Resolving Potential Chaos Associated with Spatial Distribution of Gas Filling Stations in Urban Centres for Sustainable Planning

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ARTICLE INFO	ABSTRACT
	The study aims at assessing the spatial distribution of petrol filling stations in Ilaro , Ogun state, with a view to expand the frontiers of knowledge in the provision of non-existent spatial data in respect of gas filling stations and ultimately make recommendations for their sustainable planning. The objectives are to identify and map all the petrol filling stations in the study area; `assess their conformity with planning standards; and determine the distributional pattern of the petrol filling stations. The research adopted field surveys and remote sensing, especially the instrumentality of Geographic Information System(GIS), in identifying the existing petrol filling stations as well as conducting queries to assess the level of compliance of the petrol filling stations with extant planning standards. Nearest Neighbour Analysis was equally employed in determining the distribution pattern of the facilities. With a Rn value of 0.36, the study amongst others, pointedly reveal that the locational pattern of gas filling stations in the study area tends towards clustering. The study, inter alia, recommends the need for more proactiveness and effectiveness in the development control activities of the planning authority, under whose jurisdiction, the study area falls into.

1. Introduction

The Nigeria's rapid urban growth rate (4.38%) as noted in Trading Economics [1] and the growth that attended the diversification of the Nigerian economy had spawned an increased level of consumerism in virtually all sectors of the Nigerian economy. As the economy further experiences an increased level of diversification with the oil and gas sector accounting for less than 11% of the economy [2] , virtually all other sectors of the economy still continue to depend on the oil and gas sector. The improved income and the expansion of the spectrum of the middle-class afforded the propensity for increased use of automobiles, generators and other petroleum demanding plants.

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The pathetic power situation in Nigeria had also exacerbated the increased demand for petroleum products. The foregoing had essentially created the vista for the proliferation of petrol filling stations in most urban settlements in Nigeria. Petrol filling station is defined as any facility or equipment used for the sale or dispensing of petroleum products for motor vehicles. 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. Since the petrol filling stations have spatial dimensions, it is expected that they are sited in an organized and sustainable manner.

Despite the availability of standards regulating the location of gas filling stations in Nigeria's urban centres, most gas filling stations are still located in a manner that is chaotic and has the potentiality for hazards [3]. Ayodele [4] observed that poor sitting of petrol filling stations' culminate in traffic congestion, pollution, and fire hazards. As documented in Mohammed et al. [5], the Directorate of Petroleum Resources (DPR) provides certain standards for locating a petrol filling station. Foremost, land in which a gas filling station must be sited should have been zoned for commercial/industrial use or be designated specifically for the purpose of a filling station in a subdivision. The prospective land, within which a gas filling station is envisaged, should not be less than 33 x 33 square meters or equivalent of two plots of land allow for the free flow of traffic. A gas filling station should be sited 400 meters away from the next petrol station. It 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. The distance from the edge of the road to the nearest pump should not be less than 15meters. The total number of stations within 2 km radius of the site should not be more than four (4) including the one under construction. Filling stations should not be located less than 100 meters from school, hospital, theatres, clinics and other public and semi-public buildings. Lastly, the site for a filling station should not lie within NNPC/PPMC pipeline right of way or PHCN transmission or railroad lines. As noted in Alesheikh and Golestani [6], the onus of selecting an optimal site for business enterprise such as a petrol filling station depends on factors such as proximity to population centers, distance from neighboring stations, the easements of using existing utility, and the magnitudes of environmental pollution parameters. Oetomo and Sesulihatien [7] observed other factors to take into account when making a decision about the location of business, also include customers, transport, the neighbourhood, finances and the longer term future as part of the variables that should not be wished away in the location of investments such as filling stations. Filling stations significantly contribute to traffic problems such as traffic congestion, pollution, fire and explosion in most Nigerian urban settlements [4]. This is ultimately a corollary of the lack of development control and non-conformity with planning standards in semi –urban and fully urbanized settlements. The planning oddities are expressed in poor sitting, inadequate size, limited set back from road, poor radius allowance from major facilities like schools, churches, and mosques. This culminates in environmental dis-amenities such as traffic congestion, pollution, fire and many more problems resulting from un-coordinated development.

The study area, Ilaro, is about 50 km from Abeokuta, the capital city of Ogun state, Nigeria and about 100km from Ikeja, the city of Lagos state. It is defined by co-ordinates 6.88333^{o}N and 3.01667^{o}E. Ilaro, the headquarter of Yewa South Local Government Area of Ogun State, has an area of 106km^{2}and a population of 68,617, as extrapolated from the 2006's census result of 46,999 at a growth rate of 3.5% [8] . The population growth and physical expansion had been majorly occasioned by the establishment of growth poles like the Federal Polytechnic Ilaro and Dangote cement Ibese. It is a developing urban centre, which on account of its expansion had also witnessed the proliferation of petrol filling stations, most of which are poorly sited, and essentially disregard

planning standards. In view of this, it is imperative to assess the spatial location of gas filling stations within the town in order to ascertain the extent to which they conform to the planning standards and provide the non-existent spatial database in respect of gas filling stations in the area. The study aims at assessing the location and spatial distribution of gas filling stations in Ilaro , Ogun state . The objectives are to identify and map all the petrol filling stations in the study area; assess their conformity with planning standards; and determine the distributional pattern of the petrol filling stations.

2. Research Methodology

For this study, a preliminary field survey was first conducted to identify the location of petrol filling stations, name, area in the study area, and document their geographic coordinates. A 2016 google-earth imagery of Ilaro town of 2.5 meter resolution was sourced from the Department of Surveying, Federal Polytechnic Ilaro, Ogun State, Nigeria. The imagery was imported into the environment of ArcGIS 9.2 and then geo-referenced using map to image geo-referencing method. Two shape files for roads and for the filling stations were created in ArcCatalog environment. 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. The data were saved in the project folder (created in C drive) and exported to ArcGIS 9.2. The data was converted to shape file and used to perform all the analysis. Different symbolization was used to map out the filling stations. Further, tables and charts created in Microsoft Excel were used to present the inventoried data. This helped in achieving the first objective of the work, which is to identify and map out the filling stations. For the second objective, which is to assess the conformity of the filling stations with planning standards, standards buffering and proximity analysis were done in ArcGIS. For the standard on road setbacks, a buffer of 9 meter, which is according to the Ogun State Urban and Regional Planning Law of 2010 were established on the roads abutting the identified filling stations, in order to ascertain the level of compliance with road setback. Query by location was performed using selection menu in ArcGIS environment. Data were queried to give all locations that are within the 9m buffer from the roads. For the standard of what should be the distance apart for petrol filling stations (300 meters according to Ogun State Government[9] within built up areas, query operation was done using selection menu. The essence of the query was to determine filling stations that were within the radius of 300 metre from other station. The selected stations were established as those that did not meet the criterion of 300 meter between stations. For the standard of the radius between a filling station and public facilities like hospitals, schools, churches and mosques, which, according to DPR guidelines, should be 100 meters, database of the identified public facilities was imported into the ArcGIS environment and a query by location was performed. The software was asked to find and highlight all stations that are within 100 meter from either of the public facilities. In achieving the last objective, which is to determine the distributional pattern of the petrol filling stations, nearest neighbour analysis was brought to bear. This attempts to measure the distributions according to whether they are clustered, random or regular. Nearest neighbour analysis was used to determine the distribution pattern of facilities, and has a distribution spectrum that ranges from random, regular to clustered. The nearest petrol stations neighbours to each of the petrol filling stations were determined with the nearest neighbour distance for each of the petrol filling station documented. Having determined the area the study area and ascertained the total number of petrol filling stations, the formulae below was thus applied in determining the distribution pattern.

$$R_n = \frac{D(Obs)}{0.5\sqrt{\frac{a}{n}}}$$ (1)

Rn is the nearest neighbor value; D(Obs) is the mean observed nearest neighbor distance; a is the area under study; and n is the total number of petrol filling stations. The nearest neighbour formula will produce a result between 0 and 2.15, where the following distribution patterns form a continuum:

3. Results and Discussion

Identification and Mapping of all the Petrol Filling Stations in the Study Area

From table 1 below, it is evident that there are 34 petrol filling stations in the study area. However, out of the 34 petrol filling stations, 4 (11.76%) are yet to be fully constructed, 7(20.59%) have become abandoned, while 23(67.65%) are essentially functioning. The spatial distribution of the petrol filling stations are presented in figure 1 below.

Table 1
The Location, Status, Geographic Coordinates of Petrol Filling Stations

S/N	Name Of Filling Stations	Location	Status	Easting	Northing
1	Honeywell	Ilaro – Oja – Odan Road	Functioning	498898	761106
2	Johnfolu	Tunde Ibikunle Road	Functioning	499485	761106
3	Kareem	Tunde Ibikunle Road	Functioning	499540	761153
4	AP	Tunde Ibikunle Road	Abandoned	500177	761101
5	Wellstead	Tunde Ibikunle Road	Functioning	501985	761483
6	Himbab	Tunde Ibikunle Road	Functioning	501985	761483
7	Ifotech	Papa-Federal Polytechnic Junction Road	Functioning	499471	761258
8	Abital	Papa-Federal Polytechnic Junction Road	Abandoned	499581	761498
9	Gaboma	Papa-Federal Polytechnic Junction Road	Functioning	499702	761782
10	Olufela	Papa-Federal Polytechnic Junction Road	Functioning	499837	761991
11	Awo	Papa-Federal Polytechnic Junction Road	Functioning	499900	762153
12	Buksol	Papa-Federal Polytechnic Junction Road	Functioning	500540	762439
13	Toyse	Papa-Federal Polytechnic Junction Road	Functioning	500553	762441
14	Total	Papa-Federal Polytechnic Junction Road	Functioning	500746	762510
15	Conoil	Papa-Federal Polytechnic Junction Road	Functioning	501139	762699
16	Afariogun	Papa-Federal Polytechnic Junction Road	Functioning	502768	762295
17	Kaolas	Papa-Federal Polytechnic Junction Road	Functioning	503921	761964
18	Elak	Papa-Federal Polytechnic Junction Road	Abandoned	504005	761878
19	Total2	Owode – Ibese Road	Functioning	502372	761402
20	Fabson	Owode – Ibese Road	Functioning	502452	761306

21	Elak 2	Owode – Ibese Road	Abandoned	501835	7606665
22	Ascon	Owode – Ibese Road	Functioning	501197	760130
23	Arolat	Owode – Ibese Road	Functioning	501105	760075
24	Atinsola	Gbogidi	Functioning	500501	760084
25	Himra	Gbogidi	Functioning	500036	760783
26	Arolat2	Atewolara	Functioning	501542	761445
27	Macglobus	Owode – Ibese Road	Abandoned	502934	764239
28	Ultimate	Owode – Ibese Road	Abandoned	502630	763140
29	JOAKS	Owode – Ibese Road	Abandoned	501127	759345
30	TALKEEM	Owode – Ibese Road	Functioning	501007	759602
31	UNDER CONSTRUCTION 1	Papa-Federal Polytechnic Junction Road	Underconstruction	499435	761168
32	UNDER CONSTRUCTION 2	Papa-Federal Polytechnic Junction Road	Underconstruction	499561	761564
32	UNDER CONSTRUCTION 3	Papa-Federal Polytechnic Junction Road	Underconstruction	499580	761349
34	UNDER CONSTRUCTION 4	Papa-Federal Polytechnic Junction Road	Underconstruction	501006	762580

Author's survey (2017)
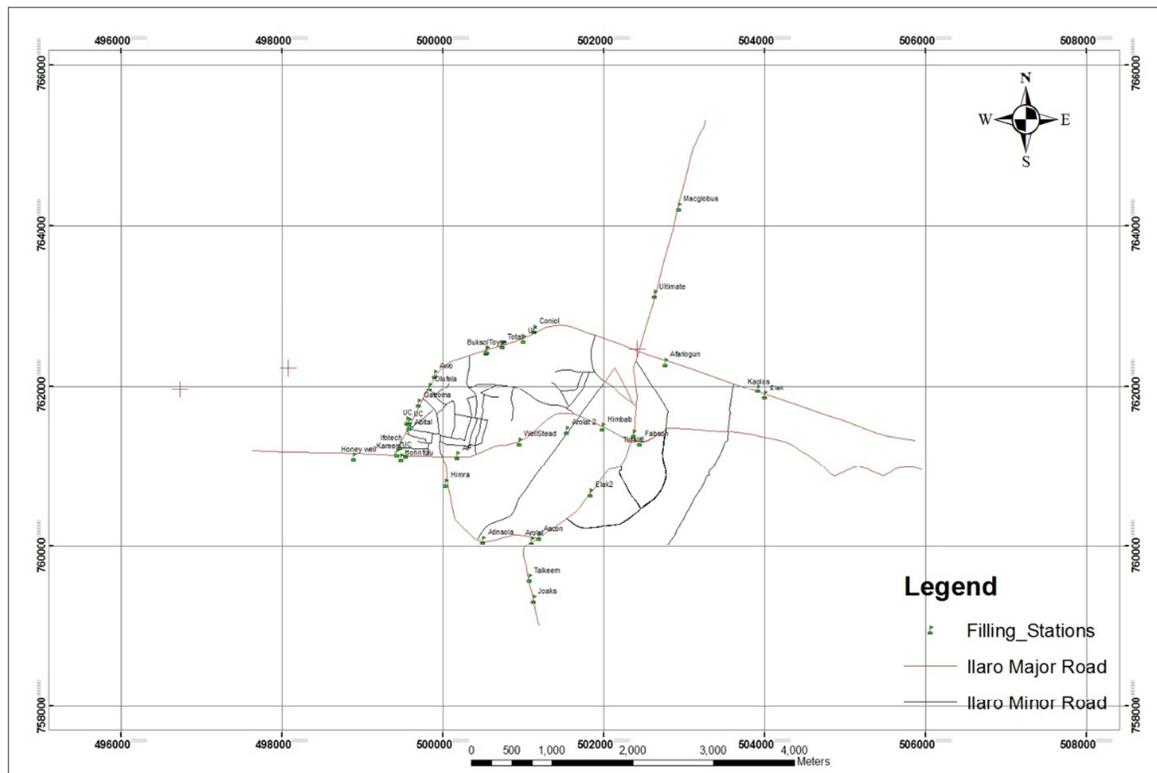
Fig. 1. Spatial locations of petrol filling stations in Ilaro town

Conformity of the Petrol Filling Stations with Planning Standards

Survey and application of GIS in determining the conformity of the petrol filling stations with planning standards relied on the Ogun State Urban and Regional Planning Law of 2010 and DPR guidelines of 2007 for approving petrol filling stations. The result of survey and ArcMap queries shown in table 2 indicates that with respect to threshold land size of $1188m^2$,just 14 (41.18%) of the filling stations can be said to be in compliance. As far as the setback standard of 9 meters from road is concerned, just 6 petrol filling stations, representing 17.65 %, can be said to be in conformity. 17 (50%) of the petrol filling stations have their nearest neighbor filling station on either side of the road locating outside the radius of 300 meters.While 11(32.35%) of the petrol filling stations comply with the minimum setback of 100 meters from places of worship, 16 (47.06%) comply with the minimum setback of 100 meters from schools, and 29 (85.29%) comply with the minimum setback of 100 meters from places of hospitals. Further, while 26(76.47%) of the petrol filling stations are located in developed milieus, 2(5.88%) are located in developing areas, and 6(17.64%) are sited in underdeveloped areas. Table 3 shows that Papa-Polytechnic Junction,a major road, carries the highest density(4.91 Km^{-1})expressed in terms of number of filling stations per kilometer , with the 16 petrol filling stations congesting a road of 3.26km stretch . This is followed by Owode-Ibese Road ,a major road, which carries the density of 2.68 Km^{-1} with 8 petrol filling stations dotting its 2.99 kilometer length; Old Garage road, a minor road ,which has the density of 2.1 Km^{-1} with 1 filling station locating on its 0.48 kilometer; Tunde Ibikunle Road,a major road, which carries the density of 1.57 Km^{-1} , with 5 filling stations locating on its 3.193 kilometer length; Gbogidi Road, minor road, with a density of 0.74 Km^{-1}, with 2 filling stations locating on its length of 2.69 kilometers; Poly-Oja-Odan road , a major road, which carries a density of 0.57 Km^{-1},and have just one filling station locating on its stretch of 1.76 kilometer; and Atewolara road, a minor road, which carries a density of 0.39 Km^{-1} ,equally with one filling station locating on its extent of 2.58 kilometer. The findings are consistent with the findings of Afolabi *et al*. [3] and Ayodele [4] in respect of their observations that petrol filling station are badly sited in Nigerian urban settlements, a phenomenon, which most times culminate in incidences of traffic congestion, pollution, and fire hazards

Table 3
Density of Petrol Service Stations by Roads

S/N	Name of Road	Length (Km)	Number of Pfs	Density
1	Papa -Polytechnic Junction Road	3.26	16	4.91
2	Owode – Ibese Road	2.99	8	2.68
3	Atewolara Road	2.58	1	0.39
4	Polytechnic – Oja – Odan Road	1.76	1	0.57
5	Tunde Ibikunle Road	3.193	5	1.57
6	Old Garage-Oke Ela	0.48	1	2.1
7	Gbogidi	2.69	2	0.74

Author;s survey(2017)

where density per road = number of petrol service stations ÷ length of road

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Distributional Pattern of the Petrol Filling Stations

The Nearest Neighbour Analysis was carried out in respect of the 34 petrol filling facilities locating in the 106 square kilometer of Ilaro town, and with mean nearest neighborhood distance of 0.29 km. With the Rn value of 0.33, the locational pattern can be said to tend towards clustering. This is obvious in the high density expressed as number of filling stations per kilometer in major road corridors of Ilaro settlement, as shown in table 3. It is equally corroborated by the finding in table 1 that 17 (50%) of the petrol filling stations have their nearest neighbor filling station on either side of the road locating outside the recommended radius of 300 meters . With the facility per population contained in DPR guideline of 2007, which stipulates that one petrol filling station should serve 5000 population, the total number of petrol filling stations that should optimally serve Ilaro's population of 68,617 is 14. The present population of 34 filling stations suggests an undue clustering. It is equally noteworthy that the clustering is apparently more expressed in the developed areas of Ilaro settlement.On the basis of the foregoing, the null hypothesis stated in respect of this study that the locational pattern of petrol stations within Ilaro is not regular and evenly spatially distributed is hereby accepted. This is similar to the findings of Chukwudi and Alagbe [10], who in their study on Site Suitability Assessment of Petrol Filling Stations (PFSs) in Oyo Town, Oyo State, Nigeria concluded the pattern of distribution of gas stations in the study area tended towards clustering.

Table 4
Distribution Of Petrol Service Stations By Road

S/N	Road	Type Of Road	Number Of Stations	%
1	Papa -Polytechnic Junction Road	Major	16	47.1
2	Owode – Ibese	Major	8	23.5
3	Atewolara	Minor	1	2.94
4	Polytechnic – Oja – Odan	Major	1	2.94
5	Tunde Ibikunle	Major	5	14.71
6	Old Garage-Oke – Ela	Minor	1	2.94
7	Gbogidi	Minor	2	5.88

Author;s survey(2017)

4. Conclusion

From the foregoing it is evident that if all parameters for assessing the locational appropriateness of petrol filling stations are critically considered ,none of the petrol filling stations in the study area is worthy of town planning approval. Just like in the studies of Afolabi *et al* [3], Ayodele [4], Mohammed *et al* [5] and Chukwudi and Alagbe [10], in Ile Ife, Kaduna, Kano and Oyo states, respectively, the observed pattern of development and functionality is therefore an indictment on the Agency responsible for managing spaces in the study area. Land is fixed and limited in supply, and the spatial expression and level of organization of settlements are the manifestations of whether land governance and control are effective [11]. The study recommends a moratorium on the approval of petrol filling stations within the fully developed road corridors within the study area, as it is evident the existing petrol filling stations had greatly flouted planning standards in their location. Certain standards discrepancies were commonplace in the course of this study. For instance while DPR standard recommends a setback of 15 meters from road, the Ogun State Urban and Regional Planning law of 2010 recommends a setback of 9 meters. The study

deems imperative the reconciliation of such discrepancies by the regulatory authorities. Moreover, it recommends the need for an audit of approval carried out in respect of petrol filling stations in the study area, by Ogun State Ministry of Urban and Regional Planning. It recommends that in order to achieve the extent of sustainable development canvassed in Rashidi *et al*. [12], there is need for more proactiveness and effectiveness in the development control activities of the planning authority, under whose jurisdiction, the study area falls into.

Acknowledgement

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Table 2
Profile of Petrol Filling Stations with Respect to Planning Standards

S/N	Name Of Filling Station	Compliance with Minimum Size Standard (1188m^2)	Compliance with minimum setback of 9 meters from road	Compliance with minimum setback of 300 meters from nearest neighbor filling station on either side of the road	Compliance with minimum setback of 100 meters for Places Of Worship	Compliance with minimum setback of 100 meters for Schools	Compliance with minimum setback of 100 meters for Hospitals	Level Of Development of the Area	
1	Honeywell	No	No	No	Yes	No	Yes	Developing	
2	Johnfolu	No	No	No	Yes	No	No	Developed	
3	Kareem	Yes	No	Yes	Yes	Yes	No	Developed	
4	AP	No	No	No	No	Yes	Yes	Developed	
5	Wellstead	Yes	Yes	Yes	No	No	Yes	Developed	
6	Himbab	No	No	Yes	Yes	No	Yes	Developed	
7	Ifotech	No	No	No	No	No	Yes	Developed	
8	Abital	Yes	No	No	No	Yes	Yes	Developed	
9	Gaboma	Yes	No	No	No	Yes	Yes	Developed	
10	Olufela	Yes	No	No	Yes	Yes	Yes	Developed	
11	Awo	Yes	No	No	Yes	No	Yes	Developed	
12	Buksol	No	No	No	No	Yes	No	Developed	
13	Toyse	No	No	No	No	Yes	No	Developed	
14	Total	Yes	Yes	No	No	Yes	No	Developed	
15	Conoil	Yes	Yes	No	No	No	Yes	Developed	
16	Afariogun	No	No	Yes	No	Yes	Yes	Under – Developed	
17	Kaolas	Yes	Yes	Yes	No	Yes	Yes	Under – Developed	
18	Elak	Yes	Yes	No	No	Yes	Yes	Under – Developed	
19	Total2	No	No	Yes	No	No	Yes	Developed	
20	Fabson	No	No	Yes	No	No	Yes	Developed	
21	Elak 2	Yes	No	Yes	No	No	Yes	Developed	
22	Ascon	No	No	Yes	No	No	Yes	Developed	
23	Arolat	Yes	Yes	Yes	No	No	Yes	Developed	
24	Atinsola	Yes	No	Yes	No	Yes	Yes	Developed	
25	Himra	No	No	Yes	Yes	No	Yes	Developed	
26	Arolat2	No	No	Yes	Yes	Yes	Yes	Developed	

27	Macglobus	Yes	No	Yes	Yes	No	Yes	Developing	
28	Ultimate	No	No	Yes	Yes	Yes	Yes	Under – Developed	
29	Joaks	No	No	Yes	No	Yes	Yes	Under – Developed	
30	Talkeem	No	No	Yes	No	Yes	Yes	Under – Developed	
31	Under Construction 1	No	No	No	Yes	No	Yes	Developed	
32	Under Construction 2	No	No	No	No	No	Yes	Developed	
33	Under Construction 3	No	No	No	No	No	Yes	Developed	
34	Under Construction 4	No	No	No	No	No	Yes	Developed	

Author;s survey(2017)