



(RESEARCH ARTICLE)



ASSESSMENT OF SPATIAL DISTRIBUTION AND RANGE OF SERVICE OF PUBLIC HEALTH FACILITIES IN IKWO LOCAL GOVERNMENT AREA OF EBONYI STATE, NIGERIA

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ABSTRACT

This study assessed the spatial distribution and range of service of public health facilities in Ikwo Local Government Area (LGA) of Ebonyi State, Nigeria. Using primary location data collected via handheld GPS alongside secondary maps, geographical datasets were integrated into a GIS environment using ArcGIS 10.5. The study evaluated facility spatial patterns using average nearest neighbor analysis, while buffering and network analyses were applied to determine service coverage radii and optimal transit routes to referral facilities. The inventory identified public health facilities spread across the local government area, comprising one secondary healthcare facility (General Hospital Ikwo located in Ndufu Alike ward) and multiple primary healthcare facilities categorized into health centres, clinics/maternalities, and health posts/dispensaries. Average nearest neighbor analysis demonstrated a spatially dispersed distribution pattern overall. Buffer analysis revealed that while most wards fall within the 15 km catchment zone of the central hospital, several southern wards including Amudo Okoffia, major parts of Etam, Ama Inyima, Ndiagu Amagu I, and Ndiagu Amagu II remain outside the service coverage area, creating severe physical accessibility barriers during medical emergencies. Additionally, coverage gaps were identified for lower-tier primary facilities using variable service radii. The study concludes that public healthcare infrastructure in Ikwo LGA suffers from geographical disparities and insufficient primary facilities relative to national framework recommendations. It recommends the formulation of a sustainable strategic plan that integrates non-governmental stakeholders to guide equitable future facility placement and improve health service delivery.

Keywords: Buffering, Distribution, GIS, Ikwo LGA, Public Health, Spatial Range of Service.

1 INTRODUCTION

Human health is a key factor in the sustainable development goal agenda. Irrespective of the developmental and technological status of the society; health care system is crucial to the welfare of the society (World Health Organisation (WHO), 2010; Bhatt & Joshi, 2013; Owoyele et al., 2015). Health care systems are organisations established to meet the

health needs of target populations; its exact configuration varies among nations. The need for health varies in space as the physical environment varies in characteristics from place to place and this invariably has implications for the pattern of demand for health care (Onokerhoraye, 1999) plans in relation to the personal and population-based health care goals within their societies, so the welfare of the public through the provision of health facilities is one of the key policies and responsibility of government, particularly in Nigeria (Scott Emuakpor, 2010). In Nigeria, health care delivery service is provided by a dual system comprising stakeholders from the public and private sectors including the private for-profit as well as the private not-for-profit organisations (Nnamuchi & Metiboba, 2015). The public health care system is the largest and central to Nigeria's health care WHO, 1998). Countries and jurisdictions have different policies and delivery operating along the lines of primary, secondary and tertiary health care systems at the local government, state and federal government respectively. (National Primary Health Care Development Agency (NPHCDA), 2013; Umukoro, 2012). The public health institutions including primary healthcare comprising health centres, clinics and health posts; hospitals (secondary healthcare); and tertiary healthcare are prominent for maintaining population health since their inexpensive services are relatively (NPHCDA, 2013). The distribution of the public health facilities was addressed in a policy contained in Nigeria's Fourth National Development Plan (NFNDP) (1981 - 1985) framework (Scott-Emuakpor, 2010) and adopted by the relevant health agencies including National Primary Health Care Development Agency (NPHCDA). However, the chaotic and lopsided spatial distribution of these public health care facilities which is perceived as unfair and socially biased has drawn a considerable attention of the medical geographical researchers and urban planners mostly in developing countries like Nigeria to consider various measures to assess the spatial distribution impact on the use of healthcare system (Scott-Emuakpor, 2010; Jimoh & Azubike, 2012; Owoyele et al., 2015). Analysing the spatial distribution of health facilities provides important information on the location of such health facilities and evaluating the range of health service is one of the most important measures to assess the accessibility of the target population to the health facility (Rob, 2003; Mansour, 2016). Many medical geographical researchers and urban planners have appreciably utilised geographic information system (GIS) to adequately provide information on the spatial patterns, accessibility and the range of service of the health facilities. Using average nearest neighbour analysis, comparing the spatial distribution of health facilities and hypothetically-based random spatial distribution to identify and quantify spatial distribution patterns of the facilities provide good approach (Hazrin et al., 2013; Owoyele et al., 2015b; Mansour, 2016). Also, network analysis can be used to evaluate the shortest accessible routes to the facilities and buffering in order to analyze the proximity and radius of service of the health facilities (Mansour, 2016; Dobrica et al., 2010; Yerramilli & Fonseca, 2014; Ejiagha et al., 2012). This technology integrates the statistical and geographic data and allow the visualisation of such spatial relationships; hence the underlying cause of the distribution can be determined (Hazrin et al., 2013; Dobrica et al., 2010). This study is targeted to examine the distribution patterns and range of service of public health facilities in Ikwo Local Government Area (LGA) of Ebonyi State, Nigeria with the view to understand the locational distribution using Geographic Information System (GIS).

1.1 Study Area

Ikwo local government is located in Ebonyi state, in the south east geopolitical zone of Nigeria. Bordered to the north is Abakaliki local government, to the east is Obubura local government of cross river state to the west is Ezza south and Onicha Local Government Area, and to the south is Abi and Yakur local government of Cross river state The region is predominantly rural, with a significant proportion of the population engaged in Agriculture and other informal economic activities (Obiahu et al., 2021). The indigenous ethnic group of the area is Igbo ethnic group they are a district subgroup who speak the Ikwo language a localise dialect that is closely related to the northeaster Igbo dialect cluster alongside Izzi, Ezza and Mgbo. Culturally, the Ikwo people Origins and ancestry trace their historical origin and ancestry to a leader / hunter figure named Enyi Nwogu, with some oral traditions indicating early historical ties to the Igala people of Idah in present day of Kogi State. The local government is sub-divided into twenty political wards namely Ama Inyima Echialike, Eka Awoke, Ekpanwudele, Ekpelu, Enyibichiri, Etam, Giring, Igbugu 1, Igbugu 11, Inyimagu 1, Inyimagu 11, Ndiagu Amagu 1, Ndiagu Amagu 11, Ndiagu Echara 1, Ndiagu Echara 11, Ndufu Amagu 1, Ndufu Amagu 11, Ndufu Alike, Ndufu Echara and Noye Alike. The study used political ward being the smallest political structure in Nigeria as the spatial zoning boundary.

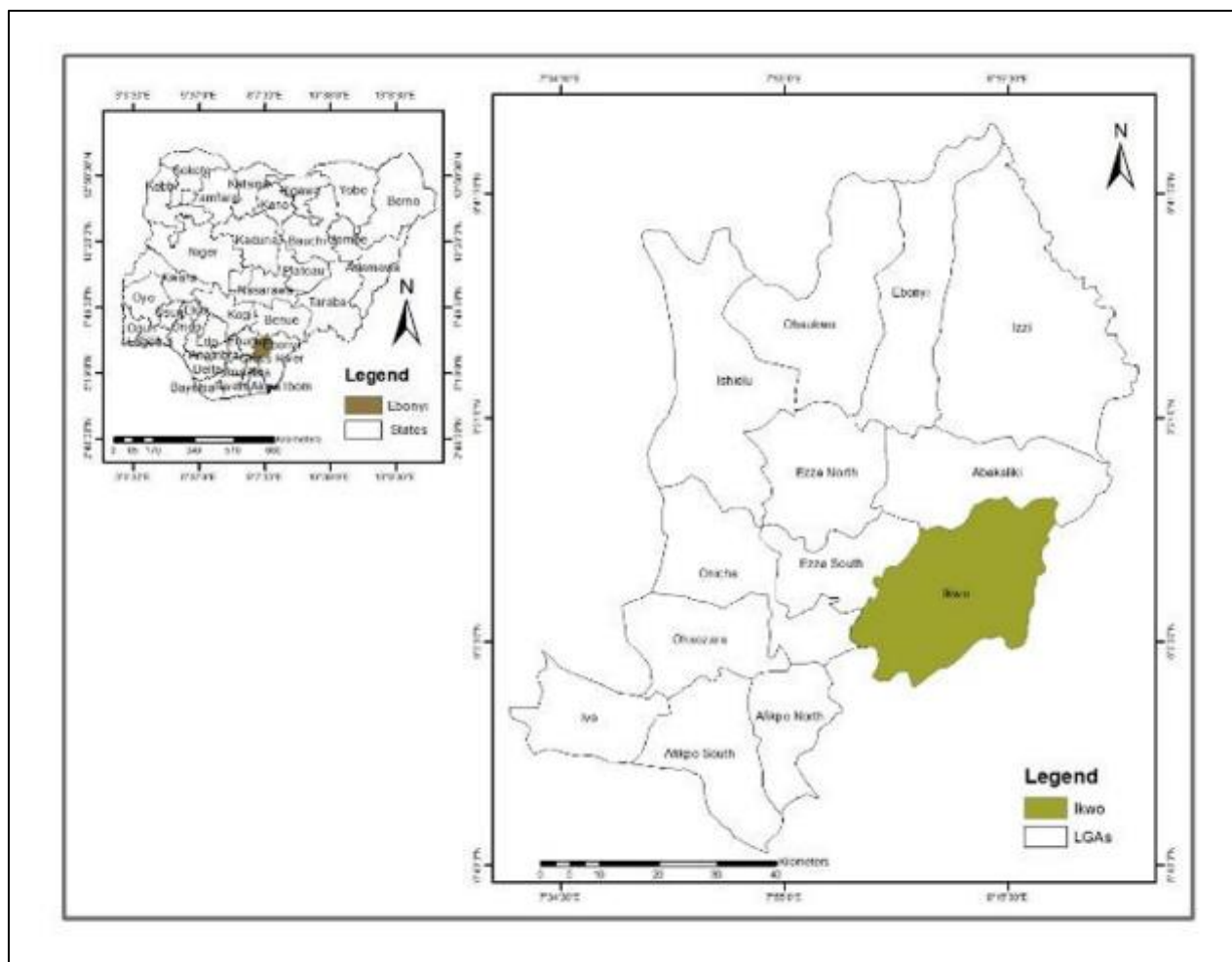


Figure 1: Map of Ebonyi State in context of Nigeria

The primary healthcare system in the Ebonyi North Senatorial District is overseen by the Ebonyi State Primary Health Care Development Agency, which is responsible for the management and coordination of PHC centres across the region. According to the agency, the district currently has a network of 137 PHC centres, with varying levels of infrastructure, staffing, and service provision (Nwakamma et al., 2024).

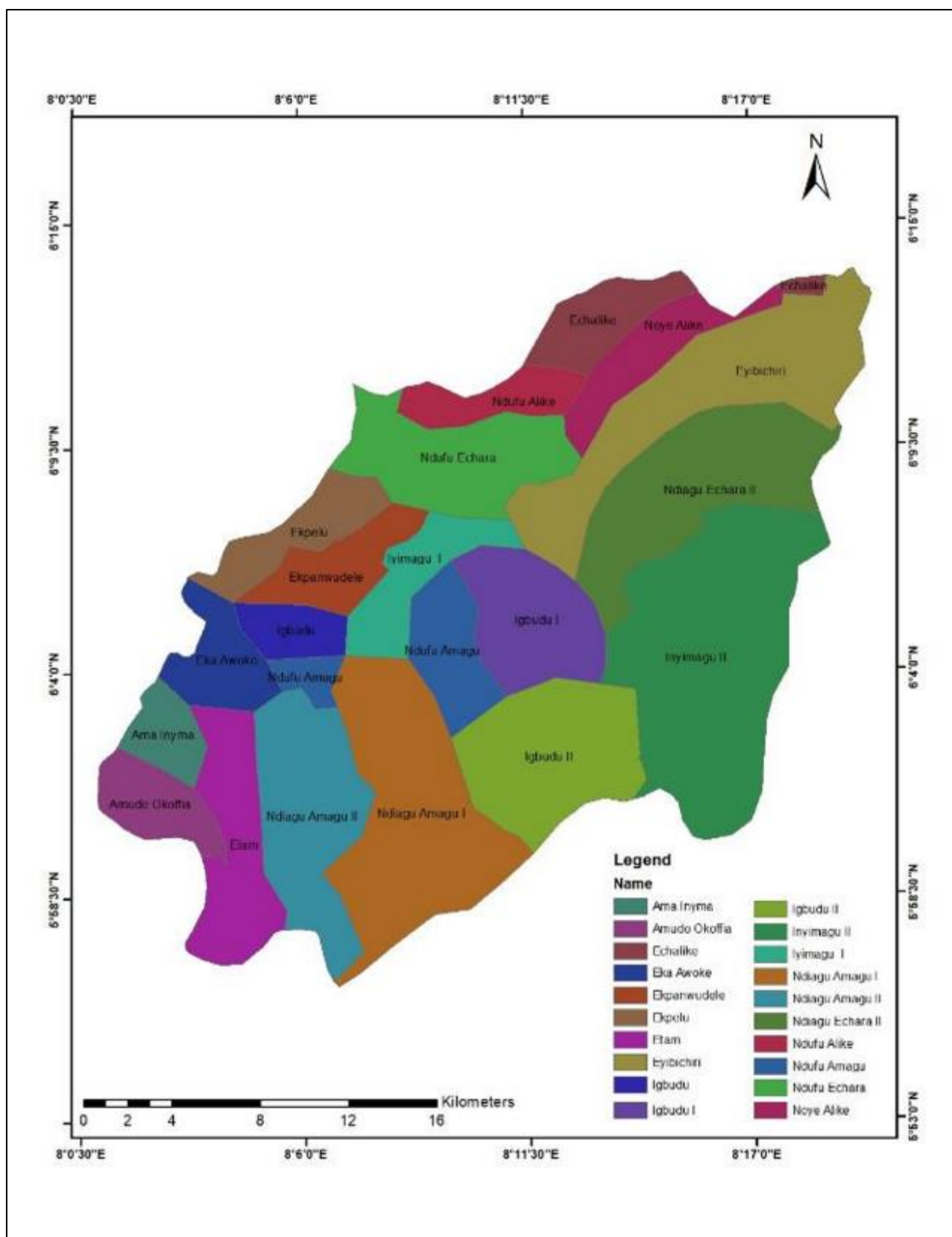


Figure 2: Administrative map of Ikwo LGA

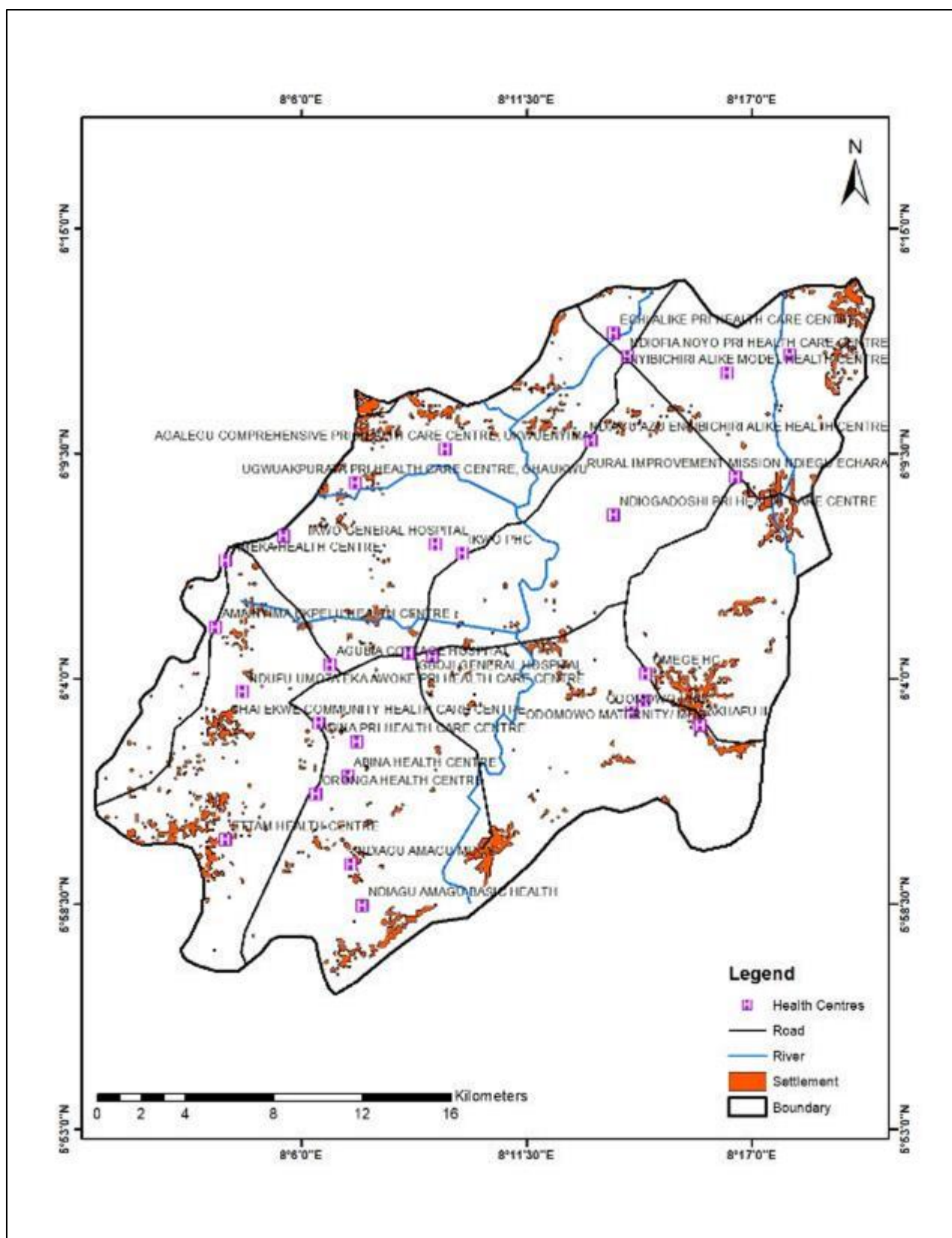


Figure 3: Political Ward map of Ikwo LGA

2 MATERIALS AND METHODS DATA COLLECTION

Data on public health facilities was obtained from Ikwo LGA headquarters and the Ebonyi State Ministry of Health and incorporated in GIS environment. All available public health facilities in the area were identified and their location was geo coded using handheld GPS (Garmin) through in situ data collection method. Population information was obtained from the National Population Commission (NPC) based on 1991 national population census. A base map containing

ward boundaries, rivers, railway and road networks were acquired from the Ebonyi State Ministry of Land and Survey and Google Earth satellite imagery of Ikwo LGA was provided by the Zonal Advance Space Technology Laboratory Application. (ZASTAL) Ndufu-Alike Ikwo. The satellite imagery was digitized in the ArcMap environment in order to update the existing base map which was found to be old. Application of GIS Technique and Spatial Data Analysis a geodatabase was created for the GIS analysis, digitization, which contained a collection of geographic datasets including the base map, GPS coordinates, attribute data, geographic features and satellite imagery for easy access and management. The spatial distribution pattern of public health facilities in Ikwo LGA was used to examine using average nearest neighbour spatial distribution of the health facilities in this area to ascertain if the distribution was clustered, random or dispersed. Average nearest neighbour index which is the ratio of the observed mean distance between each health facility and the nearest neighbour. If the index is less than one, the pattern exhibits clustering; if the index is greater than one, the features are considered dispersed (Environmental Systems Research Institute (ESRI), 2016; Hazrin et al., 2013). In order to effectively and efficiently analyse the physical accessibility and health service coverage, a variable-radius measure was used in this study in line with NFNDP (1981-1985) recommendations for different categories of health facilities ranging from hospitals, health centres, clinics to health posts/dispensaries. The variable-radius measure defines a healthcare service radius based on the facility's characteristics and characteristics of the local population as well as the land area. Radii of 15, 3, 2 and 1km, were adopted for Hospital (secondary health facility), health centres, clinics and health posts respectively. Buffering analysis was performed to measure proximity (coverage) of the residents to the health facilities while network analysis was done to identify the most efficient routes or paths to only referral secondary health facility found in the area. This involves finding the shortest routes from different regions of the LGA to the facility. The main goal is to proffer solution to the problem of geographical accessibility from all the wards of Ikwo LGA with respect to referral cases from lower level of health facilities in those political wards.

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3 RESULTS AND DISCUSSION

Public Health Facilities in Ikwo LGA A total number of fifty-three (53) public health facilities were identified in Ikwo LGA, all the health centres visited are well functional from the health facilities identified, there was only one (1) secondary health facility (Hospital) which is located at Ndufu Alike in Ndufu Alike ward, while the remaining 52 were primary health centres, consisting of thirty (30) health centres (Model Primary Healthcare Centres/clinics), twelve (12) Health Clinics (Maternities and Basic Health Centres) and Ten (10) are Health Posts/Dispensaries (Table 1).

Table 1: Public Health Facilities in Ikwo LGA S

State	Lga	Ward	Facility	Reg. number	Ownership	Facility	Longitude	Latitude
Ebon yi	Ikwo	Ndufu Amagu 1	Abina Health Center		Public	Primary	8.119224	6.026945
Ebon yi	Ikwo	Ndufu Amagu 1	Abina MDG Health Centre		Public	Primary	8.12218	6.04124
Ebon yi	Ikwo	Ndufu Amagu 2	Agalegu /Ndiofoke MDG Health Center		Public	Primary	8.14499	6.04875
Ebon yi	Ikwo	Ekpelu	Amainyima Health Post		Public	Primary	8.06436	6.08674
Ebon yi	Ikwo	Ekpelu	Amangwurw Health Post		Public	Primary	8.05851	6.07859
Ebon yi	Ikwo	Ekpelu	Ameka Health Post		Public	Primary	8.06878	6.11466
Ebon yi	Ikwo	Igbudu 1	Amuda Igbudu Health Post		Public	Primary	8.14172	6.06223
Ebon yi	Ikwo	Inyimagu 1	Amunu Health Post		Public	Primary	8.16577	6.06227
Ebon yi	Ikwo	Inyimagu 1	Cottage Hospital Agubia		Public	Primary	8.11199	6.07269
Ebon yi	Ikwo	Ekpaomaka	Ebiem Primary Health Care Center		Public	Primary	8.203208	6.074193
Ebon yi	Ikwo	Ndufu Echara	Echara MCH, Health Centre		Public	Primary	8.16568	6.11794
Ebon yi	Ikwo	Echialike	Echialike Primary Health Care Center		Public	Primary	8.13391	6.12229
Ebon yi	Ikwo	Inyimagu 1	Effemgbabu MDG Health Center		Public	Primary	8.15404	6.0769
Ebon yi	Ikwo	Ndufu Echara	Eleke Health Post		Public	Primary	8.15187	6.09996
Ebon yi	Ikwo	Ettam	Elugwu Ettam Primary Health Care Center		Public	Primary	8.06533	6.02472
Ebon yi	Ikwo	Enyibichiri	Enyibichiri Millennium Development Goal Health Centre		Public	Primary	8.21785	6.16424
Ebon yi	Ikwo	Enyibichiri	Enyibichiri Model Primary Health Care Center		Public	Primary	8.16235	6.11299
Ebon yi	Ikwo	Ettam	Ettam Primary Health Center		Public	Primary	8.06733	6.02356
Ebon yi	Ikwo	Ndufu Alike	General Hospital Ikwo		Public	Secondary	8.15561	6.12078
Ebon yi	Ikwo	Ndufu Amagu 1	Igweledoha Health Post		Public	Primary	8.09397	6.05599
Ebon yi	Ikwo	Igbudu 1	Imogo Primary Health Care Center		Public	Primary	8.16467	6.04285
Ebon yi	Ikwo	Ekpelu	Inyimagu Ameka Primary Health Care Center		Public	Primary	8.2088	6.071022

Ebon yi	Ikw o	Ndiagu Amagu 2	Item Primary Health Care Center	Public	Primary	8.09077	5.99512
Ebon yi	Ikw o	Echialike	Justice Achor Memorial Health Center	Public	Primary	8.18577	6.13459
Ebon yi	Ikw o	Ndiagu Amagu 1	Ndiagu Amagu Primary Health Care.	Public	Primary	8.12482	5.9743
Ebon yi	Ikw o	Ndiagu Amagu 1	Ndiagu Amagu MDG Health Centre	Public	Primary	8.12031	5.99117
Ebon yi	Ikw o	Ekpaomaka	Ndiechi MDG Health Center	Public	Primary	8.24582	6.07854
Ebon yi	Ikw o	Ndufu Amagu 2	Ndiegw Health Post	Public	Primary	8.14209	6.02165
Ebon yi	Ikw o	Ndegu Echara 1	Ndiogodoshi Echara Primary health C center	Public	Primary	8.13378	6.08141
Ebon yi	Ikw o	Ndufu Alike	Ndufu Alike MDG Health Centre (Elegu Ohankwu)	Public	Primary	8.12199	6.14654
Ebon yi	Ikw o	Eka Awoke	Ndufu Umota MDG Health Centre	Public	Primary	8.07587	6.06149
Ebon yi	Ikw o	Noyo	Noyo Health Center	Public	Primary	8.14382	6.12214
Ebon yi	Ikw o	Noyo	Noyo MDG Health Centre	Public	Primary	8.13591	6.11524
Ebon yi	Ikw o	Ettam	Nsuba Primary Health Clinic	Public	Primary	8.07648	6.02571
Ebon yi	Ikw o	Ndegu Echara 1	Nzashi Primary Health Centre	Public	Primary	8.24582	6.11712
Ebon yi	Ikw o	Enyibichiri	Obeagu Primary Health Centre	Public	Primary	8.17947	6.11898
Ebon yi	Ikw o	Ndufu Echara	Obegu ElekePrimary Health Care Centre	Public	Primary	8.11411	6.09498
Ebon yi	Ikw o	Amainyima	Odeligbo Primary Health Care Centre	Public	Primary	8.04125	6.02568
Ebon yi	Ikw o	Inyimagu 2	Odomowo MDG Health Centre	Public	Primary	8.23444	6.05329
Ebon yi	Ikw o	Inyimagu 2	Odomowo Primary Health Care Centre	Public	Primary	8.23041	6.04911
Ebon yi	Ikw o	Inyimagu 2	Oferekpe MDG Health Center	Public	Primary	8.262222	6.04749
Ebon yi	Ikw o	Igbudu 2	Ogagbo Health Post	Public	Primary	8.17429	5.99184
Ebon yi	Ikw o	Igbudu 2	Ogagbo MDG Health Centre	Public	Primary	8.18933	6.01022
Ebon yi	Ikw o	Ndufu Amagu 1	Ohatekwe Health Center	Public	Primary	8.10498	6.05611
Ebon yi	Ikw o	Eka Awoke	Onuafiukwa Health Post	Public	Primary	8.04091	6.07518
Ebon yi	Ikw o	Ndiagu Amagu 1	Orona Primary Health Care Centre	Public	Primary	8.10608	6.02024

Ebon yi	Ikwo	Ndufu Alike	Ukwuinyima Health Post (Nwakpu)	Public	Primary	8.15808	6.16041
Ebon yi	Ikwo	Enyibichiri	Enyibichiri Alike Model Health Centre	Public	Primary	8.27331	6.19142
Ebon yi	Ikwo	Enyibichiri II	Obegu/Enyibichiri Pri Healthcare Centre	Public	Primary	8.29914	6.19859
Ebon yi	Ikwo	Noyo	Ndiofia Noyo Pri Healthcare Centre	Public	Primary	8.23281	6.19809
Ebon yi	Ikwo	Echialike	Echi Alike Pri Health Care Centre	Public	Primary	8.22727	6.20745
Ebon yi	Ikwo	Ndegue Echara 1	Ndiogadoshi Pri Health Health Centre	Public	Primary	8.22712	6.1334
Ebon yi	Ikwo	Ndiagu Echara	Rural Improvement Mission Ndiegu Echara	Public	Primary	8.27669	6.1491
Ebon yi	Ikwo	Inyimagu 2	Inyimagu Pri Health Care Centre	Public	Primary	8.09276	6.12498
Ebon yi	Ikwo	Ettam	Ettam Health Centre	Public	Primary	8.06898	6.00123
Ebon yi	Ikwo	Igbudu	Omega HC	Public	Primary	8.24034	6.06894

3.1 Locational Distribution of Public Healthcare Facilities

The spatial analyst was used to assess the geographical location and distribution of public healthcare facilities in Ikwo LGA and a detailed geo-database was created.

3.1.1 Secondary Health Facility

Figure 4 shows the location of the secondary health facility. Only one secondary public health facility is located at Ikwo in Echara ward. This implies that the facility is not centrally located within the LGA, as it is closer to the extreme part. However, the location of the facility may be justified, considering population density. On the other hand, the location of this facility can consequently hinder physical access from the wards in the other part of the area as a result of time and travel distance to access the facility

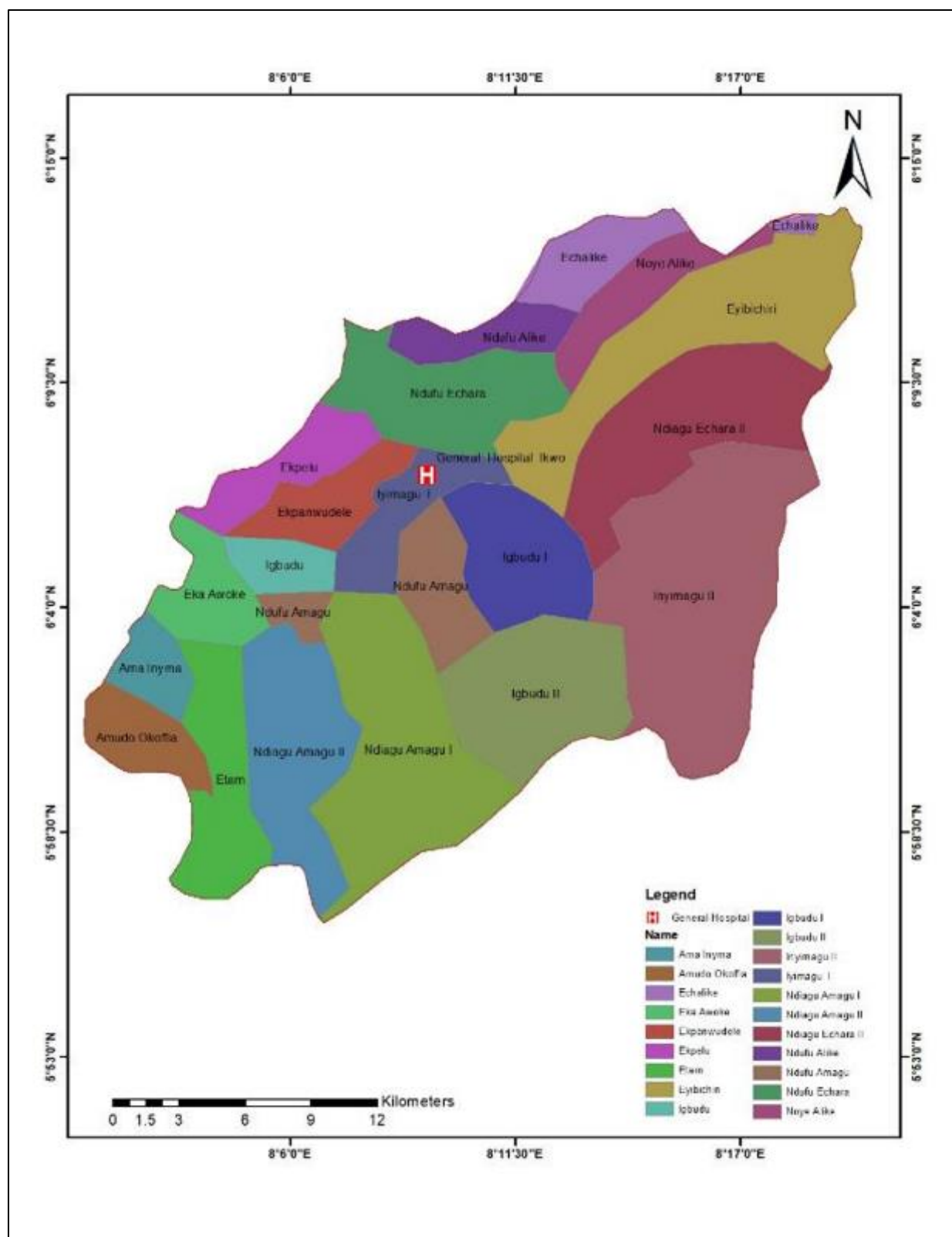


Figure 4: Map of Ikwo showing location of General Hospital

3.1.2 Primary Health Facilities

The primary health facilities identified are classified as health centres, clinics and health posts/dispensaries. The GIS maps clearly show the discrepancy between the distribution and the location of these health facilities. The findings identified the health centres in Ikwo LGA namely Eyibichiri Alike Model Health Centre, Ndiogadoshi primary health care centre, Ndiagu-Azu enyibichiri alike health centre agalegu comprehensive pri health care centre, ukwuenyima ugwuakpurata pri health care centre, ohaukwu, inyimagu pri health care centre, ameka ameka health centre, amainyima ekpelu health centre, effemgbabu, inyimagu pri health care centre.

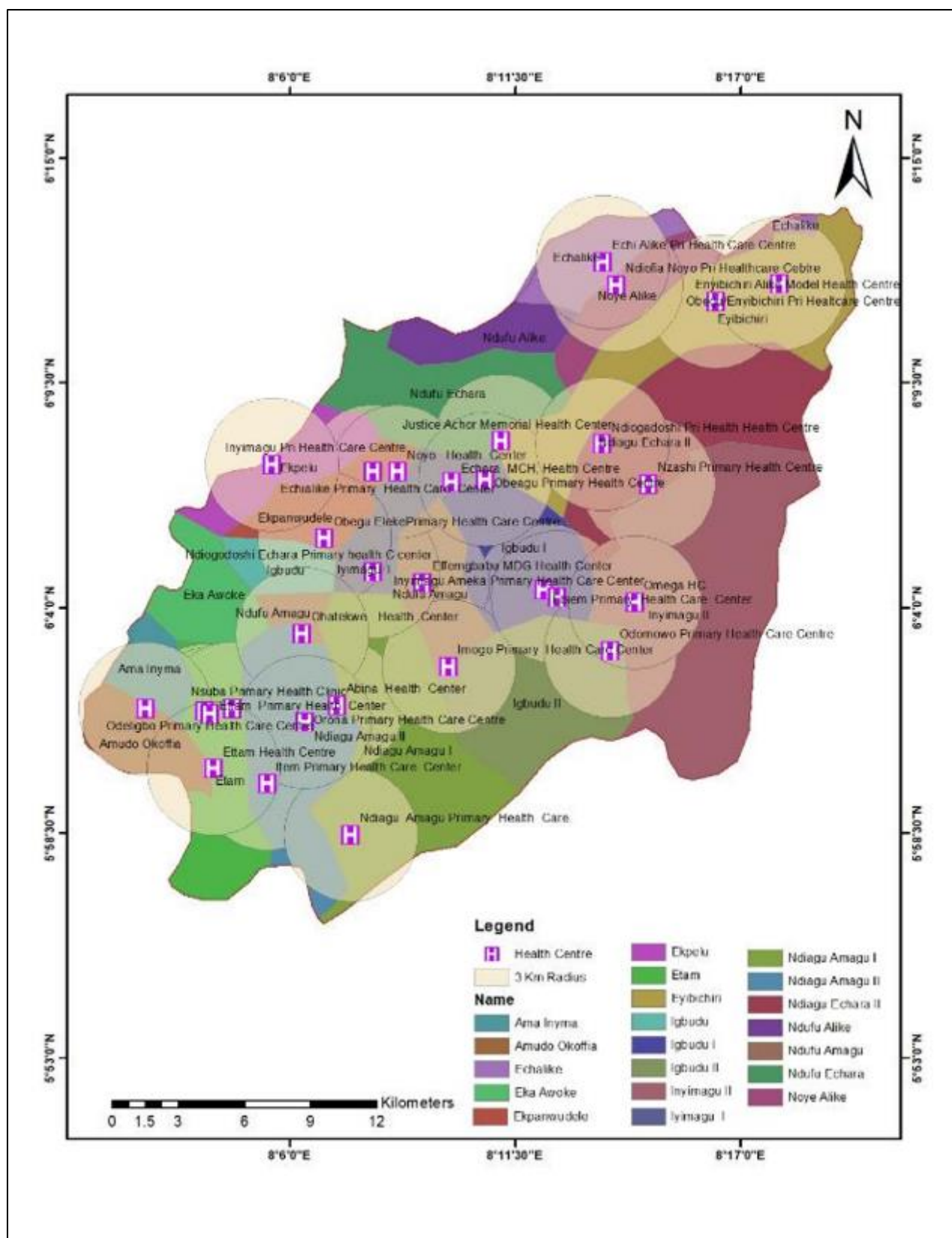


Figure 5: Map of Ikwo showing location of Health Centres

Health Centres respectively as shown in Figures 4.6. Fifty-five (55) facilities (98.2%) fall under the Primary tier (Health Posts, Health Centres, MDG Health Centres, and Model PHCs) one (1) facility (1.8%) operates at the Secondary tier: General Hospital Ikwo, located in Ndufu Alike ward. The result shows that the facilities are located in all part of the LGA as well close to each other, three Maternity were identified in the LGA. They constitute about 5.3% of the total public health facilities (Figure 5). The result shows that the identified clinics are not geographically equitably distributed, leaving some wards without clinics and where available are poorly covered. The findings further revealed that forty-

one (41) Health centres were available and this constitutes about 73.2% of the total number of public health facilities while the health post occupies 19.6% in Ikwo LGA. They are distributed across the political wards of the LGA. The further findings discovered that the health posts are not equitably and sufficiently distributed, leaving some wards without health posts and where available, are poorly covered indicating that the number of health post in the study area greatly fall below the recommendation given by NFNDP (1981 1985) framework.

3.1.3 Spatial Pattern of Public Health Facilities

The result of the spatial distribution pattern of all public health facilities (Figure 4) based on the type or level within the Ikwo LGA using average nearest neighbour analysis. The finding showed that the average nearest neighbour index for public health facilities was 2.58 ($p < 0.01$) indicating that the observed spatial pattern of the facilities was spatially randomly as shown in Figure 7. The z-score was 2.58 ($p < 0.01$), the health facilities gave large z-score indicated that there is a less than 1% likelihood that this dispersed pattern could be the result of dispersed chance. Meanwhile, further study was carried out to examine the spatial distribution pattern of clinics and health posts as the results are shown in Figure 8. The findings showed that the average nearest neighbour index for clinics and health posts was 2.58 ($p < 0.01$) and 1.96 (p Figure 8. The z-score for clinics was 1.96 ($p < 0.01$) while for health posts was 2.58 ($p < 0.001$), hence, the null hypothesis of no spatial pattern among clinics and health posts in the study area was rejected, both clinics and health posts gave large z-score indicated that there is a less than 1% likelihood that this dispersed pattern could be the result of random chance. Range of Service of Public Health Facilities The ease of access that people have to healthcare services is an important element of the quality of service they receive, and this includes the geographical location of health services. The distance that people travel for especially emergency care is very important. Thus, network and buffering analyses were employed to detect areas that are poorly or well served relative to the availability and accessibility to the identified public healthcare facilities. The road network analysis is based on the travelling distance to gain access to the nearest available public health facilities within the respective service area.

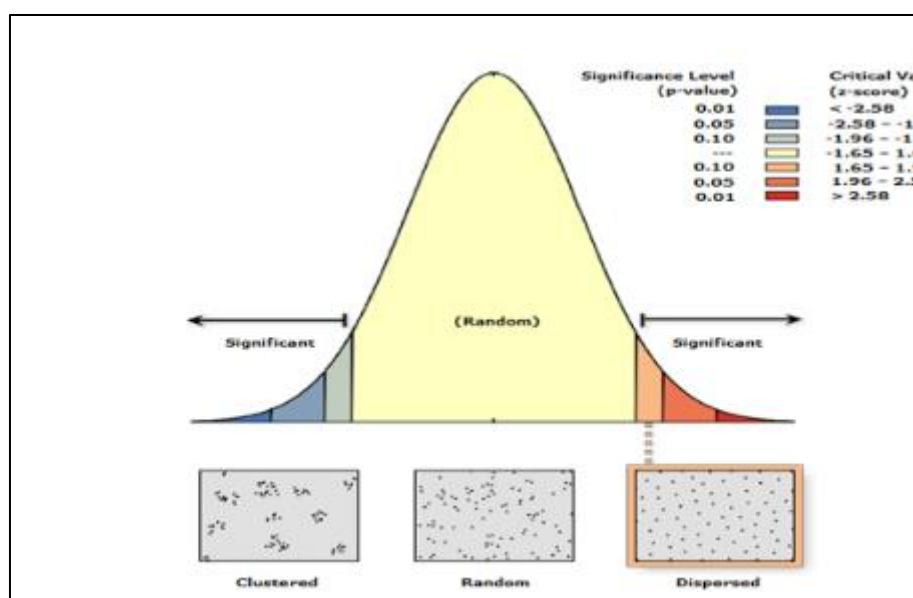


Figure 6: Average nearest neighbour result for Public Health Facilities

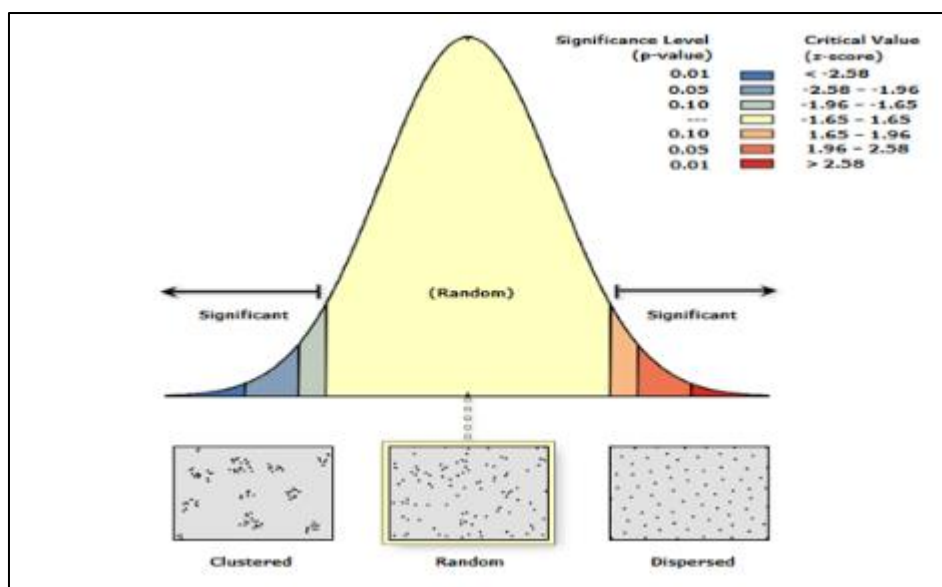


Figure 7: Average nearest neighbour result for (a) Clinics and (b) Health posts

3.1.4 Radius of Service and Proximity

Investigating proximity to public health facilities, a buffer analysis was applied and a buffer zone with radius of 15, 3, 2 and 1 km were created around the hospital (secondary health facility), health centres, clinics and health posts respectively. The finding showed that most wards in the study area are adequately covered within the 15-km catchment zone of the only secondary health facility (Hospital) meant for the entire local government area as shown in figure 8. However, most wards in the south are located inside of the 15-km catchment zone; these wards fall outside the hospital radius of service are Amuda Okofiai, major parts of Etam, Ana Inyma, Ndiagu Amagu i' and Ndiagu Amagu ii, the research reveals that complicated health issues as well as accident and emergency cases will find it very difficult to access this facility from the said region. The catchment areas for health centres across the wards overlap leaving several areas unserved when applying a (3 km service) radius, furthermore, the coverage is insufficient when evaluating specific facilities such as maternity centre (2km radius) and health post 1kmradius. Therefore, local authorities must upgrade and expand healthcare infrastructure within the study area.

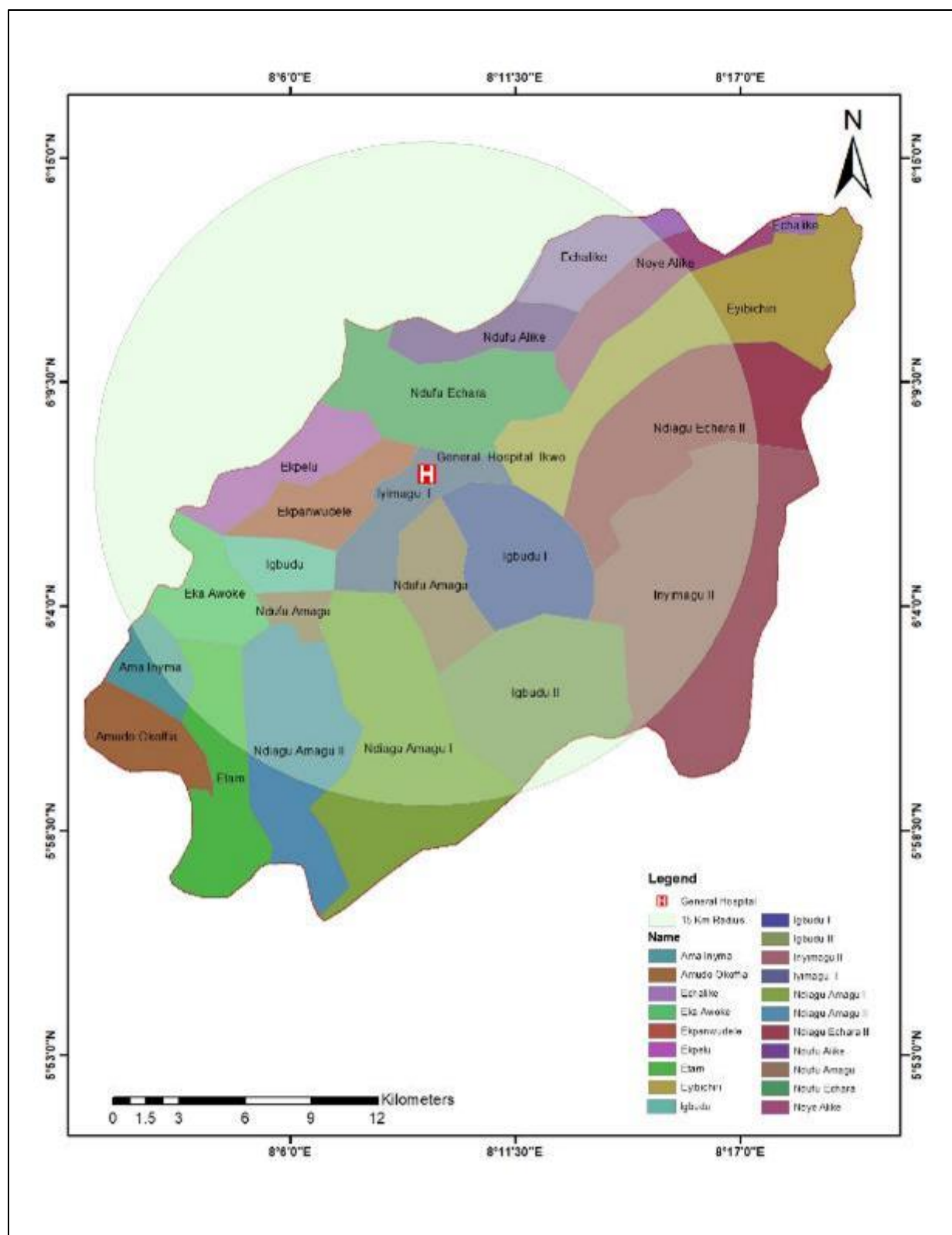


Figure 8: 15km service radius

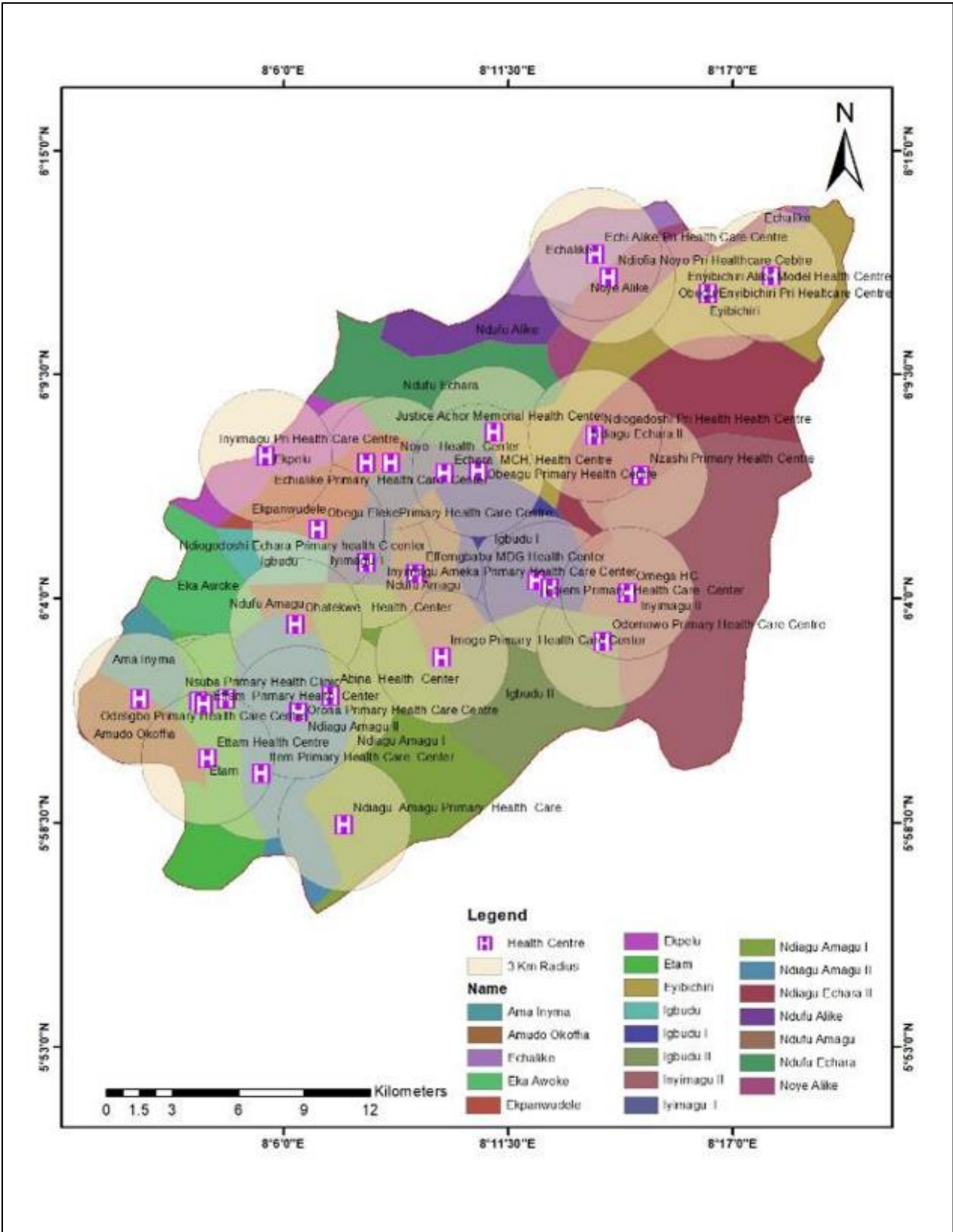


Figure 9: Service radius of Health centres

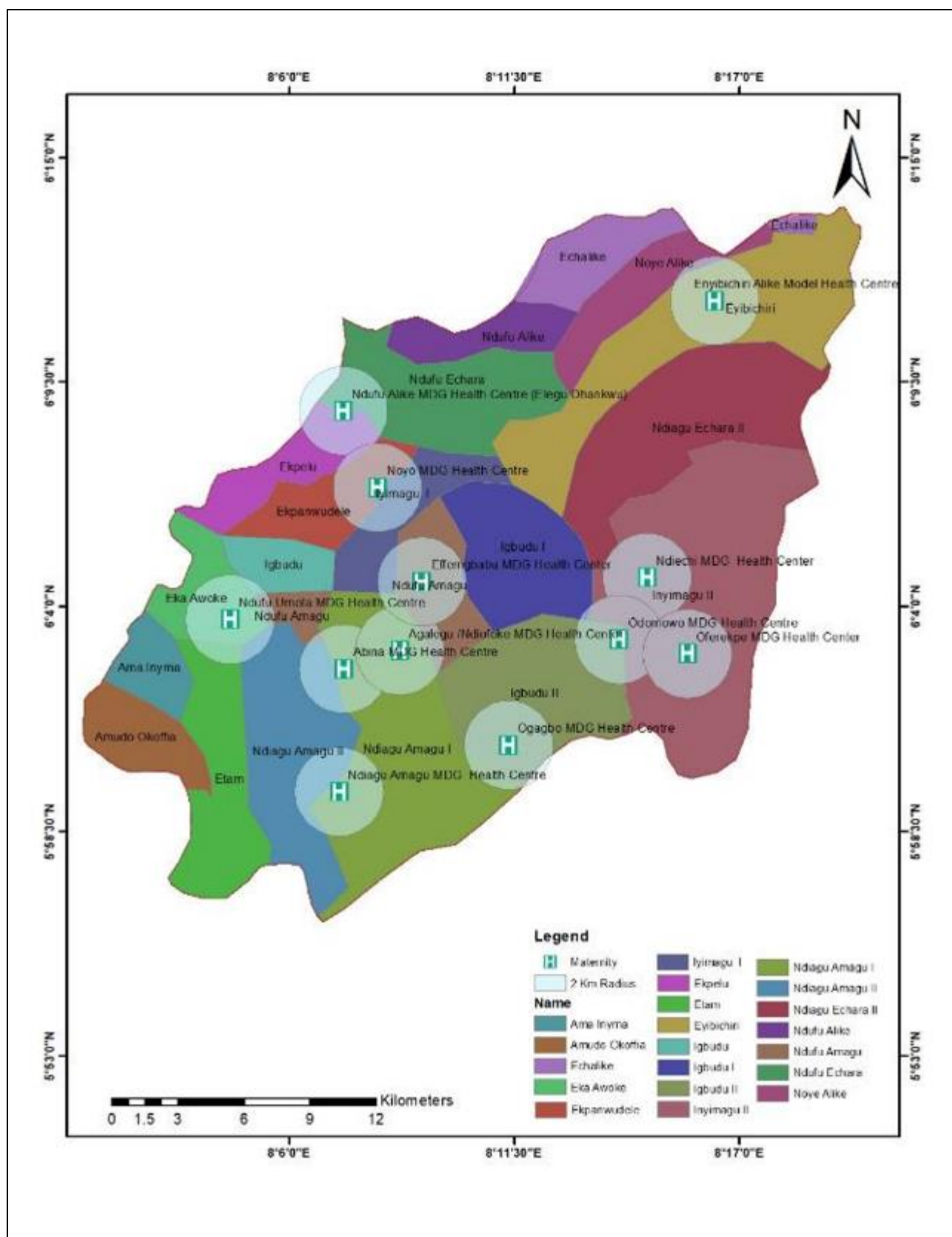


Figure 10. Service radius of Clinics

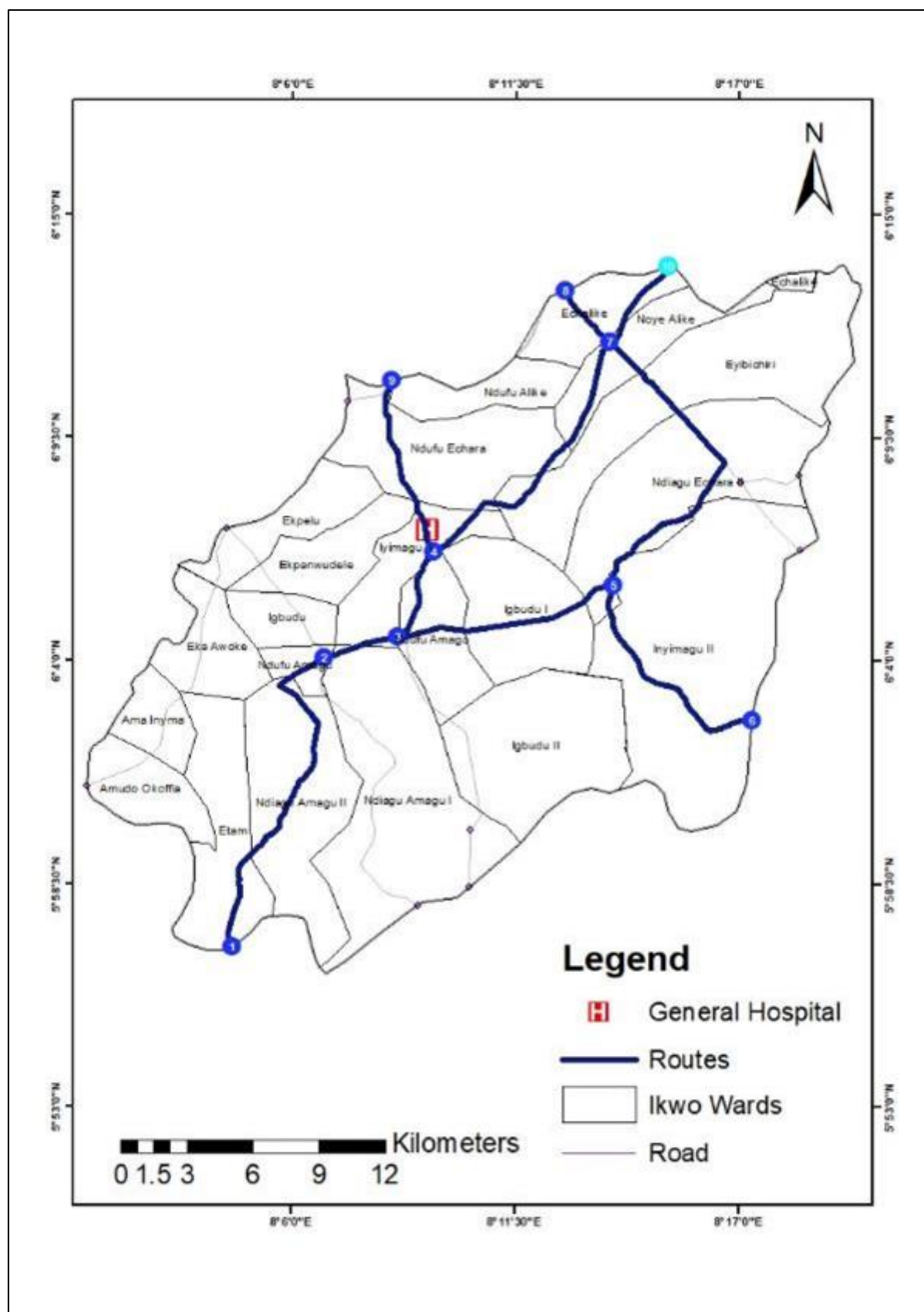


Figure 12: Network Analysis of Facilities in Ikwo LGA

The facility is located at Ndufu Alike, Ndufu Alike ward and depicted in Figure 12, The shortest accessible route from southern part of the LGA comprising Etam', Ndiagu Amagu ii, Ndufu Amagu and Iyimagu wards to Ndufu Echere was determined to cover the distance of 24 km routing through Etam road, Ndiagu Amagu road, Inyimagu Road, then Echara Road as seen in Figure 12. Similarly, the shortest accessible route from the Northwest area comprising Inyimagu ii,

Indiagu Echara, wards to Ndufu Alike, is 26 km routing through Igbudu road, Iyimagu road, Ndufu Alike road, Noyo Alike Road, Echara Alike Road then Ndufu Alike Road. The shortest accessible route from north-east comprising Echi Alike and Eyibichiri wards to Ndufu Alike is 15.4 km routing through Igbudu Road, Lastly, the shortest accessible path from north-west comprising Echialike (wards to Ndufu Alike) is routing through Etam Road, then Ndufu Alike road. The finding of this analysis validated that most of the distance of the shortest accessible route from the political wards located in the southern part is all beyond the service radius of only referral secondary health facility in Ikwo LGA.

4 CONCLUSION

This study has documented the distribution patterns and assesses the range of service of public health care in Ikwo Local Government Area (LGA) of Ebonyi State with respect to their locational distribution using Geographic Information System (GIS). The results showed total number public healthcare facilities available in the Ikwo LGA which identified a total number of forty (56) public primary health care centre; comprising of one secondary and thirty-nine primary health facilities. The analysis revealed that the health facilities across Ikwo are not dispersedly distributed, this is owing to the nature of the areas. This study has identified the deprivation in public health care facilities in the area eighteen (18) healthcare centres; ten (10) clinic and thirty-six health post are required for even distribution of health care facilities in Ikwo Local Government Area. A sustainable strategic plan to guide the distribution and location of health care facility should be given a serious attention, as this shall assist different stakeholders in health sector, as well as the authorities and other interested non-governmental organisations in the planning of health service delivery

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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