Geographies of Fuel Dispensing: Locational Analysis and Conformity of Petrol Filling Stations (PFS) to Planning Standards in Ota, Nigeria

David Victor Ogunkan (ogunkansvictor@yahoo.com)
Bells University of Technology, Ota, Nigeria https://orcid.org/0000-0003-2681-1023

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Abstract

Following the observation of the indiscriminate location of petrol filling stations, this study analyzes the location pattern and conformity of the PFS to planning standards in Ota, Ogun State. A survey of petrol filling stations in Ota was conducted to achieve the twin purposes of taking inventory and documenting their geographic coordinates. A nearest neighbour analysis was used to compute the nearest neighbor index (NNI), the Z-score, and the probability (p) value in order to determine the pattern of the distributions. Buffer and proximity analysis was done in Arcmap to analyze the conformity of PFS to the planning standard. The findings revealed that there are 50 PFS located along the 15 roads in the study area, of which 72% are owned by independent marketers, 18% are owned by major marketers, and 10% are owned by the NNPC. The spatial analysis of petrol filing stations indicates that PFS were more concentrated on the major roads, in the transitional residential zones, and in the Central Business Districts (CBD). With a nearest neighbor index (Rn) value of 0.405547 (less than 1), a Z-value of -10.171697 (less than − 1.96), and a p value of 0.00000, the distributional pattern of PFS revealed that the pattern was clustering. The study finds only 16% complied with the 400-meter distance to the next filling station; more than two-thirds (78%) of the petrol filling stations did not meet the 15-meter setback requirement; and only 10% met the 50-meter distance requirement to residential buildings. Among other recommendations, the study suggests the need for more proactiveness and effectiveness from the regulatory agencies.

Introduction

Africa and Asia are home to most of the world's fastest-growing cities. By 2050, the majority of the world's urban population will be concentrated in Asia (52%) and Africa (21%), as the urban populations of both continents are expected to triple between 2018 and 2050. (UN-Habitat, 2018). Nigeria is without a doubt one of, if not the, most significant contributors to Africa's urbanizing profile (Adeboyejo, 2015). The phenomenal growth of the urban population in Nigeria has boosted the use of automobiles, electric dynamos, and other petroleum-consuming plants. This has contributed to the rising demand for petroleum-based products, which has been exacerbated by the appalling electricity supply in Nigeria. As a result, the number of petrol stations created in various sections of the country is steadily increasing. Furthermore, the attractive price of petrol at both regulated and black-market prices has encouraged the influx of people into the petrol retailing sector, resulting in an unprecedented number of petrol filling stations (PFS) in most Nigerian urban areas.

Petroleum products are extremely combustible and frequently kept in subsurface tanks where they are sold at PFS by meter pumps. Because of the importance of retail outlet sites to people's health and safety, sufficient planning guidance and adherence to existing location criteria are required. The Nigerian Upstream Petroleum Regulatory Commission (NUPRC) of the Nigerian Federal Ministry of Petroleum Resources (FMPR) is a government body that controls the sale of petroleum products throughout Nigeria. The NUPRC, previously known as the Department of Petroleum Resources (DPR), also offers instructions and guidelines regarding how to set up and run a filling station that may sell petroleum products like

Automated Gas Oil (AGO), also known as diesel, Dual Purpose Kerosene (DPK), and Premium Motor Spirit (PMS), also known as petrol.

The NUPRC is also required by law to ensure adherence to petroleum laws, guidelines and regulations in the oil and gas industry to ensure safety and prevent health risks. Depending on the gravity of the offence, the consequences for violating the NUPRC guidelines by petrol stations range from labelling that petrol station as illegal to license revocation, and when the license is revoked, dealing, packaging, hawking, selling, or trading in petroleum or petroleum products becomes criminal.

In addition to NUPRC guidelines, the location of PFS is regulated and controlled by urban and regional planning agencies, such as planning commissions, boards, and authorities. Despite the plethora of government agencies tasked with controlling and regulating the extraction and dispensing of fuel, Nigeria is showing laxity regarding the indiscriminate citing of oil and gas stations as well as tank farms. Evidence abounds that despite the guidelines controlling the location of PFS in Nigeria, most of them are in a disorderly and potentially hazardous manner (Afolabi et al., 2011; Olapeju, 2017: Jia et al., 2022; Ulakpa, Ulakpa & Eyankware, 2022).

A petrol filling station (also known as a fueling station, gas station, or petroleum outlet) is any land, building, or equipment used for the sale or dispensing of gasoline or oil for motor vehicles or incidental thereto, and includes the entire land, building, or equipment whether the use as a petrol station is the predominant use or is only a part thereof (Ayodele, 2011). It has also been described as a location with fuel equipment and pipelines, storage containers, a service station, and building spaces for selling fuel (inflammable liquids) to customers (Nieminen, 2005)

The haphazard placement of PFS in Nigerian cities, particularly in undesirable locations, indicates a lack of regard for planning standards. Bad seating, insufficient size, a limited setback from the road, and inadequate distance allowance from important buildings like churches, schools, mosques and churches, are all manifestations of utter disregard for planning regulations. Regrettably, the growing number of PFS, the majority of which are badly sited and adjacent to residential structures and public places, has become a "typical" phenomenon in Nigerian cities. The situation in Ogun State is disconcerting, as the state government recently sealed off many PFS for building without planning approval, while NUPRC agents in the state also sealed off PFS for operating without a license.

While some studies on the indiscriminate location of PFS in the state have received some attention in the research community (Olapeju, 2017; Ogunyemi et al., 2017; Okubena & Fayomi, 2018; Adedeji et al., 2022), it is concerning that the number of academic publications on the subject is not proportionate to the magnitude of the problem in Ogun State, particularly in Ota,. It is on this premise that this examines the geographical distribution, locational analysis, and conformity of PFS to planning standards in Ota, the industrial hub of the State

The Study Area

The study area, Ota, a town in Ogun state, is home to approximately 163,783 people (according to the 2006 census). It is the administrative centre for the Ado-Odo/Ota local government area and has a total land area of about 878 km2 (about the area of San Antonio, Texas). Ota has the third-highest concentration of industries in Nigeria as of 1999. Just north of the tollgate on the Lagos-Abeokuta expressway, it is also home to a sizable market and a crucial road junction.

Most of the natives are Yoruba speaking the Awori dialect. Trading and farming are the two main industries in Ota. Due to the town's proximity to Lagos and Idiroko, two sizable markets have emerged: Kayero Market in Sango and Oja Oba along the Idiroko road. Because of their size, these markets are more commonly referred to as the Sango-Ota market. Ota, which is a part of Ogun state, shares the same geologic features as many other areas of the state, including the basement complex rock and pre-Cambrian age, which are composed of older and younger granites in the northern part of the state and younger and older sedimentary rock in the tertiary and secondary ages in the southern parts (Iloeje, 1981).

The area has a tropical rainforest climate with two main seasons: the wet season, which lasts from November until February and lasts for about seven to eight months between April and October with a break in August, and the dry season. Due to a large amount of precipitation, which totals about 250 cm (about 8.2 ft) per year, the climate is humid. Due to its proximity to the equator, the area is extremely hot and humid, with an annual average temperature of at least 180°C.

Materials And Methods

Types and Sources of Data

The data required for this study are in categories: (i) the number of PFS, the names of the streets and neighbourhoods where the PFS are situated, and (ii) the geographic coordinates of the filling stations.

Method Of Data Collection

A survey and counting of PFS in Ota were conducted to achieve the twin purposes of taking inventory and documenting their geographic coordinates. This involves identifying the locations of PFS through the guidance of the Ota Street Map. This is based on the knowledge that PFS are along the road. The number of PFS and their attribute data, such as names of the stations, location address, number of pumps, etc., were obtained through structured observation. The coordinates of the PFS and other public structures like hospitals and schools were captured using the Global Positioning System (GPS).

Methods Of Data Analysis

The geographic coordinates of PFS obtained from field GPS observation were combined with attribute data in an excel environment. A 2.5-meter resolution Google Earth imagery of Ota from 2021 was

obtained. The map-to-image georeferencing technique was used to georeference the imagery after it was imported into the ArcGIS 9.3 environment.

In the ArcMap environment, the Nearest Neighbor Analysis (NNA) was performed to examine the distributional pattern of PFS in the study area. To determine the distribution pattern, the Nearest Neighbor Index (NNI), Z-Score, and probability (p) value were computed using NNA. The method compares the actual distance between points and their closest neighbours to the distance that would be predicted by chance.

The ratio of observed to expected values is known as the nearest neighbour statistics/index, or Rn. Rn has a value between 0 (when all points are in the same place and their distances from one another are equal) and 2.14. (For a flawless, symmetrical, or uniform point pattern dispersed over an extremely large area.) The observed distance between neighbours is equal to the distance anticipated for a random distribution, which is why Rn = 1 denotes a random pattern. The nearest neighbor formula is: Rn = 2 đ √n / A

Where Rn = the description of the distribution;

đ = the mean distance between the nearest Neighbours (km);

n = the number of points in the study area;

A = the area under study (km2)

ArcGIS was used to find statistically significant spatial clusters of high values (hot spots) and low values using the Getis-Ord Gi statistic (cold spots). For each feature in the Input Feature Class, it creates a new Output Feature Class with a z-score, p-value, and confidence level bin (Gi Bin). A high z-score and low p-value suggest a spatial clustering of high values. A low negative z-score and a small p-value suggest that low values are spatially clustered. With the z-score, the degree of clustering rises (or falls). The absence of apparent spatial clustering is seen when the z-score is close to zero.

ArcMap was used to perform buffer and proximity analyses to assess the PFS's adherence to standards (as specified by NUPRC). Several queries, including those for the distances of 15 meters between the PFS edge and the road, 400 meters (about 1312.34 feet), and 100 meters (about 328.08 feet), between the PFS and the public building, were run to produce the desired results.

Results And Discussion

Distributional Analysis of Petrol Filling Stations

The results of the PFS inventory conducted at the time of the study showed that there were fifty (50) PFS in the study area. The names, locations, types, ownership, and types of roads located are shown in Table 1. The data in the Table was used for the analyses that follow.

Table 1
Details of PFS in Ota

S/N	Names of PFS	Ownership	Road corridors	Road Types	Types	Residential zones
1	Conoil	Major Marketers	Awolowo Road, Ilo-Awela,	Major	Medium	Transition
2	Vitality	Independent Marketers	Awolowo Road, Ilo-Awela,	Major	Medium	Transition
3	S.B Petroleum	Independent Marketers	Awolowo Road, Ilo-Awela,	Major	Medium	Transition
4	Swift Oil	Independent Marketers	Awolowo Road, Ilo-Awela,	Major	Medium	Transition
5	NNPC (Nigeria National Petroleum Corporation)	NNPC Outlet	Awolowo Road, Ilo-Awela,	Major	Medium	Transition
6	Omo Owo Petroleum	Independent Marketers	Coca cola Ilogbo Road	Minor	Mini	Transition
7	NNPC	NNPC Outlet	Iganmode Road	Major	Mini	Traditional core
8	Wright	Independent Marketers	Iganmode Road	Major	Medium	Traditional core
9	TAO	Independent Marketers	Ilogbo Road	Minor	Mini	Transition
10	Miom	Independent Marketers	Ilogbo Road	Minor	Mini	Transition
11	Hola King	Independent Marketers	Ilogbo Road	Minor	Mini	Transition
12	I-Sho	Independent Marketers	Ilogbo Road	Minor	Mini	Transition
13	Marns	Independent Marketers	Ilogbo Road,	Minor	Medium	Transition
14	NNPC	NNPC Outlet	Itele Road	Minor	Mega	Suburban
15	Sechco Oil	Independent Marketers	Itele Road	Minor	Mega	Suburban
16	Ficket	Independent Marketers	Itele Road	Minor	Mini	Suburban

S/N	Names of PFS	Ownership	Road corridors	Road Types	Types	Residential zones
17	PPN	Independent Marketers	Itele Road	Minor	Mini	Suburban
18	Conoil	Major Marketers	Iyana-Iyesi, Idiroko Road	Major	Mega	Suburban
19	Hobolat Oil	Independent Marketers	Iyana-Iyesi, Idiroko Road	Major	Mega	Suburban
20	Badem Oil	Independent Marketers	Iyana-Iyesi, Idiroko Road	Major	Mega	Suburban
21	King A. Solomon	Independent Marketers	Iyana-Iyesi, Idiroko Road	Major	Mega	Suburban
22	Libra Petroleum	Independent Marketers	Iyana-Iyesi, Idiroko Road	Major	Mega	Suburban
23	Ratech	Independent Marketers	Iyana-Iyesi, Idiroko Road	Major	Mega	Suburban
24	Tiptop	Independent Marketers	Iyesi Road	Minor	Medium	Suburban
25	Ultimate Oil	Independent Marketers	Iyesi Road	Minor	Medium	Suburban
26	Swift Oil	Independent Marketers	Iyesi Road	Minor	Medium	Suburban
27	Mobil	Major Marketers	Obasanjo - Idiroko Road	Major	Mega	Transition
28	Progress Oil	Independent Marketers	Obasanjo - Idiroko Road	Major	Mega	Transition
29	Jommess	Independent Marketers	Obasanjo - Idiroko Road	Major	Mega	Transition
30	Fatgbems	Independent Marketers	Oju – Ore	Major	Medium	Traditional core
31	SO	Independent Marketers	Oju – Ore	Major	Medium	Traditional core
32	AK	Independent Marketers	Oju – Ore	Major	Medium	Traditional core
33	Dukes Court	Independent Marketers	Oju – Ore	Major	Medium	Traditional core
34	Isota Petroleum	Independent Marketers	OkeSunah, Abebi Road	Minor	Mini	Traditional core

S/N	Names of PFS	Ownership	Road corridors	Road Types	Types	Residential zones
35	Mobil	Major Marketers	OkeSunah, Abebi Road,	Minor	Mini	Traditional core
36	AP	Major Marketers	Old Ota Road, Akeja,	Minor	Mini	Traditional core
37	Fowobi Oil	Independent Marketers	Ota-Idiroko Road	Major	Mega	Transition
38	SBN Oil	Independent Marketers	Ota-Idiroko Road	Major	Mega	Transition
39	Conoil	Major Marketers	Ota-Idiroko Road	Major	Mega	Transition
40	Mobil	Major Marketers	Ota-Idiroko Road	Major	Mega	Transition
41	NNPC	NNPC Outlet	Sango - Idiroko Road	Major	Mega	Transition
42	NIPCO Petroleum	Major Marketers	Sango - Idiroko Road	Major	Mega	Transition
43	Mobil	Major Marketers	Sango - Idiroko Road.	Major	Mega	Transition
44	Jonas	Independent Marketers	Winners Chapel	Major	Mega	Suburban
45	Rotalalex	Independent Marketers	Winners Idiroko Road	Major	Mega	Suburban
46	Ayokunnu Oil	Independent Marketers	Winners Idiroko Road	Major	Mega	Suburban
47	JP Oil	Independent Marketers	Winners Idiroko Road	Major	Mega	Suburban
48	NNPC	NNPC outlet	Winners Idiroko Road	Major	Mega	Suburban
49	YTK Oil	Independent Marketers	Winners Idiroko Road	Major	Mega	Suburban
50	KF	Independent Marketers	Winners Idiroko Road	Major	Mega	Suburban

In Nigeria, both the public and private sectors own petrol stations. The private sector is made up of independent marketers-individual business owners or partners-or major marketers-multinational corporations. Nigeria National Petroleum Company is a government-owned company that belongs to the

public sector (NNPC). Figure 2 demonstrates that independent marketers own more than two-thirds (72%) of the filling stations. Major oil marketers held less than a fifth (18%) of the oil stations in Ota, while NNPC held 10%. This finding is in concordance with similar studies (Sule, Shebe, Bichi & Atiyong, 2011) where it was discovered that independent marketers owned most PFS in Nigeria.

The finding is a pointer to the fact that petrol marketing is a lucrative business dominated by business owners who invest their funds to make a profit. The dominance of independent marketers in the retail sale of petroleum products benefits economic diversification because it dismantles the stranglehold of multinational corporations that had previously ruled the sector and creates employment opportunities for Nigerians in the downstream petroleum sector.

A breakdown by PFS by type reveals that half of the identified filling stations (50%) were mega filling stations. Approximately one-fourth (28%) were medium-sized PFS, while approximately 22% were mini-filling stations (see Fig. 3). In this study, a mega PFS is one with more than four dispensing machines, a medium PFS has three to four dispensing machines, and a mini filling station has one to two dispensing machines.

Table 2 shows the distribution of PFS by ownership and type. The results show that 60% of the PFS owned by NNPC were mega filling stations while 20% apiece were medium and mini PFS, respectively. The major marketers had nine (9) PFS in Ota. Two third (66.7%) of these stations were mega stations while 11% and 22% were medium and mini stations, respectively. The independent marketers had a total of 36 (44.4%) of these PFS were mega stations while 33.3% and 22.2% were medium and mini PFS, respectively.

Table 2
Ownership of PFS by Types

Types of Station	NNPC outlets		Major Marketers		Independent Marketers	
	Freq	%	Freq	%	Freq	%
Mega	3	60.0	6	66.7	16	44.4
Medium	1	20.0	1	11.1	12	33.3
Mini	1	20.0	2	22.2	8	22.2
Total	5	100	9	100.0	36	100.0

Spatial Analysis Of Petrol Filling Stations

The spatial frameworks on which the spatial analysis of PFS is predicated are road corridors and residential areas. The geographic distribution of PFS shows that the filling stations are not evenly distributed among the major thoroughfares and populated areas (see Table 3).

The fifty (50) identified PFS are along fifteen (15) road corridors as seen in Table 3.

Table 3
Number of PFS by road types and Residential zones

S/N	Road names	Number of PFS	Road Types	Residential zones	%
6	Iyana-Iyesi, Idiroko Road	6	Major	Suburban	12
15	Winners Idiroko Road	6	Major	Suburban	12
1	Awolowo Road, Ilo-Awela,	5	Major	Transition	10
4	Ilogbo Road	5	Minor	Transition	10
5	Itele Road	4	Minor	Suburban	8
9	Oju – Ore	4	Major	Traditional core	8
12	Ota-Idiroko Road	4	Major	Transition	8
7	Iyesi Road	3	Minor	Suburban	6
8	Obasanjo - Idiroko Road	3	Major	Transition	6
13	Sango -Idiroko Road	3	Major	Transition	6
3	Iganmode Road	2	Major	Traditional core	4
10	OkeSunah, Abebi Road	2	Minor	Traditional core	4
2	Coca cola Ilogbo Road	1	Minor	Transition	2
11	Old Ota Road, Akeja,	1	Minor	Traditional core	2
14	Winners Chapel	1	Major	Suburban	2

The two roads with the most petrol stations are Winners-Idiroko and Iyana Iyesi, Idiroko roads. They have 6 PFS, each of which represents 12% of the total. With five (5) each, the Awolowo, Ilo Awela, and Ilogbo roads come next. There are four (4) each on Oju-ore, Ilogbo, Itele, and Ota-idiroko roads. There are three (3) on each of the Sango-Idiroko, Obasanjo, and Iyesi roads, two (2) on Oke Sunna Road, and one (1) on each of the other roads.

The breakdown of these road corridors by road types shows that 34 of the 50 identified PFS (representing 68%) are located on major roads. This reinforces the findings of similar studies conducted in Nigeria (Dogara, 2017) and Kenya (Karanja & Gathitu, 2018), which found that PFS is typically found along major roads with high traffic volumes.

The breakdown by residential zones indicates that almost half (48%) of the PFS were located in the transitional zone. This is followed by the sub-urban zone (40%) while the traditional core had the least (12%). What can be inferred from the foregoing analysis is that PFS were more concentrated in sub-urban

and transitional zones while they were less visible in traditional core areas. Indeed, these findings corroborate that of Baichie and Wallimsi (2000) where it was reported that while less prevalent in town centres, filling stations are more prevalent on the town's exit side.

Further analysis shows that PFS were concentrated in the Central Business Districts (CBDs), populated residential areas and along major roads linking the commercial town of Ota and other notable cities. The distribution covered Sango Ota - Abeokuta expressway; Iju-Iyana Ota Road; Olorunda-Iju road and Toll-Gate cutting across areas such as Winners, Obasanjo farm, Joju, Olorunda, and Iyesi.

Distributional Pattern Of Petrol Filling Stations

Nearest Neighbour Analysis was performed on the 50 PFS in the facilities within 87539458.891718 meters of Ota to identify the distribution pattern of PFS in the study area. The results in Table 3 show that the pattern is approaching or tending towards clustered, with the nearest Neighbour index (Rn) value of 0.405547 (less than 1), a Z-value of -10.171697 (less than − 1.96) and a p-value of 0.00000

Table 4
Summary of Nearest Neighbour Analysis

Observed Mean Distance:	**212.1134 Meters**
Expected Mean Distance:	523.0304 Meters
Nearest Neighbor Ratio:	0.405547
z-score:	-10.171697
p-value:	0.000000

Meanwhile, an ideal facility location pattern should be one of regular distribution in space rather than clustering. This pattern implies that PFS in the study area exhibits unhealthy competition, which has serious negative consequences for spatial functionality, efficiency, and aesthetics.

Hot spot analysis was then performed to determine the statistically significant hotspots and coldspots of PFS sites. Hotspot areas in the study area have a statistically significant high concentration of PFS, whereas coldspot areas have a statistically significant low concentration of PFS. The result of the hotspot analysis as shown in Fig. 6 indicates that the locations of PFS in the study area can be distinguished by hotspot and coldspot areas according to the degree of their clustering. The filling stations in hotspot areas are indicated with shades of red while cold-spot areas are indicated with shades of blue on the map.

It follows, therefore, that several hotspots could be identified, the majority of which are in the central business district of the study area, with the hotspots in the Sango, Toll Gate, and Oju Ore being of particular interest. These areas are characterized by traffic congestion, particularly during a fuel crisis;

PFS compete with residential buildings, putting their occupants in grave danger in the event of a fire outbreak. Additionally, residents of nearby buildings are exposed to the pungent odour of hydrocarbon fuels as well as elevated levels of fuel vapour.

The cold hotspot zones include a pocket of areas in Ilogbo, Akeja, and Winners Chapel, but most are along the Obasanjo-Idiroko road, including Iyana Iyesi, Bells Junction, and Winners Junction. Exclusively commercial land use is evident along this road. As a result, residents are less likely to be affected by fire accidents caused by PFS, incidents of traffic congestion caused by PFS are less common, and residents are less exposed to chemical hazards caused by PFS.

Conformity Of Petrol Filling Stations To Planning Standards

Both the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Ogun State Ministry of Physical Planning and Urban Development (OSMPPUD) regulate the operation and location of PFS in the state through the DPR regulatory guidelines of 2007 and the Ogun State Urban and Regional Planning Law of 2010. While the NUPRC regulates crude oil, petroleum products, and transactions involving them, the OSMPPUD is statutorily authorized to regulate all sorts of physical development, including PFS, in all parts of the state. Thus, while the NUPRC issues operating licenses, the OSMPPUD grants physical development approval to PFS operators.

This study assesses the conformity of the PFS to the physical development standards by correlating some of these standards with the current locations of the PFS in the study area. This was accomplished by utilizing the buffering and proximity analysis tools included in ArcGIS 10. Although both the NUPRC and OSMPPUD have physical development standards that must be satisfied before the operators are given the all-clear to commence operations, this study considered the standards as specified by the NUPRC. The reason for this is that NUPRC standards are stricter than OSMPPUD standards. For instance, while the NUPRC recommends a setback of 15 meters from the road, OSMPPUD recommends a setback of 9 meters. The NUPRC requires a 400-meter distance between the existing and the proposed PFS, but OSMPPUD only requires 300 meters.

Distance Between The Location Of Filling Stations

According to NUPRC regulation, a proposed PFS should be sited 400 meters away from the existing PFS. Distances between the PFS in the study area were determined in the ArcMap environment using Nearest Buffering Operation (Figs. 7, 8 and 9). The result shows that a vast majority (84%) of the PFS were less than 400 metres from their Neighbours. This implies that the majority did not meet the 400 meters requirement for the next neighbour.

The reason for this is not farfetched. The threat of competition forces petrol retailers to consider locations where they can gain the most market share. To minimize the distance that customers should travel, they want to be in a central location (the CBD and along major roads) for their target customers.

Instinctually, all competing retailers make the same choice at the same time, which results in the PFS being clustered together and falling short of the required 400 meters to the next PFS. However, the clustering of PFS is hazardous to the adjoining residents, especially during a fire outbreak from the PFS, as the fire can easily spread to the next PFS due to proximity.

Distance From Road

According to NUPRC guidelines, the distance between the road and the PFS pump should not be less than 15 meters. The proximity analysis of PFS in Fig. 5 shows the filling stations and their setbacks. Figures 10 and 11 show that only 12 PFS (24%) meet the 15 metres setback requirement while more than two third (78%) did not meet this requirement. Most stations that did not comply with the 15-meter setback requirement are in the Toll Gate, Sango, and Ojuore Central Business Districts. The few remaining stations in this category are located along the major roads that radiate from the CBDs toward Idiroko Road, including the Obasanjo, Iyana Iyesi, Bells Junction, and Winner's corridors.

Distance To Residential Building

One requirement for PFS as stated in NUPRC guidelines is that the distance between PFS and residential structures should be kept at 50 meters. To create a buffer zone for residential buildings, a petrol station should be placed 50 meters from all sides of the built-up areas.

The nearest residential building distances to PFS were as shown in Fig. 13. The assessment of the minimum distance of PFS from residential buildings shows that the NUPRC's requirement of 50 meters between PFS and residential buildings was violated by 45 PFS, accounting for 90% of the total number of PFS that were identified (Figs. 13 and 14). It is worth noting that only one of the PFS in the central business districts meets the 50-meter distance requirement from residential buildings.

What could be observed from the foregoing analyses is that the planning standards set up by regulatory bodies to guide the location of PFS were grossly violated. If all regulatory standards for PFS location are strictly adhered to, nearly all PFS in the study area are not eligible for town planning approval. The uncontrolled and unguided pattern of development and functionality of PFS thus points to the inefficiency of the regulatory agencies in the state. The arbitrary construction of PFS without conformity to the planning standard and, most often, without approval could be a result of the following:

i. The inefficiency of regulatory bodies such as NUPRC and OSMPPUD

ii. Lack of synergic collaboration among the regulatory bodies.
iii. Corruption undermines the effectiveness and efficiency of regulatory bodies to function efficiently.
iv. Political interference in the location of PFS

Conclusion And Recommendation

There is sufficient evidence in this study to conclude that PFS are not evenly distributed, but are more concentrated in CBDs, populated residential areas, and along major roads. It is also determined that most PFS in the study area flagrantly violated all applicable regulations. Based on the findings, the following recommendations are offered

i. The NUPRC and OSMPPUD should mandate that the geographic coordinates of the proposed site be included in the application materials for PFS siting. This can assist in updating the spatial database for the PFS and checking compliance with the distance to the next PFS, public buildings, road setbacks and residential buildings.
ii. By reconciling the discrepancies in the standards for the location of PFS and safety regulations between the two regulatory bodies, the NUPRC and OSMPPUD can collaborate to ensure that petroleum and gas marketers do not compromise public safety regulations in the state. The recent resolve by the Ogun State government to partner with the NUPRC to daunt the arbitrary construction of petrol stations without approval in the state is a positive step in this direction.
iii. The regulatory bodies in the state, namely the NUPRC and OSMPPUD, should be more proactive in enforcing compliance orders for petroleum and gas operators in the siting of the PFS.
iv. Both regulatory agencies should conduct a verification and approval auditing exercise to clamp down on PFS that were either incorrectly approved or were operating illegally without approval. Those who were incorrectly approved should be reviewed, and appropriate compliance action should be taken against them, while those who operate without approval should be penalized with an additional assessment fee, and those who deviated from the approval given to them should be made to start the process over.

Declaration

Competing interests: The authors declare no competing

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Figures

Figure 1

Satellite Imagery of the Study Area

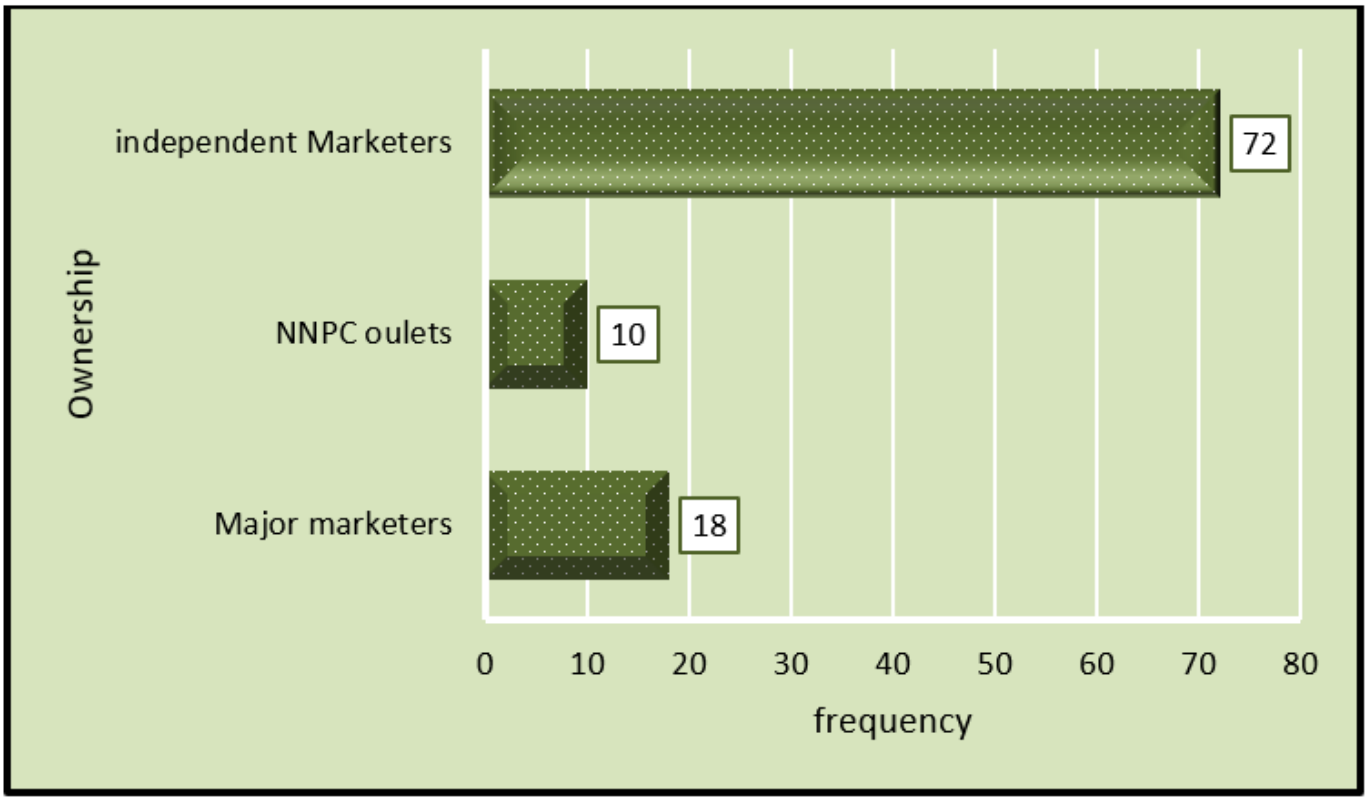

Figure 2

Distribution of Petrol filling station by ownership

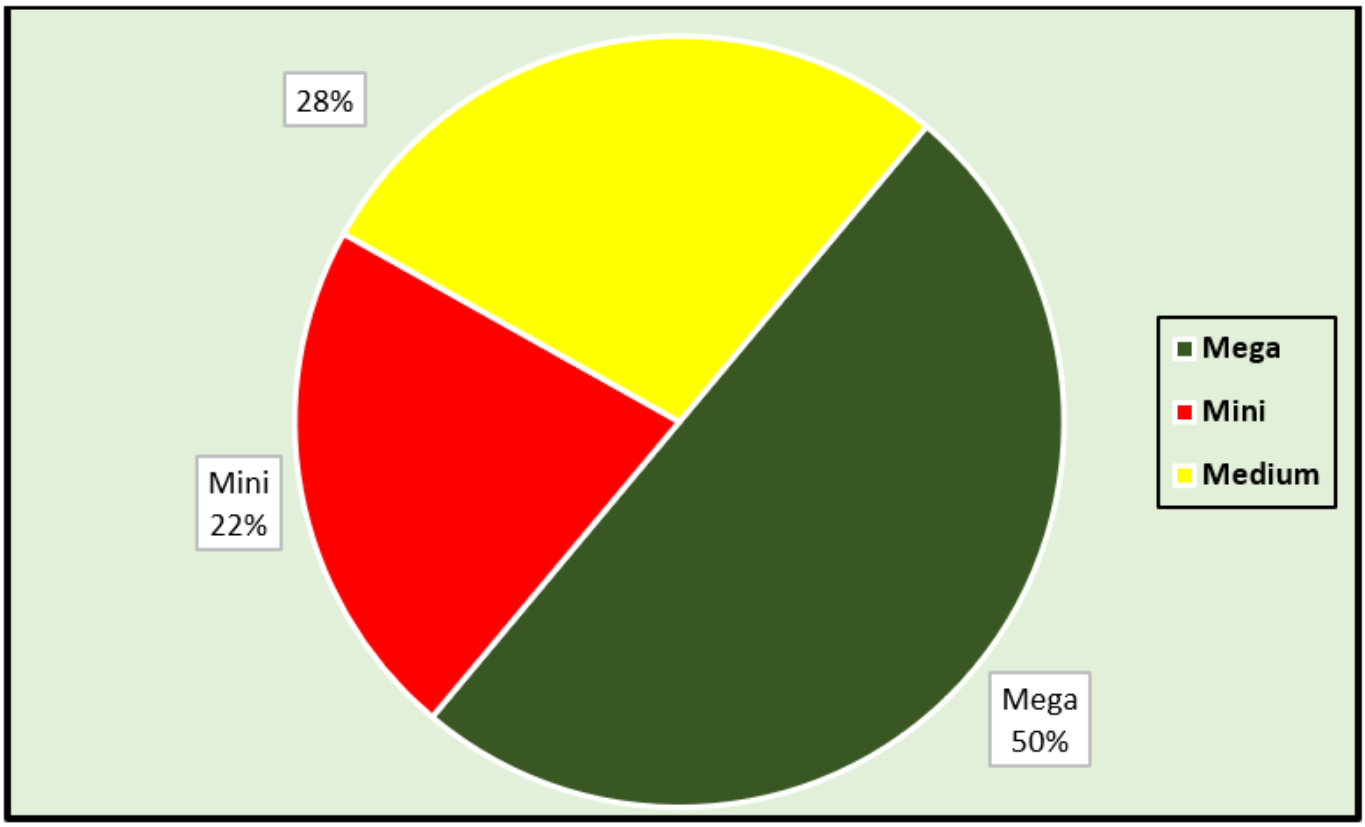

Figure 3

Distribution of petrol stations by types

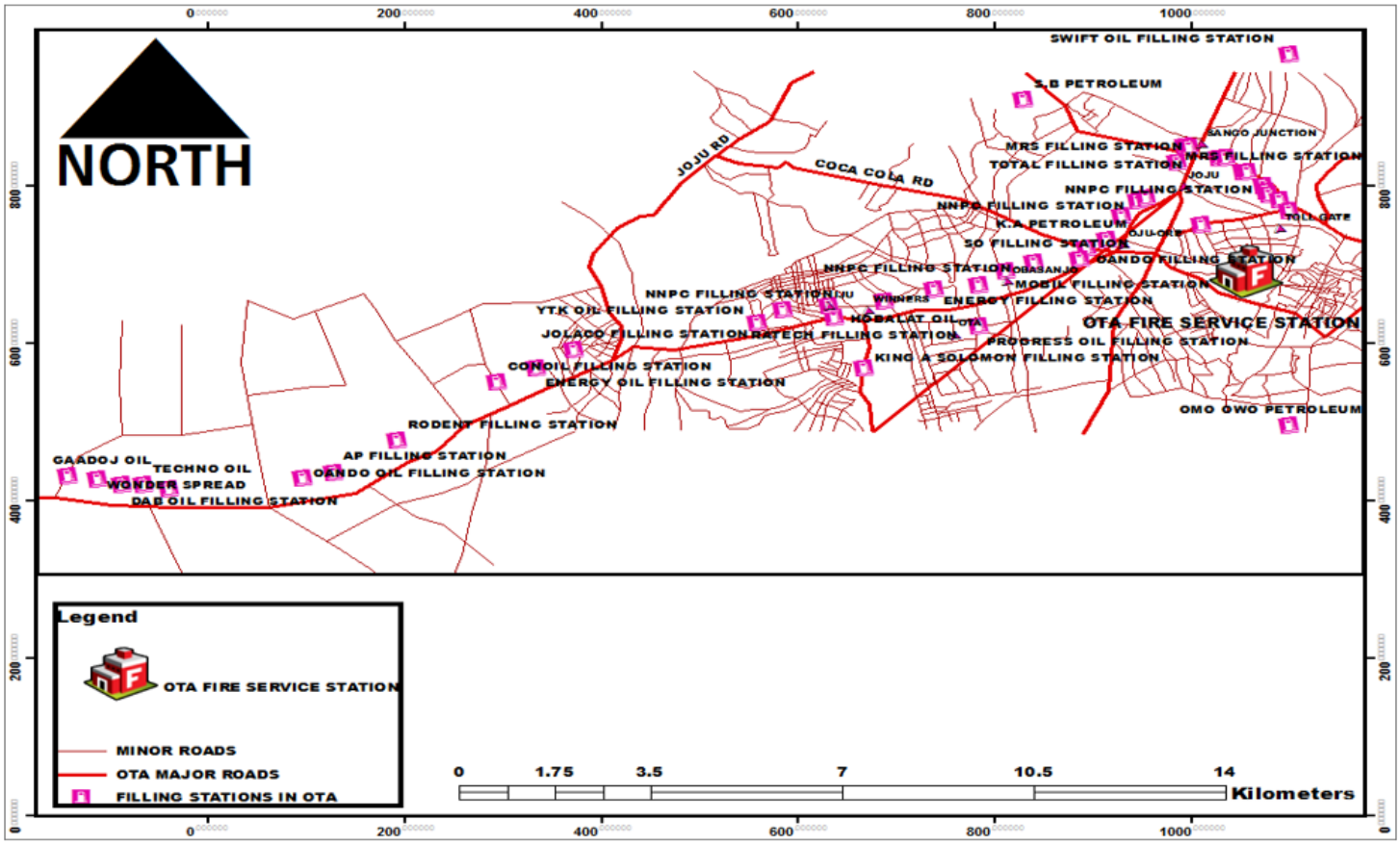

Figure 4

Spatial Distribution of PFS in Ota

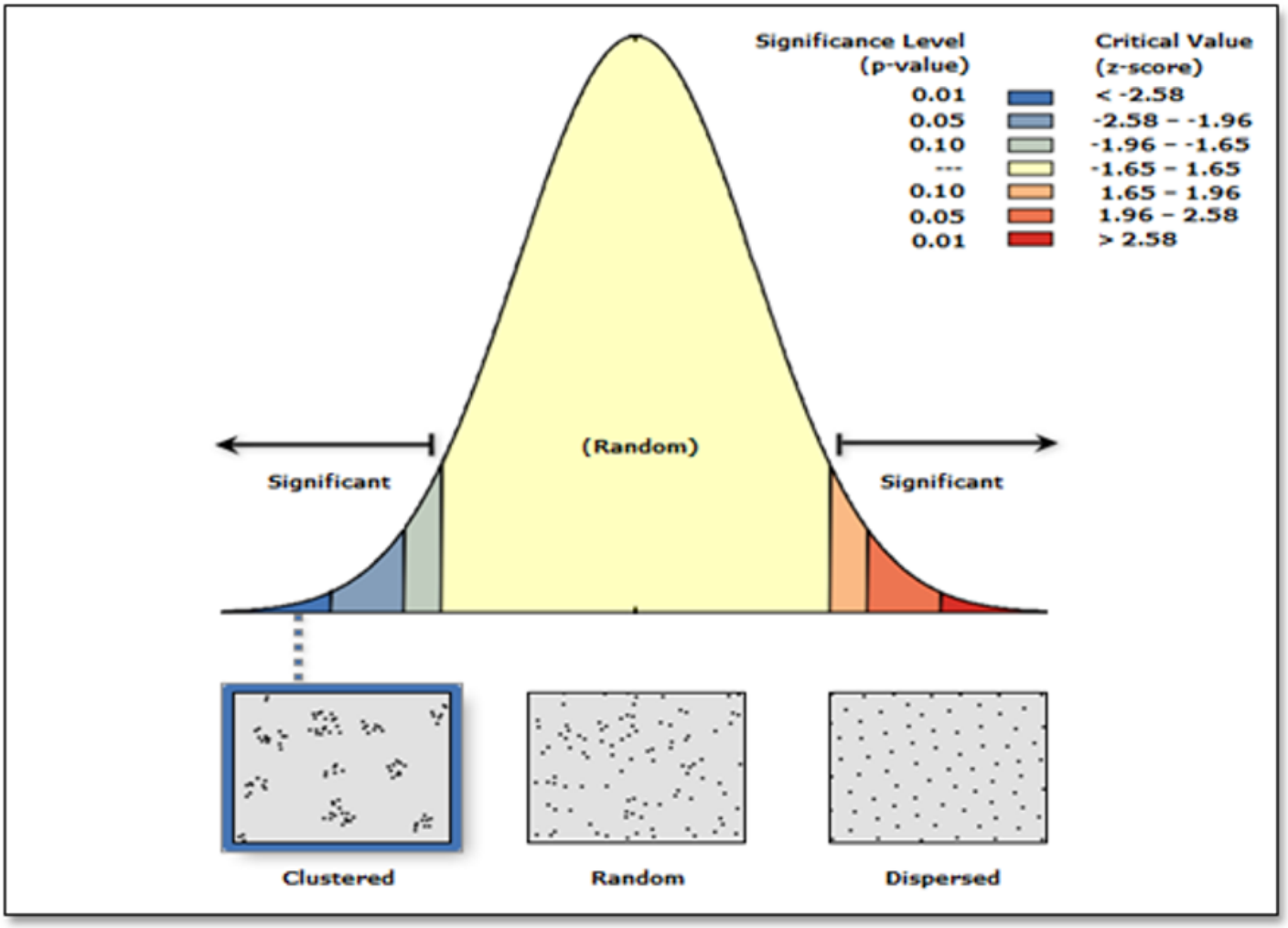

Figure 5

Summary of Nearest Neighbor Analysis

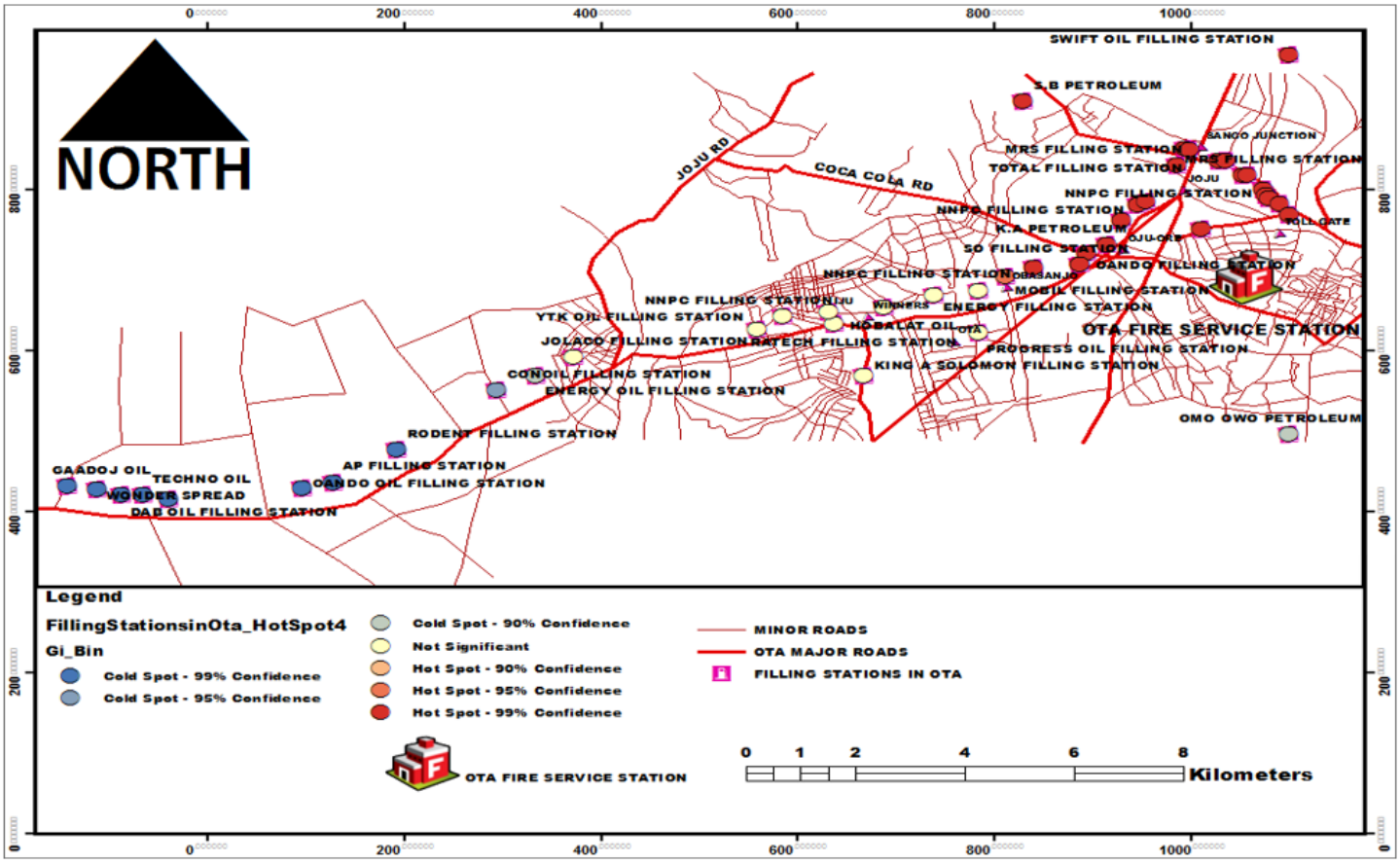

Figure 6

Hotspot Analysis of Petrol Filling Stations

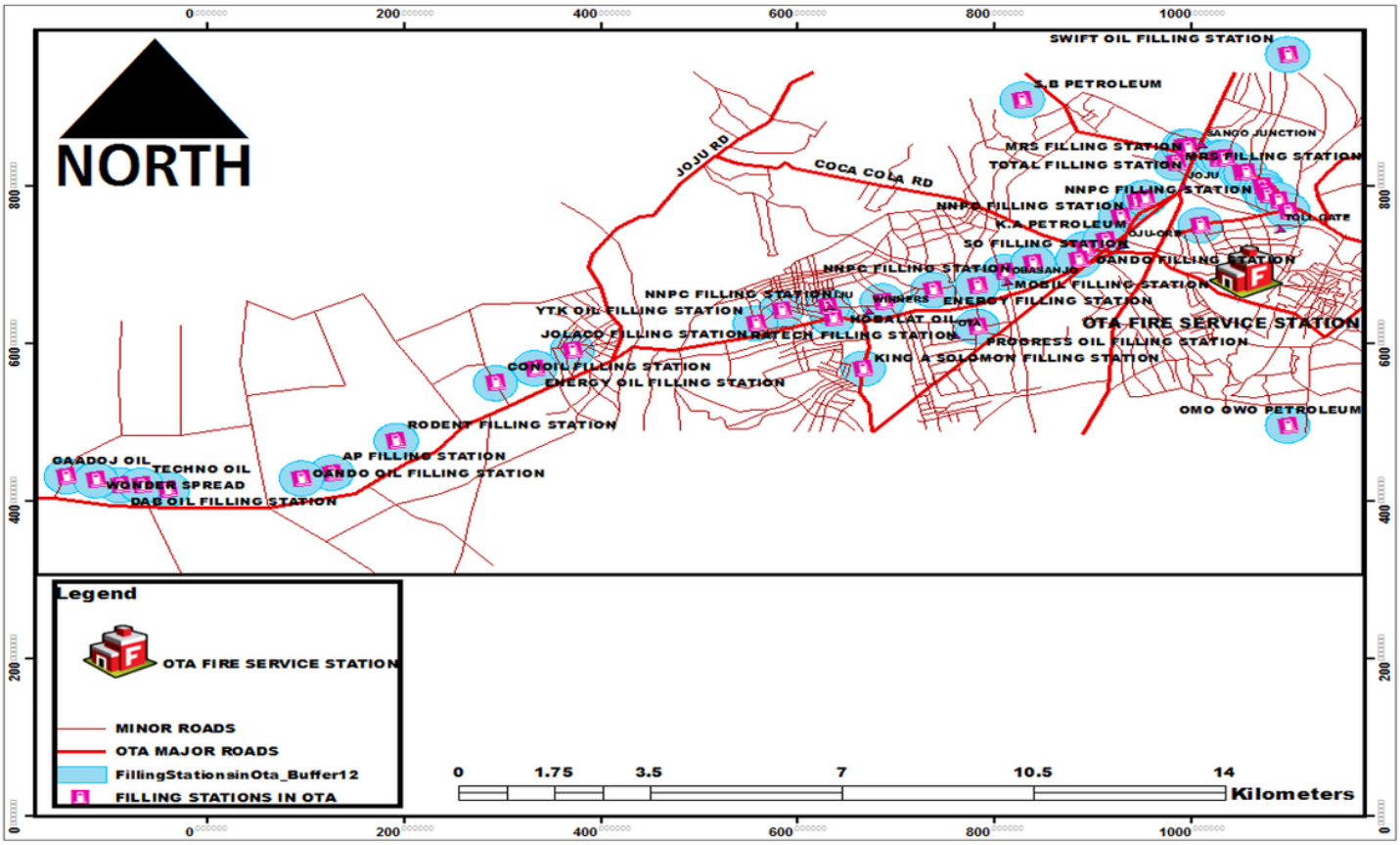

Figure 7

Location of PFS to 400m Distance from Other Filling Stations

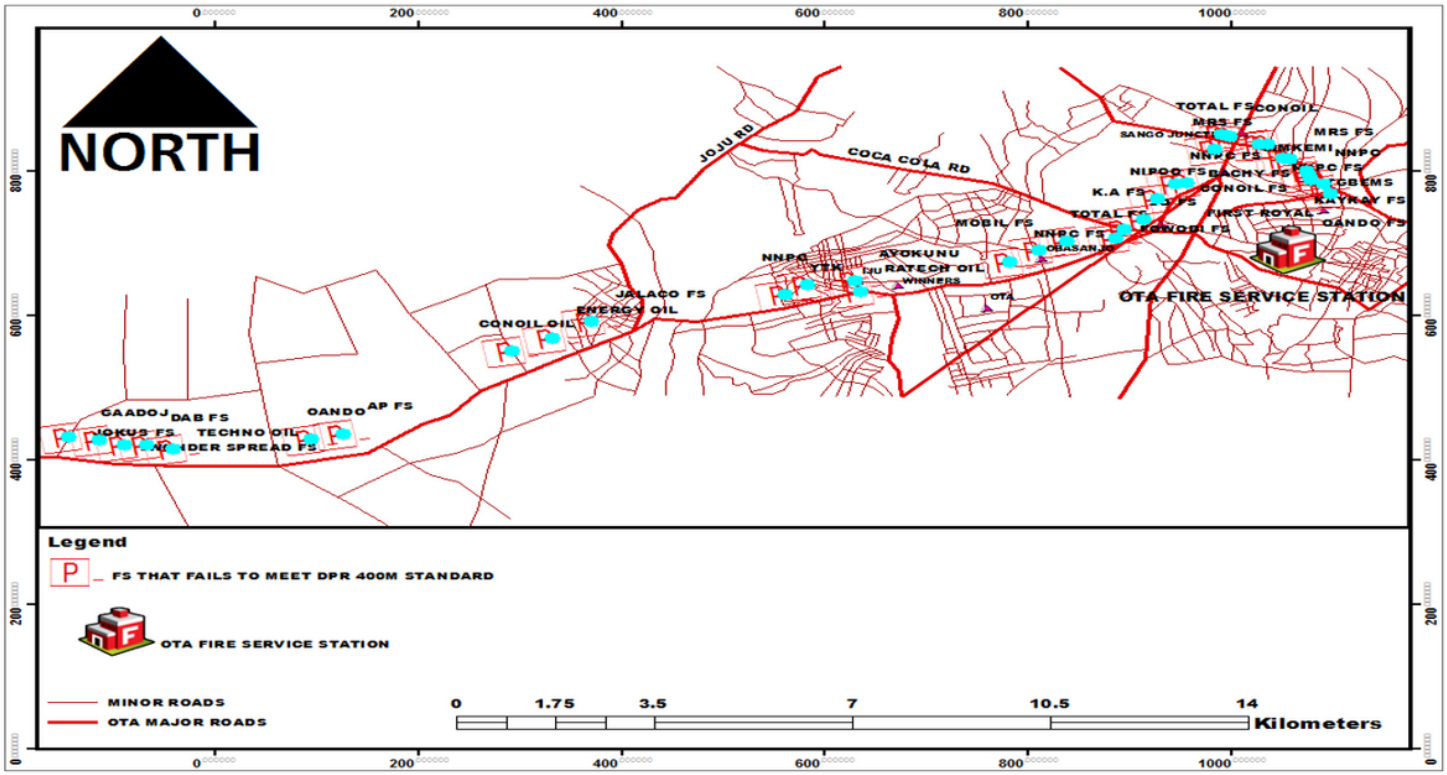

Figure 8

PFS that fail to meet the 400m distance Requirement of NUPRC

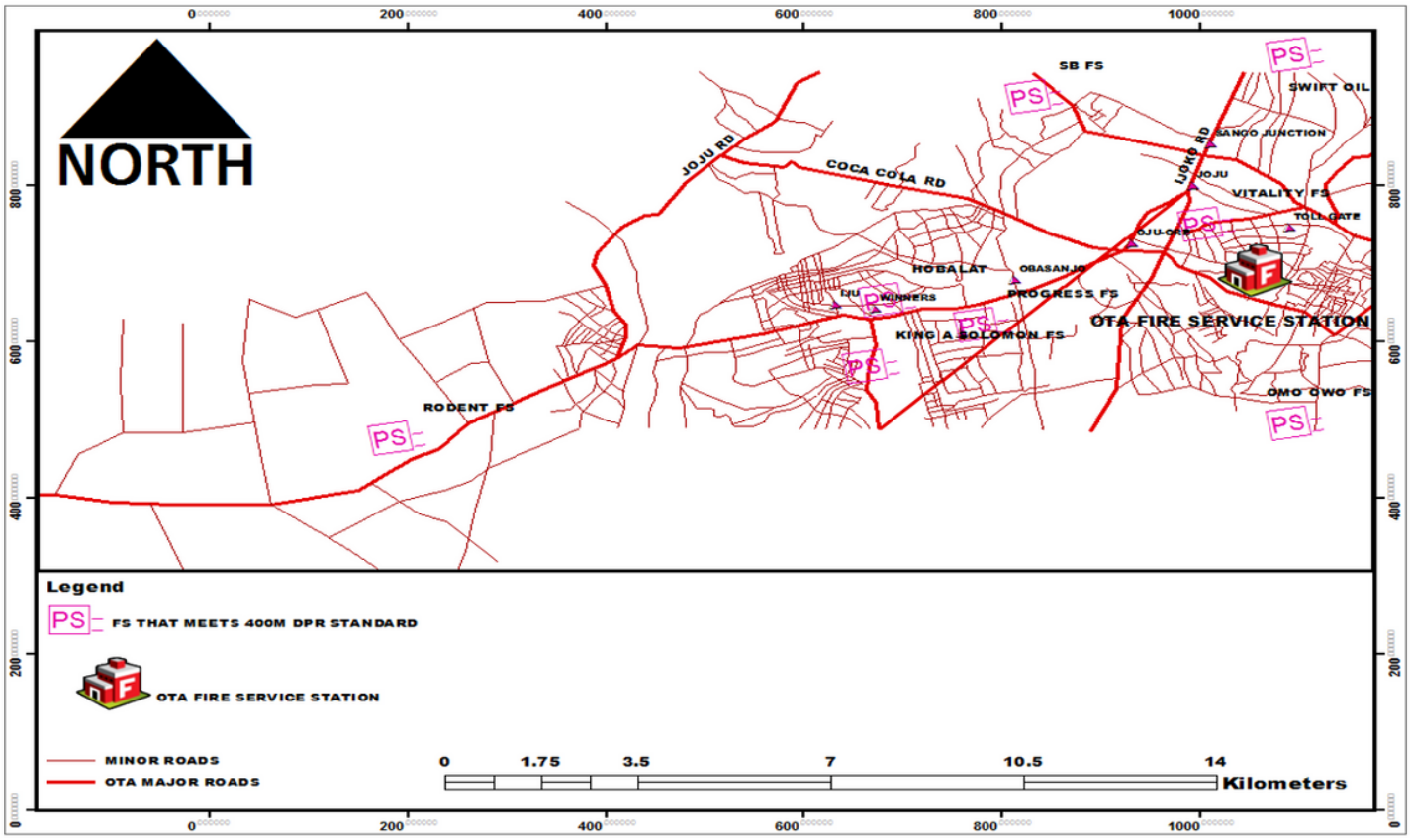

Figure 9

PFS that meet the 400mdistance Requirement of NUPRC

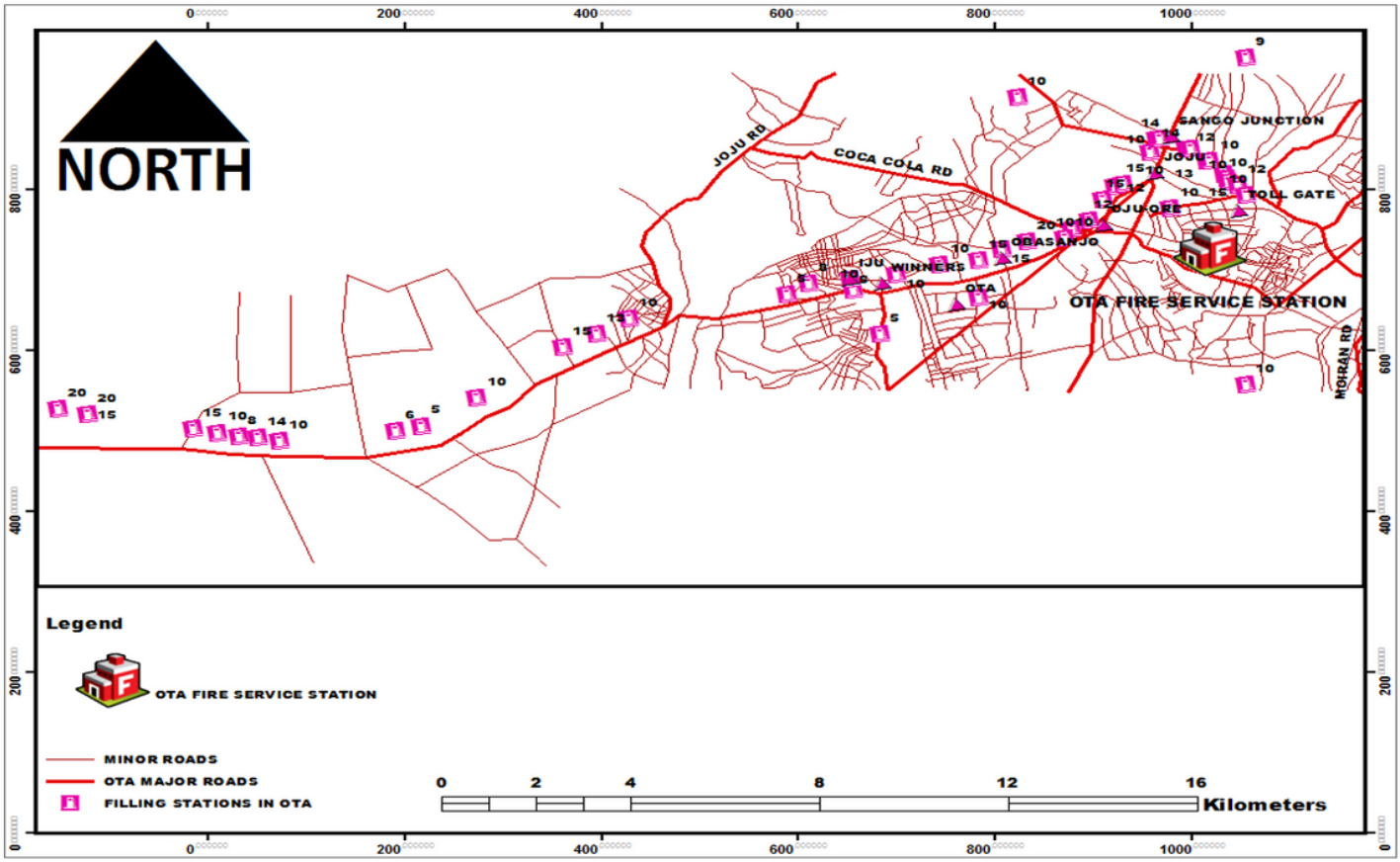

Figure 10

Filling stations with their individual setbacks Source

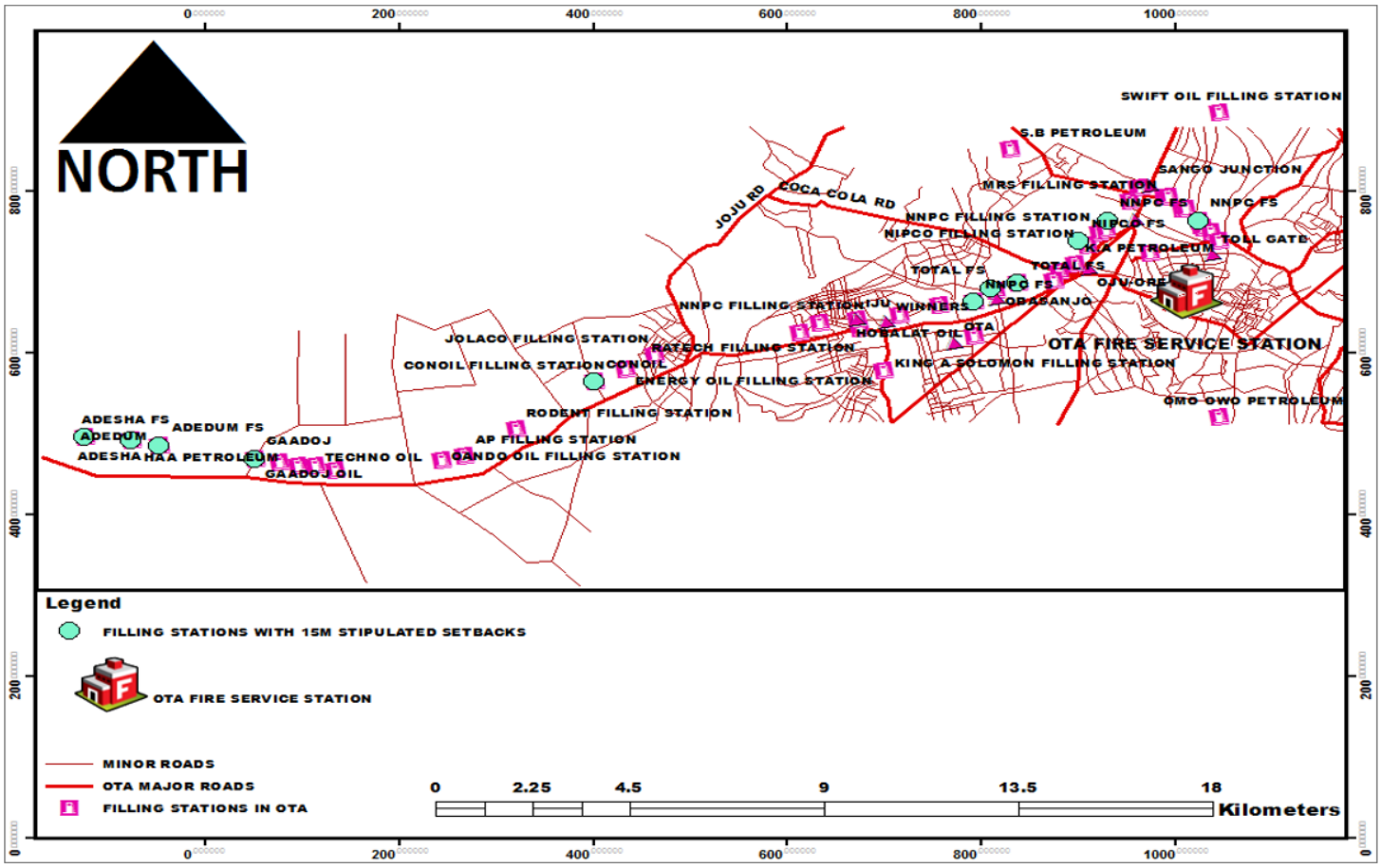

Figure 11

Filling stations with 15M stipulated setbacks by NUPRC

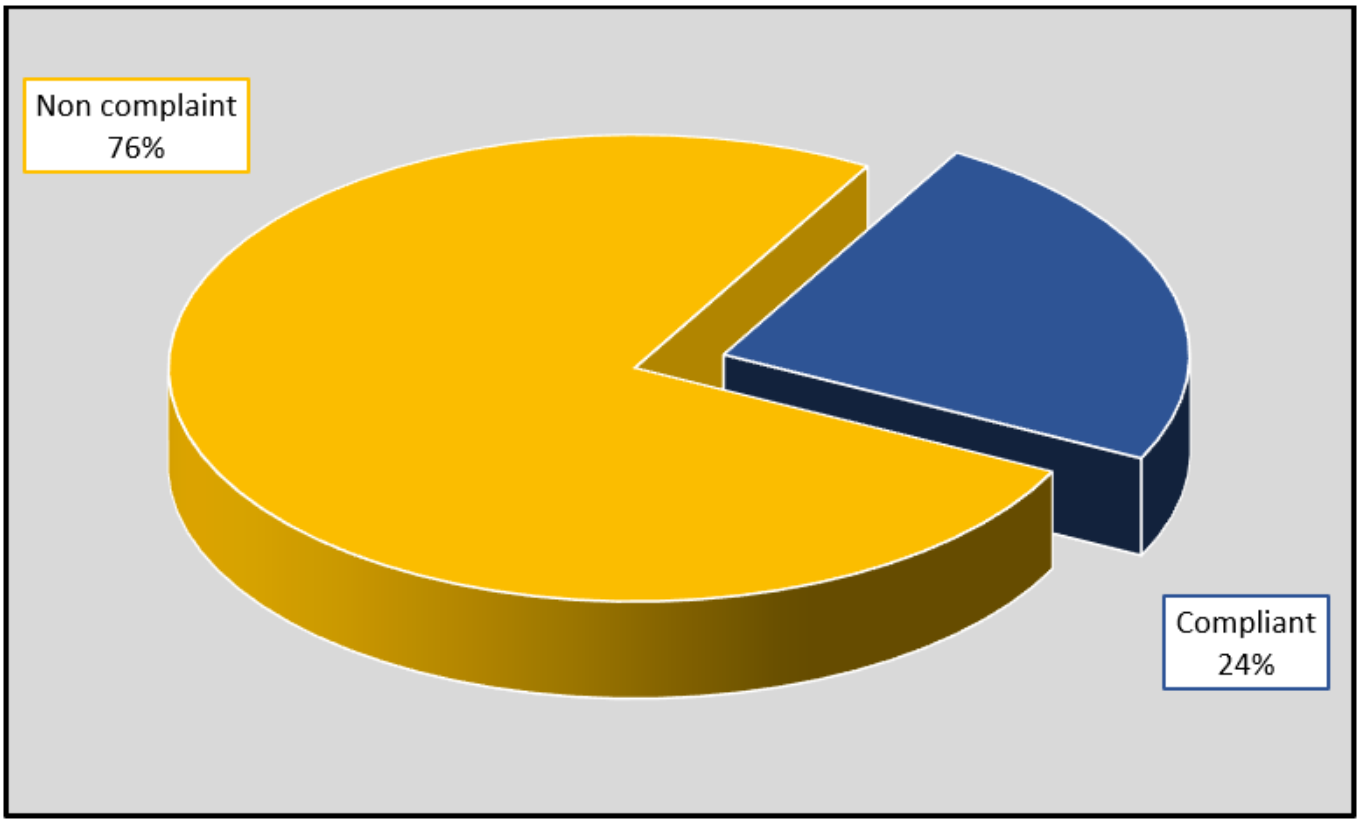

Figure 12

Filling Station and 15 metres Standard Distance from Road

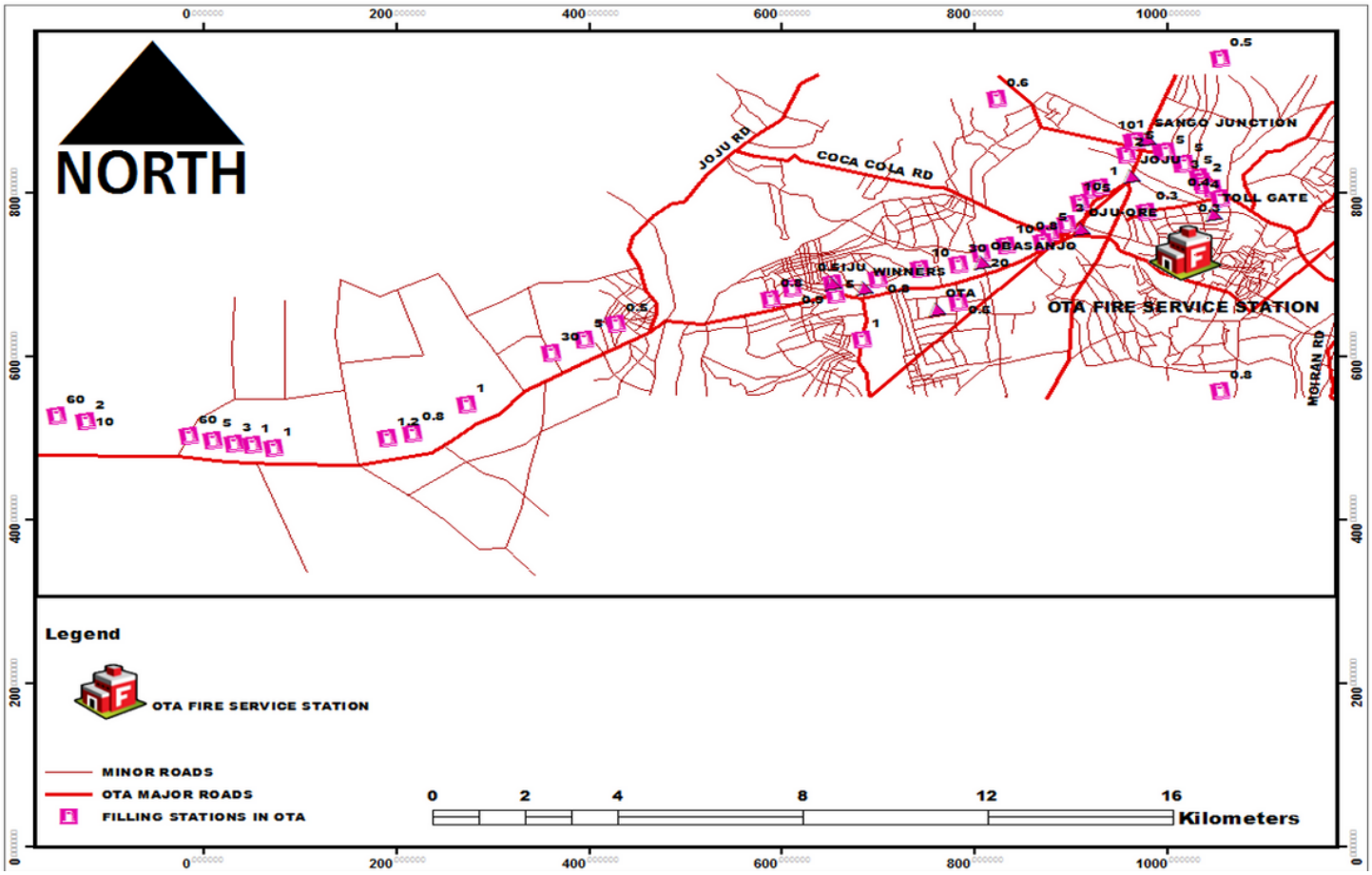

Figure 13

Nearest Distance between PFS and Residential Building

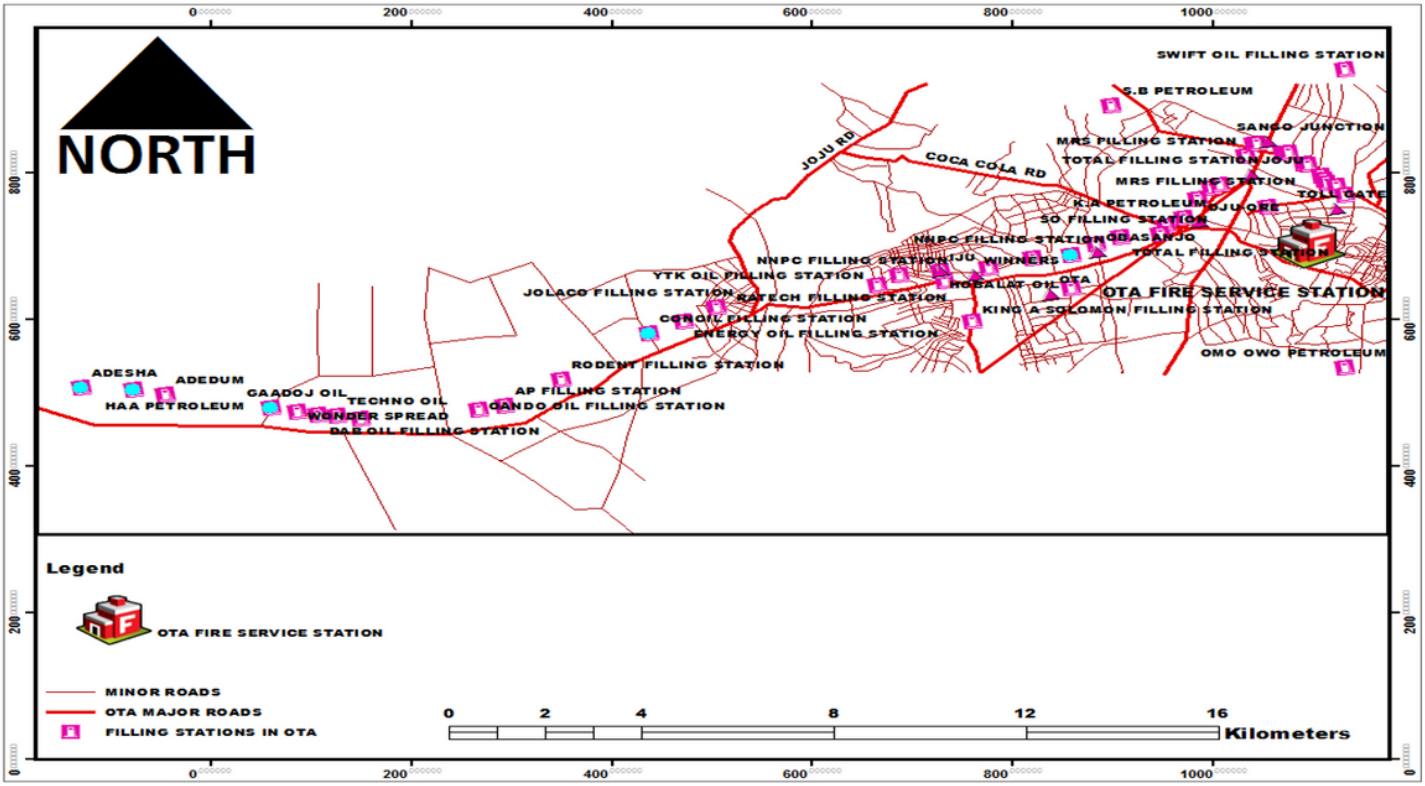

Figure 14

PFS that meet the required 50 meters standard for residential buildings (with blue shades)