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GIS-Based Analysis of the Location of Filling Stations in Metropolitan Kano against the Physical Planning Standards

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ABSTRACT: *This paper analysed the location of filling stations in Kano Metropolis against the physical planning standards set by Department of Petroleum Resource, DPR (2007) and Kano Urban Planning and Development Agency, KNUPDA (2013). Names and street addresses of the filling stations were obtained from the Department Petroleum Resource (DPR) Kano Office. Global positioning System Garmin 76X GPS was used to capture the location of the filling station. The quickbird imagery, street map, and boundary map were obtained from the Kano State Ministry of Land and Physical planning. The data were imported to Arcmap environment of ArcGIS 10, integrated and georefrenced to the same coordinate system. All the analyses were performed in the Arcmap environment using spatial statistics, spatial analyst and proximity tools available in the software. The findings revealed that there 214 filling station located along the 43 roads in the study area, of which 69% are owned by independent marketers, 26% owned by Major Marketers and 5% owned by the NNPC. Most of the station satisfied the minimum requirement of 15 metre distance from the road (96%). Equally 98% of the filling stations met the minimum distance of 100 meter from the health care facilities. However many station had not meet the criteria of 400 meter minimum distance to other stations where located on same road side and when not separated by any road or street. The research finally concludes that regulatory agencies need to look into the issue and take appropriate measures.*

KEYWORDS: *Filling stations, GIS, Location and Physical Planning Standards*

I. INTRODUCTION

The term location is used to identify a point or an area on the earth or elsewhere and this may be through the use absolute or relative terms. Location is said to be relative when it is described in relation to other point or area. An absolute location uses a specific pairing of latitude and longitude in a Cartesian coordinate grid.

The increase of urban population and the growth of the number of cars and other vehicle generate various kinds of demands, one of which is fuel. A considerable amount of cars fuel is wasted due to the long urban paths and unnecessary trips (Harrison, 1999). Increase in vehicles triggered increasing demands for fuel and by extension fuel station, since engines are made to use petroleum products and filling station are the places were fuel are sold.

Filling Station, Petrol station, gas station or petroleum outlet is defined as any land, building or equipment used for the sale or dispensing of petrol or oil for motor vehicles or incidental thereto and includes the whole of the land, building or equipment whether or not the use as a petrol station is the predominant use or is only a part thereof. Most filling stations sell petrol or diesel, some carry specialty fuels such as liquefied petroleum gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane while the rest add shops to their primary business (Ayodele, 2011)

Petroleum is no doubt a predominant source of Nigeria's revenue and foreign exchange. It has occupied strategic importance in the Nigerian economy, accounting for as high as 78 percent of gross domestic product and up to 90 percent of the country's total annual revenue and foreign exchange earnings (National Bureau of

Statistics, 2008).The petroleum industry in Nigeria is divided into two main segments, the upstream and the downstream sectors. The upstream refers to activities such as exploration, production and delivery to an export terminal of crude oil or gas. The downstream on the other hand encompasses activities like loading of crude oil at the terminal and its user especially transportation, supply trading, refining distribution and marketing of petroleum (Asada, nd). Activities of filling stations or petroleum outlets are part of the downstream sector.

According to Ehinomen and Adeleke (2012) the petroleum industry can be classified by type of actors or by sector. The actors in the Nigerian industry consist of both private and public organizations. The public actors are the government agents and functionaries such as the Nigerian National Petroleum Corporation (NNPC) and its subsidiaries, the Department of Petroleum Resources (DPR), the Petroleum Products Pricing Regulatory Authority (PPPRA), among others. The private segment consists of both indigenous and foreign actors. The indigenous actor consist of independent marketers which numbered about 1000 in 1979, a year after formulating the act which established them but increased to 7948 in 2010 (Ehinomen and Adeleke, 2012) and they are competing with the foreign or multinational marketers (referred to as major marketers) like Mobil Oil Nigeria Plc., MRS Nigeria Plc., Total Nigeria Plc., Conoil Plc., Oando Nigeria Plc. and African Petroleum Plc.
According to the DPR procedure guide for grant of approvals to construct and operate of a petrol products retail outlet (2007), before one begin petroleum retail outlet or filling station business one has to submit:

1) Three (3) copies of approved plan showing the building existing or proposed on the site and the relation to the roadways and adjoining properties.
2) A certificate signed by signed by the Chief Federal/ State Fire Officer, or by an officer authorized in that behalf, that the arrangements proposed for the prevention of fire at the site are satisfactory.
3) A certification by the Area/Town Planning Authority for the construction of a Petrol Filling Station on the proposed site.
4) A certificate signed by the divisional police Officer or a superior police officer in-charge of the police motor traffic that he is satisfied that the site and layout of the proposed filling station do not constitute an unnecessary traffic hazard.
5) Evidence that company applying is duly registered as a limited liability company by the appropriate Federal Ministry/Corporate Affairs Commission to deal in petroleum products.
6) Tax receipt and/or tax clearance certificate for the preceding 3years.
7) According to the DPR manual before operating filling station one has to certify some physical planning standards. These standards are**:**
8) Land should be zoned for commercial/industrial use or be designated specifically for the purpose in a subdivision.
9) The parcel of land should not be less than 33 x 33 square meters or equivalent of two plots of land allow for the free flow of traffic
10) A petrol filling station should be sited 400 meters away from the next petrol station.
11) A petrol station should be sited 50 meters away in all angles of the build-up areas to create a buffer zone for the residential house-the buffer zone can be devoted to any non-residential land use.
12) That the distance from the edge of the road to the nearest pump should not be less than 15meters.
13) The total number of stations within 2 km radius of the site should not be more than four (4) including the one under construction
14) Filling station should not be located less than 100 meters from school, hospital, theaters, clinics and other public and semi-public buildings.
15) The site (for filling station) should not lie within NNPC/PPMC pipeline right of way or PHCN transmission or railroad lines (Procedure guide for grant of approvals to construct and operate of a petrol products retail outlet by DPR, 2007).

Selecting a better site for business enterprise is at mind of every government and entrepreneurs who invests their capital to earn profit. Some of the variables considered when selecting location for utility are proximity to population centers, distance from neighboring stations, the easements of using existing utility, and the magnitudes of environmental pollution parameters **(**Alesheikh and Golestani, 2011)**.** Other factors to take into account when making a decision about the location of business, including customers, transport, the neighborhood, finances and the longer term future (Oetomo and Sesulihatien, 2012).

Bolen (1988) stated that every location in the earth has its analyzable advantages and disadvantages. According to him the factors can be classified into two physical conditions. These are the real physical and analysis physical. Real physical is a visible condition in relation to area such as land condition, the width, and the distance from the highway. Analysis physical, on the other hand, is physical condition obtained from physical analysis such as population analysis, neighborhood factor, and competitor analysis. Both factors are

important while locating business, this because while the physical condition can affect the nature and type of business to be conduct, analysis physical can affect the business performance. For example, if the distance between one station and the other is too close, then it will lead to decreased turnover on each station (Oetomo and Sesulihatien, 2012).

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This work focus on the location analysis of filling station in Kano Metropolis, the second largest city in Nigeria and the commercial hub of northern part of the country. The study is triggered by the fact that human and vehicle population is high in the city and from the observation it seems there may be some problems as regard location and distributions of filling stations in the city. In the word of Christeller (1933) in Abler, Adams and Gold (1973), there is some ordering principles unrecognized that governs the distribution of things and phenomena. Only when proper investigation is made that one can explain what is where and why, a question that geography holds since the epoch of Eratosthenes, since the beginning of geography.

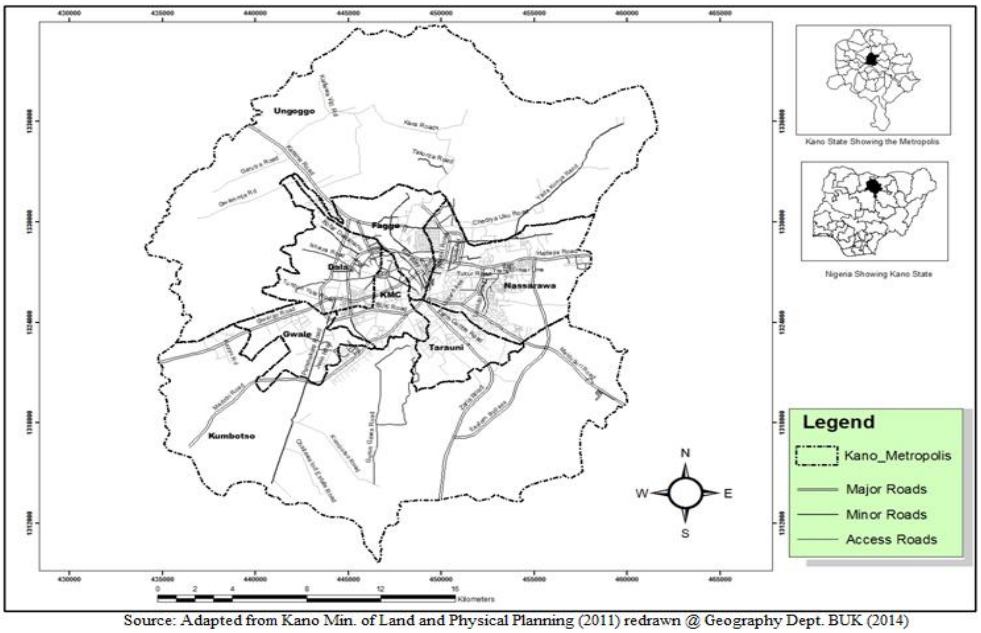
2. Study Area

The study area, Kano metropolis lies between latitude $11^0$50' to $12^0$07' N and longitude $8^0$22' to $8^0$47' E and altitude 472 meters above sea level. The climate of the area is Tropical wet and dry climate, coded Aw by the Koppen's Climatic Classification System (Olofin, 1987). Kano Metropolis bordered by Minjibir LGA to the Northeast and Gezawa LGA to the East, Dawakin Kudu LGA to the South East and Madobi and Tofa LGAs to the South West.

According historical sources Kano city was founded around Dala Hill in the 9th century A.D. (Olofin 1987, Dankani 2013). Dankani is of the view that the spatial planning and development of the area started with the building of the first city wall between 1095 and 1134, which started east of the Kurmi market near the Jakara stream. After independence, Kano witnessed an unprecedented urbanisation and rapid population growth due to socio-economic transformation in the state. According to Marafa (1999) as cited in Na'aba (2002), by the time colonial masters came in early 20th century, what constitute Kano and virtually encompassed by the wall was contained within 17.5 km^2. Today metropolitan Kano (made up of the declared urban area in accordance with the Land Use and Allocation Committee) is contained within 60 km^2, while the built-up metropolitan Kano is contained within 40 km^2 (Dankani, 2013).

The Kano Metropolis is regarded as urban Kano, as the sprawling and the expansion of the city is swallowing the peripheral area vis-à-vis the surrounding lands is gradually taking over by urban structure and site acquire an urban character. Urban Kano is located at the central part of Kano closed settled zone, and therefore having the highest density, as a result of industrialization and other economic development, it has also through time become a cosmopolitan city with all the ethnic groups.

The study area includes the eight metropolitan local government of Kano State namely Dala, Fagge, Gwale, Kano Municipal, Kumbotso, Nassarawa, Ungogo, and Tarauni. The population of the Kano Metropolis based on 2006 is 2,826,307 (National Population Commission, 2006).



Source: Adapted from Kano Min. of Land and Physical Planning (2011) redrawn @ Geography Dept. BUK (2014)

Figure 1: Kano Metropolis

II. MATERIAL AND METHODS

A preliminary survey was carried out to identify and document filling station in the area. This acquainted the researcher with the knowledge of the area and provide guide on how to source the data, types of data needed and preparation for the field work. Street maps of Kano State at a scale 1:2000 were sourced from Kano State Ministry of Land and Physical Planning. Quickbird imagery of 2013 of 2.5 meter resolution was also sourced from Kano State ministry of Land and physical planning and integrated with street map in order to produce the update street map of the study area. List of filling stations were obtained from the Department of Petroleum Resources (DPR), a department under the Ministry of Petroleum Resources responsible for registering and regulating the filling station. From the data filling station name, type and area (street) of location were identified. This served as a guide for verification and collection of the coordinate data using Global Positioning System (GPS).

Street map sourced was scanned, imported into ArcMap environment of ArcGIS 10.1 and then geo-referenced using map to image georeferencing method. Quickbird 2013 image of the area was used as a slave image for the georeferencing. Major land marks in the area like Silver Jubilee Round About, Katsina Road/Airport Round-about, Dawanau Junction and Aminu Kano Airport were used as reference points for the georeferencing.. The georeferenced maps were auto rectified and then given the same coordinate with image, Universal Transverse Mercator (UTM) Global Coordinate System (GCS) projection and Minna Zone 32N datum. UTM system was choosing because it is metric and has the capacity to enable the researcher calculate the length, distance and other measurement that may not be possible with geographic coordinate system. Two shape files were created in ArcCatalog environment and given same coordinate system with the maps and image. The shape files were later imported into the ArcMap environment and used to digitize the street map and land use map separately. Fields were created for name and the type of the road, and to calculate the length of the road in metre.

A simple checklist were drafted and used to source the detailed information on the filling station. Field visit were made to all the filling stations, and coordinate of the filling stations were obtain using GPS (Garmen 76X Model).

Data obtained from the DPR were first entered in Excel Microsoft (2007) applications to create a simple database. Columns were used as field to store information on filling station. The data were saved in the project folder (created in C drive) and exported to ArcMap environment of ArcGIS 10. The data was converted to shape file and used to perform all the analysis. Different symbolization was used to map out the filling stations. The numbers of filling station in each road were determined. In addition tables and charts created in Microsoft Excel were used to present the inventoried data. These help in achieving the first objective of the work i.e.to take an inventory and map out the filling stations. to compare location of the filling stations with standards buffer and proximity analysis were done in Arcmap. Buffer of 15 meter were created on the roads to know stations that meet the criteria of fifteen (15) metre distance from the to the road, Query by location was performed using selection menu in ArcMap environment. In addition the data were query to give all location that are withing 15m buffer. The selected stations were highlighted, right clicked was done on the shape file (containing the station) and the software was commanded to create layer from the selected features. The stations selected were identified as those not meet the distance criterion of 15m from road. Chart was created to see the proportions of the stations not meet this criterion.

Another query operation was done using selection menu, the query is to give stations that are within distance of 400 metre from other station. The selected stations are identified as those not meet the criterion of 400 meter between stations. Shape file for these stations was also created, saved and used to compute the proportion not meet 400m criterion.

A hospital (being a public building) database was also imported into the ArcMap environment and a query by location was performed. The software was asked to find and highlight all stations that are within 100 meter from the hospitals. The selected stations were identified as those not meet the criterion of 100 meter from public place (hospitals). A similar operation was done using schools shape file to identify those not meet the distance of 100 meter from school.

Worshiping places (even though public and semi public) were not included in this work because their of lack of spatial data for them, also the fact that anyone familiar with the study area (Kano Metropolis) mosque are built everywhere in the city and that comparison with them will prove difficult and nearly impossible

III. RESULTS AND DISCUSSION

The result of the analysis was presented under the sub-headings below:

5.1 Inventory of Filling Stations by Road

There exist two hundred and fourteen (214) filling stations at the time of study. These filling stations are located along the forty four (43) roads in the area in the area (table 1). However the filling stations are not equally distributed between the roads as can be observed from the table, Zaria road has the highest number of station (28) followed by Maiduguri and Katsina road with (27) and (25) each respectively, these three roads account for more than one-third of the filling stations in the area (representing 36%). This result is not surprising because the three roads are the major roads in the metropolis; they are the longest and linked Kano with major cities of Nigeria. Equally Gwarzo road, Eastern bye-pass and Hadejia Road have significant number of filling stations as can be observed from the table. On the other hand short and access roads have least number of filling stations. This can be seen in roads like IBB Way, Jakara Road, Kofar Wambai and many others with one filling station each. Indeed this finding has corroborate with that of Baichie and Wallimsi (2000) which ascertains that filling stations are not built in town centres but rather on exit roads.

Table 1: Distribution of Filling Stations by Road

S/N	Road	Type	No. of Stations	
			F	%
1	Abdullahi Bayero Way	Major	1	0.5
2	Bompai Road	Minor	1	0.5
3	Enugu Road	Access	1	0.5
4	Ibb Way	Minor	1	0.5
5	Jakara Qtrs	Minor	1	0.5
6	Kofar Mazugal Road	Major	1	0.5
7	Kofar Wambai	Access	1	0.5
8	Kumbotso Secreteriate Road	Access	1	0.5
9	Lagos Street	Access	1	0.5
10	Lawan Danbazu Link/Off Buk Road	Access	1	0.5
11	Middle/Court Road	Access	1	0.5
12	New Road	Access	1	0.5
13	Old Katsina Road	Minor	1	0.5
14	Sabo Bakin Zuwo Road	Access	1	0.5
15	Tafawa Balewa Road	Minor	1	0.5
16	Tudun Yola Road	Access	1	0.5
17	Waika-Dawanau Road	Minor	1	0.5
18	Zango Road (Dakata)	Minor	1	0.5
19	Court/Middle Road	Access	2	0.9
20	Link Road	Access	2	0.9
21	Yahaya Gusau Road	Minor	2	0.9
22	Zungero Road	Minor	2	0.9
23	Bello Road	Major	3	1.4
24	Club Road	Major	3	1.4
25	Dala Hospital Road	Major	3	1.4
26	Dambatta/Daura Road	Major	3	1.4
27	Independence Road	Minor	3	1.4
28	Zoo Road	Minor	3	1.4
29	Aminu Kano Way	Major	4	1.8
30	Murtala Moh'd Way	Major	4	1.8
31	Sharada Ind. Estate	Major	4	1.8
32	Buk Road	Major	5	2.3
33	Ibrahim Taiwo Road	Minor	5	2.3
34	Kofar Ruwa Road	Access	6	2.8
35	Madobi Road	Major	7	3.2
36	Panshekara Road	Minor	7	3.2
37	Sani Abacha Way (Airpport Road)	Major	8	3.7
38	Hadejia Road	Major	9	4.1

39	Eastern Byepass	Major	14	6.5
40	Gwarzo Road	Major	17	7.8
41	Katsina Road	Major	25	11.5
42	Maidaguri Road	Major	27	12.4
43	Zaria Road	Major	28	12.9
	Total		214	98.6

Source: Field Survey (2014)

5.2 Distance from Road

According the physical planning Standards set by DPR (2007) Procedure guide for grant of approvals to construct and operate of a petrol products retail outlet, the distance from the road to filling station pump should not be less than 15meter. Since filling station were represented as point facilities and road as line feature, a buffer of 15m was created on the road and data query by location was made in ArcMap environment. The query assisted with "selecting all locations that are completely within 15meter road buffer.' The result is presented in Figure 2 and 3.

The result revealed that only eight stations (4%) did not meet the criteria of 15m minimum distance from road (figure 3). These stations include those along the access road (e.g. Jakara and New road) and a few along the major roads (one station along Zaria, Katina, Daura/Dambatta road each.
This result confirmed that majority of the filling stations meet the standard criteria of locating 15m distance from road. Among the filling stations that did not meet this criterion 62% are independent marketers, 38% are major markers and none is NNPC.

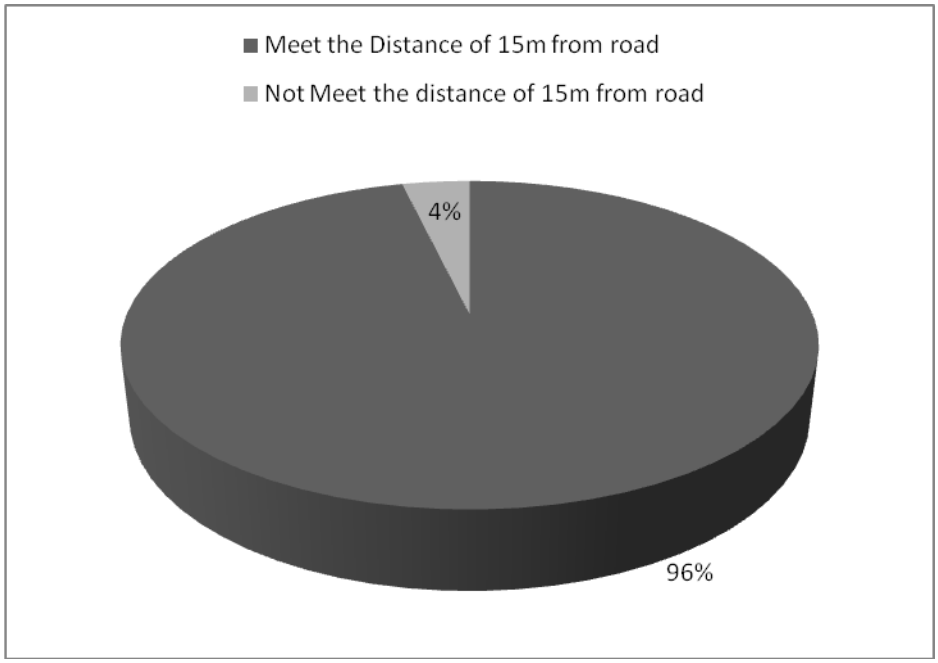


Figure 2: Station and 15 metre Standard Distance from Road

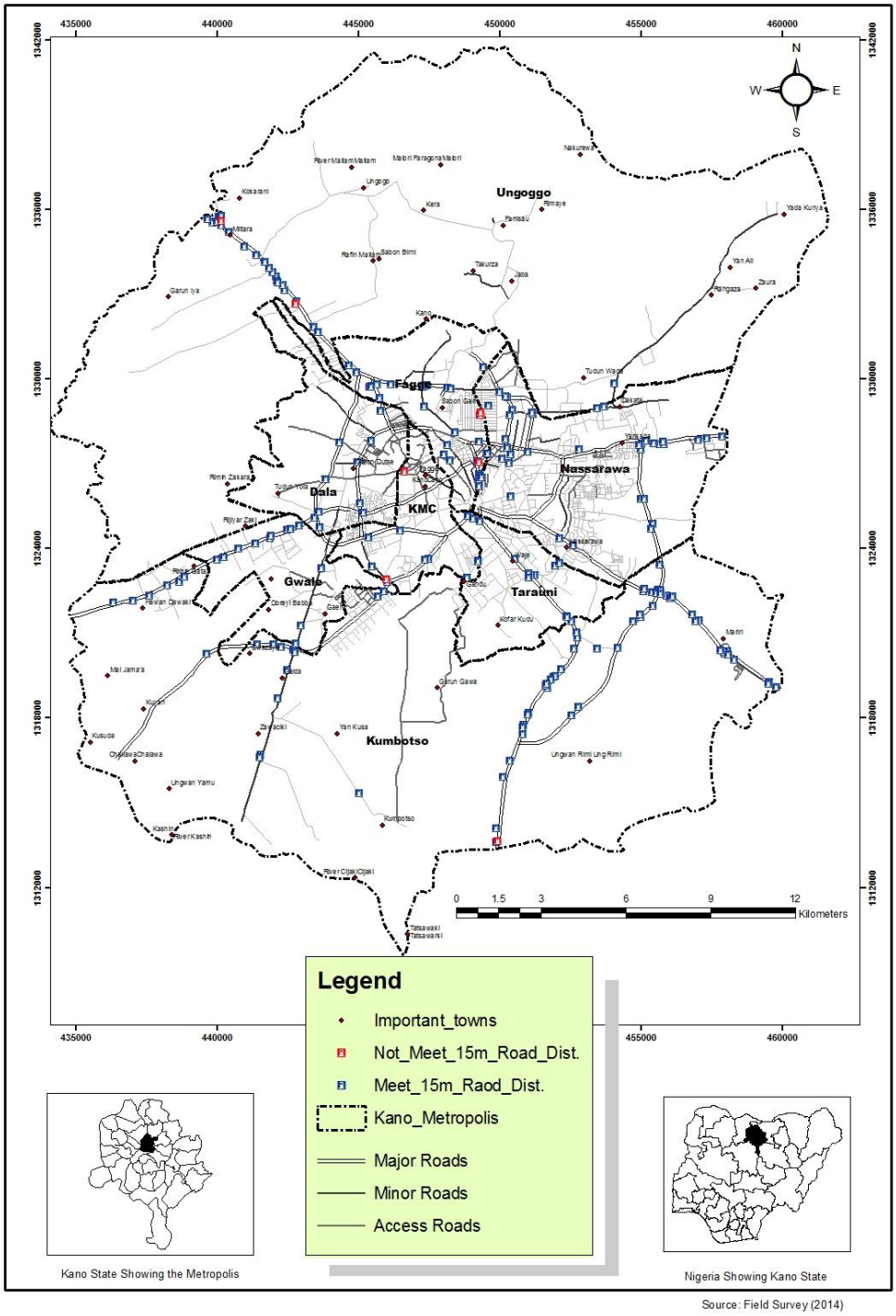


Figure 3: Filling Station and 15 meters Distance from Road

4.3 Distance between the Location of Filling Stations

Distances between stations in the area were determined in ArcMap environment using proximity operation of the analysis tool. The finding revealed that longest distance between neighbouring filling stations was about 3,700 metre. This was found between Gasau Petroleum along Kumbotso Secretariat and Misbahu Garba Nigeria ltd along Panshekara road. Apart from the two mentioned, the mean distance between neighboring filling stations was about 300 metre. The shortest distance of less than a metre and was observed were neighboring station lied back to back. The result also shows that more than half of the filling stations were less than 400 metre to their neighbours. However about only 24% of the station could not meet the minimum distance of 400 metre from their neighbours (with no road separation).

In a nut shell more one-quarter of the filling station did not to satisfy the standard of 400 metre distance from the nearest neighbour (figure 4). The filling stations that had not satisfied these standards are found in most roads. The highest number of those not meet the minimum standard of 400m distance between the location of filling station was observed in Katsina and Gwarzo road, which are major road linking Kano to other major Nigeria's cities (figure 5). The likely reason for these play out may be due to the market along these areas and the fact that regulator bend to this rule and give waver to the filling stations (as regard the standards) in heavy traffic roads.

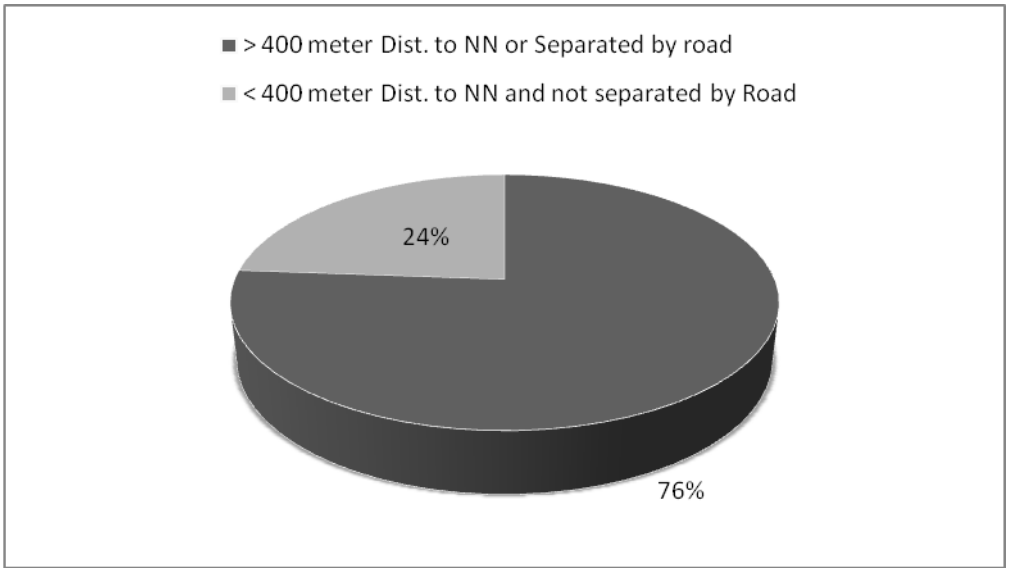


Figure 4: Filling Stations in Relation to 400m Distance to Other Filling Station

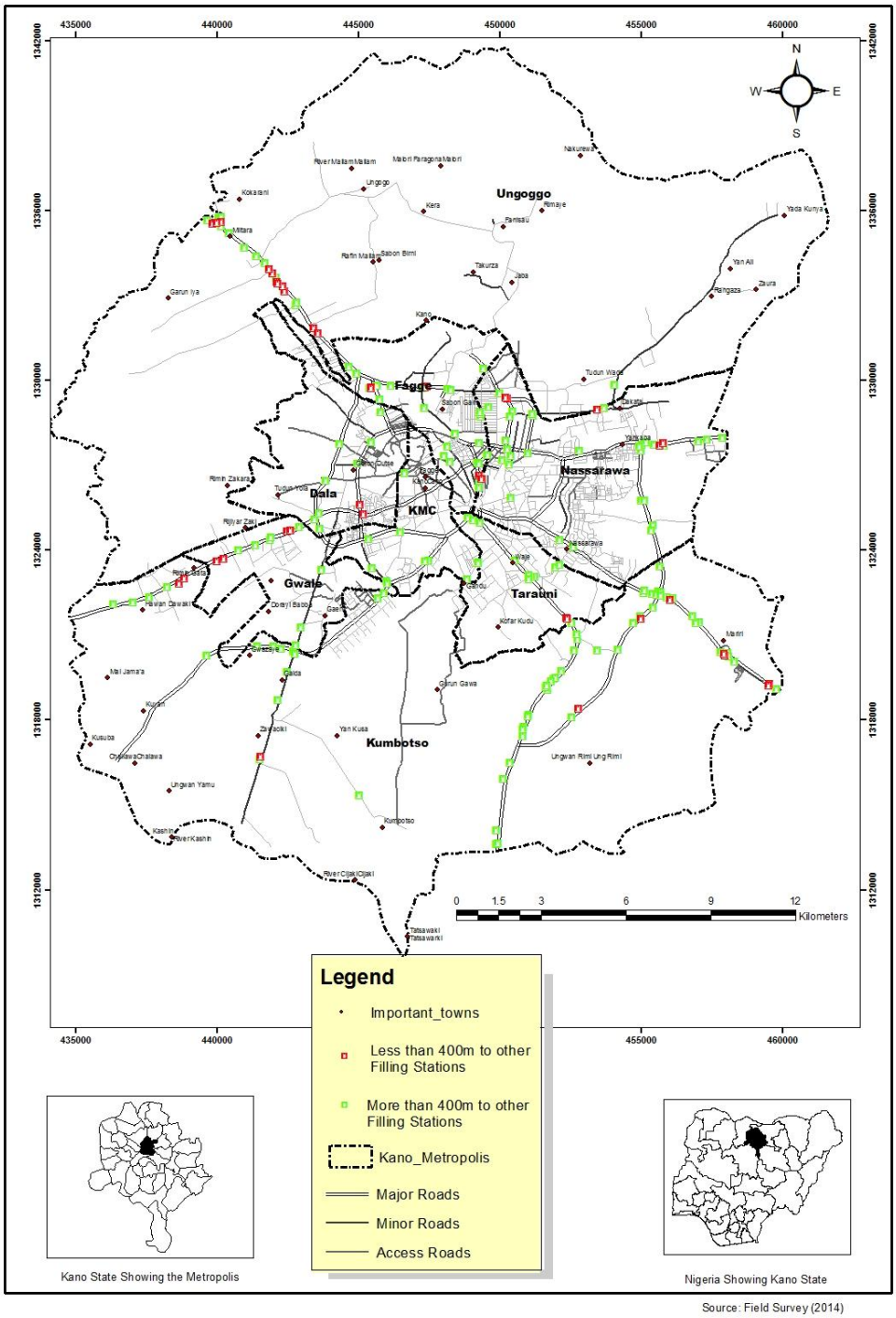


Figure 5: Location of Filling Stations in Relation 400m Distance Other Stations

5.4 Distance to Health Facilities

According the criteria set by the DPR filling station are not allow to operate adjacent to public institution like hospitals. In case they are to operate, the minimum distance of 100meter has to be maintained. Thus a comparison was made between the location of filling station and their distance to the hospital. The findings revealed that majority of the stations meet this standard (figure 4.4.3). Only few of the station (2%) could not meet the criteria. These stations are mainly major and independent marketers and none among them is NNPC outlet. In essence distance of filling station to the hospital is one major criterion the regulators not play with because only few station.

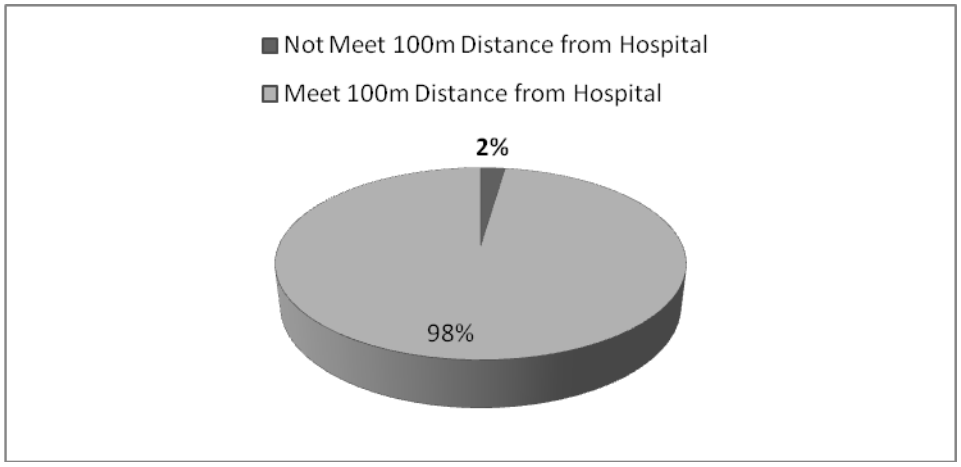


Figure 6: Filling Station Distribution in Relation to 100m Distance to Hospital

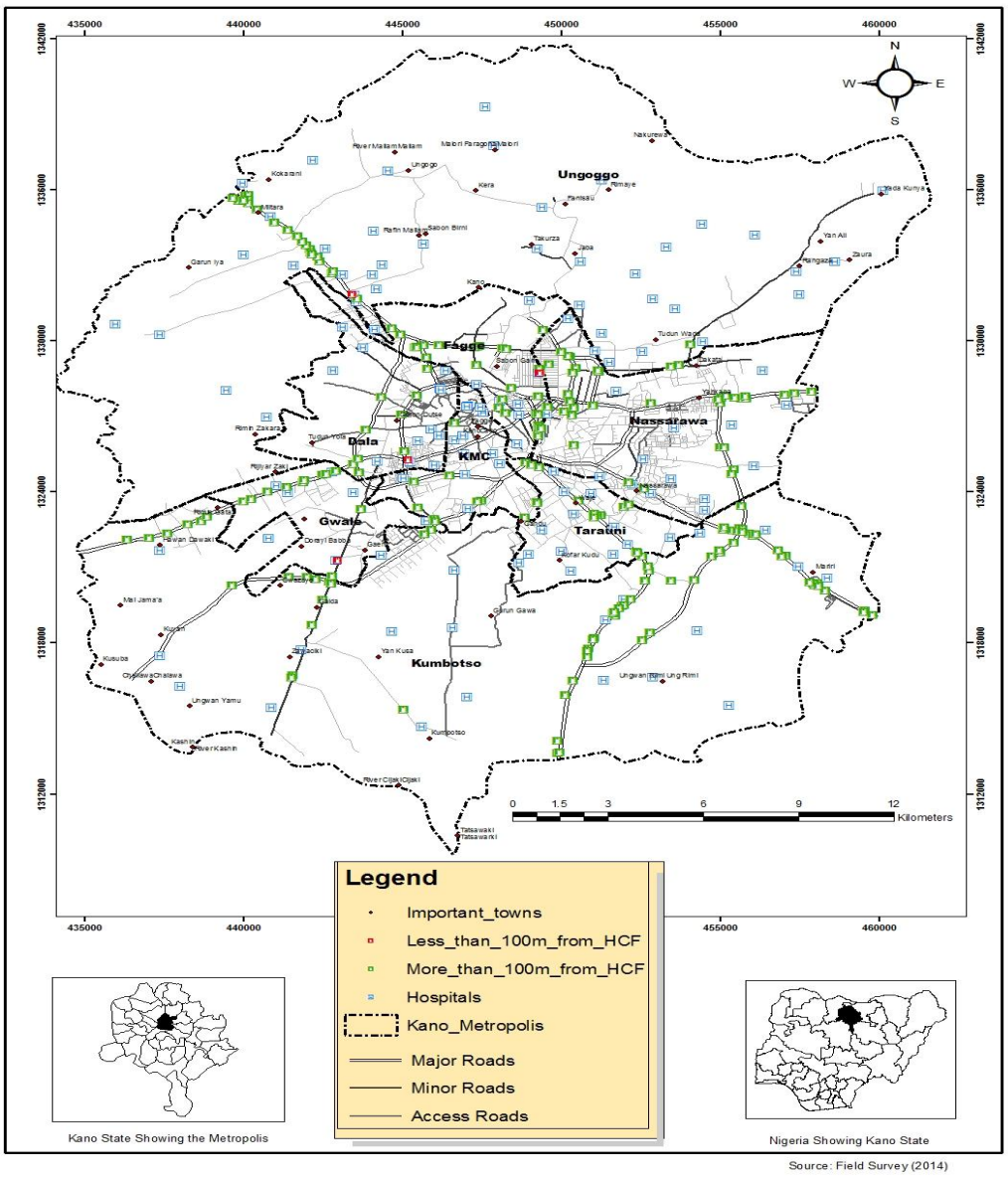


Figure 7: Location of Filling Stations in Relation to Health Care Facilities

5. Conclusion and Recommendations

Filling stations in Kano metropolis are more concentrated along the major roads (high ways) especially Zaria road, Katsina road and Maiduguri road. These three roads account for more than one-third of the filling station in the area. Even though filling station complies most to the standard regarding distance from the road and from public buildings specifically hospital, many stations did not meet the minimum distance of 400 metre from other station. Indeed it is common in the area to see two stations lie back to back. This has been observed in almost all the major road. Finally the paper conclude with the following recommendations

1) That there is need for more studies on filling station especially issues related to site selection and optimization. Also issue like people's perception on the location of the filling station can be investigated.
2) The distance of filling station to other public institution like school and mosque has not been considered by this study simply because the school and mosque are too many in Kano metropolis; this can be area for future research.
3) Discrepancies were observed as regard the compliance with standards, as such regulatory agencies need to look into the issue and take appropriate measures.

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