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GEOSPATIAL ANALYSIS OF DISTRIBUTION AND ADEQUACY OF PRIMARY HEALTH CAREFACILITIES IN WARRI METROPOLIS

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ABSTRACT

The study was aimed at the geospatial analysis of Primary Health Care facilities in Warri Metropolis. The study adopted GIS methodology to carry out the study. The objectives included design of a spatial database, acquisition of both primary and secondary datasets, creation of a spatial database and spatial analyses were carried out to generate results for a Decision Support System. Spatial database was designed and created. Vector data model was adopted for the study where the Primary Health Centres were represented as points, the roads as polylines while the buildings footprints, water bodies, swamps and the boundary of the study area were represented as area (polygon) shapes. The results generated showed that there were Twenty Eight PHCs within the study area with fourteen each in Uvwie and Warri South Local Governments. The distribution pattern exhibited by the PHCs was random without any clustering or dispersal. The Nearest Neighbour Ratio according to the summary is 1.062096 while the z-score and p-score were respectively given as 0.628596 and 0.529613. The study also showed that forty one thousand, one hundred and sixty seven (41,167) buildings were adequately served by the PHCs within the study area. This represents 94.87% of total buildings (43,393) in the study area while those outside the buffer zones were 2226 buildings representing 5.13% of the total and can attend a primary health centre closest to them. The study was concluded having achieved the aim and the objectives and recommendations made

in line with the findings.

KEYWORDS: Geospatial analysis, Primary health care, Vector data model, Geodatabase.

1.0 INTRODUCTION

The United Nations Department of Economic and Social Affairs (UNDESA, 2015) believed that one of the ways to ensure healthy lives and promoting well-being for all at all ages is the 3rd Sustainable Development Goal (SDG) which is one of the 17 global goals set by the United Nations for transforming our world. It was also documented that availability and quality of health services are integral to strong primary health care and universal health coverage and contribute to achieving the sustainable development goals (WHO, 2022). Lack of equality in geographic access to health care has made accessibility to health care as one of the primary challenges in achieving the 3rd SDG, hence resulting in unmet targets towards reducing maternal and neonatal mortality, epidemics of HIV/AIDS, Malaria, Hepatitis B and Tuberculosis (Norheim *et al.* 2015; Stenberg *et al.* 2017). This was noticed in the study area where primary health care facilities are concentrated in the city centres without recourse to the rural dwellers that actually needs their services.

Health system as an organizational set-up is charged with the responsibility of distributing and servicing the health care needs of a given population thereby achieving positive health outcomes (Jin *et al*., 2015). The locations of the primary health care centres in Nigeria are based on political rather than the purpose they were meant for as found in the works of Wiseman *et al.* (2016) who submitted that availability of the health care facilities is often prioritised over accessibility by many politicians and other decision-makers in Sub-Saharan Africa and especially in Nigeria and also corroborated by Iyioha and Nwabueze (2016). One of the important factors to be considered by the policy makers when citing primary health care facilityis to understand the spatial relationship between locations of existing health care centres and physical accessibility to them (Mansour, 2016).

The North-Western and North- Eastern regions have the poorest health outcomes in Nigeria, with Northeast being the worst affected area which was partly due to the security challenge in the area that led to destruction of lives and property including the available Health Care Facilities in the area (Usman *et al*., 2020). Akinpelu *et al.* (2018) used multimedia GIS approach in locational analysis of Primary Health facilities in Ikorodu Local Government of Lagos State. The result showed that most health care facilities were clustered around the

urban centre whereas at the rural areas of the local government, the facilities were sparsely distributed hence making accessibility in the rural area much more difficult than the urban centre.

Geospatial technology which is made up of GIS, Remote Sensing and GPS has a potential role in monitoring and mapping the distribution of health care services and understanding the prevalence of diseases in a region (Bejleri *et al*., 2015). Health GIS was developed in the past to map and monitor the geographic accessibility of health care centres by population groups to address the disparities and inequalities; to study the prevalence of disease burden and map the spread of any epidemic in a particular region both in spatial and temporal domains (Luis & Cabral, 2016). Past studies have shown that various techniques like hotspot analysis, floating catchment area method, nearest neighbour method, buffer zone analysis, location-allocation analysis, Moran's I method, Ordinary Least Square (OLS) and Geographically Weighted Regression (GWR) method are effective to address various public health-related issues, both in the spatial and temporal context in past studies (Environmental Systems Research Institute, 2018). Improvement in health care leads to improvement in life expectancy, which serves as a robust indicator of human development (Awoyemi *et al*., 2017)) which therefore require that there is need for adequate and equitable distribution of Health Care Facilities in any given region or nation.

The study therefore was aimed at carrying out the geospatial analysis of adequacy of primary health care facilities in Warri Metropolis with a view to find out the spatial distribution of the facilities within the study area which is comprised of Uvwie and Warri South Local Government Areas and to also look at whether the available ones are adequate or not. GIS and allied technologies were used to carry out this study. The study area is Warri and environs, Delta state, Nigeria. Delta State is one of the 36 states of the Federal Republic of Nigeria (Figure 1) and it has a population of 5,663,362 inhabitants according to the National Population Commission (NPC) and National Bureau of Statistics (NBS) estimates of 2016. The state is bounded in the north by Kogi State and in the western part by Ondo State, at the eastern part by Niger River and at the south by Bayelsa State and the Atlantic Ocean. It is the major hub of petroleum activities and commercial activities covering the Warri South, Warri North, Warri South West and Uvwie Local Government Areas of Delta State, Nigeria. The city of Warri, Deltastate lies within longitudes 4° 58' 39.087" and 5° 51' 11.015" East of the Greenwich Meridian; and latitudes 5° 22' 43.412" and 6° 09' 35.692" north of the

Equator.

The study area houses the Warri Refinery and Petrochemicals located at Ekpan with the majority of international and local oil companies operating in Nigeria having their operational offices close by. One of the nation's major seaports is sited within Ugbuwangue, Warri. Delta Steel Company located at Aladja and Otorogu Gas Plants at Otor-Udu, near Warri. Warri has an international stadium with a capacity of 30,000 which is the home of Warri Wolves football club, which has hosted two editions of the African Women Football Championship in 2002 and 2006 respectively and was in contention as one of the venues to be used for the FIFA Under-17 World Cup in Nigeria in 2009.

There are various institutions of higher learning sited within the Warri Metropolis such as Federal University of Petroleum Resource Effurun (FUPRE); Petroleum Training Institute (PTI) Effurun; College of Education at Edjeba, Warri; Delta State Nursing School, Ogunu, Warri, Eagle Heights University, Omadino, Warri and Nigeria Maritime University Okerenkoko, Warri.Major health care facilities in Warri are Westend Hopsital, Airport Road, Warri, Central Hospital, Warri, Capital Hill Clinic, Airport Road, Warri, Lilly Hospital Ltd, Deco Road, Warri, Shabach Hospital, PTI Road, Effurun, Concord-Bay Pharmacy, Warri, GKS Pharmacy Ltd, Warri and Safari Pharmacy and many more.

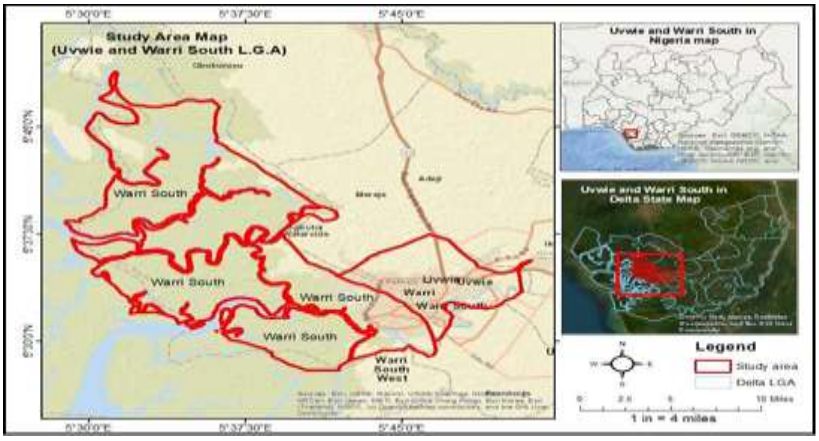


Figure 1: The location of the study area.

2.0 METHODOLOGY

The study adopted GIS and allied technologies in carrying out the study. GIS methods were adopted by Zeiler (1999); Oloyede-Kosoko *et al.* (2010), Alfa and Ahmadu (2021), Onosemuode and Omorogbe (2017), Amusa *et al*. (2018), Lawal and Anyiam (2019) and a host of scholars in spatial modelling. Geospatial data can be acquired using a variety of

technologies and can be entered into GIS (Folger, 2009). The datasets are both primary and secondary. The primary dataset is the coordinates indicating the geographic locations of the primary health care centres within the study area. The coordinates were picked with the use of handheld GPS with a very high accuracy. These coordinates were downloaded into the computer system which has ArcGIS 10.8 installed in it. These coordinates served as the geographic or geospatial data which were later linked with the semantic data gotten from oral interview from the field.

The secondary data sets were in various geographic coordinate systems. They include the shapefiles of states in Nigeria, the local governments within Delta State from where the study area. The datasets came from array of sources and were converted to common Geographic Coordinate System using ArcGIS 10.8 which is the implementation software. The map of Delta State was scanned and georeferenced from where the map of the state was extracted through vectorisation. This was overlaid with the various shapefiles of the entities and projected using WGS 84 Zone 31N coordinate system. The shapefiles created for the study were populated with the attribute information from social survey (Oral interview, field observations and data from Delta State Health Management Board).

The inventory of the PHCs is listed in Table 1. The table comprises of the Twenty Eight primary health facilities within the study area. Their locations within the political wards, their geographic coordinates (latitudes and longitudes), their names and addresses, facility level (primary) and ownership. The two local governments both have fourteen health centres each. Some wards have one facility while others have more than one.

Table 4.1: Inventory of all the primary health care facilities in the study area.

S/no	State	Lga	Ward	Lattitude	Longitude	Facility name/ address	Facility Level	0wnership
1	Delta	Uvwie	Alaka	5.56053	5.78784	Alaka primary health centre / nepa line road Off effurun/sapele road, effurun.	Primary	Public
2	Delta	Uvwie	Alaka	5.55222	5.79811	Erovie primary health centre / oshobor street, Abasimo area, alegbo, effurun.	Primary	Public
3	Delta	Uvwie	Alaka	5.57047	5.78521	Uvwie secretariat health post / uvwie lga Secretariat, agric rd, gra, eeffurun.	Primary	Public
4	Delta	Uvwie	Ekpan 1	5.56221	5.74337	Ekpan 1 primary health centre / behind micro Finance bank at ekpan round	Primary	Public

						about, ekpan.		
5	Delta	Uvwie	Ekpan 2	5.57658	5.74215	Ekpan 2 primary health centre / before blue waters hotel, niger cat, ekpan.	Primary	Public
6	Delta	Uvwie	Enerhen 1	5.53338	5.78639	Enerhen 1 primary health centre / ayaro quarter.	Primary	Public
7	Delta	Uvwie	Enerhen 2	5.52552	5.77453	Enerhen 2 primary health centre/ 8, 2nd sido Street off mcc road, enerhen	Primary	Public
8	Delta	Uvwie	Ohorhe	5.57806	5.78037	Ohorhe primary health centre / new site Mechanic village, off sapele road, effurun.	Primary	Public
9	Delta	Uvwie	Ugborikoko	5.53525	5.75975	Ugborikoko primary health centre / end of allen close off onokuta street (ejiro school rd.) Ugborikoko.	Primary	Public
10	Delta	Uvwie	Ugboroke	5.55222	5.73481	Aruakpor-umah primary health centre / Aruakpor-umah village.	Primary	Public
11	Delta	Uvwie	Ugboroke	5.54345	5.74821	Ugboroke comprehensive primary health centre / kuyuni street, off nnpc bypass rd. Ugboroke	Primary	Public
12	Delta	Uvwie	Urhumarho	5.55392	5.78514	Urhumarho primary health centre / behind ufuoma lock up shops, effurun market, Effurun.	Primary	Public
13	Delta	Uvwie	Ugbomro	5.57092	5.81776	Ebrumede primary health centre	Primary	Public
14	Delta	Uvwie	Ugbomro	5.57274	5.83422	Fupre health centre	Primary	Public
15	Delta	Warri south	Avenue	5.54075	5.74021	Edjeba health post / edjeba community town Hall.	Primary	Public
16	Delta	Warri south	Ekurede	5.52531	5.74235	Ajamimogha primary health care / aboh lane Ajamimogha.	Primary	Public
17	Delta	Warri south	Ekurede	5.53392	5.72769	Ekurede urhobo primary health care / ekurede Urhobo health centre road by court 4.	Primary	Public
18	Delta	Warri south	Ekurede	5.53153	5.71322	Ogunu primary health care / ogunu village Behind primary school, ogunu.	Primary	Public
19	Delta	Warri south	Obodo	5.62671	5.64965	Omadino health care centre / omadino Community.	Primary	Public
20	Delta	Warri south	Ekurede	5.52937	5.71833	Ugbuwangwe primary health care centre /health centre road, ugbuwangue.	Primary	Public
21	Delta	Warri south	Ode - itsekiri	5.50272	5.71085	Orugbo primary health care / orugbo town.	Primary	Public
22	Delta	Warri south	Igbudu	5.51759	5.76495	Igbudu primary health care / igbudu road	Primary	Public

						Behind essi compound.		
23	Delta	Warri south	Okere ward	5.52714	5.74683	Eboh primary health care/ eboh road warri.	Primary	Public
24	Delta	Warri south	Okere ward	5.51834	5.73729	Nigerian police clinic / area command Headquarter, warri.	Primary	Public
25	Delta	Warri south	Okere ward	5.51516	5.74527	Warri south sub- secretariat primary health Care/sub-secretariat warri sapele road, warri.	Primary	Public
26	Delta	Warri south	Pessu	5.50898	5.75350	Pessu primary health care / pessu health Centre by police station	Primary	Public
27	Delta	Warri south	Ubeji	5.55922	5.68801	Ifie primary health care / health centre road, Ifie- kporo.	Primary	Public
28	Delta	Warri south	Ubeji	5.57085	5.70450	Ubeji primary health care / ubeji ugbokodo Road, ubeji.	Primary	Public

Source: Nigeria Health Facility Registry (2023)

3.0 RESULTS AND DISCUSSION

3.1 Spatial distribution

The spatial distribution of the primary health facilities in the study area was examined using the Spatial Statistics tool in ArcToolBox embedded in ArcGIS software used for the study's analyses. The tool adopted was Average Nearest Neighbour. The tool uses Eucledian distance to calculate the distances between each of the hospitals. The diagram in Figure 2 shows the generation of the Spatial Statistics Tool for the Primary Health Centres.

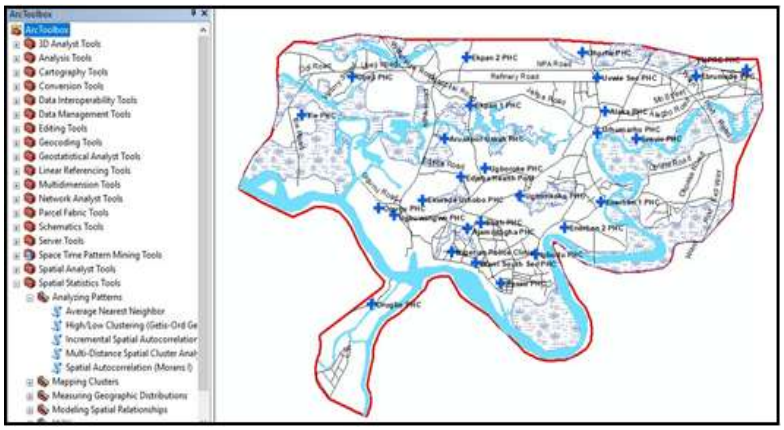


Figure 2: Generation of the spatial statistics tool for the primary health centres.

The Average Nearest Neighbour according to ESRI (2018) calculates a nearest neighbor index based on the average distance from each feature to its nearest neighboring feature. The result of the Average Nearest Neighbour showed that the Primary Health Centres were random in their distribution within the study area as indicated in the result generated in

Figure 3. The Nearest Neighbour Ratio according to the summary is 1.062096 while the z-score and p-score were respectively given as 0.628596 and 0.529613. The distribution of the Primary Health Centres were not clustered nor dispersed. The simple interpretation is that the health centres are distributed all over the geographic space within the study area. Figure 4 is the summay of the Primary Health Centres Average Nearest Neighbour. The summary of the results from the distribution pattern is given in Table 2.

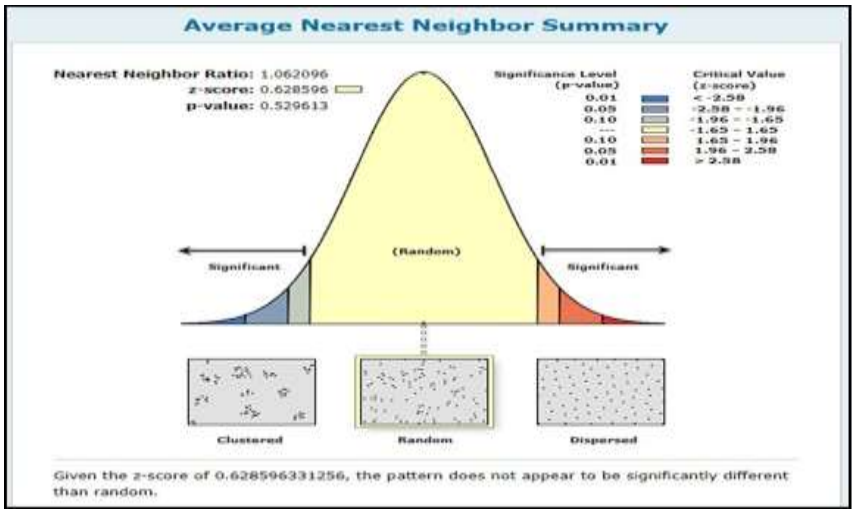
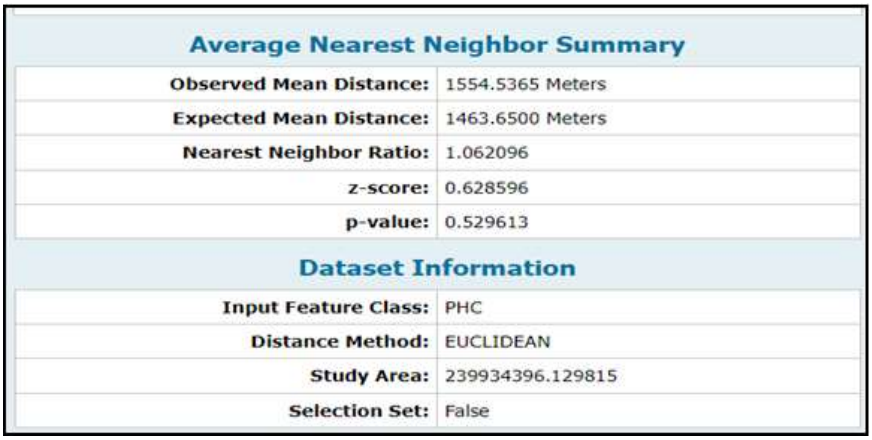


Figure 3: Result of the primary health cenres average nearest neighbor.



Average Nearest Neighbor Summary

Observed Mean Distance:	1554.5365 Meters
Expected Mean Distance:	1463.6500 Meters
Nearest Neighbor Ratio:	1.062096
z-score:	0.628596
p-value:	0.529613

Dataset Information

Input Feature Class:	PHC
Distance Method:	EUCLIDEAN
Study Area:	239934396.129815
Selection Set:	False

Figure 4: Summay of the primary health centres average nearest neighbor.

Table 2: Summary of the distribution pattern.

Parameters	**Primary health centres**
Observed mean distances	1,554.5365m
Expected mean distances	1,463.6500m
Nearest Neighbour Ratio	1.062096
z-score	0.628596
p-value	0.529613
Distribution	**Random**

3.2 Determining the adequacy of the primary health care facilities

This section of the study examined the adequacy of the primary health care facilities within the study area. In the list of minimum standards to be met before putting up a primary health care facility by the National Primary Health Care Development Agency (2023), the service delivery area for a primary health care centre is a political ward and the estimated coverage population is between 10,000 and 20,000 people within the locality in which they are located. This is one of the reasons why there must be at least one primary health care facility within a political ward within the study area and around the country at large.

3.2.1 Buildings within PHC buffer zone

The diagram in Figure 5 shows the study area boundary in red outline, the distribution of the primary health centres and the buffering tool settings indicating the input features which are the Primary Health Care facilities, the output feature class which is the derived shapefile fromthe process and the linear unit representing the distance of buffer.

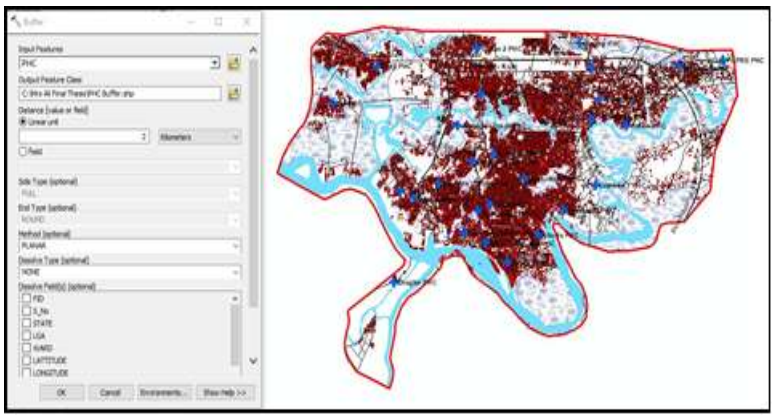


Figure 5: Setting up of the Buffer distance of 2Km of Primary Health Care facilities.

The primary health care facilities were buffered at the radius of 2Km (the distance is taken as a tentative distance to travel to the health facilities) as shown in Figure 6 with the assumption that the radius within a political ward cannot be more than 2Km. The buffer zone created is a polygon which covered up all other features under the buffer zone. The buffer zones were then hollowed to produce Figure 7 with the buffer zones shown as rings of 2Km radius around each of the health facilities.

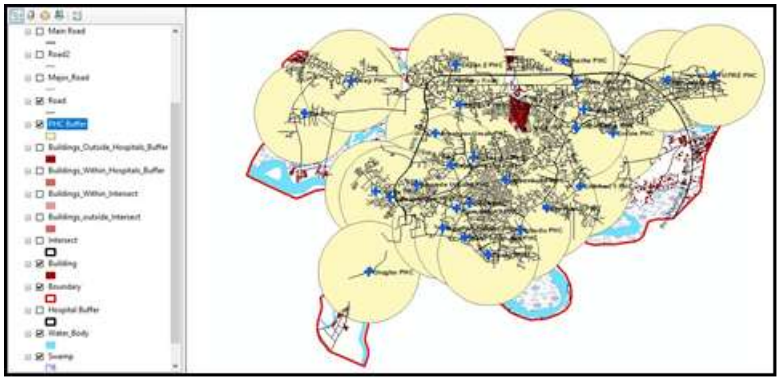


Figure 6: Buffer distance of 2Km of primary health care facilities.

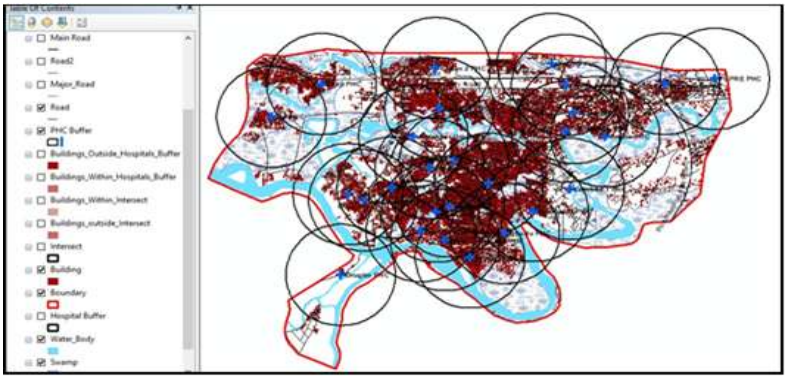


Figure 7: Hollowed Buffer distance of 2Km of Primary Health Care facilities.

The diagram in Figure 8 shows the "Selection by Location" tool set up. This was used to set up the parameters that were used to select buildings within the PHC buffer zone of 2Km. The building layer is the target layer while the PHC buffer is regarded as the source layer and the condition was to select features from the target layer (Building) that are completely within the source layer (PHC Buffer). The selected buildings within the buffer of the PHC buffer is as shown in Figure 9. The result is shown in Figure 10. The buildings within the PHCs buffer zone that were adequately served by the services were forty one thousand, one hundred and sixty seven (41,167) representing 94.87% of total buildings (43,393) in the study area. The map is shown in Figure 11. The summary is shown in Table 3.

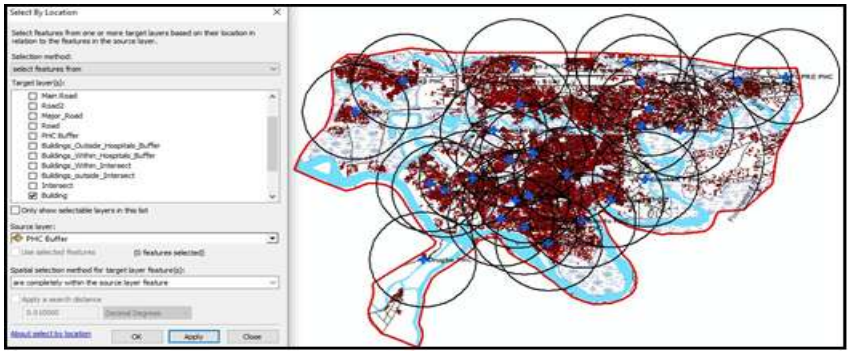


Figure 8: Selection by Location tool set up.

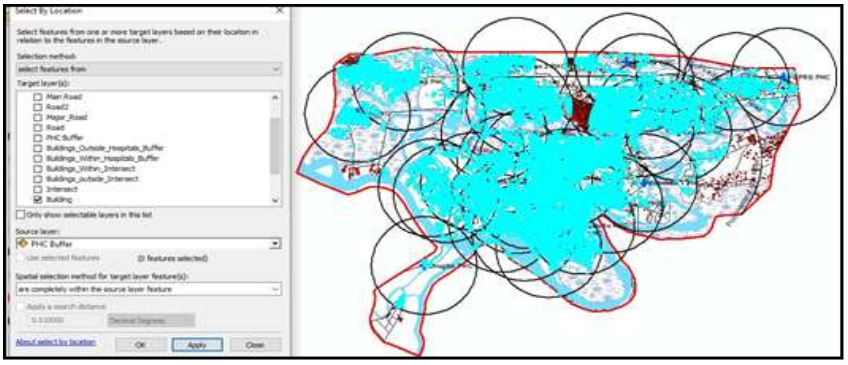


Figure 9: Selection of buildings within the buffered zones.

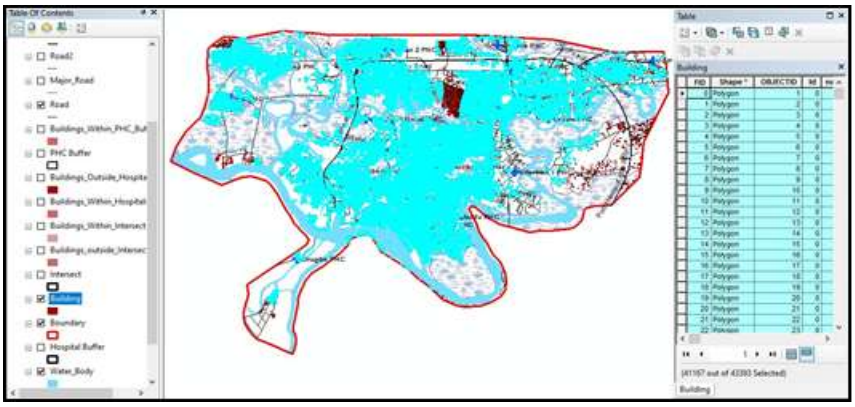


Figure 10: Result of buildings within the buffered zones.

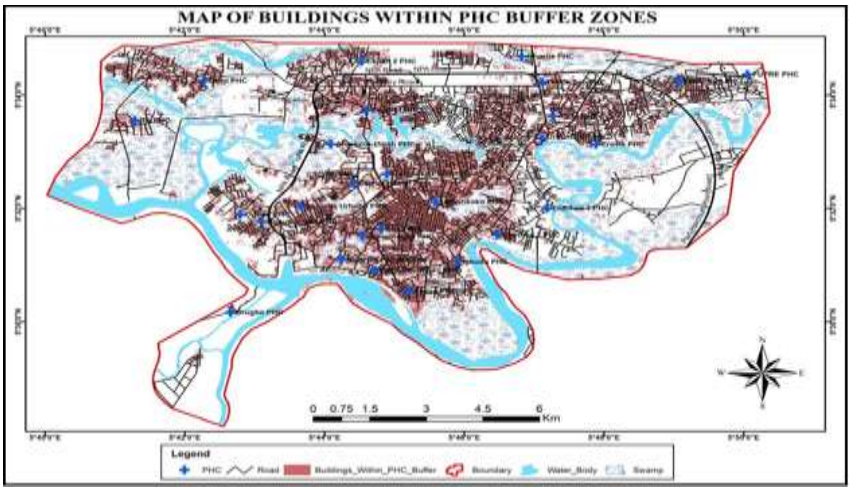


Figure 11: Map of Buildings within PHC Buffered zones.

3.2.2 Buildings within PHC buffer zone

The study went further to look at the buildings outside the buffer zone of the PHCs. The switch selection tool on the attribute table of the Building shapefile was used to select the buildings outside the buffer zone. This selection is shown in Figure 12 and the result in Figure 13with the number of buildings outside the buffer zone of the PHCs standing at two thousand, two hundred and twenty six (2226). The map in Figure 14 indicates the buildings

outside the buffer of the PHCs. The summay of the selections within and outside the buffer of the PHCs is given in Table 3.

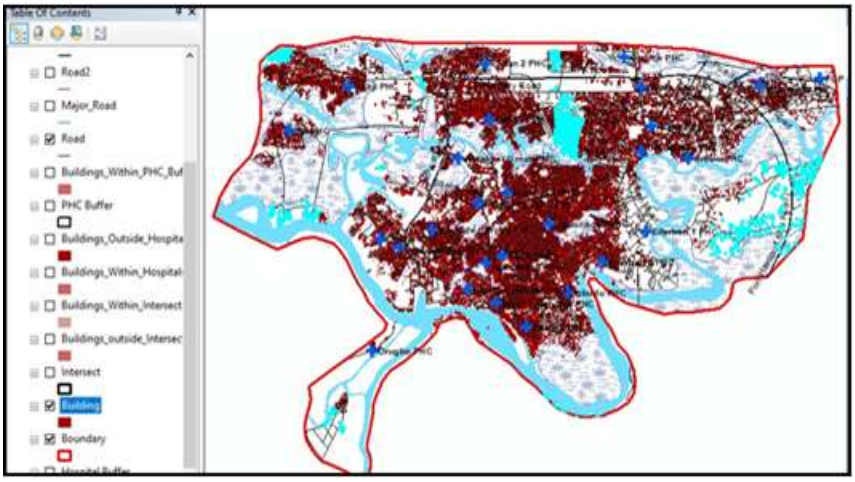


Figure 12: Selection of Buildings outside PHC Buffered zones.

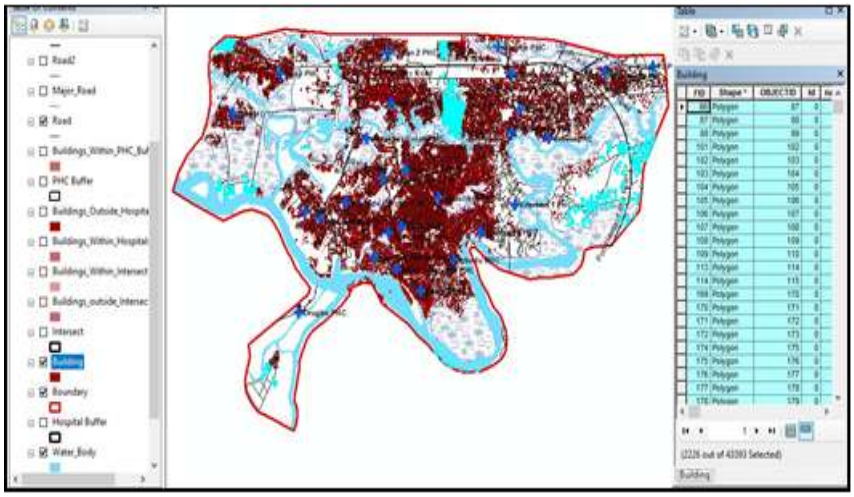


Figure 13: Result of Buildings outside PHC Buffered zones.

Table 3: Buildings Within and Outside the intersect of buffer zones of the hospitals.

S/N	Buildings	Number	Percentage of Total
1	Within Primary Health Centres buffer	41,167	94.87
2	Outside Primary Health Centres buffer	2,226	5.13
	Total	43,393	100

Source: Authors, 2023

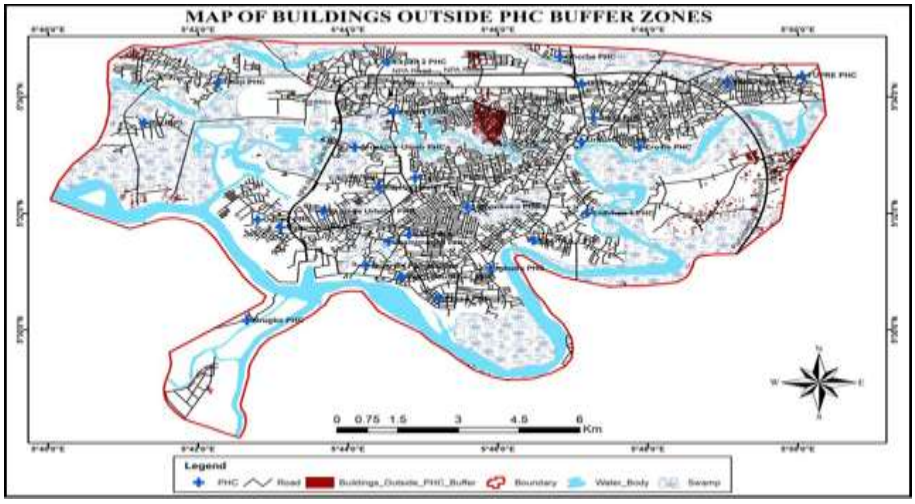


Figure 14: Map of Buildings outside PHC Buffered zones.

3.3 DISCUSSION OF RESULTS

The result of the Average Nearest Neighbour showed that the Primary Health Centres were random in their distribution within the study area as indicated in the result generated in Figure 3. The distribution of the Primary Health Centres were not clustered nor dispersed. The simple interpretation is that the health centres are distributed all over the geographic space within the study area.

The selected buildings within the buffer of the PHC buffer is as shown in Figure 9. The result is shown in Figure 10. The buildings within the PHCs buffer zone that were adequately served by the services were forty one thousand, one hundred and sixty seven (41,167) representing 94.87% of total buildings (43,393) in the study area. On the other hand, a total of Two Thousand, Two Hundred and Twenty Six (2,226) buildings representing 5.13% of the total buildings in the study area were not served by any of the health facilities. The implication is that the primary health centres are perceived to be adequate because of the percentage of coverage. The buildings outside the buffer zone can attend a primary health centre closest to them.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The study showed that GIS and allied tools like Remote Sensing and Global Positioning Systems can be used to solve spatial problems including health care management in the study area and elsewhere. The analyses carried out included, buffering of the primary health centres by 2Km to check for the coverage of these facilities within the study area. The extent of the coverage was gotten to be 94.87% which was good enough. The Average Nearest Neighbour

was also used to find the distribution pattern of the facilities which showed a random distribution pattern. The various analyses yielded results that can be used for a Spatial Decision Support System.

4.2 Recommendations

The following are therefore recommended after the findings. They are:

1. GIS and allied tools should be adopted in the management of health care in the study area and elsewhere.
2. Since the distribution is random, provision should be made for areas where the coverage of the primary health centres could not serve so that residents within these areas enjoy health care services like other parts of the city.
3. The data needs for the study could not be met because most of the offices in charge of these health centres do not have the required data sets for this study and where they were available they were not readily released for the research.
4. Further study is recommended to locate new sites for the areas where the existingfacilities could not cover in terms of their services.

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