Locational Characteristics of Filling Stations in the Residential Zones of Osogbo, Nigeria

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Abstract. This study assessed the locational characteristics of filling stations in Osogbo, Nigeria. Multi-stage sampling technique was employed for the study. Three residential zones: the core, transition and suburban zones were identified, 121 filling stations were identified across the 3 residential zones, these comprised 46, 61 and 14 in the core, transition and suburban zones respectively. In each zone, 1 out of every 10 filling stations were selected, thus, 5, 7 and 2 filling stations in the core, transition and suburban zones making a total of 14 filling stations were selected. In selecting the sampled residents, buildings within 500 metres radius to each selected filling station were surveyed. A total of 3,056 residential buildings were identified. Using systematic random technique, 10% of the total numbers of buildings were sampled resulting in the selection of 311 residents for questionnaire administration. The data collected include coordinates of the facilities using the Global Positioning System (GPS). GIS was used to spatially locate the filling stations on digitized Google Earth Thematic map of Osogbo, also, the Nearest Neighbour Analysis was adopted in the analysis to establish the spatial spread of filling stations in the residential zones of Osogbo. The findings revealed a geographical spread of filling stations across the different residential areas of Osogbo. The study also revealed that the distribution of filling stations in the core, transition and suburban areas of Osogbo were highly clustered which is an indication that planning standards are not strictly adhered to when siting filling stations.

Keywords: Locational, Filling Stations, Nearest Neighbour Analysis, Residential Zones, Spatial

Introduction

Human beings do not only depend on the physical environment for survival; rather they are involved in various technological activities aimed at affecting the world around them (World Health Organisation, 2010). Man's continuous effort for the production of automobiles and petroleum products necessitated the construction and location of filling stations at strategic areas in most urban centres (Abdul, Suriatani & Remy, 2009). According to Omole (2001), a filling station is a commercial facility where fuel and lubricants for cars and other products are sold. Filling stations are absolutely necessary in modern technological society (Mohammed, 2014; Olufayo, 2018) however; they constitute numerous risks to the health of employees, neighbouring residents, patrons and the living environments (Odeh, 2017).

On a global scale, the number of filling stations is on a steady increase in different parts of the world (Dogara, 2017). This growth especially in Nigeria has resulted from the rising population and increase in the purchase of vehicles. In addition, the profit margin of fuel at both the control price and the black-market rates has influenced people to venture into the filling station sector (Blamah *et al.*, 2012). Thus, this has brought about the proliferation and

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haphazard construction of filling stations without adequate consideration to the possible effects of its location on the people and the environment.

According to Keeble (1969), filling stations are expected to be located in areas where they can be easily accessed and where the dangers posed by its location can be minimised. The location of filling stations in spite of its quality to the economy and survival of any city is supposed to be driven by the environmental policy and urban planning legislation (Afolabi, Olajide & Omotayo, 2011; Dogara, 2017).

Rapid growth of towns and cities in Nigeria has produced greater demand for vehicles, motorcycles, generators, among others. This rapid growth in most of our urban centers has necessitated the increased demand for more fuel consumption (Ayodele, 2011; Olufayo, 2018). Filling stations are poorly located in a disorder manner with potentiality for hazards in most Nigeria's urban centres (Afolabi *et al.*, 2011). The poorly located filling stations are associated with several problems. These problems among others include pollution, explosion, traffic congestion, breeding of criminal gangs, accidents. According to Samuel (2011), some of the challenges associated with the location of filling stations are traffic congestion, pollution, fire, explosions, among others. However, the dimension and the degree of these problems depend on variables such as location, size and set back, and conformity with urban planning regulations.

Location of filling stations has been marred with violation of urban planning standards in most of Nigerian urban centres (Omole, 2001; Alabi, 2004; Ayodele, 2011; Olapeju, 2017). Many of these filling stations do not have the necessary safety measures to allow them to receive operating licenses from the authorities regulating their operations. Furthermore, the filling stations are situated in close proximity to each other and majorly in residential areas (Michael, 2008; Kaduna State Urban Planning Development Agency, 2009; Abdullahi, 2012; Papadopoulou & Antoniou, 2014).

The dimension and extent of the problems in terms of physical, social, economic and environmental effects have not been adequately explored. Safety practices in the location of filling stations are of paramount importance. Filling stations emit volatile organic and flammable compounds which always make them a risk of fire or explosion (Sangotola *et al.*, 2015). Considering the associated risk and hazards with the location of filling stations in neighbourhoods, analysis of its location impacts should not be taken for granted. The safety of the people as well as the protection of the environment in addition to adherence of approved standards must be a major concern for the regulatory bodies in approving the location of filling stations.

Osogbo is a fast growing urban center in Nigeria considering the rate of its physical development and population growth that it boasts. One of the common features of this city is traffic jams. This may be attributed to the long queues in the nearby filling stations especially in periods of fuel scarcity or due to the clustering of filling stations at a particular location. It is on this note that this research intends to examine the spatial characteristics of filling stations in different residential zones of Osogbo, Nigeria. More so, this study would serve as an initiative to government, other stakeholders and the public on the need to document the location impact of filling stations within residential zones of Osogbo, Nigeria.

Literature Review and Conceptual Framework

Vicinity Guidelines for Filling Stations Location

The guidelines for the location and operation of filling stations in Nigeria stipulate that application for the granting of permit to all filling stations of all categories shall be by the Department of Petroleum Resources (DPR) (DPR, 2009). The DPR have the responsibility of determining whether an application has met the requirement for Approval to Construct (ATC)

or not. Some of the requirements that filling stations are expected to acquire before they can be licensed to operate are:

a. Environmental Impact Assessment (EIA) Report on the proposed filling station prepared by DPR approved consultants.
b. The total number of petrol stations within 2km stretch should be 4 on both sides of the road, including the one under construction for a single carriage. For dual carriage way, 4 petrol stations on the same side could be considered.
c. The distance between existing between petrol stations on approved sites and the proposed one should be 400m apart.
d. The distance between one petrol station to the nearest residential building should be minimum 50m apart.
e. The distance between one filling station and the nearest place of public assembly should be 100m apart.

Generally, as stipulated in the DPR Procedure Guide (2010) under the Petroleum Act CAP 150 of 1967 and captioned "Specific Directives," the implications for flouting the DPR guidelines by filling stations ranges from classifying that filling station as unlicensed to withdraw of license depending on the magnitude of the offence (DPR, 2011). A cursory glance at the spatial distribution of filling stations in Nigeria cities revealed that most of the stations do not adhere to all these guidelines. Also, filling stations have continued to encroach in residential buildings due to lack of government political will or commitment to enforce the urban planning laws, hence, landowners and developers determine the use of the available land in most of Nigerian cities.

Health Impacts

Several studies have established that the location of filling stations in an area provide suitable grounds for the prevalence of various types of environmental pollutant emanating from oil fumes (Sangotola *et al.*, 2015; Markus *et al*., 2015). These studies noted that the exposure of residents' to diesel; petroleum fumes and other petroleum components such as benzene, sulphur dioxide, nitrogen and formaldehyde has contributed significantly to cancers, acute myeloid leukaemia and acute non-lymphocytic leukaemia. Other health challenges emanating from the inhaling of fumes from filling stations are irritations (nose and throat), Broncho constriction and dyspnoea especially in asthmatic individuals. Furthermore, the emission of heavy metals such as arsenic, vanadium emanating from filling stations penetrates the alveolar epithelium and initiate lung inflammation in people with lung lesions or lung diseases living around the filling stations. In addition, some items and chemicals used in the general cleaning at the service stations as well as washing of cars may be dangerous and injurious to the body. Constant use of these chemicals, its accidental leakages or spillage may cause respiratory problems, inflammation of the skin or chemical burns. The filling station therefore increases people's susceptibility to respiratory and skin infections.

Environmental Impacts

The dark side of oil (especially fuel for refuelling vehicles) is the environmental problems it presents; thus, its service location points must be purposefully and deliberately set in order to minimize its effects on both human beings and their immediate surroundings. Mshelia, Abdullahi and Dawha (2015) noted that noise, traffic congestion, soil pollution, fire outbreak and traffic accidents are some of the severe consequences of sitting of filling stations in an area. Volatile organic compounds in petroleum motor spirit pollute the air with associated environmental health effects (Sangotola *et al.*, 2015). In areas where fuel stations are located very close to rivers, these vapours pose a potential threat to aquatic life. Volatile

organic compounds have deleterious effects on general health, plants, roofing materials and visibility in areas where filling stations are located (Alam *et al.*, 2014).

General System Theory

The General System theory (GST) propounded by Ludwig von Bertalanfy in the 1940s (Sunstein & Hahn, 2005). It conceived a system as relationship between various objects and their attributes. It noted that the objects in a complete system have attributes which make them complementary. As such the relationship between the objects and how they operate together makes a system whole. The system theory relies on the philosophy that the complete is bigger than the individual parts; the individual parts comes together to form a whole and that any change in the individual parts of the system will affect all other parts through a chain reaction and there is inter-relationship between the individual parts to form a whole. Thus, a system is therefore conceived as an entity, physical or conceptual, that is composed of interrelated parts.

The significance of a component of the system theory is that it depends upon its relationship with other components within the system. It implies that every system is made up of (sub-system) constantly interrelating with one another for the survival of the system. System theory is applicable to the location of facilities and services within the city. It connotes that the city is a complete system between man, environment, social activities, technological activities, economic activities among others. As such human beings require an interaction with all these in a complete system for a healthy environment. In the location of filling stations, the urban environment relies on the location and effective supply of fuel from filling stations without detrimental effects on other systems within the environment. Thus, a situation whereby the filling station (sub-system) begins to constitute nuisance in the environment such that it begins to affect other sub-system then the cycle of the system is broken.

Materials and Methods

This study area is Osogbo, the capital of Osun State, Nigeria which also doubles as the administrative headquarters of Osogbo and Olorunda Local Government Areas (LGAs). Osogbo is located between latitudes 7°42’20” and 7°49’20” North of the Equator and longitudes 4°30’20” and 4°38’20” East of the Greenwich Meridian. It has a total land area of 47 square kilometres and shares boundary with Ifelodun, Ede North, Atakunmosa West, Egbedore and Boripe Local Government Areas as shown in Figure 1 (Osun State Government, 2006). According to the 1963 population census results, Osogbo has a population of 152,424 people. In 1991, the population increased to 250,951 inhabitants (National Population Commission, 1991). In 2006, the population of Osogbo was 381,405. Based on this figure, the population was estimated to be 527,954 in 2017 at an annual growth rate of rate of 3% (National Bureau of Statistics, 2016).

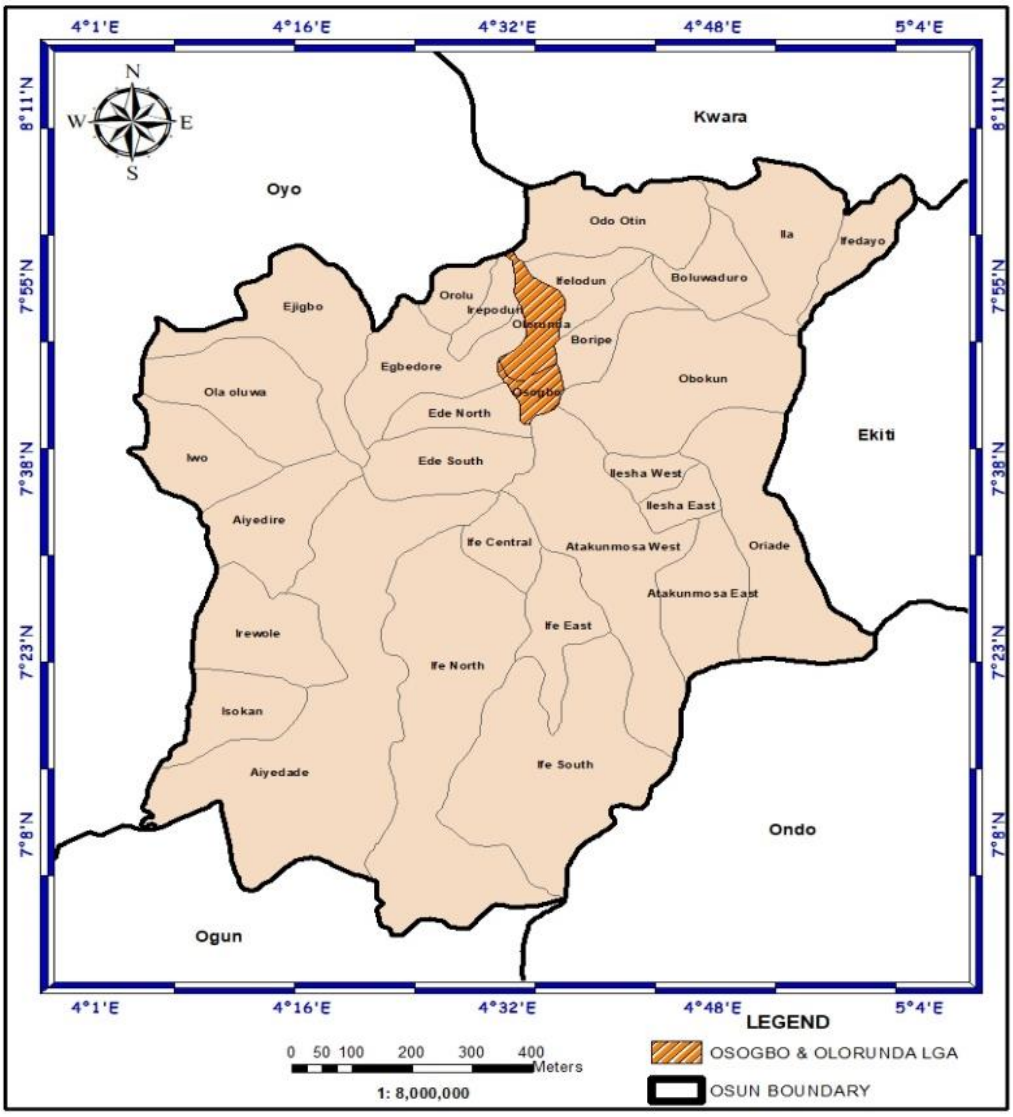

Figure 1. Osogbo within the context of Osun State
Source: Office of Surveyor General of the Federation (2020)

All residents living within 500 meter radius around functioning filling stations in Osogbo metropolis constitute the research population. The sampling frame for this study includes the total number of filling stations and the residents living within 500 metres radius around the filling stations in Osogbo. Reconnaissance survey reveals that there are 121 filling stations in Osogbo.

The multistage sampling technique was adopted for this study. Osogbo was first stratified into the identified residential zones in the city (the core, transition and suburban). This helped to showcase the location of the filling stations across the different residential zones. The second stage is the identification and selection of filling stations across the different identified residential zones. Information obtained from the DPR coupled with authors' reconnaissance survey revealed that there are 121 identified and functioning filling stations across the three residential zones of Osogbo. These comprised 46, 61 and 14 in the core, transition and suburban respectively. In each zone, one (1) out of every ten filling stations was selected using random sampling without replacement. This resulted in selection of 5 filling stations in the core, 7 in the transition zone and 2 in the suburban zone making a total of fourteen (14) filling stations selected. This is presented in Table 1.

Table 1. Selected filling stations in the study area

S/No.	Name of Filling Station	Location
Core Zone		
1	Habeeb Petroleum	Olaiya
2	Mobil	Ayetoro
3	Mutep oil Nigeria Ltd	River side
4	BOVAS	Ata Oja
5	Adolak	Ayegbaju Market
Transition Zone		
1	NNPC	Temidire
2	Ade kabelo	OkeBaale
3	Globuf International consult	Ota Efun
4	Oando	OkeAyepe
5	BOVAS	Jaye
6	NIPCO	Lameco
7	MRS	Powerline
Suburban Zone		
1	BOVAS	Agunbelewo
2	NNPC	Dada Estate

Source: Authors' compilation, 2021

However, in selecting the sampled residents, buildings within 500 metres radius to each selected filling station were surveyed. Findings from the Google Earth coupled with authors' reconnaissance survey revealed that there are total of 3,056 residential buildings within the specified radius (Table 2), this comprised of 1,777 residential buildings in the core, 1,110 in the transition zone and 176 in the suburban zone. The residents in the 3,056 buildings across the residential zones form the sampling frame for the study from which the sample size was selected.

Using systematic random technique, 1 out of every 10 residential buildings was selected in the study area, this amount to 10% of the total number of buildings. On this premise, a total of 311 residential buildings were selected comprising 177, 116 and 18 residential buildings in the core, transition and suburban residential areas respectively. In each of the selected residential building, the target respondents were an adult who has lived in the area for a minimum of one year. Thus, the sample size for the study comprised 311 residents on which questionnaire was administered. Data collected include coordinates of the facilities using the Global Positioning System (GPS). GIS was used to spatially locate the filling stations on digitized Google Earth Thematic map of Osogbo, also, the Nearest Neighbour Analysis was adopted in the analysis to establish the spatial spread of filling stations in the different residential zones of Osogbo.

Table 2. Selection of residential buildings within 500metre radius

Residential Zone	Selected Filling Stations	Location	No of Buildings within 500m Radius	No of Selected Buildings (10%)	Total
Core	Habeeb Petroleum	Olaiya	322	32	177
	Mobil	Ayetoro	304	30	
	Mutep oil Nigeria Ltd	River side	351	35	
	BOVAS	Ata Oja	370	37	

	Adolak	Ayegbaju Market	430	43	
Transition	NNPC	Temidire	150	15	
	Adekabelo	OkeBaale	202	20	116
	Globuf International consult	Ota Efun	132	13	
	Oando	OkeAyepe	152	15	
	Bovas	Jaye	121	12	
	NIPCO	Lameco	126	13	
	MRS	Powerline	227	28	
Suburban	BOVAS	Agunbelewo	80	8	18
	NNPC	Dada Estate	96	10	
Total	13		3056	311	311

Source: Google Earth; Authors' compilation, 2021

Results and Discussion

Distribution of Filling Stations in Osogbo

The pattern of distribution of the available filling stations in the study area shows geographical spread across the different residential areas of Osogbo, however, a lot of disparity exists especially when looking at the number of filling stations in the different residential zones. There are 121 filling stations spread across the residential zones of Osogbo out of which 46, 61 and 14 spread across the core, transition and suburban area respectively, Figure 2 shows the satellite imagery of the distribution of the filling stations in Osogbo, while Figure 3 shows the location of filling stations along major roads across residential zones of the study area.

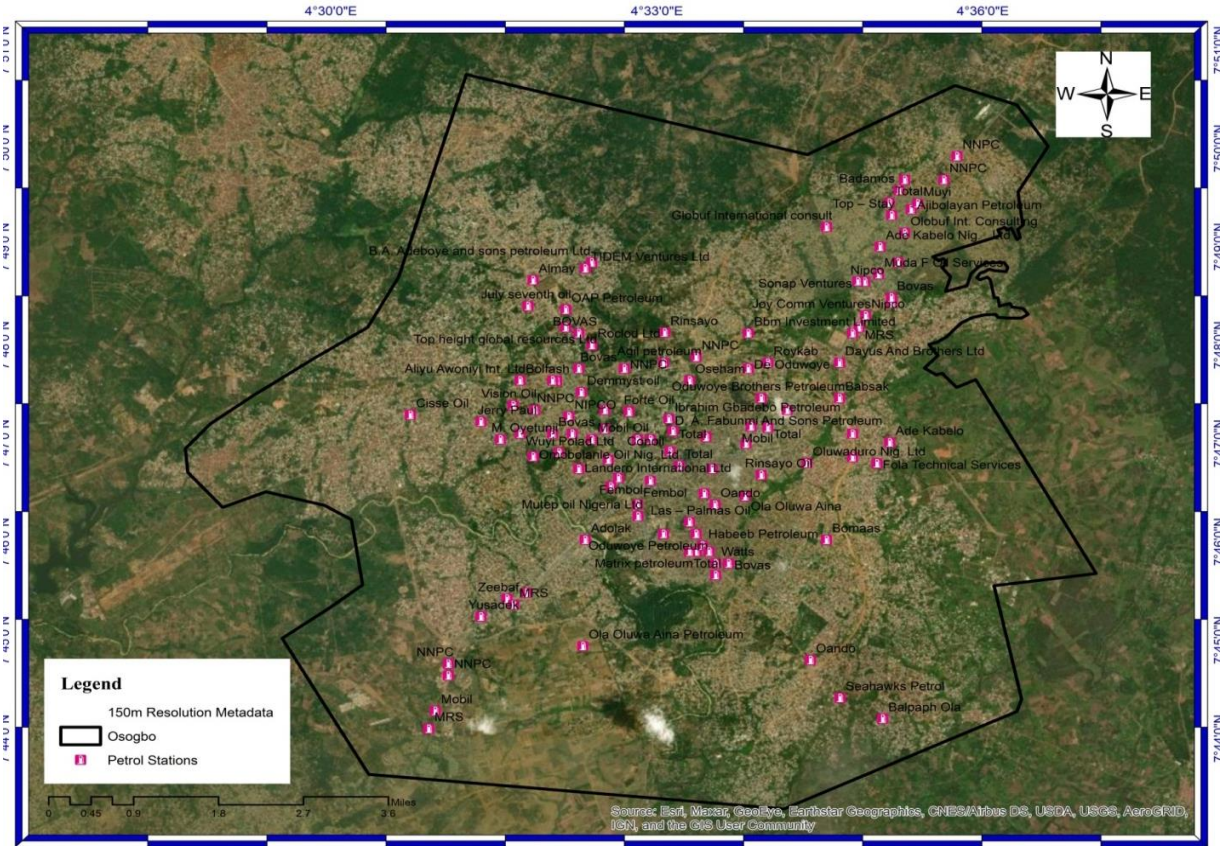

Figure 2. Satellite imagery of the distribution of filling stations in Osogbo
Source: Google Earth 2021; Authors' compilation, 2021

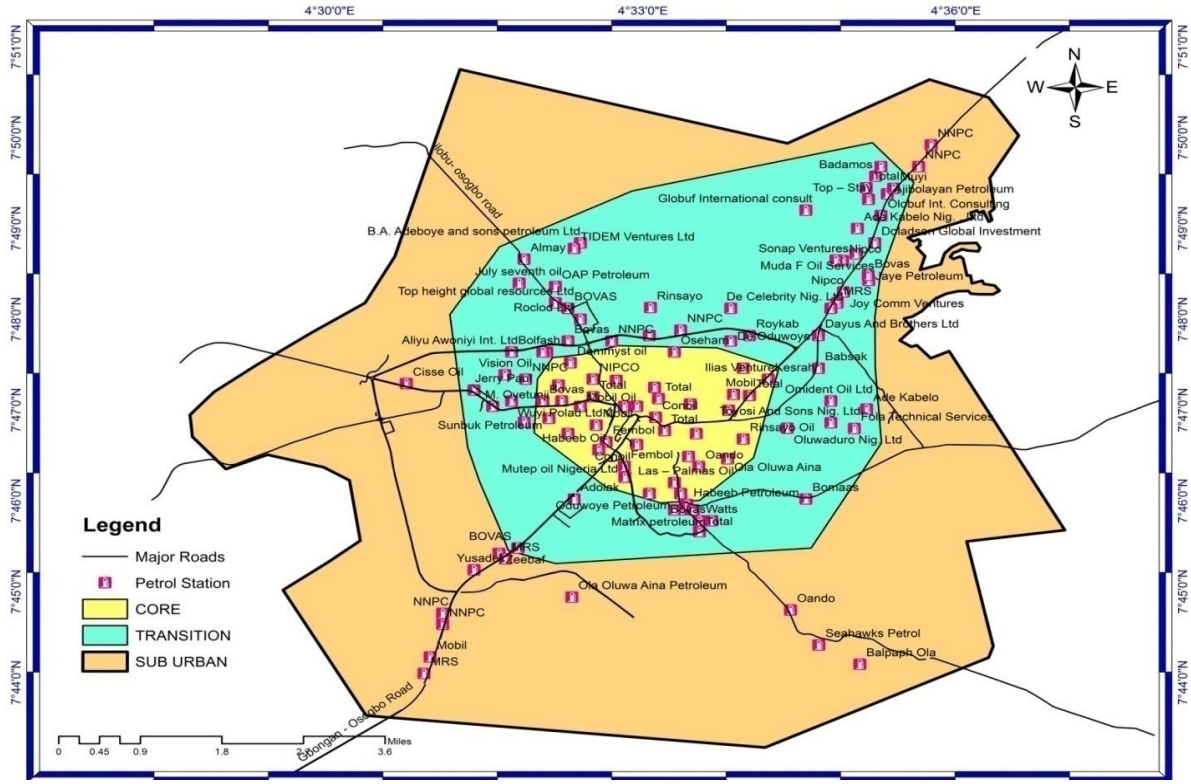

Figure 3. Spatial location of filling stations across residential zones of Osogbo
Source: Authors' compilation, 2021

Findings further revealed that the available filling stations are not proportionally distributed across the residential zones of the study area. In the core area of Osogbo, there are fouty-six (46) functioning filling stations and this represent 38.0% of the total filling stations in the study area, thirteen (13) of the filling stations are owned by major marketers while the remaining thirty-three (33) are owned by independent marketers. Most of the identified filling stations in the core area are closely located to each other and are located along the major roads in the city. It is also notable that majority of the filling stations are located within the ring road of the city. Also noteworthy is the high concentration of the filling stations along Olaiya area and Old Garage (Figure 4).

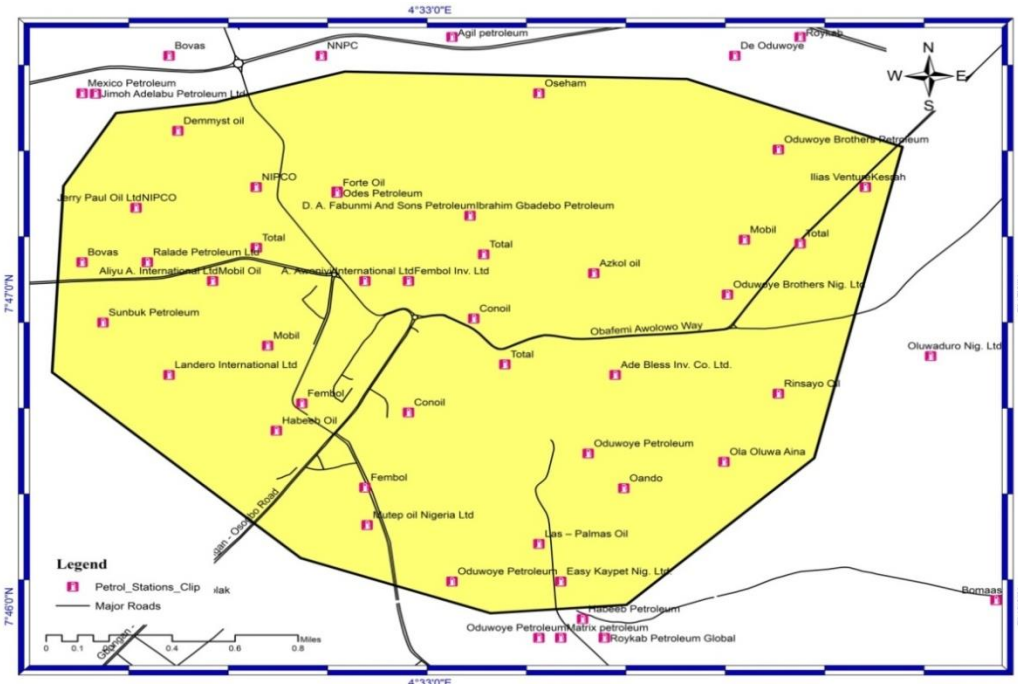

Figure 4. Spatial location of filling stations in the core area of Osogbo
Source: Authors' compilation, 2021

There are sixty-one (61) filling stations in the transition zone of Osogbo and they are sparsely located when compared to those in the core area of the city. The transition zone has the highest concentration of filling stations with 50.4% of the total filling stations in the study area, ten (10) of these filling stations are owned by the major marketers while the remaining fifty-one (51) belong to the independent marketers. They were highly concentrated along the Igbonna Road, Station road and Oke Baale Road (Figure 5).

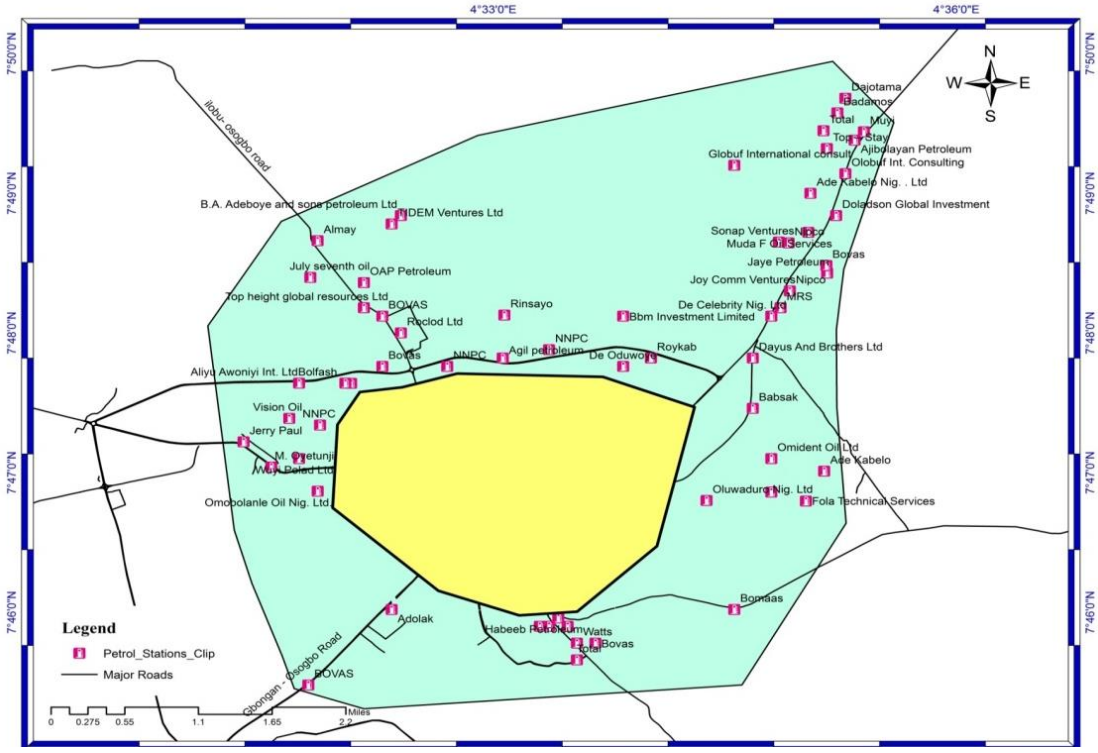

Figure 5. Spatial location of filling stations in the transition zone of Osogbo
Source: Authors' compilation, 2021

The sub-urban zone of Osogbo consist of very small proportion of the filling stations in the study area. There are fourteen (14) filling stations and this represents 11.6% of the entire filling stations in Osogbo. They are located at the outskirts of the city. These areas include Station road, Agunbelewo road and Oke-Fia road of the city (Figure 6). They were sparsely located along the major roads on the outskirts of the city.

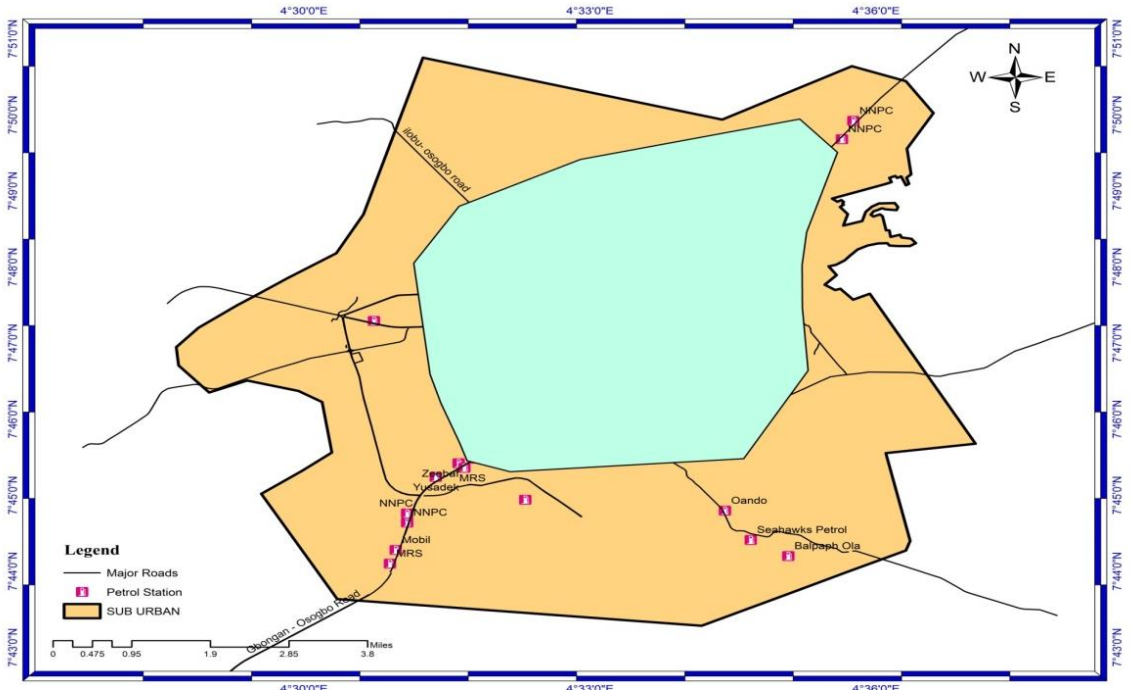

Figure 6. Spatial location of filling stations in the suburban zone of Osogbo
Source: Authors' compilation, 2021

Nearest Neighbour Analysis (NNA) of Location of Filling Stations in Osogbo

To determine the pattern of distribution of filling stations in Osogbo, the nearest neighbour analysis was used to establish the existing pattern of distribution as to whether the distribution is regular, random or cluster in the different residential zones of the study area. The model specify the degree to which any observed distribution deviates from what may be expected, if the distributions of points are random. The locations of filling stations in the study area were captured through handheld Global Positioning System (GPS) to determine the coordinates of the filling stations. Also the spatial analyses were carried out in the GIS form. The NNR has indices that range from zero (when there is no distribution at all) to 2.15 (when filling stations have a maximum spacing and are regularly distributed). The closer the calculated index value is to zero, the more clustered the distribution and conversely, also the closer the calculated index value is to 2.15, the more dispersed the distribution (Omole, 2002 cited in Olugbamila, 2016). A purely random distribution has an index of 1.0 value; above 1.0 indicate a tendency towards spacing and those below 1.0 indicate clustering that is,

$R_n = 0$: the distribution is clustered.

$R_n = 1$: the distribution is random.

$R_n = 2.15$: the distribution is regular.

In analysing the pattern of distribution of filling stations in the core zone as shown in Table 3, and Figure 7, the Rn of 0.52 is less than 1 which indicates that the distribution of filling stations were highly clustered. The z-score of -6.13 fall above -<-2.58 >+2.58 as a result of p-value of 0.0, (denoting +0.0 standard deviation away from the mean) which is less

than 0.05 critical levels; hence the probability that this clustered pattern could be the result of random chance.

Table 3. Result of NNA in the distribution of filling stations in the core zone of Osogbo

Zone	Observed Mean Distance	Expected Mean Distance	Nearest Neighbour index (Rn)	Z-score	P-value
Core	244.8752	464.0729	0.527	-6.128	0.000

Source: Authors' compilation, 2021

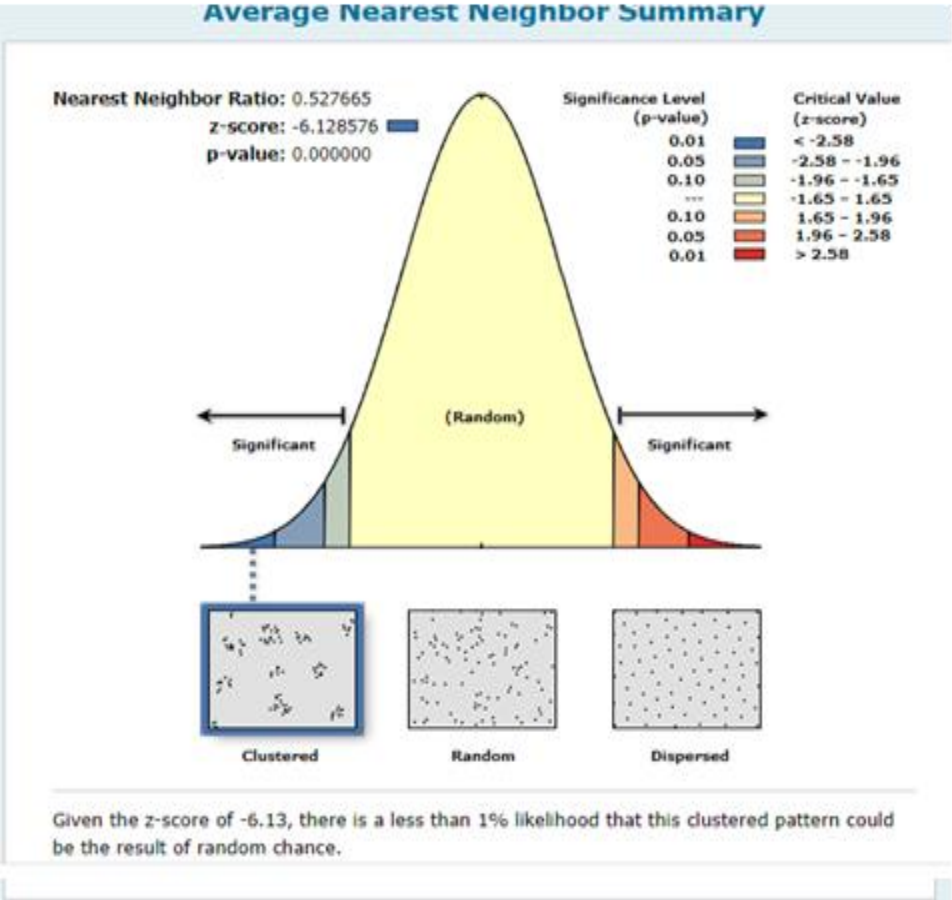

Figure 7. NNA of filling stations in the core area of Osogbo
Source: Authors' compilation, 2021

Presented in Table 4 and Figure 8 is the NNA result of filling stations in transition zone of Osogbo with Rn of 0.54 which is less than 1 and indicates that the distributions of filling stations is clustered in the transition zone of the study area. The z-score of -6.8 fall between -<-2.58 >+2.58 as a result of p-value of 0.0, (denoting +0.0 standard deviation away from the mean) which is less than 0.05 critical levels; hence there is the probability that this clustered pattern could be as a result of random chance.

Table 4. The result of NNA in the distribution of filling stations in transition zone

Zone	Observed Mean Distance	Expected Mean Distance	Nearest Neighbour index (Rn)	Z-score	P-value
Transition	282.556	518.597	0.544	-6.800	0.000

Authors' compilation, 2021

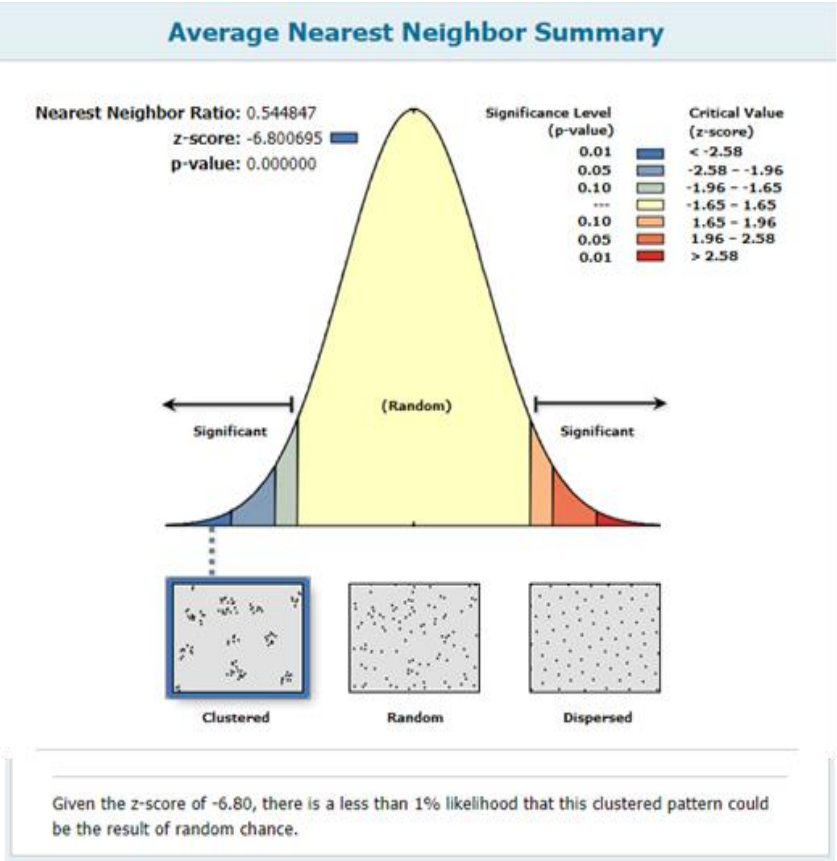

Figure 8. NNA of filling stations in the transition zone of Osogbo
Source: Authors' compilation, 2021

Presented in Table 5 and Figure 9 is the NNA result of filling stations in the suburb zone of Osogbo with Rn of 0.16 which is less than 1 and indicates that the distributions of filling stations is clustered in the suburb zone of the study area. The z-score of -5.9 fall between -<-2.58 >+2.58 as a result of p-value of 0.0, (denoting +0.0 standard deviation away from the mean) which is less than 0.05 critical levels; hence there is the probability that the observed clustered pattern could be as a result of random chance.

Table 5. The result of NNA in the distribution of filling stations in suburb zone

Zone	Observed Mean Distance	Expected Mean Distance	Nearest Neighbour index (Rn)	Z-score	P-value
Suburb	120.640	722.738	0.166	-5.960	0.000

Authors' compilation, 2021

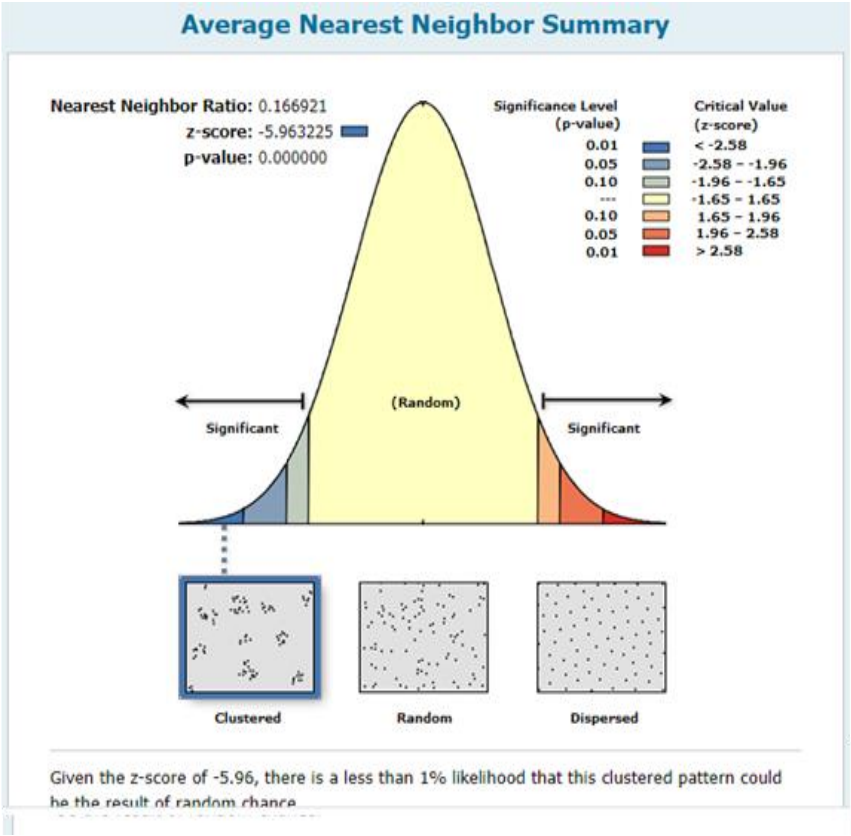

Figure 9. NNA of filling stations in the suburban zone of Osogbo
Source: Authors' compilation, 2021

The above results revealed that a high proportion of the filling stations are owned by independent marketers. Findings on the distribution pattern of filling stations in the different residential areas of Osogbo revealed that distribution of filling stations were highly clustered. The nearest neighbour index results show that core residential zone had an index of 0.52, while the transition and suburban zones had 0.54 and 0.16 respectively. However, the clustered patterns of filling stations distribution in the study area is an indication that planning standards are not adhered to when sitting filling stations.

Conclusion and Recommendation

The study concluded that in the different residential areas, there was significant variation in the location of filling stations, and as such, the pattern of distribution of filling stations differed invariably. Given these findings, it is important that recommendations that could enhance policy response are proffered. Based on the research findings the following were recommended: urgent need for development control activities to be enforced adequately so as to ensure that filling stations act in accordance with set standards. This would help in ensuring that filling stations are properly sited, thus curbing haphazard development of filling stations across the study area; The DPR and the planning agency should prosecute filling stations that defaults the existing guidelines and regulations. This can be by sealing the filling station for certain period of time, withdrawing their license of operation, revoking of their planning approval; as this will serve as a deterrent to other filling stations that want to flout the law. Also, regular awareness should be carried out to enlighten owners of filling station and developers of dangers of nonconformity to set standards.

It is therefore hoped that if these recommendations are adopted, problems associated with haphazard development of filling stations in Osogbo would be minimized.

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