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Locational Impact of Petrol Filling Stations Close to Residential Buildings in Ife Central, Nigeria

M.A. Oyinloye[1]*, O.E. Abiola[2]

[1]*Dept. of Urban and Regional Planning, Federal University of Technology, Akure, Nigeria*
[2]*Dept. of Urban and Regional Planning, Federal University of Technology, Akure, Nigeria*

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Abstract *- The emergence and indiscriminate siting of fuel petrol stations all across the country call for urgent investigation of the impact of their sitting at close proximity to residential areas and absurd places at Ife Central, Nigeria. This project was conducted to assess the locational impact of petrol filling stations (PFS) close to residential buildings in Ife Central, Nigeria. The spatial locational pattern of fuel stations was analyzed and its resultant impact on Ife Central, Nigeria, to determine the degree of compliance of the PFS with planning standards and regulations; and assess the physical, social and economic relationship between the PFS and residential land uses in the study area. Fifty-two (52) were sampled for data collection. A two-phase mixed-method approach was adopted, using qualitative interviews to validate identified factors. Upon the validation of the location factors through an inductive approach, a quantitative questionnaire was formulated. Using a quantitative survey, data were collected from 340 respondents. The data were then analyzed using factor analysis and structural equation modeling to determine the factors and their relationship with factors of location. The analysis reveals cumulative non-compliance to principles and standards by all the PFS. The nearest neighbour ratio was 0.56, showing the PFS distribution was cluster distribution pattern of the fuel stations, portraying an unorganized distribution. This cluster distribution pattern impacts negatively on the residents' wellbeing, environment, and socio-economic life. The study also identified owner preferential choice and planning standards; storage material and factor of location; environmental impact assessment; type of license; and distance between the tanks and site management and administration as the five factors that directly influenced the choice of location of the Petrol Filling Stations (PFS).*

Keywords: *Petrol Station, Residential, Impact, Planning Standards.*

I. INTRODUCTION

The relevance and importance of technological advancement and man's need for energy (man-made) generation are high and enormous. Fossil fuel is still relevant in meeting the energy demand; its utilization in the automobile makes the strategic building of petrol filling stations (PFS) important to meet the demand of vehicle owners (Iman, Ismail, & Martin, 2009). However, in recent times, there had been a proliferation of filling stations sited across different parts of the country with rising concerns for safety as a sizable number of them do not meet nor comply with the stipulated operational licenses requisite safety measures (fire standards, layout, location, and waste management) by the regulatory bodies. They were sited in close proximity to each other and in residential areas contrary to the guidelines for siting such accident-prone facilities. These practices, therefore, pose a dangerous trend and heightened public health risk on the neighboring life, properties, and environment (Afolabi et al., 2011).

Fuels are primarily hydrocarbons containing volatile organic compounds such as benzene, some of which are injurious and harmful if in contact with skin and as well posit low dosage upon exposure to it (Linet et al., 1996). The safety of lives and properties and protection of the environment are therefore of major concerns revolving around the petrol filling stations. At ambient temperature, petrol and other vehicle fuels are potentially hazardous. Petrol gives off vapour when mixed with air in appropriate proportions. It burns with explosive force if ignited. Moreover, all petroleum products are potential pollutants, which, if not properly handled or managed, can damage the environment - injurious to aquatic life and harmful to human health if inappropriately handled (Health and Safety Executive, 2018).

Petroleum is a dominant source of revenue and foreign exchange in Nigeria. It strategically accounts for about 78% of Gross Domestic Product and up to 90% 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 - 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 crude oil at the terminal and its user, especially transportation, supply trading, refining distribution, and marketing of petroleum (Asada, 2010). The public actors are government agents and functionaries such as the Nigerian National Petroleum Corporation (NNPC) and its subsidiaries, the Department of Petroleum Resources (DPR), the Petroleum Product Pricing Regulatory

Authority (PPPRA), among others. The private segments consist of both indigenous and foreign actors. The indigenous actors consist of independents marketers, which numbered about 1000 in 1979, a year after formulating the act which established them but increased to 7948 in 2010. They compete with the foreign or multinational marketers like Mobil Oil Nigeria Plc., MRS Nigeria Plc., Total Nigeria Plc., and Africa Petroleum Plc. Studies have reported that inhalation of benzene in the environment caused mucous membrane irritation, heart attack, cancers of the lung, brain, and stomach, leukaemia, aplasia, dermatitis, and bone marrow depression (Sangotola, Fasanmade, Ayanrinde, Olatinwo, & Olaniran, 2015)

II. STUDY AREA

The city of Ile-Ife (Figures 1.1-1.3) is the headquarter of Ife Central Local Government Area of Osun State, Nigeria. It is located on latitudes 7˚26' N and7˚32' N of the equator and longitude 4˚29' E and 4˚37' E of the Meridian. The population of the area is about 167,254 persons consisting of 88,403 males and 78,801 females, based on the 2006 census result (Nigeria Population Commission, 2007). The vegetation in Ile-Ife is made of three canopy heights, the tallest trees up to 25m high with canopies far apart, the middle layer 10-15m high with rather discontinues and irregular canopy, and the third layer comprises of dense saplings and shrubs generally less than 5m high. The vegetation in Ile-Ife is made of three canopy heights, the tallest trees up to 25m high with canopies far apart, the middle layer 10-15m high with rather discontinues and irregular canopy, and the third layer comprises of dense saplings and shrubs generally less than 5m high. The floor is originally covered by a fairly thick layer of the little forest.

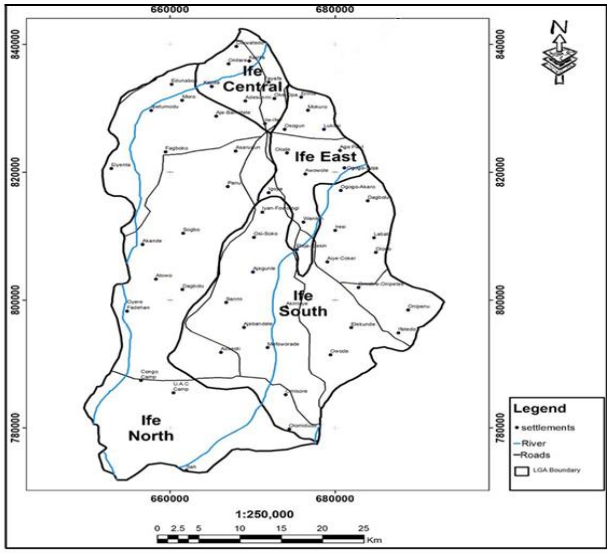

Fig.-1: Map of Ife showing Ife Central Local Government

Source: Author's Fieldwork (2018)

III. MATERIALS AND METHODS

The following data were used in carrying out this research work: The primary source included the administration of structured and unstructured questionnaires, oral interview, personal observation, topographical map of Ile-Ife of 1966 with the scale of 1:50,000 produced by the survey department of the state, Geographic information system (GIS), Global Positioning System(GPS). Two different questionnaires were prepared; one for fuel station owners or managers and the other for residents in the study area. There were fifty-two fuel stations covered or analyzed in the study area, and they were all enumerated to determine their level of compliance with the guidelines set by the Department of Petroleum Resources. The second questionnaire was used to conduct a survey of residents' opinion regarding the location of fuel stations and their implications around them. The entire filling stations located in the study area were altogether sampled. A purposive sampling method was adopted to administer questionnaires. This sampling technique represents a group of non-probability sampling techniques; and a judgmental or selective sampling of which the researcher relies on his whims and whims to select the respondent. A total of ten (10) respondents with close proximity to each petrol station were randomly sampled, forming the sample size for residents living around the filling station. A total of three hundred and forty (340) questionnaires were administered to get the necessary information for this research. The Global Positioning System (GPS) was used to pick the coordinates of the petrol stations in the study area, while the satellite imagery was used to randomly sample the number of buildings within 50 meters and 100 meters range to the petrol stations.

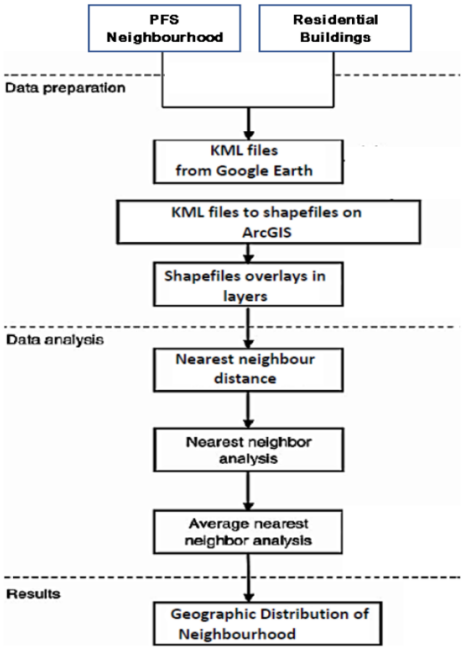

Fig.- 2: Nearest neighbourhood analysis

IV. DATA ANALYSIS AND PRESENTATION

Table-1: Socio-economic status of the respondents living in the neighbour

Socio-economic	Frequency	Percent
Gender of the respondents		
Male	181	53.2
Female	159	46.8
Age distribution of the respondents		
18-35	246	72.3
36-60	89	26.2
60 and above	5	1.5
Marital status of the respondents		
Single	157	46.2
Married	175	51.5
Divorced	8	2.4
Educational qualification of the respondents		
Primary	5	1.4
Secondary	137	40.3
Tertiary	171	50.3
Technical	27	8.0
Occupation of the respondents		
Farming	4	1.2
Trading	180	52.9
Civil servant	43	12.6
Others	113	33.2
Years		
Less than 5 years	53	15.6
5-10	52	15.3
10-20	71	20.9
Above 20	164	48.2
Total	340	100
Nativity of the Respondents		
Native	175	51.5
Non-Native	165	48.5
Total	**340**	**100**

Source: Author's Fieldwork (2018)

A. Spatial Location of Petrol Stations and their Coordinates

The geographic coordinates of all the petrol filling stations in the study area are presented in Table 2. The spatial distribution showing the locations of the PFS across the study area with the satellite imagery is presented in Figure 2. From the figures, it is clear that the PFS is widely located across the study area, particularly along the major transportation routes of the town, with concentration at the hub of the study area.

Table-2: Names and coordinates of petrol stations

SN	Longitude	Latitude	Petrol Stations	Streets Name
1	671883.00	826751.00	Dee Miskaf Energy Resource	Aderemi Road
2	671924.00	826707.00	Total Arubidi	Aderemi Road
3	673270.11	829167.54	Emerald Light	Aladanla
4	673287.11	829267.54	Total	Aladanla
5	673770.11	833884.54	SDG Mult Ilink Venture	Alakowe
6	668305.11	828872.54	Poplat Service Station	Ede-Road Beside OAU
7	672065.11	828793.54	Amazing Investment	Fajuyi
8	672291.11	828793.54	Forte Oil	Fajuyi
9	672380.11	828878.54	Raynud	Fajuyi
10	670811.00	829679.00	Ayofat Global Services Ltd	Hezekiah Oluwasanmi Road
11	670871.00	829607.00	Fotab	Hezekiah Oluwasanmi Road
12	671298.00	829039.00	Olafat Unique Concept Ltd	Hezekiah Oluwasanmi Road
13	666621.11	828905.54	Basic Connextion	Ibadan Road
14	666765.11	828928.54	Eko Oil & Gas	Ibadan Road
15	666357.11	828911.54	Folab	Ibadan Road
16	666707.11	828899.54	Ife Mobid	Ibadan Road
17	668356.00	828505.00	Energy Oil and Gas	Ife-Ibadan Express Road
18	668898.00	828226.00	Poplat	Ife-Ibadan Express Road
19	672510.00	827517.00	Sam'd Oil	Ifewara Road
20	674082.11	830514.54	Gboye Investment	Ikoyi
21	672934.11	828946.54	Hammedal	Ilesha Garage
22	671508.00	827628.00	Total	Iremo Road
23	664499.11	830626.54	Friend Top	Kajola Akile Alewe Eran
24	674085.11	830699.54	Adunfak Investment	Kojumole
25	670701.11	827859.54	Conoil Burnt	Lagere
26	670315.11	827982.54	MRS Petrol Station	Lagere
27	670498.11	827924.54	Poplat	Lagere
28	670172.11	828051.54	Total	Lagere Ife-Ile
29	670304.11	827987.54	Tentacle Investment	Lagere Ife-Ile
30	669562.11	828057.54	Access Inter-Biz	Mayfair Road
31	669169.11	828121.54	Bofat Petrol	Mayfair Road
32	669363.11	828069.54	Exodus Petrol Station	Mayfair Road
33	669027.11	828271.54	Metrol Petrol Station	Mayfair Road
34	672889.00	828388.00	Bovas	More Road
35	672780.00	828069.00	Olafat Unique Concept Ltd	More Road
36	673067.00	828834.00	Simeon's Oil Nigeria Ltd	More Road
37	670830.00	827812.00	Oando	No1 Aderemi Road
38	670996.00	827620.00	Dollars Oil Petroleum	No28 Aderemi Road
39	673580.11	829870.54	Adegboye General Enterprise	OAU Phase 2
40	673606.11	829921.54	Total	OAU Phase 2
41	673880.11	830179.54	Meritan Oil & Chemical	OAU Phase 3
42	673470.11	829698.54	NIPCO	OAU Phase1
43	665201.11	828811.54	Oando Petrol & Gas	Ooni Layout Ibadan Road
44	673824.11	832286.54	Latosen Petrol Investment	Opa
45	673707.11	831754.54	Virgo Service	Opa
46	674381.00	828995.00	Keto Oil	Reinhard Bonnke Road
47	668139.44	829131.83	AP Oil	Road 1 OAU Campus
48	671784.11	828415.54	BOVAS	Sabo Junction
49	671513.11	828251.54	Forte Oil	Sabo Junction
50	665782.11	828964.54	Adeyanju	Toll Gate
51	664652.11	828595.54	Dollas	Toll Gate
52	664925.11	828692.54	Segfar Petrol &Gas	Toll Gate

Source: Author's Fieldwork (2018)

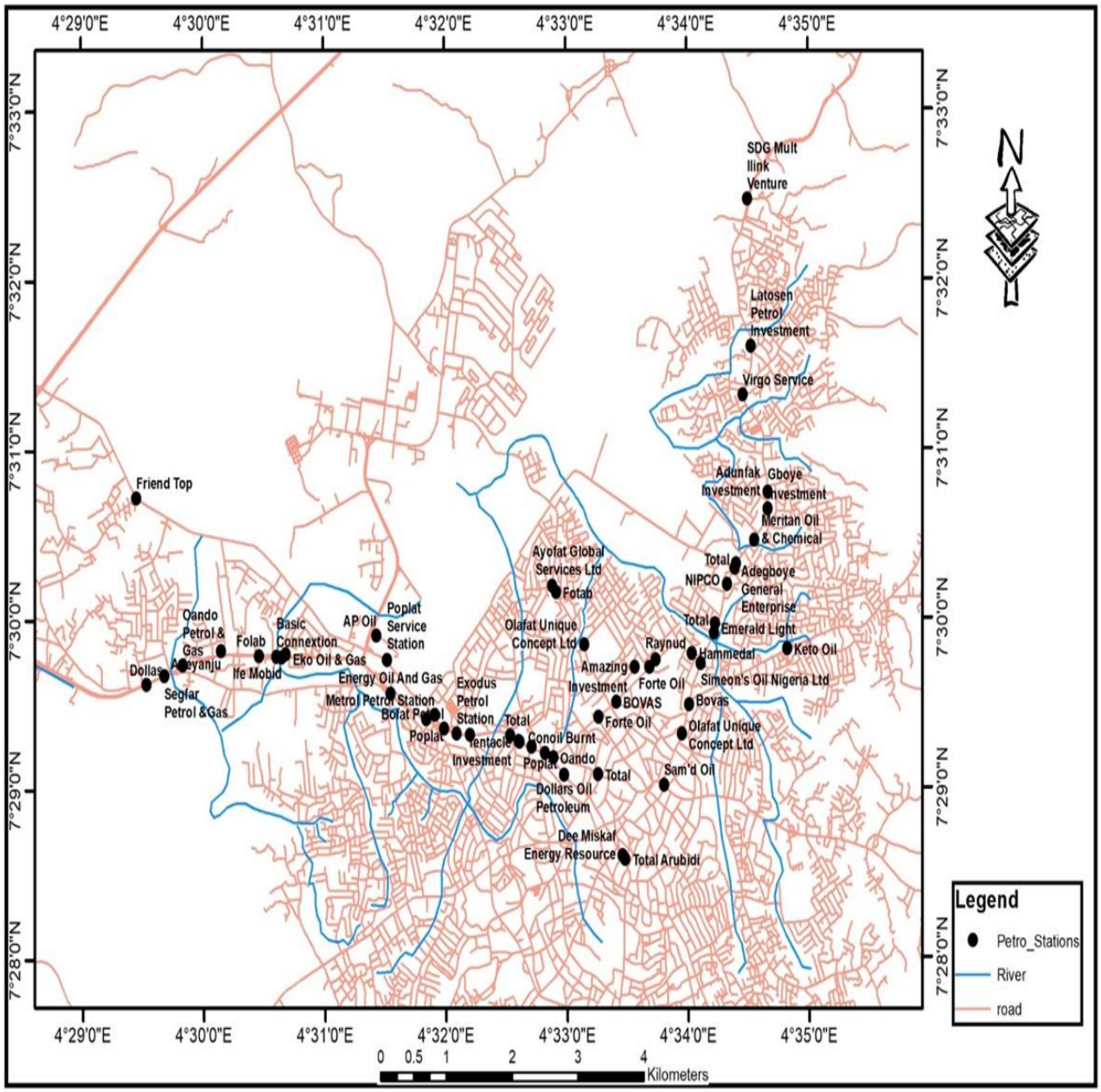

Fig.- 3: Spatial distributions of petrol stations Ile-Ife Central

Source: Author's Fieldwork (2019)

B. Nearest Neighbour Analysis

The nearest neighbourhood analysis statistic was utilized to determine the locational pattern of the fuel stations in the study area. The proposed statistic, Rn by Clark and Evans (1954), as stated in Ogundahunsi (2014), was applied. The equation of the statistic is defined in equation 3.1

$$R_n = 2\bar{d}\sqrt{\frac{n}{A}}$$

where $R_n$is the nearest neighbourhood index, A is the land area of the study area, $\bar{d}$ is the total mean distance between the fuel stations, and n is the number of fuel stations.

The values obtained for R_n ranges from zero to 2.15, and when its value is: $0<R_n<1$, then the distribution is considered clustered; when $1<R_n<2.15$, then the distribution is considered random; and $R_n \geq 2.15$, then the distribution is considered regular.

The average nearest neighbour analysis summary of the PFS in the study area is presented in Table 3 and is graphically demonstrated in Figure 3. The distribution of the PFS sites is randomly distributed across the city.

The mean distance of all the PFS in the study area is 307.47 meters. The nearest neighbour ratio is 1.77 with a z - score of -6.135950 and a corresponding p-value of 0.000. The analysis index is less than 1, thus implying that the spatial distribution of PFS in Ife is located in a clustered pattern.

Ideally, the spatial distribution pattern of facilities should be regular for easy accessibility with a minimum standard for location between one PFS and the other. On the contrary, the PFS in the study area was located in a clustered and irregular pattern that is void of the minimum spacing standard. This implies that the PFS was closely located in parts of the study area in an irregular, clustered pattern. The import of cluster distribution of facilities prone to high flammability and toxicity pertains to the health and safety of lives and properties in the neighbourhood. This pattern of distribution revealed poor enforcement of standards by the regulatory bodies and non-compliance to the urban plans and standards by the owners. The spatial pattern of the PFS in the study area revealed an unfair competition between fuel station owners and the inefficiency of the regulatory bodies.

The irregular spatial distribution of PFS in cities constitutes a social and economic menace to neighbourhoods as queues of vehicles at stations often result in serious traffic congestions. The adjoining neighbourhood (residential buildings and their occupants) is exposed to danger in case of a fire accident.

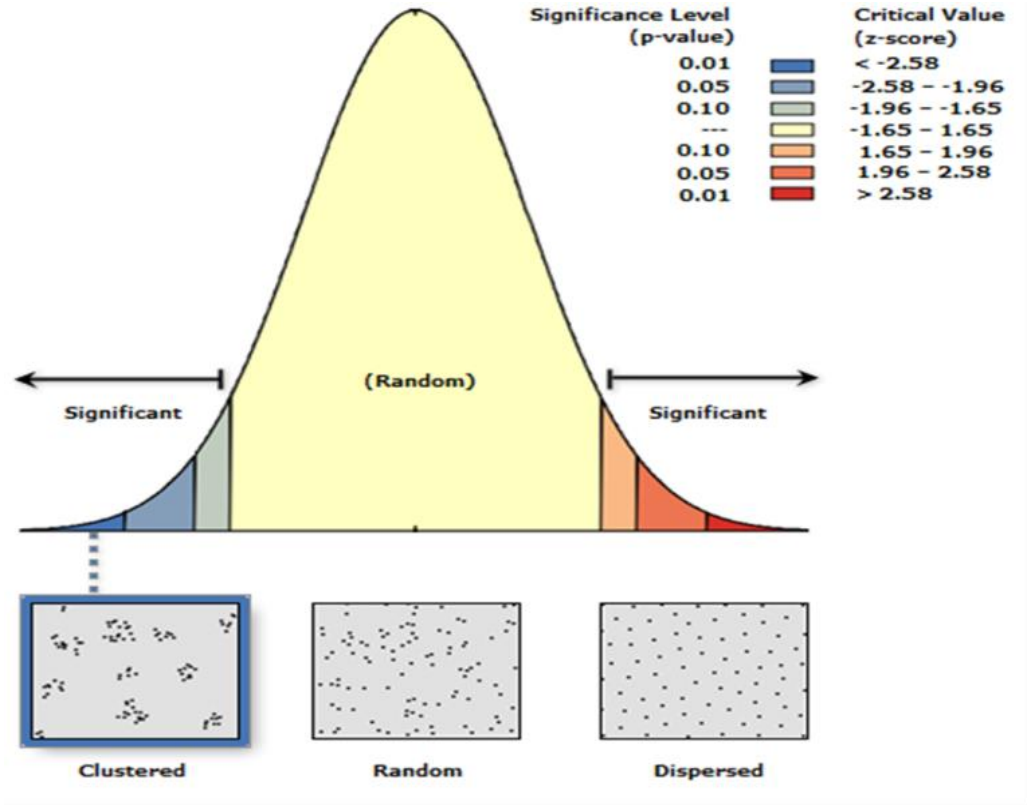

Fig.-4: Nearest neighbour analysis of neighbourhood markets
Source: Author's fieldwork, (2019).

Table-3: Nearest neighbour analysis summary of the PFS

Parameters	Value
Observed Mean Distance:	307.4650 Meters
Expected Mean Distance:	553.7756 Meters
Nearest Neighbour Ratio:	0.555216
z-score:	-6.135950
p-value:	0.000000

Source: Author's Fieldwork (2019)

Table-4: Results of size-area compliance and 8 m buffer of the PFS

Name	Area (m^2)	Area Compliance	No of Buildings within 8m buffer	8 m Buffer	400 m buffer
Access Inter Biz	1319	C	2	NC	NC
Adegboye General Enterprise	1471	C	2	NC	NC
Adeyanju	1166	NC	1	NC	C
Adeyemi	2333	C	0	C	NC
Adunfak Investment	1509	C	1	NC	NC
Amazing Investment	811	NC	3	NC	NC
Ap Oil	1050	NC	7	NC	NC
Ayofat Global Services Ltd	537	NC	5	NC	NC
Basic Connextion	1524	C	2	NC	NC
Bofat Petrol	2990	C	0	C	NC
Bovas	760	NC	2	NC	NC
Conoil Burnt	592	NC	5	NC	NC
Dee Miskaf Energy Resource	2034	C	3	NC	NC
Dollars Oil Petroluem	1069	NC	3	NC	NC
Dollas	428	NC	4	NC	NC
Eko Oil &Gas	1337	C	5	NC	NC
Emerald Light	1000	NC	2	NC	C
Energy Oil and Gas	2006	C	1	NC	NC
Exodus Petrol Station	631	NC	4	NC	NC
Folab	1022	NC	0	C	NC
Forte Oil	1512	C	1	NC	NC
Forte Oil	2707	C	2	NC	NC
Fotab	1419	C	4	NC	NC
Friend Top	1105	NC	5	NC	NC
Gboye Investment	523	NC	3	NC	NC
Hammedal	1286	C	1	NC	NC
Ife Mobid	624	NC	6	NC	NC
Keto Oil	501	NC	4	NC	NC
Latosen Petrol Investment	628	NC	2	NC	NC
Meritan Oil & Chemical	1915	C	5	NC	NC
Metrol Petrol Station	3374	C	5	NC	NC
MRC Petrol Station	1613	C	0	C	NC
NIPCO	1055	NC	4	NC	NC
Oando	1284	C	1	NC	NC
Oando Petrol &Gas	1495	C	0	C	NC
Olafat Unique Concept Ltd	829	NC	0	C	NC
Olafat Unique Concept Ltd	2881	C	0	C	C
Poplat	1449	C	2	NC	NC
Poplat	668	NC	2	NC	NC
Poplat Service Station	1150	NC	2	NC	NC
Reynut	1354	C	0	C	NC
Sam'd Oil	1334	C	3	NC	NC
SDg Multi Link Venture	1873	C	1	NC	NC
Segfar Petrol &Gas	672	NC	3	NC	NC
Simeon's Oil Nigeria Ltd	1194	NC	0	C	NC
Tentacle Investment	1216	C	3	NC	NC
Total	1253	C	1	NC	NC
Total	2288	C	2	NC	NC
Total	1184	NC	0	C	NC
Total	5354	C	0	C	NC
Total Arubidi	1719	C	0	C	NC
Virgo Service	316	NC	3	NC	NC

Table-5: Setback to residential land use

Setback to residential land use	Frequency	Percentage
50	30	57.69
100-150	8	15.38
200-250	5	9.62
300-350	9	17.31
Total	52	100.00

Source: Author's Fieldwork, (2018)

C. The setback of 50m to residential building

The 50 m setback to residential land use is presented in Table 5 and shown in Figure 4. The results show that the PFS with 50 m setback of residential land use has the highest percentage of 57.7 %, while those with 100 – 150 m setback of residential land use is 15.4 %, and those with 200 – 250 m setback of residential land use is 9.6 %, and 300 – 350 m is 17.3 %. The result of this study reveals that lives and properties in proximity to the PFS with less than 50 m are at great risk to fire outbreaks, environmental pollution (water, land, and air), and health risks are among numerous risks associated with the non-compliance. This study reveals high non-compliance to distance or setback of residential land use guidelines to the PFS in the study area. Many of the PFS operations did not follow the planning standards before constructing the petrol station(s) or a residential building. In the case of any mishaps such as pollution of the environment (air, water, and soil), the effect could still be feasible on lives and properties within the close proximity.

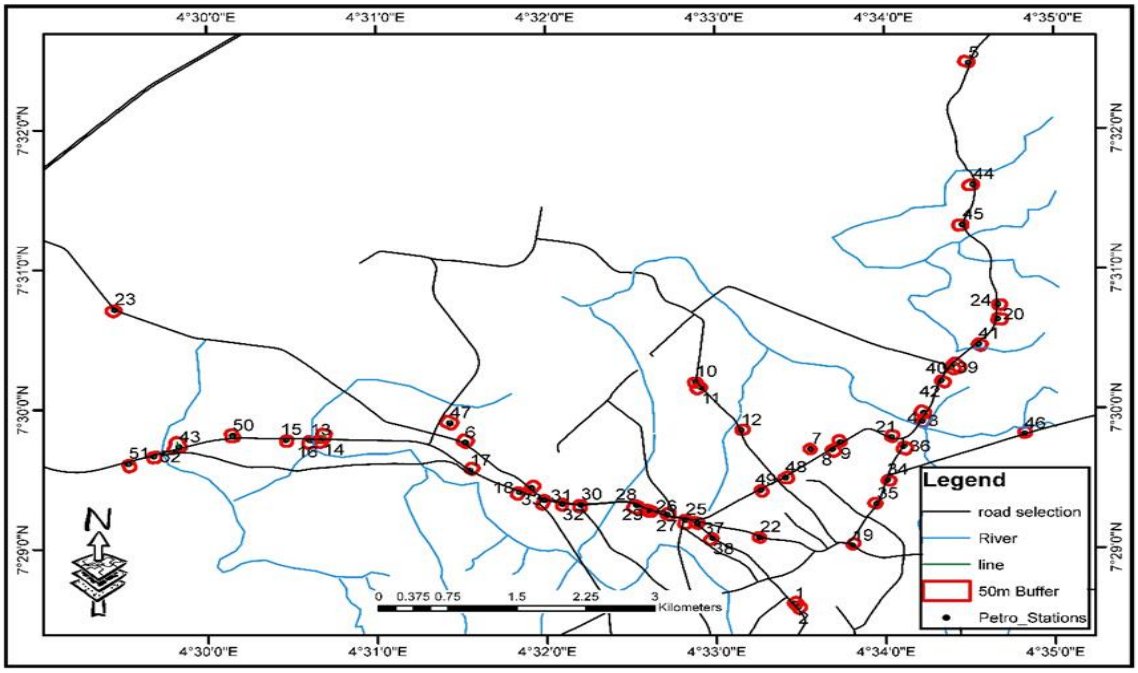

Fig.-5: Setback to residential buildings (PFS with 50 m buffer)
Source: Author's Fieldwork, (2018)

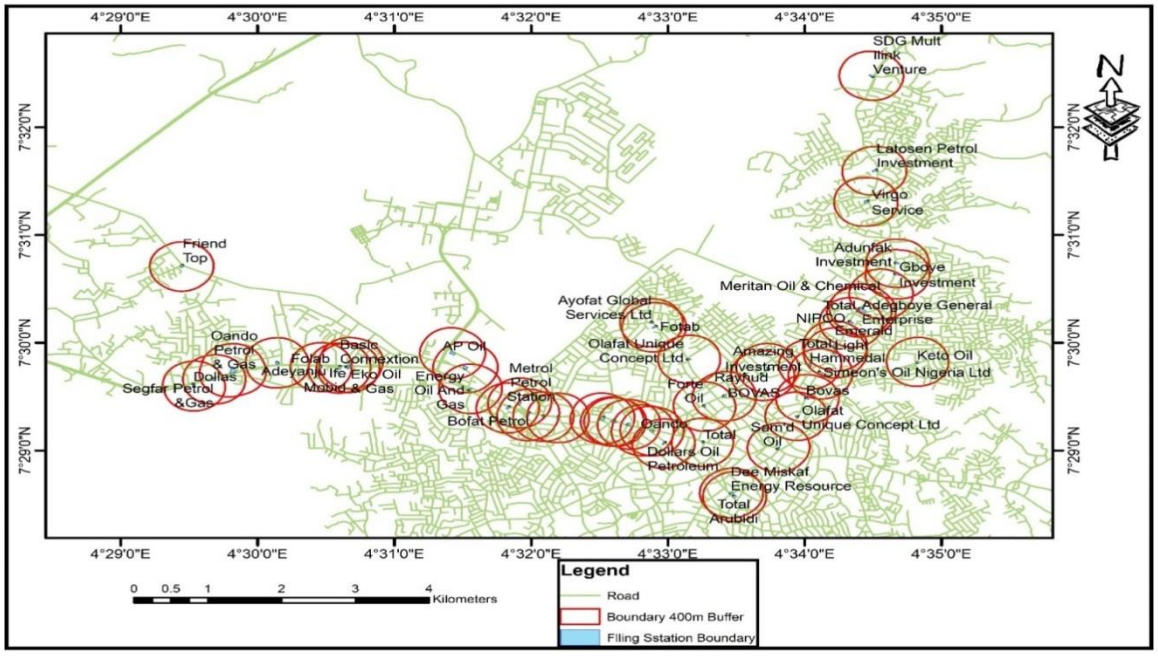

Fig.- 6. Distance between two PFS
Source: Author's Fieldwork, (2018)

Table-6: Proposed factors, their variable names, attributes

S/N	Proposed factors	Attributes
1	Entrepreneurial influence	Reason for Location
2		Factor for location
3	Site management	Other services in Station
4		Storage capacity
5		Materials for storage
6		Coating materials
7	Planning standards	Distance between tanks
8		Setback to residential land use
9		Setback to infrastructure
10		Turning radius
11		Distance to the road
12		Distance from health care
13		Pump setback to the pavement
14	Environmental-impact assessment	Suitability before siting
15		Assessment before siting
16		Approval of the government
17		Original land use
18		Size of the station

Source: Author's Fieldwork (2018)

Table-7: Correlation of respondents' responses p-values (Pearson)

Variables	Health risk	Type of pollution	Water pollution	Proximity to gas stations	Opinion on gas station	Socio-economic life	Common ailments
Health risk	**0**						
Type of pollution	0.130	**0**					
Water pollution	0.174	**< 0.0001**	**0**				
Proximity to gas station	0.530	0.684	0.132	**0**			
Opinion on gas station	**< 0.0001**	**0.022**	**0.046**	0.403	**0**		
Social economic life	**0.0002**	0.052	0.310	0.129	**< 0.0001**	**0**	
Common ailments	**< 0.0001**	**0.006**	0.321	**0.011**	0.213	0.802	**0**

Values in bold are different from 0 with a significance level alpha=0.05

Table 7. above shows the correlation which exists between various response variables of the respondents. Health risks presented by siting the PFS close to residential areas are statistically significant to the opinion on gas stations, common ailments, and socio-economic life of the respondents.

The type of pollution experienced by the respondents is statistically significant to water pollution, common ailments, and opinions of respondents on gas stations. Likewise, proximity to the gas stations of the respondents is significant to the common ailments experienced by the respondents. The opinions of respondents on gas stations are also statistically significant to the socio-economic life of the respondents.

V. CONCLUSION

Based on the analysis done and the result obtained or presented, it can be concluded that:

1.The spatial distribution pattern of PFS at Ife Central, Nigeria, is clustered using the ArcGIS tool.

2.There was partial compliance with the principles, standards from concerned regulatory, monitoring planning bodies from the side sides of the PFS. No single PFS met the cumulative standards.

3.Using factor analysis and structural equation modeling, five factors were identified to have influenced the choice factors of locating the PFS, they are owner preferential choice and planning standards, storage material and factor of location, environmental impact assessment, type of license, and distance between the tanks and site management and administration.

4.The clustered distribution pattern of the PFS impacted both the wellbeing of the residents and the environment. Traffic congestion, parking inconveniences, noise pollution characterized the environmental discomfort created. Also, air pollution, noise pollution, and water were strongly identified as the resultant effect of the services and operations of the PFS. Soil pollution was also identified.

5.The services of the PFS had negative impacts on the wellbeing of the residents, as respiratory diseases top the list, leukaemia, and nervous breakdown were also reported. This confirmed the literature, thus categorizing them as long-term non-carcinogenic health problems. Short-term health issues were also reported for being exposed to the vapors of gasoline dispensed by the PFS, and they include fever, diarrhoea, cough, and cold.

6.The study revealed that there was a high level of awareness among the residents on the health and environmental effect of the PFS in the area. At the same time, there was low awareness among the PFS operators on the impact of their activities.

7.Non-synergetic principles and standards had been observed between the regulatory bodies and the local authorities.

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