GIS-BASED LOCATIONAL ANALYSIS OF PETROL FILLING STATIONS IN KADUNA METROPOLIS

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ABSTRACT

Location of environmental sensitive commercial and service activities in densely populated urban areas are guided by planning principles and standards, expressed in either structure plans or land use development plans. There has been an upsurge of filling stations within Kaduna metropolis thereby raising the questions about their certified locations. This study analysed the location of filling stations in Kaduna Metropolis against the physical planning standards set by Department of Petroleum Resource (DPR) and Kaduna Urban Planning and Development Agency (KASUPDA). Names and addresses of the filling stations were obtained from the Department of Petroleum Resource (DPR) Kaduna. Global Positioning System **(GPS)** Garmin 78s map was used to capture the locations of the filling stations. The findings revealed that there are 228 filling stations located along the 26 roads in the study area, of which 74% are owned by independent marketers, 18% owned by Major Marketers and 8% owned by the NNPC. There is significant correlation between the number of filling stations and the road hierarchy. However, 86% of the filling stations did not meet the minimum distance of 100 meter from the health care facilities. 84% did not meet the criteria of 400 meter minimum distance to other stations where located on same road side. The research recommends that the regulatory agencies should take appropriate measures to ensure that filling stations operators comply with the standards.

Keywords: GIS, Analysis, Petrol, Filling Station, DPR, Kaduna metropolis

INTRODUCTION

Background to the Study

Technological advancement in the automobile industry has had a significant impact in the petroleum industry which has also trigger the building of petrol service stations (Petrol Filling Stations) at strategic locations to meet the demand of vehicular operations (Abdul *et al.*, 2009). The significant roles petroleum products play in any economy are well known. Chinambu (2012) acknowledged that, petroleum is a key driver of industrial activities. Besides the industrial development, the transportation sector is presumed to be the major consumer of fuel to facilitate mankind's movement patterns around the globe (Taylor, Sichinsambwe and Chansa, 2016).

In recent times, there has been a sustained increase in the number of petrol stations established in different parts of the country. The reasons for such unprecedented increase are not far-fetched. Firstly, the increasing population in the country and the attendant increase in the purchase of vehicle; Secondly, the attractive price of petrol both at control price and black market price which made more people to go into petrol retailing business (Uchegbu, 2002).

Nigeria is blessed with abundant natural resources and at present, the ninth world producer and sixth world exporter of crude oil (CBN, 2010). Despite this, population growth rate has continued to outpaced the ability of Government to build essential infrastructures, enact and enforce legislation needed to make life in safe, rewarding and healthy (W.H.O, 2010). This rapid growth rate of most urban centers has increased the use of automobiles, generators and other petroleum demanding plants. The pathetic power situation in Nigeria has exacerbated the increasing demand for petroleum products, leading to the proliferation of petrol filling stations and consequently, with less consideration of the minimum environmental safety requirements for their operations (Afolabi, Olajide & Omotayo, 2011). Safety practices in locating petrol filling stations are of utmost importance in preventing hazards and reducing potential risks that could affect humans and their environment.

In most large urban areas of Nigeria, there is high demand for land for socio-economic activities. This high land demand often results to land scramble and illegal conversion of land uses, leading to haphazard development and the deliberate location of petrol filling stations in unsuitable areas that are highly vulnerable to hazard (Kaduna State Urban Planning Development Agency, 2009). Increase 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. It has been discovered that, petrol filling stations are located close to residential areas and in some cases close to commercial and industrial activities (Mshelia, *et al.*, 2015).

The Kaduna metropolis has an area of 111 km square, covering an area of 1° latitude (10-11°N) and 1° longitude (7-8°E) surrounding Kaduna city. The area covers 12,347 sq km, approximately 25% of the State. It is located in an ecological zone generally described as the northern Guinea Savanna Zone. It has been traditionally characterised by a mono-modal rainfall system and a growing period of 150-180 days. Kaduna metropolis is made up of Kaduna North, Kaduna South, Chikun and part of Igabi Local Government Areas (LGA). It consist of 25 districts which includes Doka, Barnawa, Ungwan Muazu, Sabon Tasha, Makera, Television, Matagyi, Narayi, Kakau, Maraban Rido, Afaka, Gabasawa, Kwarau, Riga chikun, Kawo, Hayin Banki, Badiko, Badarawa/Malali, Tudun Wada, Rigasa, Kamazou, Nasarawa, Kabala. These districts serve as Kaduna metropolis as displayed in figure 1. This work focused on the GIS-Based analysis of filling stations in Kaduna Metropolis against physical planning standards in one of the largest city in Nigeria.
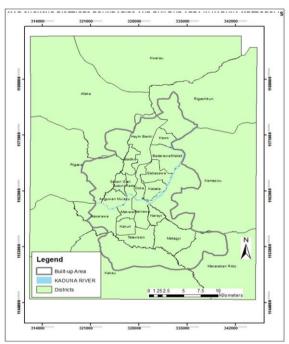
Figure 1: Kaduna Metropolis and Built-up Area

Source: Adopted from Kaduna Ministry of Land and Urban Planning (2012) redrwan at KASU (2016)

MATERIALS AND METHOD

Methodology
This study carried out survey to identify and document filling stations in the study area. This provided the researcher a good knowledge of the study area and provided guide on the nature of the data required and the extent of the field work. Street maps of Kaduna Metropolis at a scale of 1:2000 were sourced from the Kaduna State Ministry of Lands, Survey and Country Planning. A Quickbird imagery of 2016 of 2.5 meter resolution was also sourced from Kaduna Geographic Information System (KGIS); this was integrated with street map in order to produce an updated street map of the study area. The Department of Petroleum Resources (DPR) which is a department under the Ministry of Petroleum Resources responsible for registering and regulating the filling station provided the list of petroleum stations in the area. From the DPR provided data; filling station name, type and area (street) of location were identified. This was used as a guide for verification and collection of the coordinate data using Global Positioning System (GPS).

The obtained street map was scanned, imported into ArcMap environment of ArcGIS 10.1 and then georeferenced using map to image georeferencing method. Quickbird 2016 image of the area was used as a slave image for the georeferencing. The georeferenced maps were auto rectified and then given the same coordinate with image. Shape files were created in ArcCatalog 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 was 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 were also obtained from Department of Petroleum Resources and used to create a simple database. 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. To compare location of the filling stations with standards buffer and proximity analysis were done in Arcmap. Different queries were performed to obtain desired results.

Kaduna metropolis is an example a careful urban planning by the colonialists in 1920's which was gradually altered due to poor development control and city management (Al-Amin & Dadan-Garba, 2014). This work adopted the definition and concpept of metropolis from Cunningham (2005). In this work, a metropolis is the chief and sometimes capital, city of a country, state, or region, a central or principal place. It is a large and important city, usually the chief city in its region.

RESULTS AND DISCUSSION

Existing Filling Stations by Road Section
The findings revealed that there are two hundred and twenty seven (227) filling stations at the time of study. These filling stations are located along twenty six (26) roads in Kaduna Metropolis as shown in Table 1. However the filling stations are not equally distributed between the roads as can be observed from the table 1, Nnamdi Azikiwe Expressway has the highest number of filling stations (83) followed by Sabon Tasha/Kachia road and Zaria expressway with (32) and (15) each respectively, while Abuja/Kaduna expressway has 14 filling stations, these four roads account for more than one-third of the filling stations in the area (representing 64%). This result is not surprising because the three roads are the major roads within the metropolis; they are the longest in terms of length and linked Kaduna with major cities of Nigeria. Equally Television bye-pass road, Ali Akilu road, Kachia road and Mando 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 Aliyu Makama road with (8), Link road (6), Television garage road (5), Junction road (4), Constitution road (2), and many others with one filling station each. Indeed this finding has corroborate with that of Baichie and Wallimsi (2000) where they reported that filling stations are not built in town centres but rather on exit roads.

Another feature of the location of filling station is that they tend to be dominant on the exit side of the town. One major reason for that is most drivers fuel their vehicle when moving out of the city. For example, there are 83 filling stations along the Nnamdi Azikiwe expressway representing 37%, fifteen (7%) are situated on the exit side along Kaduna to Zaria expressway. Equally fourteen (6%) along Abuja-Kaduna expressway and seven (3%) along Lagos/Birnin Gwari road are located on exit side from Kaduna (figure 1).

It was discovered that 86% of the filling stations are located on the major road, about 13% on the secondary or minor roads and only 1% on the access road (figure 2). Attempt was made to see if there exist any relationship between the road rank and the number of filling station using Pearson product moment correlation and it was discovered that there is significant

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relationship even at alpha=0.01 because the p-value for the relationship is 0.00110. In other words the higher rank of the road the more the number of filling stations located along it.

Table 1: Existing Filling Stations by Road in Kaduna Metropolis

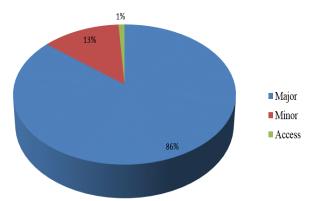| S/N	Roads Names	Road Type	No. Of filling stations	%
1	Abuja/Kaduna Expressway	Major	14	6%
2	Ahmadu Bello Way	Major	5	2%
3	Ali Akilu Road	Major	8	4%
4	Aliyu Makama Road	Minor	6	3%
5	Constituition Road	Major	2	1%
6	Dutsima/Ribadu Road	Minor	2	1%
7	Golf Course Road	Minor	1	0%
8	Junction Road	Major	4	2%
9	Kachia Road	Major	7	3%
10	Karaye Road	Minor	1	0%
11	Kano Road	Minor	2	1%
12	Lagos/Mando Road	Major	7	3%
13	Link Road	Major	6	3%
14	Mohamadu Buhari way	Major	2	1%
15	Murtala Mohammed Road	Minor	3	1%
16	Nnamdi Azikiwe Express	Major	83	37%
17	Nuhu Aliya Crescent	Minor	2	1%
18	Polytechnic Road	Minor	2	1%
19	Rigasa Road	Minor	4	2%
20	Sabo Tasha/Kachia Road	Major	32	14%
21	Shagari Road	Minor	1	0%
22	Television Garage Road	Minor	5	2%
23	Television ByePass Road	Major	11	5%
24	Zango Road	Minor		0%
25	Zaria Expressway	Major	15	7%
26	No Street Name	Access	1	0%
	TOTAL		**227**	**100%**

Source: Field Survey (2016)

Figure 2: Existing Filling Station by Road Type in Kaduna Metropolis

The density of filling station per road length was calculated and the results revealed that there is wide variation in the density of filling station between roads. The length of each of the road in km was determined and the density of filling stations per km of each was computed. It was found out that although Nnamdi Azikiwe Expressway, Sabon Tasha/Kachia road and Zaria expressway have the highest number of filling stations, other roads like Junction road, Link road, and Nnamdi Azikiwe Expressway topped in relation to density per km (Table 1). Indeed the density of filling stations per km in roads like Nnamdi Azikiwe Expressway, Junction road, Sabon Tasha/Kachia road, Abuja/Kaduna expressway and Television bye-Pass among others exceed the minimum KASUPDA (2007) that says there must be at least 3 stations in every two km.

Physical Planning Standards
Filling station business is regulated by DPR, a department under the Ministry of Petroleum Resources saddled with responsibility to register and regulate the downstream petroleum sector. In addition there exists Kaduna State Urban Planning Department Authority (KASUPDA) whose duty is to regulate all development within the metropolitan Kaduna. Filling stations has to meet the planning standard set by these agencies for their business safety. This study correlate the planning standard (already discuss in chapter one) and current location of the filling station in the area. This was achieved using proximity analysis tools available in ArcGIS 10.3.

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 3. The result revealed that only eighty seven (87) stations (38%) did not meet the criteria of 15m minimum distance from major roads (figure 3) while three (3) stations (1%) did not meet the criteria of 15m minimum distance from minor roads . These stations include those along the major roads (e.g. Nnamdi Azikiwe, Kaduna/Abuja, Zaria/Kaduna expressway, Ali Akilu, Kachia, Television bye-pass, Link road) and a few along the minor road (Television Garage road).
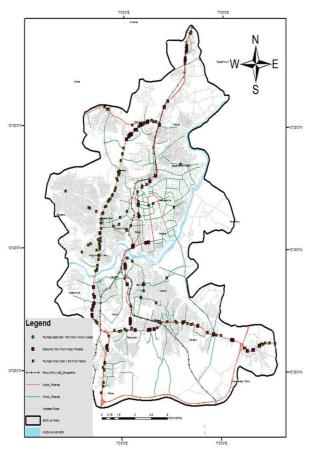
GIS-Based Locational Analysis of Petrol Filling Stations in Kaduna Metropolis

Figure 3: Filling Station Located against the 15m Standard Distance from Road
Source: Field Survey (2016)

This result confirms that majority of the filling stations meet the standard criteria of locating the nearest pump 15m distance from road. Among the filling stations that did not meet this criterion 50% are independent marketers, 33% are major marketers and 17% are NNPC.

Distance between 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 2487.4 metres. This was found between Kamoh Oil and Himshat Petroleum Nigeria ltd all along Rigasa road. Apart from the two mentioned, the mean distance between neighboring filling stations was about 230 metres. The shortest distance of less than a metres 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 metres to their neighbours. However about only 24% of the station could not meet the minimum distance of 400 metres from their neighbours (with no road separation).

In a nut shell more than one-quarter of the filling stations did not to satisfy the standard of 400 metre distance from the nearest neighbour (figure 4). The filling station that had not satisfied this standard was 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 Nnamdi Azikiwe expressway, Zaria expressway and Kachia road, which are major

road linking Kaduna to other major Nigeria's cities (figure 6). The likely reason for these playout 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.
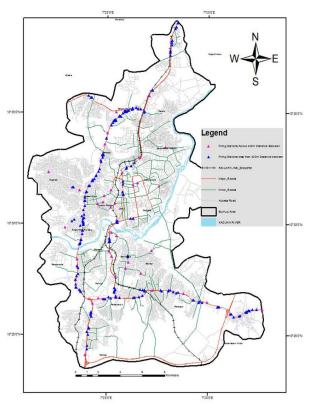

Figure 4: Filling Stations in Relation to 400 metre Distance to Nearest Filling Station
Source: Field Survey (2016)

Distance of Filling Stations 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 (196) making 86% of the stations meet this standard (figure 5) While (33) stations making (14%) could not meet the criteria. These stations are mainly 10 of major and 23 independent marketers and none among them is NNPC outlet. In essence distance of filling station to the hospital is one major criterion the regulators do not play with because only few station.
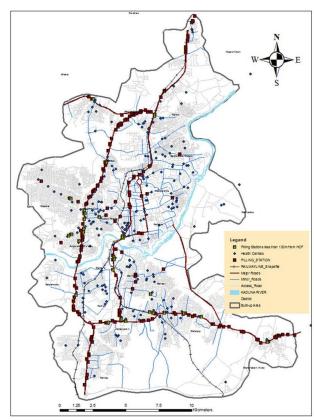
GIS-Based Locational Analysis of Petrol Filling Stations in Kaduna Metropolis

Figure 5: Location of Filling Stations in Relation to Health Care Facilities in Kaduna
Source: Field Survey (2016)

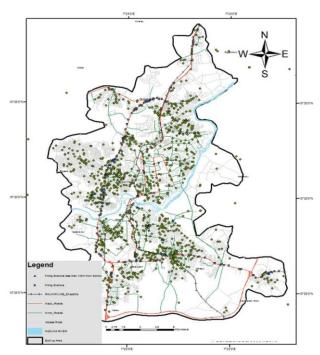**Distance of Filling Stations to Schools**
Based the criteria set by the DPR filling stations are not allowed to operate adjacent to public institution like schools. In case they are to operate, the minimum distance of 100meter has to be maintained. Thus a comparison was made between the location of filling station and their distance to the hospital. The findings revealed that majority (196) making 86% of the stations meet this standard (figure 6) While (33) stations making (14%) could not meet the criteria. These stations are mainly 8 of major and 25 independent marketers and one among them is an NNPC outlet.

Conclusion and Recommendation
There is a high concentration of filling stations within Kaduna metropolis but they are not evenly distributed, rather they are more concentrated along the major roads (highways) especially Nnamdi Azikiwe expressway (western bye-pass), Zaria expressway, Kachia road, Kaduna/Abuja expressway and Mando road. These five account for more than one-third of the filling station in the area.

The DPR should make it compulsory for the filling station operators when submitting their EIA report to include the geographic location of the site. This can be helpful in updating the spatial database for the filling stations successfully. Discrepancies were observed as regard the compliance with standards, as such regulatory agencies need to look into the issue, take appropriate measures and should (in future) ensured that only sites met the minimum standards were given permission to do the business.

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Figure 6: Location of Filling Stations in Relation 100m distance from Schools
Source: Field Survey (2016)

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