or 1.5 km walking distance where densities permits as the service area or the optimum distance zone of influence around each Heart to Heart site.

### **3. 1. Spatial Query (select by attribute)**

Spatial Query was used in this project to test the database created. This is the process of selecting features based on location or spatial relationship. It is achieved through a query expression built to select features that can match the selection criteria from a database using the Select by Attributes tool. Query expressions can either be single or multiple criteria.

### **3. 2. Query for HCT Centre's in the Study Area**

From the database query result, eleven (11) HCT Centres in Oyo East Local Government, were identified. Further database query show that twelve (12) HCT Centres are in Oyo West Local Government and twelve (12) HCT Centres in Atiba Local Government. Figures 1- 3 show all maps of the three-local government with the HCT centers.

### **3. 3. Query for HIV Drugs centres in the Study Area**

Further query gave result of the HIV Drugs Centers that are within Oyo Metropolis and only two centers were found to be in existence in within Oyo Metropolis.

### **3. 4. Query for condition of HCT Centres, HCT Pharmacy Store and HIV Trained Staff in the Study Area**

The database was subjected to more test to know condition of HCT Centres, HCT Pharmacy Store and HIV Trained Staff in the Study Area. It was shown that that there are (6) HCT Centres which are in better condition while and fifteen (15) HCT Centres have Pharmacy Store whereas two (2) HCT Centres have HIV trained staff.

Multiple Queries for HCT Centres which are in Better Condition, HCT Centres having Pharmacy Store and HCT Centres with HIV Trained Staff in the Study Area shows in the that there are (2) HCT Centres which are in better condition, having Pharmacy store and having HIV trained Staff.

## **Spatial analyses**

**Network Analysis:** Network analysis is a set of interconnected lines making up a set of features through which the resources can flow. For examples, roads, rivers, pipelines, railways, telephone and electric lines are networks that can be modeled in GIS. There are many classic network type problems including finding best route, the closest facilities, the shortest route and even the service area. Network in GIS operates on the line features, but it also includes the surrounding area and associated attributes. Best route involve tracking all possible route and presenting the one with the shortest path. The closest facilities refer to feature along the network that are designed and displayed the best way to get to or from them.

**Network Dataset Creation:** A set of participating features classes is defined, properties are set, and a graph is mad. The properties of a network dataset affect how network elements are discovered from features coincidence, refine the connectivity model, and optimize solve performance. Once a network dataset is defined, a build process will generate the network elements that enable network analysis. Whenever a network source is edited, the network dataset must be rebuilt.

**Best Route Analysis:** This operation is carried out to determine the most optimal route or path one can go through in arriving at a given destination. It generates a least cost path on a network between a pair of predefined locations, using both geometric and attributes data. This form of analysis not only shows the shortest and best path that can be taken to arrive a destination, it also gives the direction to be taken, and also the total distance to travel to arrive at the given destination with the specified distance units. How the result of the best route from oke olooa to state hospital shows the result of analysis of the direction of best route shows the map of best route from oke olooa to state hospital. Results of the alternative route from Oke Oloola to state hospital, direction of the alternative route and maps are shown in Figures 4 and 5 respectively. A comparison of route distance is shown in Table 1.

**Table 1.** Comparison of route distances

Location	Best route	Alternative route	Differences in distance
Oke Oloola to State Hospital	5.2 km	5.3 km	0.1 km (100m)

**Service Area Analysis:** A network service area is a region that encompasses all accessible road (i.e. road that are within a specified impedance) Service area created by network analyst help to evaluate accessibility. Concentric service areas were created and show how accessibility varies with impedance. The ideal distance from HCT to ART should be 2500m. Figures 6 and 7 show maps of the HCT centers served by the state hospital and Shekinah hospital respectively. The highlighted area in Figure 6 and Figure 7 surrounding each HCT centre is the area covered by each HIV Drugs centres. This was done based on the ideal distance of 2500m (2.5 km) from HCT to ART. The uncovered areas are the unserviced areas.

**Average Nearest Neighbor:** Nearest Neighbor operation was used to determine whether the HCT centres are dispersed, random or cluster in Oyo metropolis. This was done using analyzing pattern (Average Nearest Neighbor). This result will guide and supports health planners, decision makers, administrator and its agencies to know where to site a new HIV Drugs centres in Oyo metropolis. However, result show that the HIV Drugs centers are dispersed. Also show the average nearest neighbor summary and dataset information respectively. Average Nearest Neighbor Index (Rn) for HIV Drugs centres within Oyo metropolis was calculated based on average distance on straight line from each facility to its nearest neighboring facility. The Rn was 28.8. The Rn value indicates that spatial pattern of HIV Drugs centres in Oyo metropolis are dispersed (Figure 8). The Z-score (74.813624) and P-value (0.00000) indicated that the

pattern of HIV Drugs centres in Oyo metropolis exhibited significant dispersion. This means, the pattern of HIV Drugs centres in the study area was significant differ from the random pattern.

#### **4. CONCLUSIONS**

This project was undertaken to exploit the capability of GIS in analyzing the spatial distribution pattern of the existing HIV Drugs centres within Oyo Metropolis. The system developed in this project would serve as a Decision Making Supporting System (DSS) for solving problem relating to healthcare both present and future in Oyo metropolis. Oyo East, Oyo West and Atiba Local Government local government have 11, 12 and 12 HCT centres respectively within Oyo metropolis. Only two HIV Drugs centres State Hospital and Shekina Hospital exist in the whole Oyo metropolis. The study also revealed that accessibility to HIV Drugs centres that exist within HCT centres in the study area were not enough. Again, only two HCT centres have both Pharmacy store, adequate HIV trained staff and their hospital are in good condition (State hospital and Oroki Medical centre). The State Hospital provides HIV Drugs while Oroki Medical centre does not. It is expected that the database design and the output maps from spatial analysis result will aid decision-makers to make right choice in siting HIV Drugs centres, this can further be applied at nationwide scale to enhance the sustainability and development of HCT centres.

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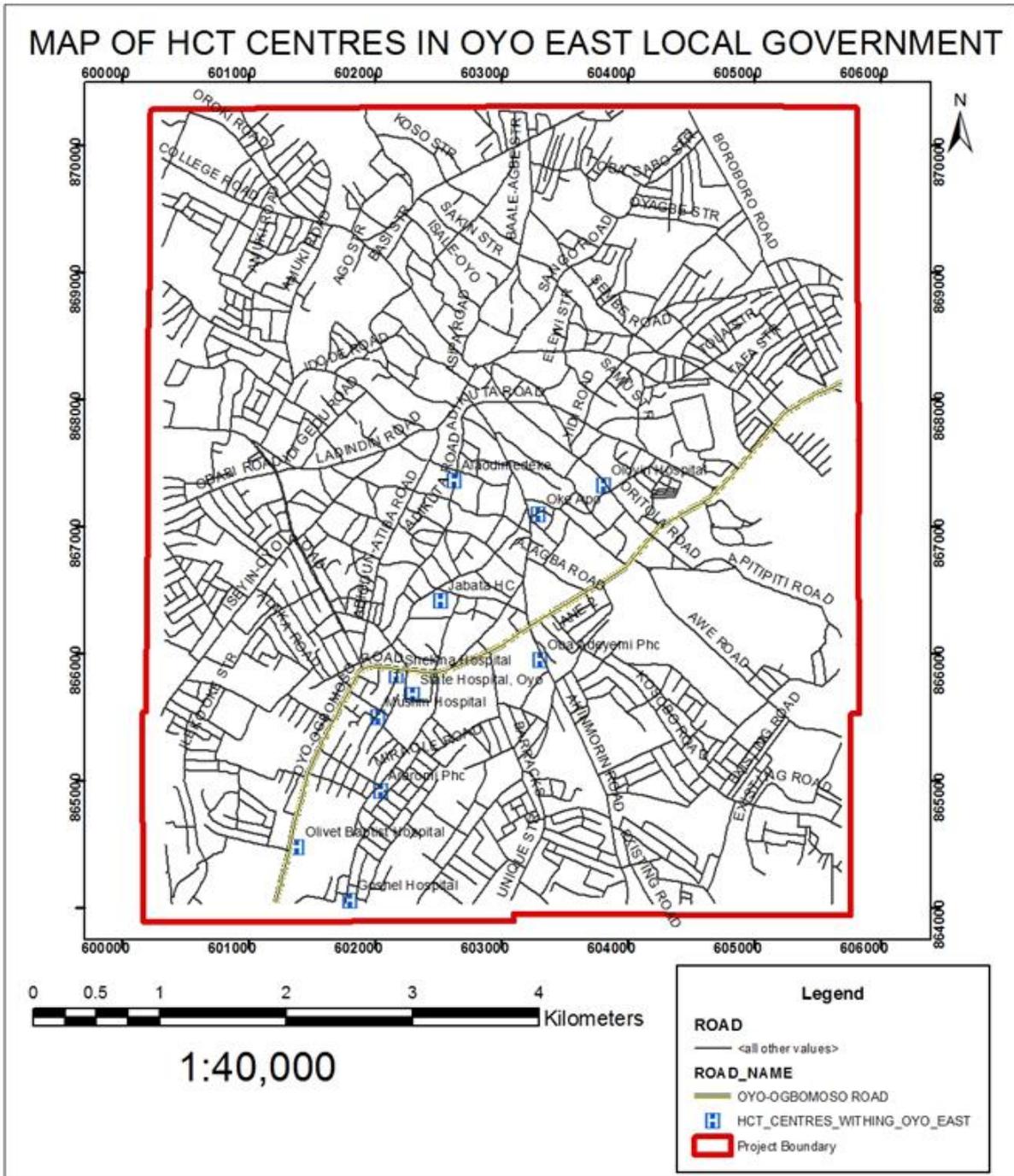
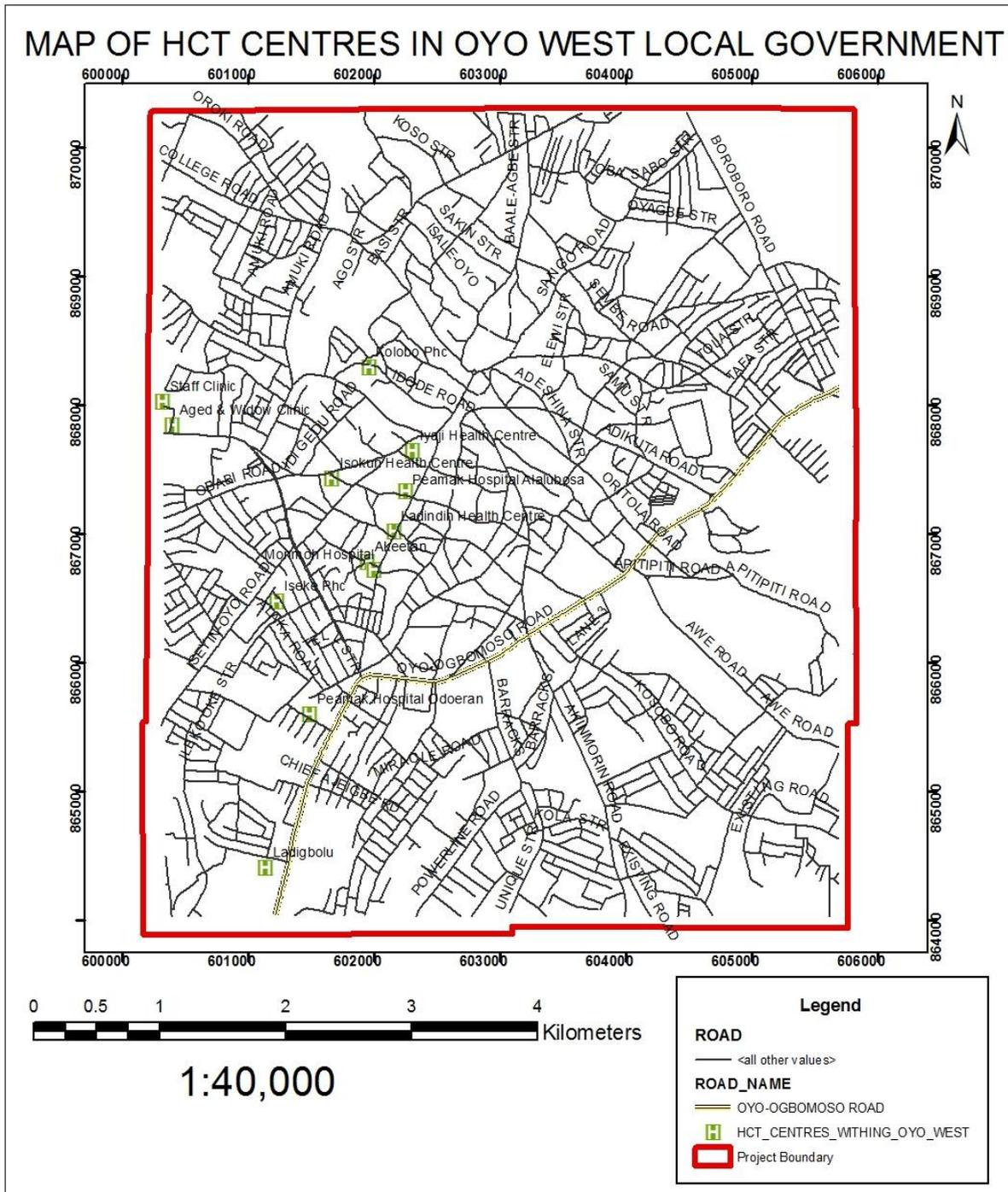


Figure 1. Map of HCT Centres in Oyo East Local Government



**Figure 2.** Map of HCT Centres in Oyo West Local Government

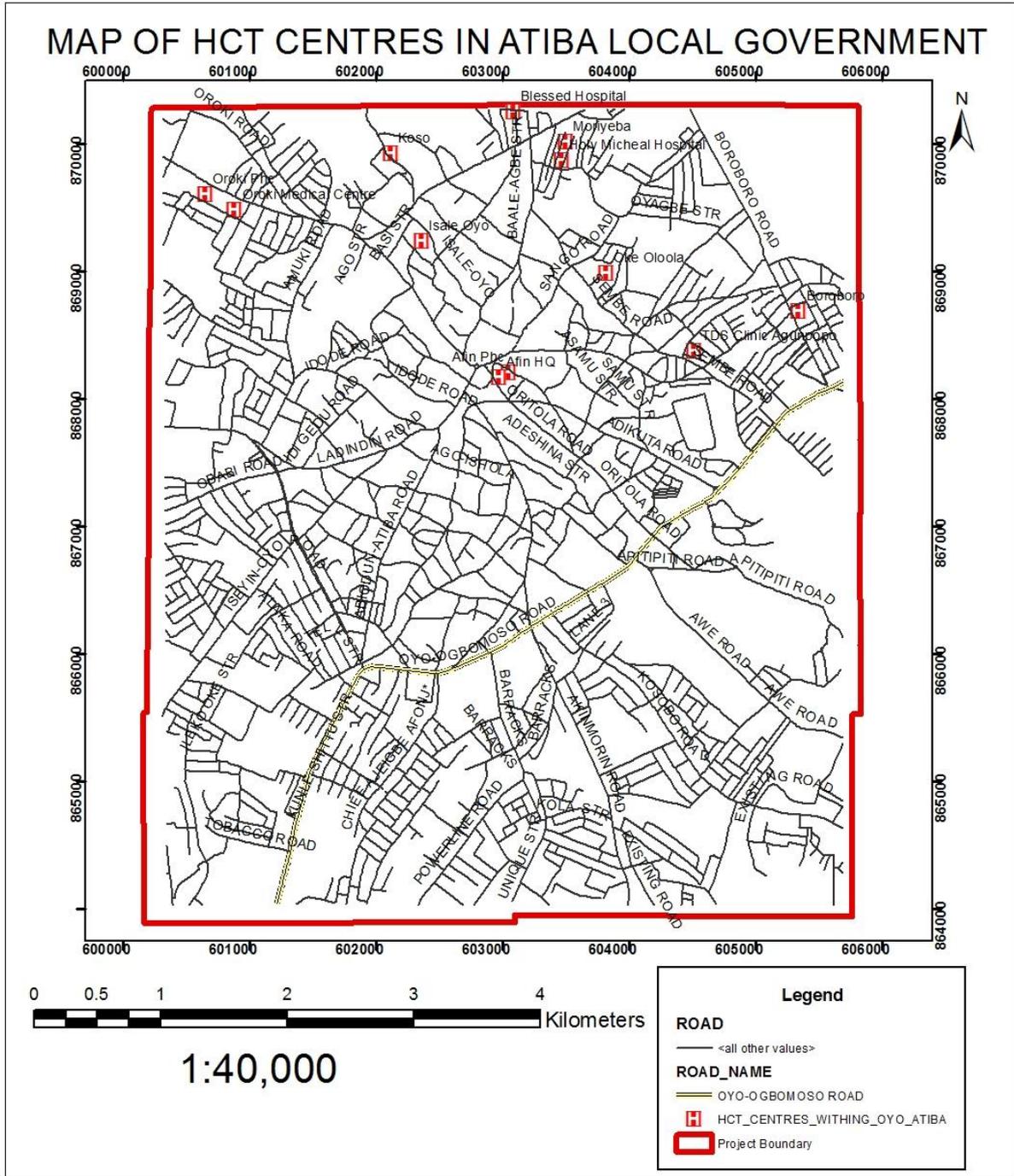


Figure 3. Map of HCT Centres in Atiba Local Government

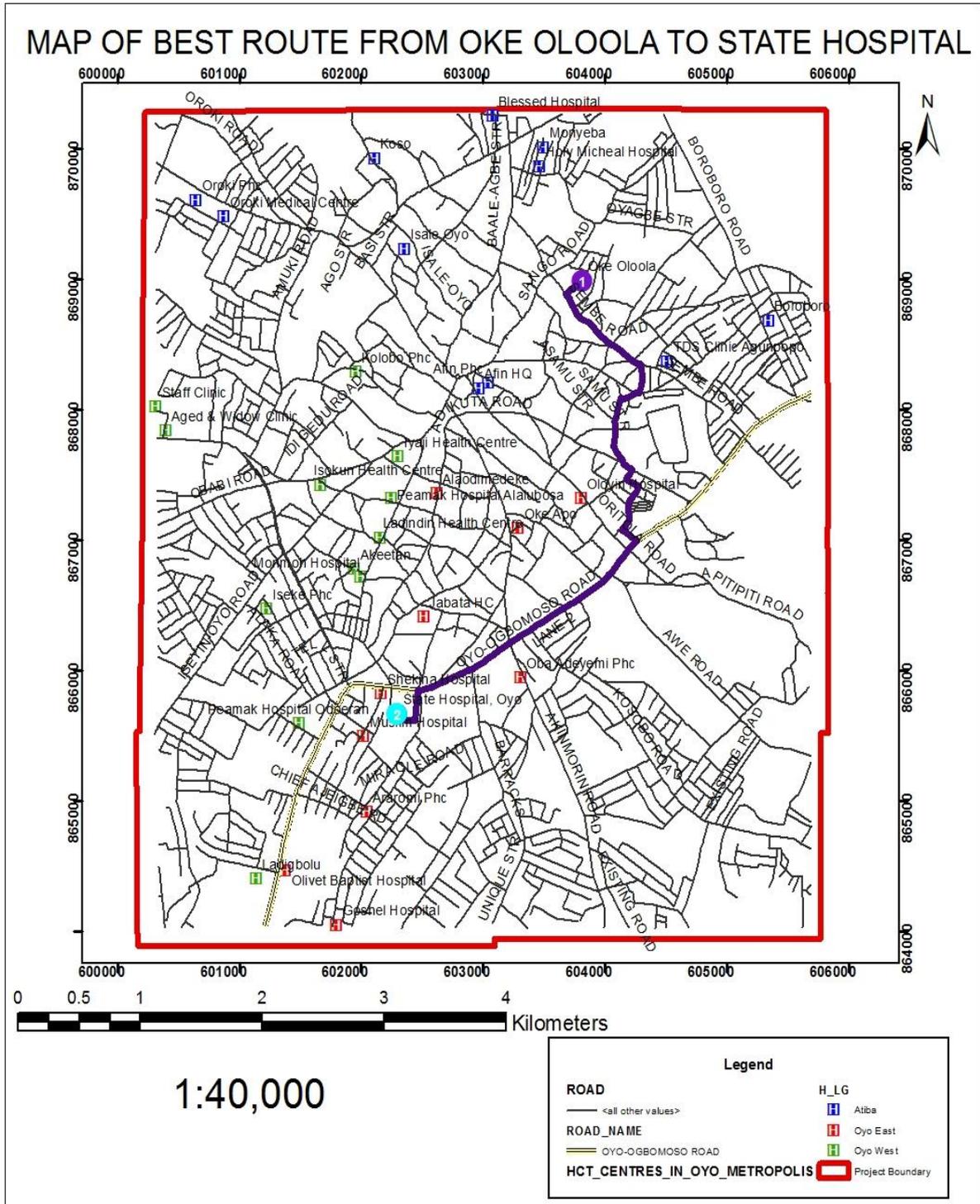
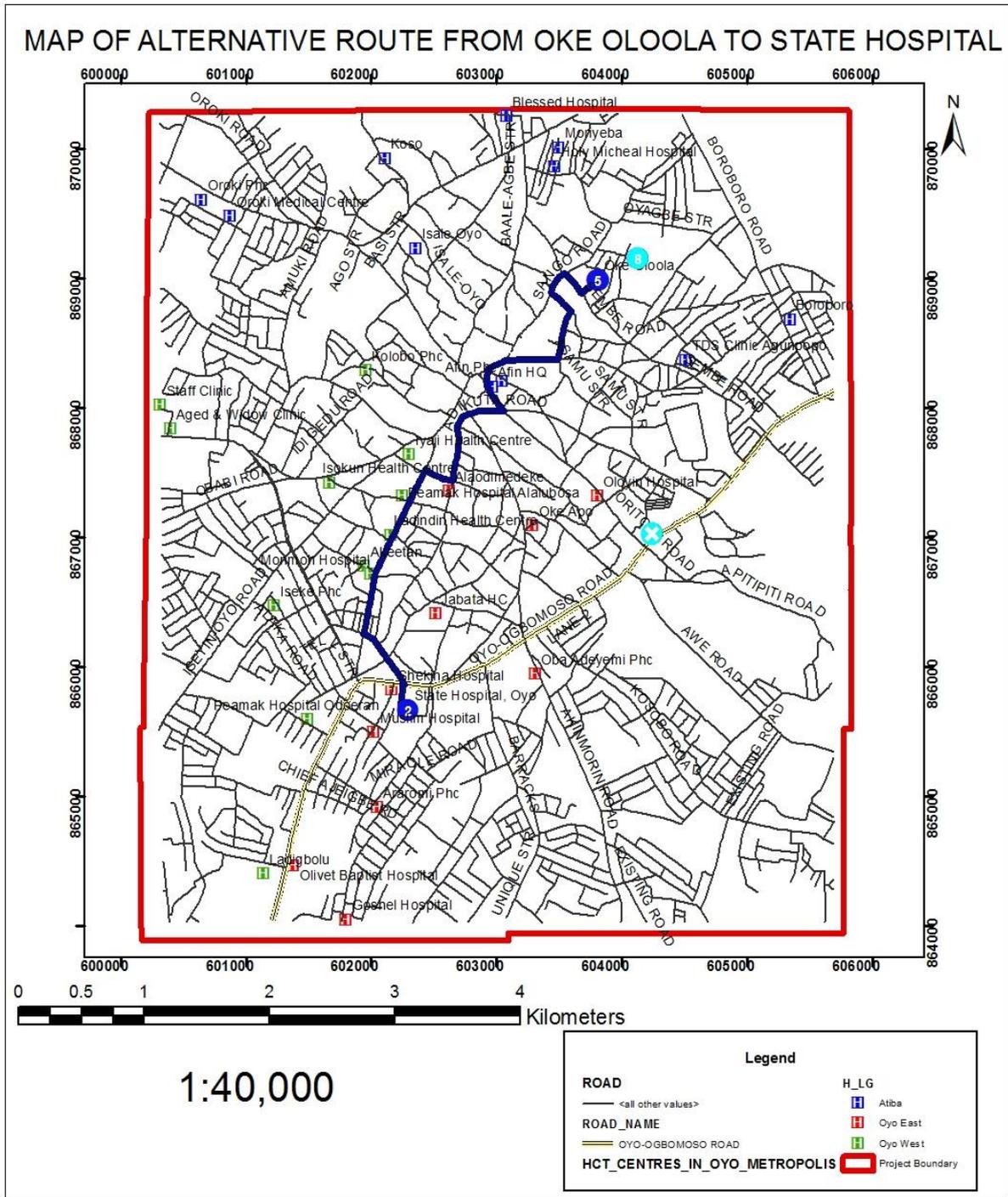
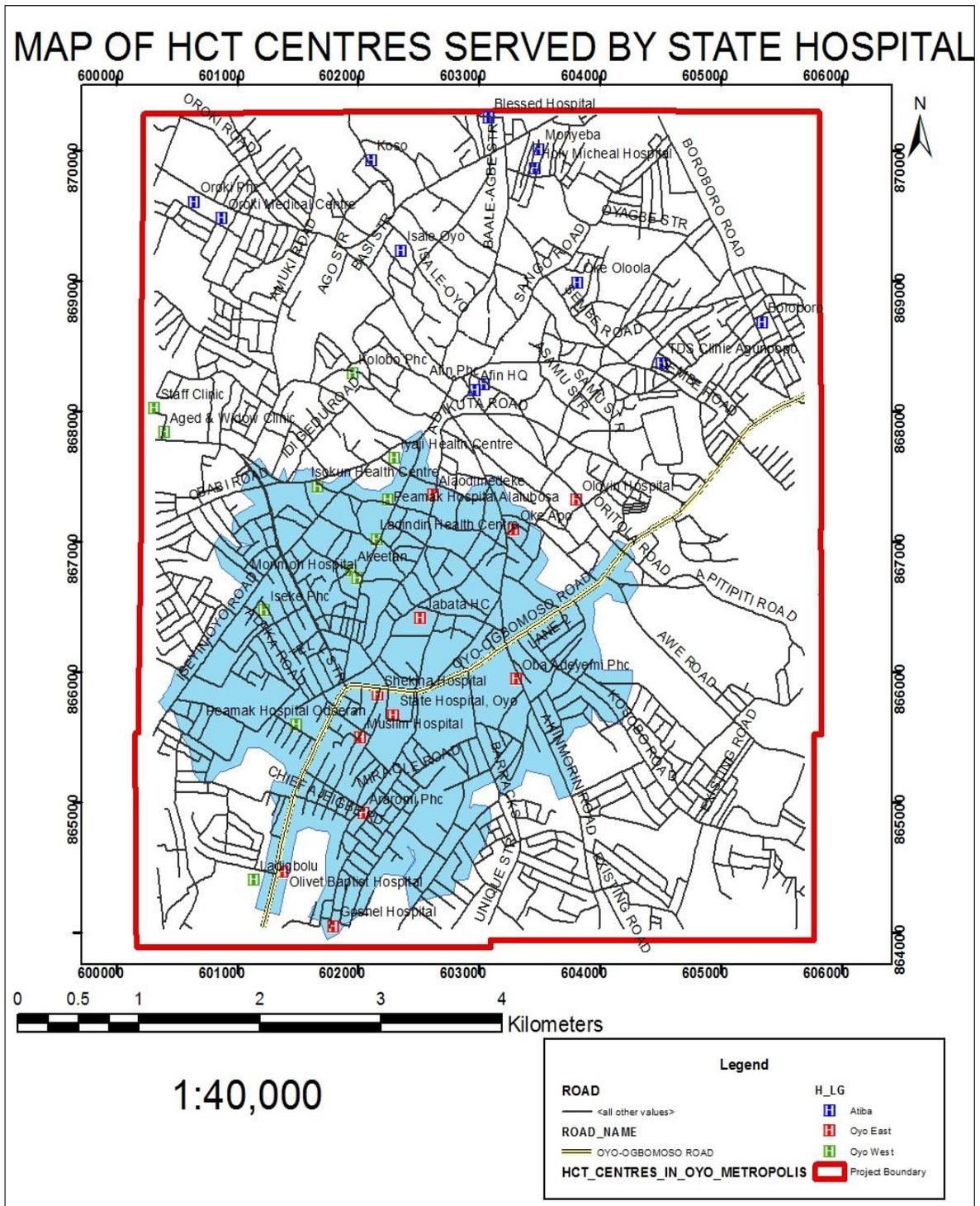


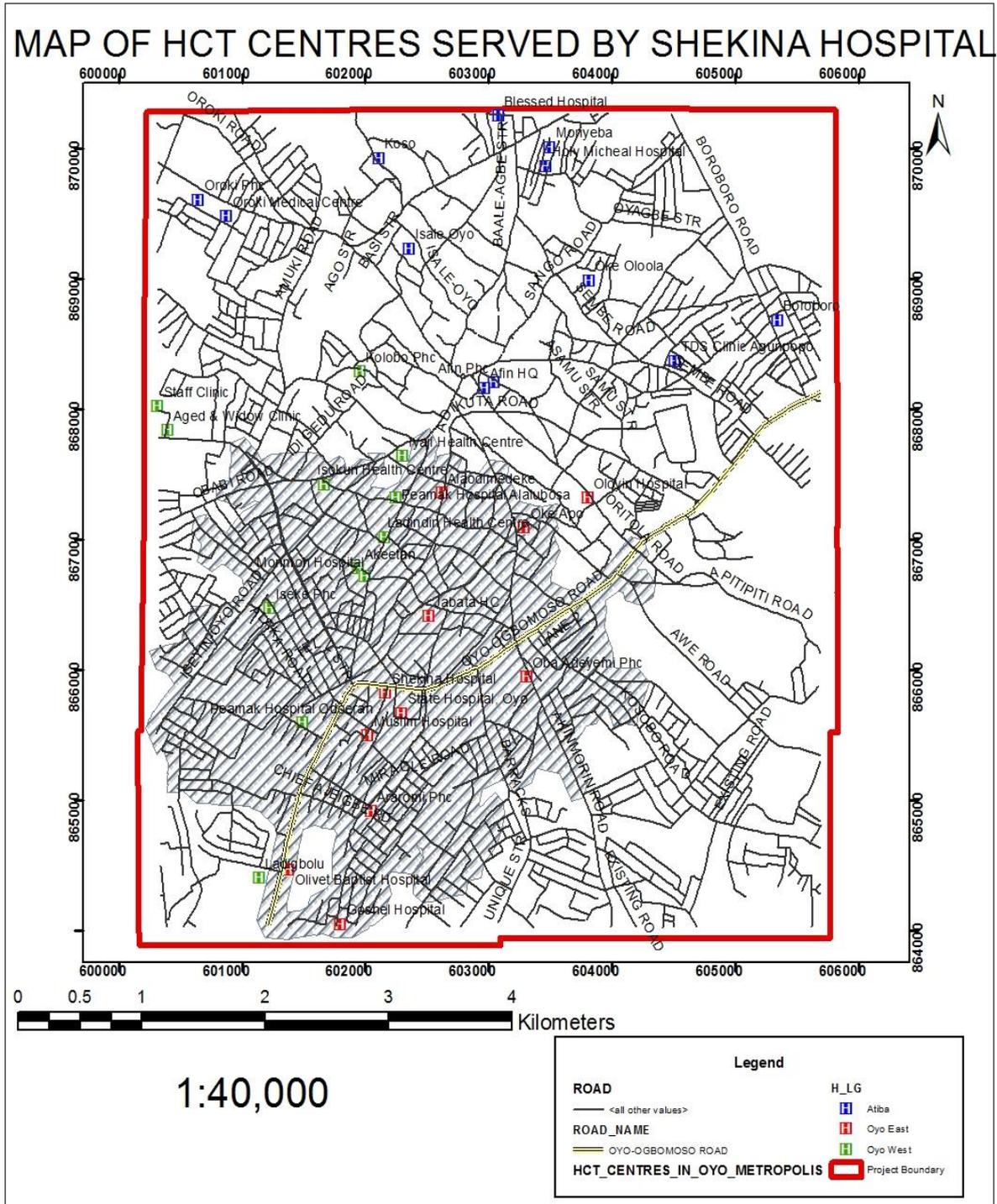
Figure 4. Map of best route from Oke Oloola to State Hospital



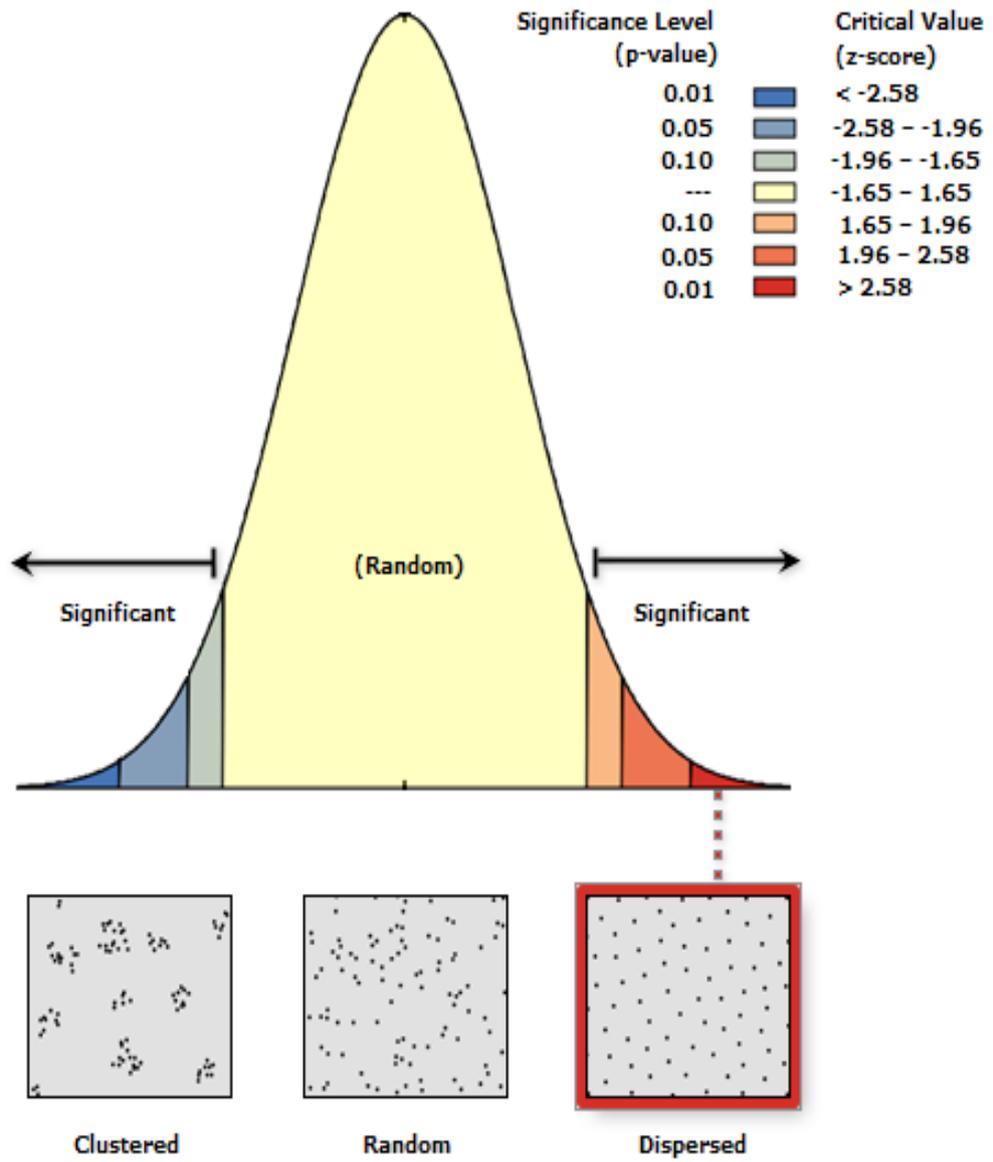
**Figure 5.** Map of alternative route from Oke Oloola to State Hospital



**Figure 6.** Map of HCT centres served by State Hospital



**Figure 7.** Map of HCT centres served by Shekina Hospital



**Figure 8.** Result of Average Nearest Neighbor Analysis give a z-score of 74.8136242237