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An Assessment on the Locational Pattern of Petrol Filling Stations along Lasu-Isheri Road Corridor

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Abstract
This study aimed at assessing the location and spatial distribution of petrol filling stations along LASU/Isheri Road, Ojo, Lagos state. The objectives are to map out all the petrol filling stations in along Lasu/Isheri road; to examine the volume of traffic along the road corridor; to determine the contribution of petrol filling stations to the traffic volume on the road, and to ascertain the road traffic challenges that are caused by the petrol filling stations (PFS). Geographical Positioning System (GPS) was employed to collect primary data; also, questionnaires and traffic count sheets were employed. The study found that the PFS along the road corridor is clustered with a Z-score of -7.34 and NNI of 0.440285. Also, the maximum peak hour volume was estimated to be 4198.6 pcu/hr. The PFS along the corridor are seen to contribute significantly to the traffic volume on the corridor. Finally, the dominant traffic challenges along the corridor include traffic gridlock which sometimes results into road traffic crashes which are triggered by the concentration of PFS in the study area, the proximity of PFS to a road intersection, overflow of the queue into the roadway, and to a minimal extent parking of tankers along the roadway and lack of setback. This study suggests strategies that can be adopted for locating PFS to ensure the free flow of traffic along the road corridor where they are located.

Keywords: Locational Pattern, Petrol Filling Station, Traffic Volume, Lasu/Isheri, Lagos State.

1. Introduction
The scientific inventiveness of man geared towards the development of the automobile and the discovery of petroleum triggered the building of petrol service stations at strategic locations to meet the demand of vehicle owners. Abdul *et al* (2009).However, in recent times, the rapid increase of urban population and the growth in vehicle ownership rate has generated various kinds of

demands, one of which is fuel. According to Adeniran *et al* (2017); Ekine and Okidim (2013), premium motor spirit (PMS) or fuel as it is normally called in Nigeria is the second most used product after food in Nigeria.

Petroleum is no doubt a predominant source of Nigeria's revenue and foreign exchange. It has occupied strategic importance in the Nigerian economy, accounting for as high as 78 percent of gross domestic product and up to 90 percent of the country's total annual revenue and foreign exchange earnings (National Bureau of Statistics, 2008). The increase in vehicles have triggered the increasing demands for fuel and consequently, the need for more fuel station to meet up with the demand since engines are made to use petroleum products. Given this development, many marketers take advantage of this need to build service stations haphazardly without considering the possible effect of the locations of the stations. It has now generally been recognized that economic development can be a major contributing factor to growing socio-environmental challenges particularly when such development is not sustainable (Blamah *et al.*, 2012)

The petroleum industry in Nigeria is divided into two main segments, 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 of crude oil at the terminal, transportation, supply, trading, refining distribution, and marketing of petroleum (Asada, nd). Activities of filling stations or petroleum outlets are part of the downstream sector. A Petrol Station, Filling Station, Gas Station, Fueling Station, or Service Station is a facility which sells fuel and lubricants for motor vehicles, the common fuel sold is petrol and kerosene. According to Keble (1968), in siting, a petrol station, accessibility, traffic impact, and environmental safety should be given due consideration. The development of commercial activities on arterial roadways often results in a change in traffic flow characteristics, an increase in traffic, and a change in accident characteristics. The environmental impacts of the locations of petrol stations are therefore not negligible and may not be ascertained unless an impact analysis is carried out.

In some major urban cities in Nigeria, land-use activities along arterial roads are not being regulated and coordinated, and as such expose the region to hazards such as traffic gridlock, pollution, accidents, fire explosion, and other environmental problems. According to (Ayodele, 2011), in highly urbanized areas, filling stations is a significant contributor to traffic problems such as traffic congestion, pollution, fire, and explosion. The extent of these problems depends on variables such as location, size, and distance from road e.t.c. Regions close to filling stations experience a lot of noise, congestion, and other traffic-related problems, especially when there is fuel scarcity which results in long queues causing an overflow of vehicles into the roadway thereby reducing the width of the carriageway meant for the efficient movement of automobiles and pedestrians. The resultant effect of such overflow and long queues is traffic congestion which in turn causes delays, loss of productive man-hour, increase in pollution, energy consumption, and environmental degradation amongst others. Ehinomen and Adeleke(2012) opined that the distribution of petroleum is a complex task that involves transporting and storing across the country.

Several studies (Ayodele, 2011, Msheila et al, 2015, Samuel *et al.*, 2015) have looked into the location of filling station and its impact on the environment in different regions of Nigeria. Ayodele (2011) examined the spatial distribution of filling stations in Kaduna North where the study identified the pattern and distribution problem in the area and found that there were about 22 filling stations in the area and the distribution is uneven as the stations are mostly concentrated along major roads. Also, the study looked at the setbacks and locational situation of these stations and concluded that 69.5% did not conform to the standard. *The study did not further consider the resultant effect of the non-conformity of filling station locations to set standards on traffic flow.*

Similarly, Mshelia *et al.* (2015) evaluated the environmental effects of the petrol stations in their neighborhoods in Maiduguri and Jere. The presence of petrol stations vis-a-vis residential houses within 100m radius of location in the township; hazards associated with their activities/operation; and the perception of residents/petrol stations workers on the effects pose by those petrol stations were critically examined. Only purposed -built petrol stations both functional and non-functional as of 2010 were considered in the study. Out of the 138 petrol stations in the study area, 122 (88.41%) were functional and 16 (11.59%) were non-functional. *The study did not pay particular attention to the impact of the spatial distribution of these filling stations on the free flow of traffic along the carriageway.*

Samuel *et al.* (2015) carried out a study on the proliferation of petrol filling stations about the minimum environmental safety requirements by the Department of Petroleum Resources (DPR) that 'distance from the edge of the road to the nearest pump and the next petrol filling station should not be less than 15 and 400 meters respectively. Findings from the z ratio analysis revealed that at 152 degrees of freedom and 95% confidence level, the petrol filling stations in the study area neither conform to the required distance of 400m apart nor conform to the required distance of 15m from the road. *The study failed to analyze further the impact of this non -conformity on traffic flow along the road.*

Other similar studies are Afolabi, Olajide, and Omotayo (2011) assessed safety practices in filling stations in Ile-Ife, South-Western Nigeria. Olapeju (2017) which assessed the location and spatial distribution of petrol filling stations in Ilaro, Ogun State. Ogundahunsi (2019)examined a locational analysis of fuel stations, in Ilesa, Osun State, Nigeria. The proliferation of petrol filling stations along the Lasu/Isheri road is quite disturbing. The road is one of the major arterial roads in Lagos state, it cut across two LGAs within the state, Ojo, and Alimosho Local Government Areas. It is a 16km long dual carriageway on which there are numerous filling stations haphazardly spread along with it and some more under construction. Filling Stations along the road were observed to be too close to each other; some even were developed side-by-side therefore having a higher propensity of enormous and wider effects on the immediate environment. This study, therefore, considered the assessment of the location and spatial distribution of petrol filling stations along LASU/Isheri Road, Ojo, Lagos state.

1.1 Aim and Objectives

This study aimed at assessing the location and spatial distribution of petrol filling stations along LASU/Isheri Road, Ojo, Lagos state. The objectives are to map out all the petrol filling stations in along Lasu/Isheri road; to examine the volume of traffic along the road corridor; to determine the contribution of petrol filling stations to the traffic volume on the road, and to ascertain the road traffic challenges that are caused by the petrol filling stations (PFS).

2. Methodology

This study is a survey research design that factor data sourcing from field observation, traffic survey, questionnaire administration, interview, and relevant literature.LASU/ISHERI road is a 16km road located between Latitude 6°28'27.1"N and longitude 3°12'08.6"E, which cut across two major Local Government areas; Ojo and Alimosho LGAs. About 70% of the length of the road lies within Alimosho LGA. These LGAs occupy the southwestern part of the Lagos metropolis with Alimosho LGAs been tagged as the largest LGA in Lagos state in terms of population with an estimated population of over

1,277,714(NPC, 2006). Ojo LGA, on the other hand, has an estimated population of 598,071 (NPC, 2006), and is located between latitude 60 22′N and 60 32′N and on longitude 30 4′E and 30 20′E. The local Government Area is bounded by six other local government areas and is among the seven Local Government Areas occupying the coastal plain of Lagos metropolis. The predominant land uses in this area are commercial, educational, religious, recreational, and residential land-use.

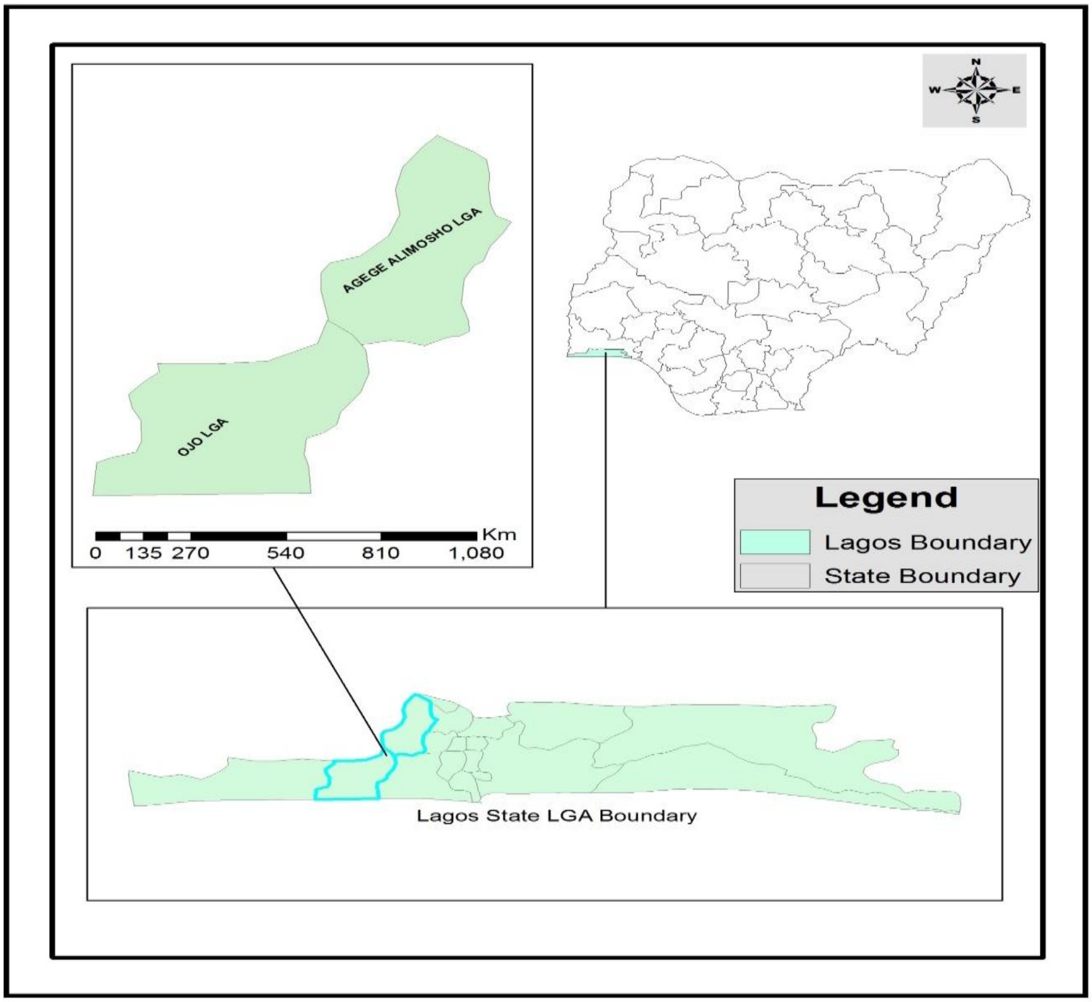

Figure 1.Map of Nigeria showing Lagos state and Lagos state LGA Boundaryhighlighting the LGAs under study.

LASU/Isheri road is a four (4) lanes dual carriageway with a width of 3.65metere per lane and an approximate length of 16km. The predominant land-use types along the road are commercial, educational, religious, recreational, and residential land-use. Filling stations are part of the commercial land use type present along the road. A total of 47 functional stations are spread along the road servicing the teeming population in the region (see Figure 2)

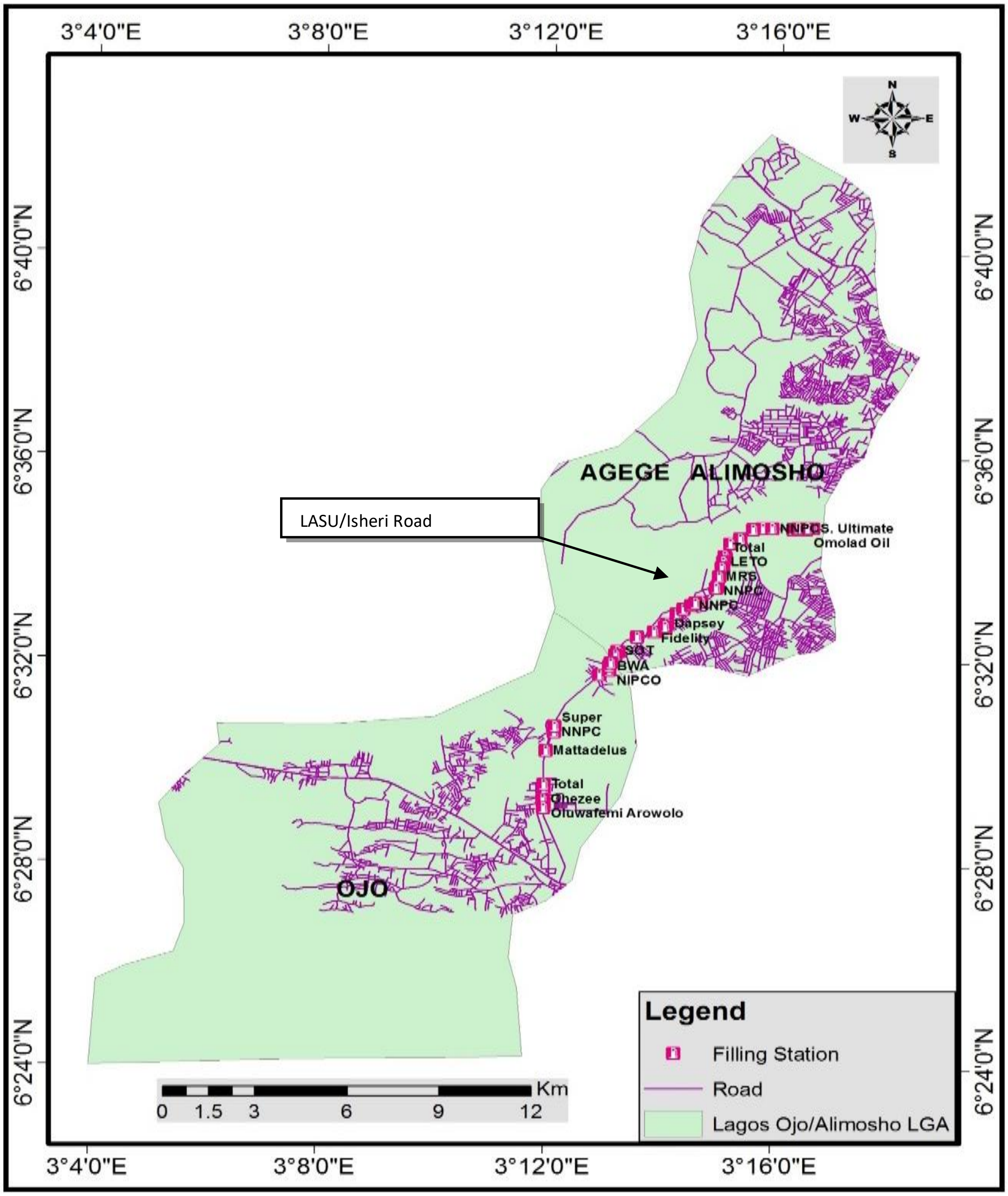

Figure 2.Study area map showing the road under study and the distribution of filling stations across it. Source: Author's spatial analysis (2017)

The primary data for this study was sourced for through physical observations, traffic surveys, administration of structured questionnaires, and interviews, this is in a bid to identify the filling stations within the study area. Data such as the coordinates of the filling station with which the exact location, distance, and the spatial distribution of the filling stations can be ascertained would be gotten through the use of a GPS device. The traffic volume data of filling stations and the road understudy was also collected. Secondary data was gotten from published journals, unpublished thesis, and relevant texts.

For primary data, the population of the study includes all the filling stations along the road under study, based on the reconnaissance survey carried out on the study area and a total of 47 filling stations were counted along the road. The number of population is the basis for the population of the study.

Table 1. Names of petrol filling stations in the study area

No.	Names of Filling Station	Location Address	No.	Names of Filling Station	Location Address
1	OluwafemiArowolo	Agboroko	24	Omolad Oil	Pako
2	Eterna	Estate Gate	25	S. Ultimate	Pako
3	Total	Ipaye	26	Petrocam	Orheptal
4	NNPC	Iba Express	27	Walesat	Power-line
5	Jomess	Obadore	28	Oyinade	Idowu Egba
6	NIPCO	Obadore, Afolabi	29	Jagam	Lanre
7	BWA	Afolabi	30	Total	Lanre
8	HABOL	Ewedogbon	31	Oleum	Pat-coll Drive
9	RT Evolution	O'mark Bus Stop	32	FBM	General
10	Ufedo Ojo	Olowonla	33	MRS	General
11	Best Option	Omolade	34	NNPC	Alhaji Ede
12	Y.T.K.	Igando	35	Dapsey	Olowonla
13	NNPC	Igando	36	Tad Oil and Gas	Olowonla
14	Conoil	College	37	Fidelity	Akesan
15.	Toluwalashe Oil	Carwash	38	Sabola Oil	Araromi
16	LETO	Lanre	39	SOT	Ewedogbon
17	Vitality	Lanre	40	Swift Oil	Adekson
18	Mustuk	Odo-Eran	41	Sungaz Oil	Vulcanizer
19	AASO	Idowu egba	42	Super	Iba Express
20	Swift Oil	Diamond Estate	43	Mattadelus	Iba Junction
21	NNPC	Diamond Estate	44	Techno Oil	Ipaye
22	Al-Moruff Oil	Power-line	45	Ghezee	Estate 1st Gate
23	Jonas Petroleum	Power-line	46	Odunade	Village
			47	De Potter Pet. Station	Igando

A stratified sampling technique was adopted in the study. During the reconnaissance survey carried out on the study area, a total of 47 filling stations were counted and coordinate reading was taken with a GPS device. The data was extracted from the GPS and imported into the Arc-GIS environment through which a Nearest Neighbour Analysis was carried out to get the spatial distribution of the filling station. The spatial map indicated that some of the filling stations exhibit high clustering, medium clustering, and low clustering. Thus, the population was divided into three (3) strata; high, medium, and low clustering, samples were then randomly drawn from this each stratum. The sample size for the study was derived based on the recommendation of the Institute of Transportation Engineers (ITE) for trip generation rate study which states that "if analyst intends to establish a local trip rate, it is recommended that at least three (3) sites or preferably, at least, Five (5) be surveyed" (ITE, Trip Generation Handbook). For this study, five samples would be drawn from each of the strata, giving a sample size of fifteen (15).

Also for the questionnaire administration, samples were drawn from the three (3) regions identified above; questionnaires were administered to the commuters at bus stops close to sampled filling stations. Therefore, questionnaires were administered at fifteen (15) bus stops across the road. Purposive sampling technique was adopted by the researcher in administering the questionnaire to sample commuters that are not in haste. Twenty (20) questionnaires were administered in each bus stop, 10 questionnaires were administered during the AM and PM peak periods respectively across the fifteen (15) bus stops, to realize three hundred (300) commuters sampled. The sample frame and size are summarized in the table below.

Table 2. Sample frame and size

SAMPLE FRAME	SAMPLE SIZE		
	Filling stations	Bus Stops	Number of respondents in each cluster
High clustered stations	5	5	100
Medium clustered station	5	5	100
Low clustered station	5	5	100
Total	**15**	**15**	**300**

Regarding the method of data analysis, spatial analysis (Nearest Neighbour Index Analysis) using the ArcView GIS Software was used to map out all the petrol filling stations along Lasu/Isheri road. Descriptive analysis (tables) was used to examine the volume of traffic along the road corridor. Descriptive analysis (table), ITE weighted average trip generation rate formula was used to determine the contribution of petrol filling stations to the traffic volume on the road. It was also used to ascertain the road traffic challenges that are caused by petrol filling stations (PFS).

Nearest Neighbour Analysis

This is the spatial analysis of the distance between a point and its closest neighboring point to determine if the point pattern is random, regular, or clustered. The nearest neighbor index is expressed as the ratio of the observed distance divided by the expected distance. The expected distance is the average distance between neighbors in a hypothetical random distribution. If the index is less than 1, the pattern exhibits clustering; if the index is greater than 1, the pattern is tending towards dispersion. The nearest neighbor index produces results that range from 0 to 2.15, a result of exactly 0 depicts clustering, 1 depicts randomness, and 2.15 depicts regularity.

The nearest neighbor index (NNI), R_n is given as:

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

Where:

R_n = NNI/the description of the distribution;

$\bar{d}$ = the mean of the observed nearest neighbor distance (km);

n = the number of the points in the study area;

A = the area under study (km^2)

Trip Generation Rates Analysis

To get the local trip rate of the study sites, the weighted average trip generation rate formula would be adopted from the ITE manual. The weighted average trip generation rate represents the number of trips per unit of the independent variable

$$\text{Weighted Average Trip Rate} = \frac{\sum Vehicletrips}{\sum Independent \quad variables}$$

…………... equation 3.3

Where:

Vehicle Trips = the total of all trips entering plus all trips exiting a site during a designated period.

3. Results and Discussion

Spatial Distribution/Pattern of the Filling Stations along Lasu/Isheri Road

From the survey carried out, there are 47 functional filling stations along the road corridor of study which is 16kilometers long. The survey was centered on the proximity of filling stations from one another along the road. ArcGIS 10.3 Spatial Statistics extensions were used to derive the distance between each feature centroid to that of the nearest feature (filling station). The result revealed that the observed mean distance between adjacent or close filling stations is 162.24 meters as opposed to the expected mean distance of 368.49 meters as proposed by the Arc-GIS software. The Arc-GIS software also revealed that the pattern of the petrol station along the road is clustered with a Z-score of -7.34. That is, there is a less than 1% probability that the clustering is a result of random chance. From Figure 3 a Z-score of less than -2.58 describes a clustered pattern. From Table 3 below, the nearest neighbor index is 0.440285. If the nearest neighbor index is less than one (1), the pattern exhibits clustering, and if the index is greater than one (1) the trend is the dispersion or competitive. Thus, the clustered pattern can be said to be severe in its clustering since its derivation from zero (0) is slight. The Spatial pattern map of filling station showing the severity of clustering at a different location the road is shown in Figure 4. Embedded in the cluster are different degree of clustering which includes, High clustering, medium clustering and Low clustering, each of these clusters have varying degrees of impact on the traffic flow on the roadway.

It is a widely known fact that the filling station is one of the major attractors of traffic amongst other land-use types. The clustering of filling stations along the corridor has a negative implication on the flow of traffic in that since the expected distance between each station has not been adhered to. The haphazard location violates the fundamental objective of planning which is providing the right site for the right use at the right time for the right purpose to achieve spatial functionality, efficiency, and aesthetics. During periods of fuel crises, queues of vehicles at few stations that had fuel often resulted in severe traffic hold-up on an adjoining road. This has negative implications for social and economic activities in the city.

Table 3. Average Nearest Neighbour Summary for Lasu/Isheri road.

Observed Mean Distance:	162.2388 Meters
Expected Mean Distance:	368.4862 Meters
Nearest Neighbor Ratio:	0.440285
z-score:	-7.340863
p-value:	0.000000
Dataset Information	
Input Feature Class:	Filling Station p
Distance Method:	EUCLIDEAN
Study Area:	25527031.306881

Source: Author's Spatial Analysis (2017)

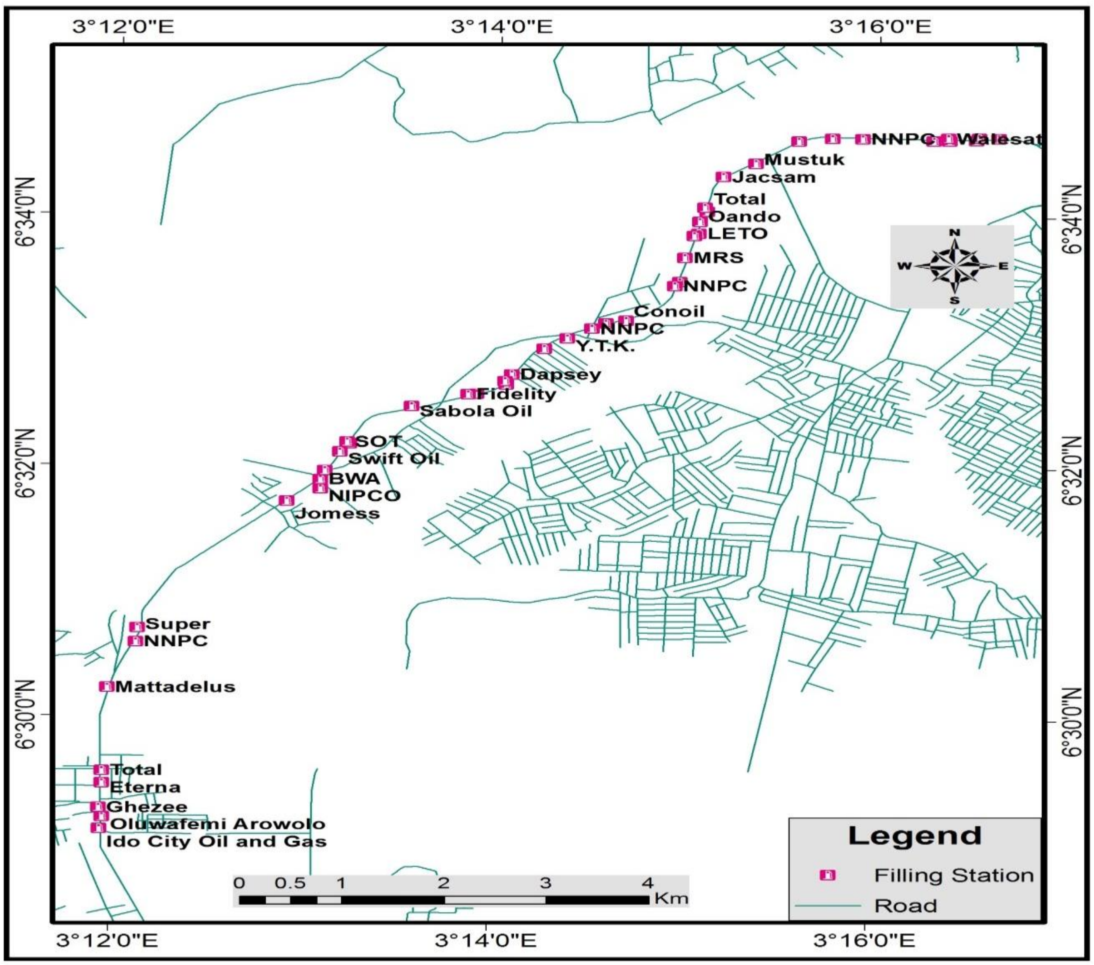

Figure 3: Spatial pattern of filling stations along Lasu/Isheri road

Source: Author's Spatial Analysis (2017)

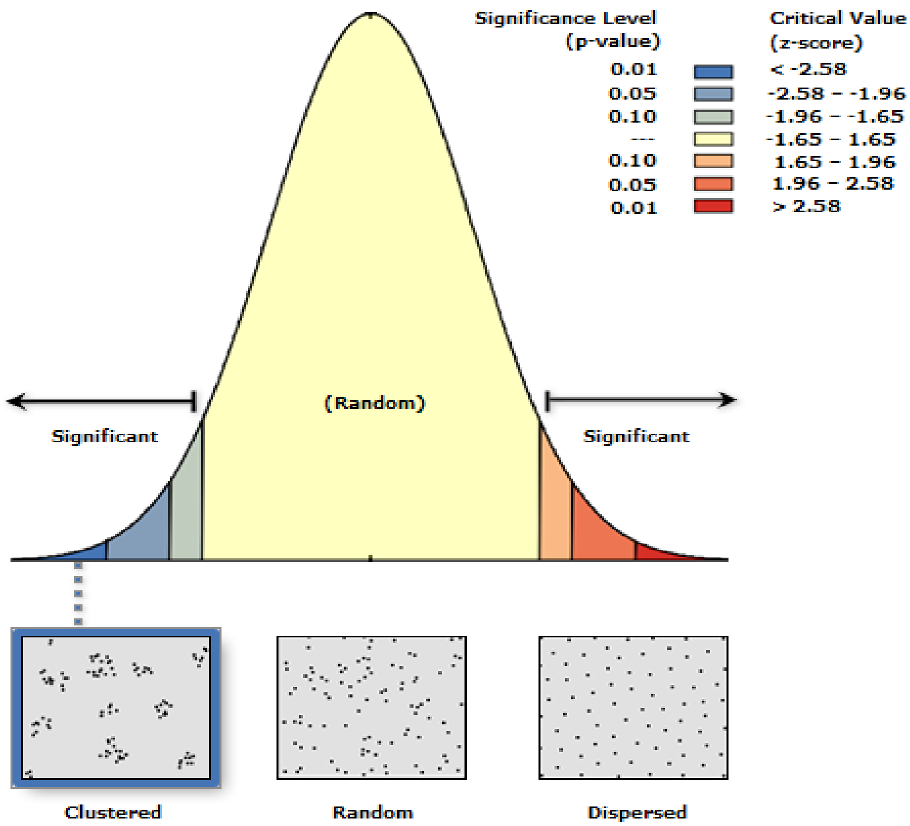

Figure 4: Nearest neighbor analysis of filling station location along Lasu/Isheri road.Source: Author's Spatial Analysis (2017)

Vehicle composition and volume of traffic along the road corridor

The volume of traffic along the corridor was converted to Passenger Car Unit which is a vehicle unit used for expressing highway capacity. One car is considered as a single unit, cycle, the motorcycle is considered as half car unit. Bus, truck causes a lot of inconvenience because of its large size and is considered equivalent to 3.0 cars or 3.0 PCU.

Type of Vehicle	PCU
Car, taxi, pick up	1.0
Cycle, motorcycle, Tri-cycle	0.5
Bus, truck,	3.0

Source: Wikipedia

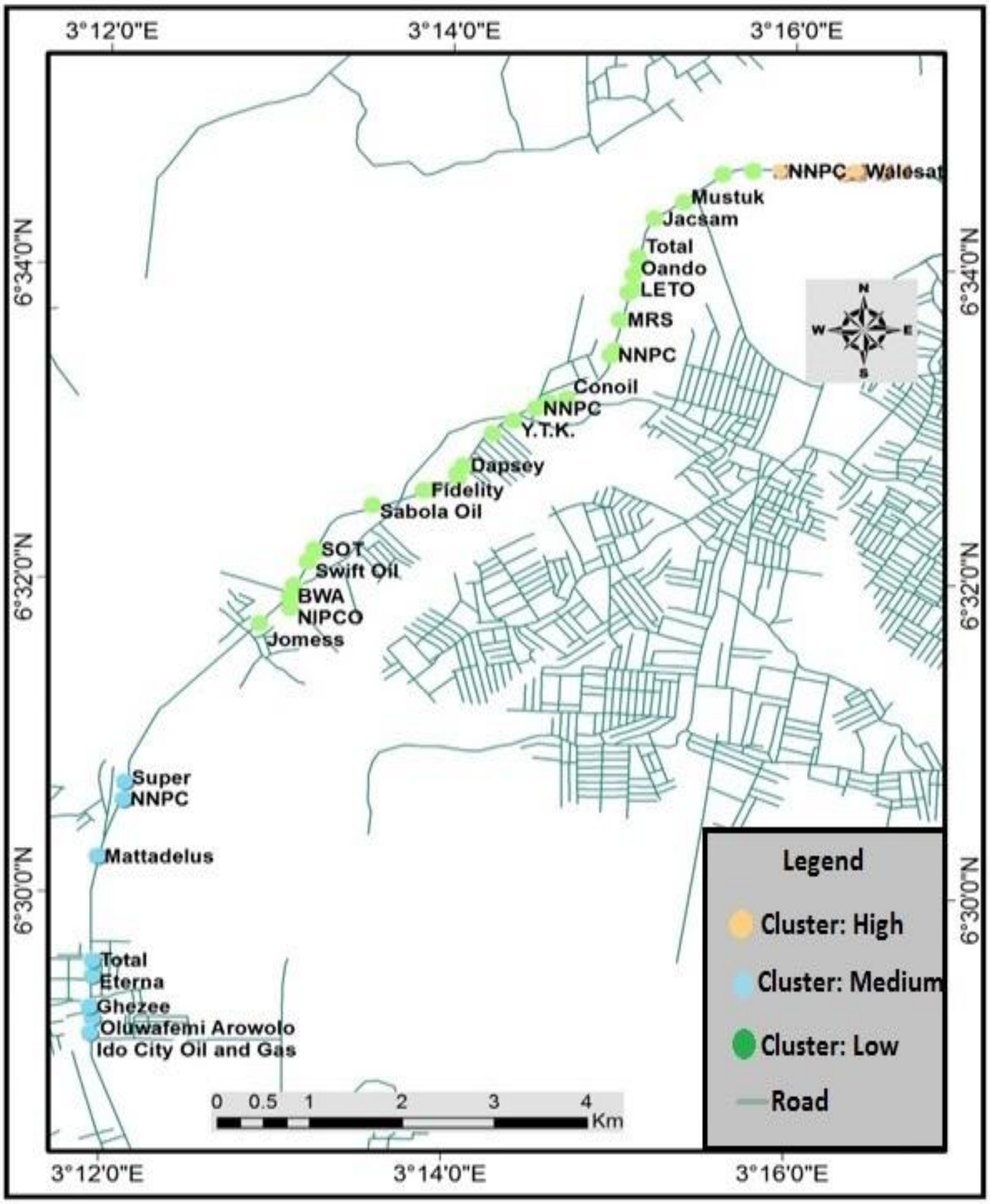

Figure 5: Spatial pattern map of filling station showing the severity of clustering at different location of the road

SOURCE: Author's Spatial Analysis (2017)

Figure 5 and Table 4 reveals the volume per hour variation among the days of the week. The maximum / highest hourly volume was estimated to be 3862.7 pcu/hr which was recorded on Monday. The lowest or minimum volume for the week was observed on Saturday (2210.1pcu/hr). This shows that the traffic volume along the road is usually high during weekdays and low on the weekend. The results of the traffic volume on the road depict a high level of land use activities going on in the area.

The volume of traffic along the road which is considerably high with a peak hour volume of (4198.6pcu/hr), reveals the reason why there is always traffic congestion on the road during peak periods, knowing high traffic volume have negative implications on traffic flow. It also explains the reason why there is a high demand on the petrol filling stations along the corridor necessitating in-flow and out-flow of traffic at filling stations which at times due to the haphazard siting of the filling station impedes traffic flow along the corridor especially during the period of fuel scarcity when there is usually spillover of queues to the roadway thereby reducing the carriage capacity of the road and consequently causing traffic congestion.

Table 5 Traffic Volume in PCU

Days of the week	Traffic vol. (pcu/hr)
MONDAY	3862.7
TUESDAY	3649.8
WEDNESDAY	3588.9
THURSDAY	2739.1
FRIDAY	2221.4
SATURDAY	2210.1
Maximum peak hour traffic volume(pcu/hr)	4198.6

Note: The maximum peak hour traffic volume was gotten by dividing the maximum peak hour traffic volume (3862.7) which was observed on Monday by the Peak Hour Factor (PHF): 0.92

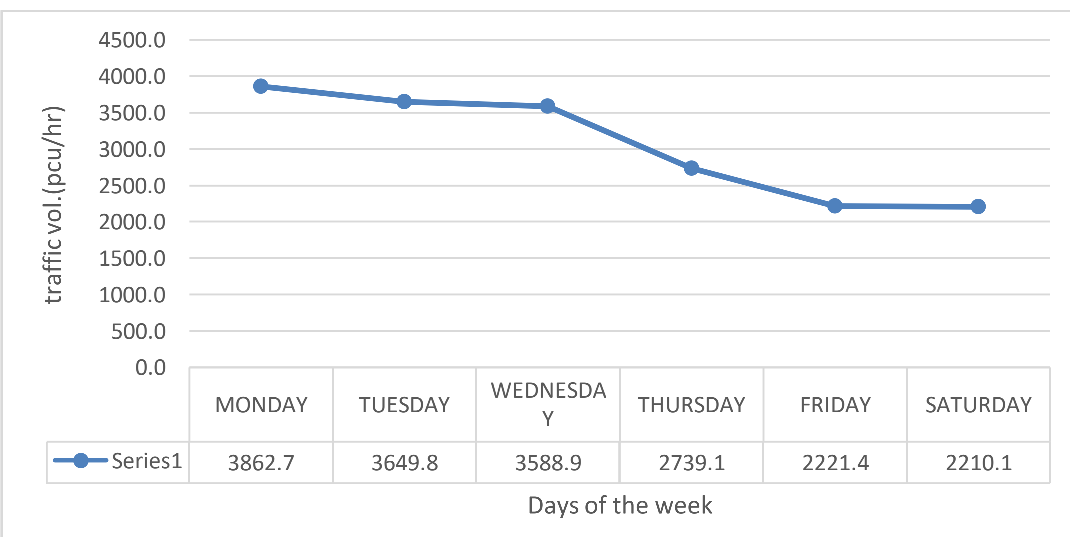

Figure 5.Average vehicular volume per hour variation for the week.

The contribution of filling stations to the traffic volume on the road

To ascertain the contribution of filling stations to traffic volume along the road, a trip generation rate analysis was carried out

The trip generation rate of petrol filling stations

The site selected for the study is chosen based on the region of the road that exhibits high clustering, medium clustering, and low clustering. Five (5) filling stations were randomly selected from each class and sampled. The site characteristics considered includes:

- Gross Floor Area (GFA): The Gross Floor Area of the filling station.
- The number of Fuelling Positions (FP): This is the number of available fuelling positions in the filling station.
- AM/PM Vehicular Entry and Exit: This refers to the volume of traffic entering and exiting the filling station per unit time.
- AM(Ante-Meridian) Peak Period: Morning peak period.
- PM (Post-Meridian) Peak Period: Evening peak period.

Characteristics of Highly Clustered Filling Station

Table 5 reveals the observed characteristics of the clustered filling stations within the study area. These characteristics to some extent enhance the efficiency of the filling station. Filling stations with extensive Floor Area can service more vehicles compared to ones with a small Floor Area. Likewise, the number of Fuelling Positions has direct implications on the service rate of filling stations. It can be inferred from the survey that the Gross Floor Area and several Fuelling Positions determine the rate of vehicular traffic attracted to the filling stations and also the level of Service of the filling stations. (see Table 5).

This explains the reason why there is always traffic gridlock around this region especially during periods of fuel scarcity. The volume of traffic attracted to the filling stations is high (due to large GFA and FP), queues from this filling stations tend to spill over to the roadway, the cumulative effect of this clustered station is seen in the severity of the traffic gridlock in this region.

Table 5. Site characteristic of high clustered filling stations

Filling Stations	Characteristics		AM trip		PM trip	
	GFA (Ft2)	FP	Vehicles Entering	Vehicles Exiting	Vehicles Entering	Vehicles Exiting
Petrocam	38180	18	413	266	430	393
Al-moruf	18320	14	263	159	213	109
S.Ultimate	12200	14	167	91	173	62
NNPC	29400	11	334	289	175	101
Swift Oil	7250	5	139	77	167	75
Average	21070	12.4	439.6		379.6	

Source: Author's Field Survey (2017).

Characteristics of Medium Clustered Filling Stations

The cumulative effect of the vehicular trip generated by these filling stations on the roadway during periods of high demands is mildly felt because they are not too clustered. However, in some cases, the impact is highly felt because the filling stations within the region have limited capacity in terms of GFA and the number of FP and are not able to efficiently service the teeming vehicular traffic it attracts. (see Table 6).

Table 6. Site characteristic of medium clustered filling stations

Filling stations	Characteristics		AM trips		PM trips	
	GFA (Ft2)	FP	Vehicles Entering	Vehicles Exiting	Vehicles Entering	Vehicles Exiting
Techno Oil	49579	8	284	252	282	198
Total Oil	6401	8	199	152	151	99
Ghezee	36103	10	186	152	191	121
Eterna Oil	9608	9	339	285	254	234
OluwafemiArowolo	7500	6	227	198	176	97
Average	21838.2	8.2	454.8		360.6	

Source: Author's Field Survey (2017)

Characteristics of Low Clustered Filling Stations

As seen in Table 4.7, the average GFA is estimated to be 28968.2ft² while the average number of fuelling position is 9, and the distribution of filling stations within this region are seen to tend towards dispersion. This explains the reason this region is mildly affected by the overflow of queue unto the roadway during periods of high demand. On average, the filling stations are said to have fair enough capacity to service the number of vehicular traffic it attracts.

Table 7. Site characteristic of low clustered filling stations

Filling station	Characteristics		AM trips		PM trips	
	GFA (ft2)	FP	Vehicles Entering	Vehicles Exiting	Vehicles Entering	Vehicles Exiting
Conoil	38430	10	144	109	102	89
Oando	19300	10	154	127	117	90
Tolohunlase	22325	8	299	245	185	130
NNPC Igando	29386	11	222	206	200	185
Total oil	35400	6	133	63	150	65
Average	28968.2	9	340.4		262.6	

Source: Author's Field Survey (2017).

AM/PM Peak Period Trip Data for the Filling Stations

The trip data for the AM peak period and the PM peak period of the days' data were collected are shown in Tables 8, 9, and 10 for filling stations that exhibit high clustering, medium clustering, and low distribution respectively. The trip rates shown are rates per number of fuelling positions (FP) and 1000 square feet of gross floor area (sq. ft. GFA). These rates are calculated using specifically the data collected during the same day.

AM/PM Peak Peri

The Vehicular trip generation characteristics of the clustered filling stations along the road under study are examined through the site characteristic survey. The preliminary estimates of vehicular trips generated by this type of land use are obtained and early peak (A.M.) and late peak (P.M.)Vehicular Peak hour rates needed for traffic impact assessments are established. The independent variables used for this study are selected due to their measurability from the study site. Tables 6 reveal the vehicular trip generation rate of each independent variables, 21 vehicular trips were generated per 1000ft^2 of gross floor area, 37 vehicular trips were generated per fuelling positions. Therefore, all things being equal, a filling station with 12 fuelling positions would generate (12x37) 444 vehicular trips during a typical AM peak period. Also, looking into the percentage of directional traffic in and out of the filling station, it is revealed that the percentage of vehicles entering the stations are higher than the ones exiting during peak periods, the situation is worst during PM peak period where 61.01% of the trip to the station is recorded entering the station while only 38.99% was recorded exiting the station within the same hour. This suggests that the service rate is low within the region which thus leads to long queues at the stations and the adjacent road.

Because the region where these rates are generated from is clustered (i.e. the observed distance between the filling stations is short), the cumulative effect of trips generated by each filling station hurt the flow of traffic within the region, especially during periods of high demand where the trip to filling stations rise by almost 20-50%. During this period, cases of spilled queues unto the roadway may arise from almost all the filling stations within the region thereby resulting in serious traffic gridlocks which consequently make traffic movement through the region stressful, and time and energy-consuming.

Table 8. AM/PM Peak Period Trip Data for High Clustered Filling Station

Variables	Weighted average vehicular trip rate of high clustered FS
AM Peak Period Trip Data for High Clustered Filling Station	
Peak hour	7 AM – 9 AM
Average trips	439.6
Trip rate (per 1000 ft^2 GFA)	20.86379
Trip rate (per fuelling position)	36.63333
% Entering	59.87%
% Exiting	40.13%
PM Peak Period Trip Data for High Clustered Filling Station	
Peak hour	4 PM – 6 PM
Average trips	379.6

Trip rate (per 1000 ft^2 GFA)	18.01614
Trip rate (per fuelling position)	31.63333
% Entering	61.01%
% Exiting	38.99%

Source: Author's Field Survey (2017).

AM/PM Peak Period Trip Data for medium clustered Filling Station

The trip generation characteristics of the regions that exhibit medium clustering of filling stations along the road under study are examined through the site characteristic survey. As observed in Table 7, the trip generation rates per 1000ft^2 GFA and FP are 21 and 57 vehicular trips during the AM peak period and 17 and 45 vehicular trips respectively during the PM peak period. Considering the percentage of trips that enters and exits the station within the same hour, it is revealed that the number of vehicles entering the station is higher than the ones exiting, especially during PM peak period were 58.46% of trips at the stations entered and only 41.54% exited within the same hour which depicts that there are always queues in the stations within the region.

The high volumes of traffic that the filling stations within the region experienced during the peak hour can lead to spillback into adjacent roadways and thereby increase the potential for traffic congestion and collisions and this potential is high for this region because the filling stations are to a certain degree clustered.

Table 9. AM Peak Period Trip Data for medium Clustered Filling Stations

Variables	Weighted average vehicular trip rate of medium clustered FS
Peak hour	7 AM – 9 AM
Average trips	454.8
Trip rate (per 1000 ft^2 GFA)	20.8259
Trip rate (per fuelling position)	56.8500
% Entering	54.31%
% Exiting	45.69%
PM Peak Period Trip Data for medium Clustered Filling Stations	
Peak hour	4 PM – 6 PM
Average trips	360.6
Trip rate (per 1000 ft^2 GFA)	16.5124
Trip rate (per fuelling position)	45.0750
% Entering	58.46%
% Exiting	41.54%

Source: Author's Field Survey (2017).

AM/PM Peak Period Trip Data for low clustered Filling Stations

The trip generation characteristics of the regions that exhibit low clustering of filling stations along the road under study are examined through the site characteristic survey. From the collected data, it was determined that the average trip generation rate during a typical AM period was 11.74trips per 1,000 square feet GFA and the PM peak hour was 9.07 trips per 1,000 square feet GFA. Likewise, the filling stations were found out to generate 37.8 and 29 trips per fuelling positions during AM and PM peak periods respectively. Also, the percentage of trips entering the station is higher than the ones exiting, which shows there is a queue in the stations. Despite the high volume of trips generated by the stations in this region and the rate of the queue at the stations, the impact will be minimally felt by the roadway because the stations are spaced and not close to each other. See Table 4.10 for details.

Table 10. AM/PM Peak Period Trip Data for low clustered Filling Stations

Variables	Weighted average vehicular trip rate of low clustered FS
AM Peak Period Trip Data for low clustered Filling Stations	
peak hour	7 AM – 9 AM
Average trip	340
Trip rate (per 1000 ft^2 GFA)	11.7370
Trip rate (per fuelling position)	37.7778
% Entering	55.93%
% Exiting	44.07%
PM Peak Period Trip Data for low clustered Filling Stations	
peak hour	4 PM – 6 PM
Average trips	263
Trip rate (per 1000 ft^2 GFA)	9.0651
Trip rate (per fuelling position)	29.1778
% Entering	57.43%
% Exiting	42.57%

Source: Author's Field Survey (2017).

Summary of the percentage contribution of filling stations to the traffic volume along with the road understudy

Tables 11a and 11b reveal the contribution of filling stations to the traffic volume along LASU/Isheri road during AM and PM peak periods respectively. It is shown that filling stations' contribution to traffic volume during the AM peak period is higher than its contribution during the PM peak period for the high, medium, and low clusters.

However, the contribution to traffic volume differs with varying degree of clustering of the stations. The high clustered stations are seen to contribute more to traffic volume along the road corridor with 21.2% contribution rate followed by the medium clustered stations and low clustered stations which contributes 21.2%, 15.6% respectively, as seen in (Table 11c).

This exposes that filling stations along the road corridor contributes significantly to the traffic volume on the road. An increased traffic volume brings about a corresponding increase in traffic problems experienced on the road if it is not properly managed. The areas where highly clustered filling stations are located are the worst hit by the traffic flow problems experienced during the AM peak period.

Table 11a: Percentage contribution of filling stations to the traffic volume along the road corridor during AM peak period

Level of clustering of filling stations	Number of trips generated during peak period (pcu/hr)	Percentage contribution of filling stations to the peak hour traffic volume (4198.6pcu/hr) along the corridor.	Implications
High clustered stations	477.8	11.4%	Increase in traffic volume during AM peak period Reduction in traffic flow rate during AM peak period. Increase in traffic density Increase in the traffic flow problems
Medium clustered stations	494.4	11.8%	
Low clustered stations	369.6	8.8%	

Source: Author's Data Analysis (2017)

Table 11b: Percentage contribution of filling stations to the traffic volume along the road corridor during PM peak period

Level of clustering of filling stations	Number of trips generated during peak period (pcu/hr)	Percentage contribution of filling stations to the peak hour traffic volume (4198.6pcu/hr) along the corridor.	Implications
High clustered stations	412.6	9.8%	• Increase in traffic volume during PM peak period • Reduction in traffic flow rate during PM peak period • Increase in the propensity for traffic congestion to occur
Medium clustered stations	392.0	9.3%	
Low clustered stations	285.4	6.8%	

Source: Author's Data Analysis (2017)

Table 11c Summary of the contribution of filling stations to the traffic volume along the road corridor

Level of clustering of filling stations	Number of trips generated during peak period (pcu/hr)	Percentage contribution of filling stations to the peak hour traffic volume (4198.6pcu/hr) along the corridor.	Implications
High clustered stations	890.4	21.2%	Increase in traffic volume Reduction in traffic flow rate. Reduction in the LOS of the road on days when demand

Medium clustered stations	886.4	21.1%	on fuel is high and during peak periods. Increase in traffic flow problems.
Low clustered stations	655	15.6%	

Source: Author's Data Analysis (2017)

The concentration of filling stations

Regarding the concentration of petroleum filling station in the study area, 81.7% of the sampled populations are of the view that the petrol filling stations are too many and close to each other on the 16km length of the road, while only 16.7% indicated that the filling stations are not too concentrated. This is a pointer to the reason there is always congestion on the road during periods of fuel scarcity and high demand. This clustering has a combined effect on the roadway.

Filling Station as Part of the Causative Factor of Traffic Problems

From the study, 91.7% of the respondents perceived that the petrol filling stations across the road contribute significantly to the traffic problems experienced on the road.

Predominant traffic problem experienced on the road

From the study, 69.3% of the respondents agreed that the predominant traffic problem caused by filling stations along with the road traffic congestion, which in turn result in delay and waste of productive man-hour, excessive burning of fuel, air, and noise pollution to mention but a few. Other problems include Road traffic crashes (24%), Fire accident (2.7%) and traffic law abuse (1%)

Reasons for the observed traffic problems

As gathered from the respondents, the reasons for the traffic problems on the road are as follows:

a. As seen in Table 12, 59.3% of the respondents agreed that stations situated close to U-Turns or intersections on the road cause traffic gridlock. Long queues form the filling station extending into the roadway oftentimes makes negotiating the U-turns/intersections difficult. Also, vehicles do illegal stop by at filling stations to pick up passengers instead of the dedicated bus-stop therefore most times causing traffic delay on the road especially when the station is close to an intersection.
b. 54.3% reported the blatant disregard for the setback to the adjoining road regulations by filling station owners. The filling stations setbacks are not enough to accommodate excess queues and the turning movement of long vehicles. This consequently results in traffic gridlocks and road traffic crashes.
c. Often queues from filling stations extend into the roadway thereby impeding the flow of traffic. 92.3% of the respondent agreed to the fact that this factor is a major reason for traffic gridlock on the road especially during periods of high demands.
d. The clustering of filling stations also adds to the traffic challenges experienced on the road. Petrol Stations along the road were noticed to be too close to each other; as supported by 78.3% of the respondent, some were even developed side-by-side- side thereby resulting in a wider negative impact on the immediate environment.

e. Wrong parking by tankers about to off-load fuels on the roadway also disrupt the free flow of traffic along the road. Though this is not a common sight on the road, however, on days when it does happen, it results in a serious traffic bottleneck.

f. Also, 86.7% of the respondent indicated that often, the turning movement of petrol tankers and other vehicles in and out of filling stations impedes traffic flow along the carriageway.

Table 12. Reasons for the observed traffic problems

Reasons		Yes	No	Void
The proximity of filling stations to U-turns/Road intersection	Freq.	179	91	30
	%	59.3	30.3	10.0
Lack of setback of filling stations from the roadway.	Freq.	163	99	38
	%	54.3	33.0	12.7
Overflow of the queue from Filling station into the roadway especially during fuel scarcity	Freq.	277	12	11
	%	92.3	4.0	3.7
Filling stations are too close to each other	Freq.	235	31	34
	%	78.3	10.3	11.3
Parking of petrol tankers along the roadway	Freq.	137	142	21
	%	45.7	47.3	7.0
Turning movement of petrol tankers and other vehicles in and out of filling stations	Freq.	260	32	8
	%	86.7	10.7	2.6

Source: Author's Data Analysis (2017)

From the results, it is revealed that the siting of filling stations on the road exhibits clustering with a Z-score of -7.34 and the nearest neighbor index of 0.440285. The northern part of the road exhibits high clustering of filling stations while regions towards the south show a medium clustering. The central region of the road showed low clustering of the filling station. This could be attributable to the differential in the land use activities in the different parts of the road. Land use activities around the region with high clustering include recreational, religious, residential, and a lot of small and medium scale businesses. This activity attracts a large number of vehicular traffic which eventually gets serviced by the filling stations around. Similarly, land-use activities in the region with low clustering includes educational (Lagos state university), a major residential estate, and lots of small and medium scale businesses which attracts high traffic to the region thereby increasing the attractiveness of the region to filling station investors which in turn poses a negative implication on the free flow of traffic in the region.

The maximum peak hour traffic volume on the road was estimated to be 4198.6pcu/hr. This results in high vehicular density along the road, especially during peak periods. This also contributes to the length of queues at the filling stations, in that more vehicles are queuing for fuel unlike in areas dominated my High Occupancy Vehicles (HOVs). These queues inevitably spread unto the roadway during periods of high demand for fuel thereby reducing the capacity of the roadways and therefore causing a traffic bottleneck.

As also revealed by this study, the average number of trips generated by the stations can be said to be high considering the number of trips generated per site characteristics such as the Gross Floor Area, Fuelling Positions, and AM & PM traffic volume on the adjacent roadway. The contribution of filling stations to the traffic volume on the road is estimated to be 21.2% for the high clustered stations, 20.9% for the medium clustered stations, and 15.6% for the low clustered stations. These high volumes of traffic attracted by the stations to the region pose a degree of traffic hazards such as traffic congestions and its attendant problems.

Finally, as gathered from the survey carried out on the study area, it was revealed that the traffic impact of filling stations is not to be undermined judging from the result of the traffic problem analysis. The dominant traffic problems as gathered from the survey include, traffic gridlock which sometimes results into road traffic crashes which are triggered by the concentration of filling station in a region, the proximity of filling station to a road intersection, overflow of the queue into the roadway, Turning movement of petrol tankers and other vehicles in and out of filling stations, parking of tankers along the roadway and lack of setback.

4. Conclusion and Recommendations

This study has observed that the siting of petrol stations on the study road are not evenly distributed as some pattern show a high clustering, medium clustering and low clustering as shown by the nearest neighbor index analysis, the filling stations spread across the road are too many, there is over 47 filling station on the 16km long road and some are still under construction. Judging from the number of trips attracted to the area by the filling stations especially the highly clustered ones, it can be said that the clustering of stations within a region has a negative implication on the flow of traffic on the roadway. Certainly, this is as a result of the utter disregard for planning regulation on the minimum distance that must exist between filling stations set by the department of petroleum resources (DPR) practiced by oil marketer and it may perhaps be due to the overt increase in human population and vehicular ownership and other domestic/industrial equipment that consumes fuel. This incessant increase in demand for fuel has resulted in the establishment and spread of fuel filling stations in towns and cities today. Even though there is a need to make sure that fuel is readily available in every region of the nation as it is a major source of energy and therefore important for the economic development of a nation, its negative impacts from the processes of fuel retailing should not be overlooked.

It is therefore pertinent to note that, location of filling stations along a major road corridor should be strictly regulated and monitored, due regards must be given to planning criteria, safety, and environmental concerns, knowing that citing filling stations haphazardly have a negative implication on traffic flow especially during the period of high demand on fuel.

5. Recommendations

To alleviate the identified traffic impacts of filling stations on the roadway and also for future development, recommendations are made based on the findings from the study and views of respondents toward inhibiting such impact. Recommendations made from the findings. There should be:

i Strict enforcement to reduce clustered petrol filling stations; and

ii Adoption of seamless traffic management techniques such as directional signs, etc. particularly around petrol filling stations.

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Appendix

RESEARCH QUESTIONNAIRE

DEPARTMENT OF TRANSPORT MANAGEMENT TECHNOLOGY

SCHOOL OF MANAGEMENT TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE

ONDO STATE

Dear sir/madam,

I am conducting research titled **"the impact of land use on traffic flow: a study of filling stations along LASU/Isheri road".** Kindly answer the following questions for me as frankly as possible. All you are required to do is to simply tick the answer of your choice. No names are required. I promise that the responses will be treated with strict confidentiality and used for the stated purpose.

Thanks

Akinsulire, Esther Seun

Researcher

SECTION A

1. Gender: (a) Male (b) Female
2. Age: (a) 18 – 25 years (b) 26 – 33 years (c) 34 - 42 years (d) 43 – 50 years (e) 50 and above.
3. Educational Status: (a) primary (b)Secondary (c) Tertiary (d) No formal education

SECTION B

4. Do you reside within this region? (a) Yes (b) No
5. If yes, for how long? (a) 0 - 5 years (b) 6 - 10 years (c) 11 - 15 years (d) 16 - 20 years (e) 21 years and above
6. Are you very familiar with Lasu/Isheri road? (a) Yes (b) No
7. If yes, do you agree with the fact that there are too many filling stations located along the road? (a) Yes (b) No
8. If yes, are these filling stations causing traffic problems along the road? (a) Yes (b) No
9. If yes, which of these problems is predominant? (a) Traffic congestion (b) Road traffic crashes (c) Fire accident (d) petrol spillage on the road (e) others, (Pls specify)..
10. Which is/are the reason(s) for the problems above? Please tick (√) as appropriate

REASONS

The proximity of filling stations to U-turns/ road intersection
Lack of setback of filling stations from the roadway.
Overflow of the queue from Filling station into the roadway especially during fuel scarcity
Filling stations are too close to each other
Parking of petrol tankers along the roadway
Turning movement of petrol tankers and other vehicles in and out of filling stations