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Analysis of the Spatial Distribution and Characteristics of Petrol Filling Stations in Minna, Niger State

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Abstract

In many developed countries, urban growth has an increased use of automobile manufacturing, in turn influencing the need for fueling services and consequently the construction of petrol filling stations, which lack the minimum requirements for operation according to the DPR criteria for PFSs. The study analyzed the distribution and characteristics of petrol filling stations, which was supplemented using GIS techniques and tools like buffers and the average nearest neighbor tool, and integrated with the physical planning standards set by the Department of Petroleum Resources (DPR). However, names and street addresses of the PFSs were obtained from through field observation. Maps, field observation, and satellite images were used to collect locational information about the area. The result indicates that there are 79 petrol filling stations located in the Minna metropolis. Premium Motor Spirit (PMS) is the major product traded by the stations; the overall pattern of the distribution of PFSs in the area is clustered where the z-score is -7.864847 and the pvalue is 0.000000 as the Nearest Neighbor index is <1. The major factors governing the spatial distribution and characteristics of filling stations are the traffic flow and exit site from the city, which are part of the owner‘s preference. However, most of the petrol filling stations had not satisfied the minimum requirement of 1089 m² land area, 50 m set back

from the nearest residential structures representing 25.3% and (20.8, 32.1, 29.2%) respectively. Also, many stations had not met the criteria of 400 m minimum distance to other stations on the same axis, representing 84.8%. The study concluded that the substandard requirement of PFSs in the study area poses threats on the health and safety of users and residents in the vicinity and environs. Based on these findings, it is recommended that the regulatory agencies take proactive planning measures and integrate GIS in a manner that ensures that filling station operators comply with the standard.

Keywords: Analysis, Spatial Distribution, Characteristics, Petrol Filling Stations, Minna.

Introduction

The advancement of technology in the automobile industry has a significant influence in the petroleum industry which also propelled the building and redevelopment of petrol service stations (petrol filling stations) at strategic locations to meet the demand of vehicular operations (Abdul *et al*., 2009). Petroleum products have played more significant roles in the country's economy. Chinambu (2011) acknowledged that petroleum is the key driver of industrial activities. Studies have shown that a petrol filling station is a facility where fuel and lubricants for automobiles are sold (Sangotola *et al.*, 2015). Petrol filling stations are installations that sell petrol (PMS—Premium Motor Spirit), diesel (AGO—Automobile Gas Oil), and kerosene for public consumption; however, some are incorporated with other land uses (Mshelia *et al.*, 2015). In recent times, there has been a sustained increase in the number of petrol stations established in different parts of the country. The reasons for such unprecedented increase include: the growing number of population in the country influencing the attendant increase in the purchase of vehicles, the attractive price of petrol both at control price and black market prices which made more people to go into the petrol retailing business (Uchegbu, 2002). However, many marketers take advantage of this need and build service stations haphazardly without giving consideration to the possible effect of the location of the service stations on other land-use determinants. It has now generally been recognized that economic development can be a major contributing factor to growing

environmental problems, particularly when such development is not sustainable to adjoining land use (KASUPDA, 2009). The increase in human population globally is a causal factor for the increase of automobiles as such an influential factor in the petrol filling stations, which provide fuel and lubricants on which automobiles run (Afolabi *et al.*, 2011). This prompts the need for control and management of future development of petrol filling stations (Ministry of Housing and Lands, 2012). This form of land use has socio-economic and environmental impact either negatively or positively on the society which includes provision of convenient goods and services, business opportunities and competition between petrol filling station, leakage of fuel on surface and ground water thereby leading to pollution, pollution of storm water runoff also result in pollution of the immediate environment, generation of traffic and risk of explosion due to the flammable nature of petrol (Weyer, 2011). In the Petroleum Act of 1969, some of the regulations stipulated to avoid and mitigate the negative impacts of petrol filling stations include ―employees hired on a site shall be educated on how to utilize the fire-fighting equipment,‖ directives to employees in case of fire shall be clearly and concisely expressed and prominently displayed,‖ and "no smoking" symbols shall be posted as needed in restricted areas,‖ etc.

Most of these petrol service stations sell petrol, diesel, and kerosene. PFS are characterized in terms of locational optimization by population and service it renders, such as automobile repairs, car washes, and mini shopping complexes. Filling stations highly contribute to traffic problems such as traffic gridlock, pollution, fire, and explosion in most cases in urban settlements in Nigeria (Ayodele, 2011). As documented in Mohammed, Musa and Jeb (2007), it is recommended by DPR provides certain standard for PFS and should be sited away from usual human traffic, secluded from entrance of buildings and also public congregation place; however, petrol filling stations are distributed haphazardly due to the corollary of the lack of development control and non-conformity with planning standards in urbanized settlements. Though, planning oddities are expressed in poor sitting, inadequate size of land allocated, limited set back from other land use like residential property, road and poor radius allowance from major facilities like worship place and school (Mohammed *et al*, 2007). This culminates in environmental hazards and disamenities such as traffic congestion, fire, pollution, and many problems resulting from uncoordinated development. The Minna metropolis is a developing urban city, considering its expansion had also witnessed the proliferation of PFS, most of which are poorly sited and essentially

disregard to planning standards. This study is also borne out of the non-existence of spatial data in respect of petrol filling stations in the area, as no study has been conducted in this regard. Presenting information on the pattern of distribution of petrol filling stations in Minna metropolis is required given the city‘s rapid spatial growth. The primary goal of this study is to close the gap by analyzing the spatial distribution and characteristics of petrol filling stations in Minna metropolitan area. It also examines the conformity and extent of adherence of distribution with physical planning regulation. It further looks at the effects on adjoining land uses. By means of preemptive and counter-planning measures, Minna can optimize its economic benefits while averting possible menace arising from planning standards and managing its development in Minna.

Literature Review and Conceptual Framework

The debate on the theoretical exposition begins with the obnoxious facility location model, which categorizes facilities into desired and undesired, with desired facilities placed in close areas and undesired facilities in nearby areas. The location of a petrol filling station is a significant issue, requiring consideration of population, distance, and time for drivers to slow down (Rana and Garg, 2014).

Due to the need for software with intuitive user interfaces, the use of GIS in spatial analysis has grown in popularity in recent years. Research has demonstrated that GIS has a significant influence on the locational analysis of gas stations in urban areas. According to Camellia (2010), drivers in Abidjan look for solace in locating the closest gas station that appears to be accessible. The integration of GPS and GIS technology for database and digital mapping for effective and efficient information management served as the foundation for Emwandongo's (2013) research. However, it was shown that GIS-based technology was capable of analyzing the spatial distribution of service utilities such as PFS in a study carried out in Kaduna by Ayodele (2011). However, this study represents the initial attempt to use the application. According to Mohammed et al. (2007), location science dates back to Pierre de Fermat and his contemporaries, including Battista Cavallieri (1526–1597) and others, who theorized the Euclidean spatial median problem in the early seventies. Alfred Weber's theory sometimes referred to as the location triangle for industrial location, states that the best place to produce a good is where the point of production is closest to the market and the source of raw materials. Centrality is the quality and accessibility of being at the center of the transportation system (Inyang and Ogbonna, 2001). However, the model for the location of

annoying facilities was based on what was wanted and what was not, with facilities in livable areas being considered desirable and others capable.

METHODOLOGY

Minna is a city in the west-central Nigeria predominantly occupied by the major ethnic groups Hausa, Gwari, and Nupe. It is the capital of Niger State and the headquarters of Chanchaga local government since the creation of Niger State in 1976. It has an area of 884 hectares and a population of 304,113, with an estimated 513,491 by 2024. It is located on longitude 6o 33‘ 26‖ of the equator and latitude 9o 36‘ 45‖ of the Greenwich meridian. It houses all of a full-fledged local government's administrative and operational needs as the municipal council's headquarters. Minna extends from the North by its boundary with Bosso local government at 8 km and from the centre of the town is the Obasanjo shopping complex roundabout, and finally bounded on the east, south, and west with Bosso extensions (Census, 2006).

The sample population of this research is 79, which is the frame of all the petrol filling station in Minna metropolis of Niger state, as it includes the attendant of the each PFS. Since the population is of a high number, the entire population size would be used as it includes three (3) respondents (attendant) at each petrol filling stations therefore the population size of the respondents at the petrol filling stations is 237.

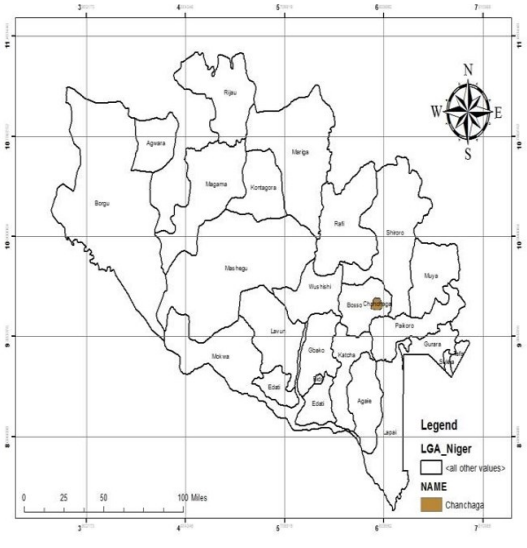


Figure 1: Map of Niger State showing The study area.



Figure 2: The study area

Objectives	Data Required	Instrument for collecting data	Methods of data analysis	Data presentation
To identify the existing spatial distribution and its characteristic pattern of PFSs.	Location; Number of pumps; Year of existence, Types of services	Physical Observation and use of GPS	Descriptive Analysis	Table, graphs and map
To assess the factors responsible for the pattern of distribution	Ownership preference, Socio- economic activities,	Questionnaire administration and Observation	Descriptive Analysis	Table, graphs and charts
Examine the effects on adjoining land use	Frequent free vehicles bottlenecking etc.	Questionnaire administration and Observation	Descriptive Analysis	Tables and charts
To determine the conformity and extent of adherence to planning regulation	Distance and Geographical Coordinates; Documented Standard for PFSs	Global Positioning System (GPS), measuring tap, and physical observation	Systematic approach using GIS (ANN)	Maps

RESULT AND DISCUSSION

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

Table 1, presents comprehensive coordinate of PFS captured with GPS and GIS was used to mapping; it is evident that there are 79 petrol filling stations in the study area as it can also be seen in figure 3 according to road/spatial distributions. However, out of these petrol filling stations, 5(6.33%) are yet to be fully constructed, 14(17.72%) have become abandoned whereas 60(75.95%) are fully functional.

Furthermore, the result of the transition mapping in figure 3 shows that PFS are majorly sited along major roads exit and entrance of the study area which cause environmental / traffic gridlock as some are isolated posing no threat to adjoining land use.

Table 1: Location, Status Geographic Coordinates of petrol Filling Stations

S/N	Name of Filling Stations	Location	Status	Easting	Northing
1.	Total	Chanchaga / City Gate Road	Functioning	232460	1061516
2.	Bovas	Chanchaga – City Gate road	Functioning	232472	1061474
3.	Conoil	City Gate Road	Functioning	232472	1061474
4.	Mubashir Investment LTD	Shango Road	Functioning	232909	1060378
5.	Asio and Sons Nigeria LTD	Shango Road	Abandoned	233095	1059878
6.	Azman Oil and Gas LTD	Shango Road	Abandoned	233187	1059683
7.	Saba Investment LTD	Shango Road	Abandoned	233213	1059662
8.	NNPC	Shango Road	Functioning	233495	1059013
9.	Oando	Western bypass, tunga	Functioning	233531	1059163
10.	Matrix	Western bypass, tunga	Functioning	233169	1059979
11.	Etasha Commercial Cons. Company	Opp. NECO, Dutsen kura	Functioning	232891	1059929
12.	NAPL	Off Nnamdi Azikwe Road	Functioning	232649	1059941
13.	NNPC	Western bypass, tunga	Functioning	232441	1059780
14.	Total	Western bypass, tunga	Functioning	232399	1059846
15.	Mobile	Western bypass, tunga	Functioning	232361	1059747
16.	Oando	Western bypass, tunga	Functioning	232218	1059811
17.	Gura Nigeria LTD	Western bypass, tunga	Functioning	232117	1059801
18.	Mobile	Bosso road	Functioning	231423	1060081
19.	Garima	Tudun Fulani	Functioning	231087	1060287
20.	Garisco Investment LTD	Tudun Fulani	Functioning	231039	1060314
21.	U.S Koko	Bosso road	Functioning	230936	1061558
22.	Gajere	Western bypass, tunga	Functioning	230974	1061615

23.	South Gate Investment LTD	Western bypass, tunga	Abandoned	231562	1062209
24.	Forte Oil	Western bypass, tunga	Functioning	229071	1062648
25.	A.A Butu and Sons Nigeria LTD	Tudun Fulani	Functioning	228934	1062649
26.	Ofyelagyi Petroleum	Tudun Fulani	Abandoned	228921	1062784
27.	Total	kafinTella	Functioning	228885	1062897
28.	Alh. Abdulkadir and Sons	kafinTella	Abandoned	228829	1063145
29.	Under construction	Dutsan Kura	Under construction	228909	1063468
30.	First El-Shabab Nigeria LTD	Western bypass	Functioning	228768	1063465
31.	Hajaratu Global Service LTD	Western bypass	Functioning	228731	1064337
32.	Nasfa Global Concept LTD	Western bypass	Abandoned	227531	1064460
33.	Salihi International Company LTD	Angwuan – Biri area	Functioning	226829	1065748
34.	First El-Duniyah Oil and Gas LTD	Angwuan – Biri area	Functioning	229716	1066805
35.	I.P Oil Company Nigeria LTD	Angwuan – Biri area	Functioning	229780	1067382
36.	Abu Hafsah Global Vent LTD	Angwuan – Biri area	Functioning	229912	1067342
37.	Under construction	Angwuan – Biri area	Under construction	229937	1067281
38.	One Links	Bida road	Abandoned	230174	1067122
39.	Under Construction	Bida road	Under construction	226565	1066555
40.	Muhabat Tunga Global Resource	Bida road	Functioning	226741	1060366
41.	Aug Petroleum	Bida road	Abandoned	226804	1060455
42.	Baura Global co. LTD	Bida road	Abandoned	227415	1060635
43.	Total	Bida road	Functioning	227799	1061110
44.	Jibeco Nigeria	Bida road		227895	1061374
45.	Adamu Iliyasu Petroleum Nigeria	Bida road	Abandoned	228449	1061407
46.	A.A. Rano Nigeria LTD	Bida road	Functioning	228579	1061592
47.	Aliyu Shehu Petroleum LTD	Bida road	Functioning	228629	1061637

48	Oando	kafinTella	Functioning	229209	1061656
49.	A.Y.M Shafa	kafinTella	Functioning	233791	1061774
50.	Reflex Oil and Gas Nigeria LTD	kafinTell a	Functioning	233813	1061074
51.	Solex Petroleum	Radio Niger Road	Functioning	233844	1061264
52.	A.S Petroleum	Radio Niger Road	Functioning	233757	1061447
53.	NNPC	Radio Niger Road	Functioning	234565	1061802
54.	A.A Erena	Radio Niger Road	Functioning	234503	1065302
56	NNPC	Radio Niger Road	Functioning	234461	1065872
57.	Garima Petroleum	Radio Niger Road	Functioning	234444	1065841
58.	Raji Petroleum	Radio Niger Road	Abandoned	234500	1065941
59.	Unibros Global	Maikunkele Road	Functioning	233239	1066001
60.	Conner Stone Oil CST	Maikunkele Road	Functioning	233126	1065645
61.	Muhabbat Tunga Global Resource	Maikunkele Road	Functioning	232432	1065523
62.	E.C.E Resource Nigeria LTD	Off Bosso Road	Functioning	232420	1065199
63.	First Jaaz Global Resource	Bosso Road	Functioning	232450	1065162
64.	Murmusa Nigeria LTD	Adjacent OBJ Compex	Functioning	232283	1065150
65.	First Al-Fijir Drime Concept LTD	Opp. OBJ Complex	Functioning	231036	1064878
66.	Forte Oil	Opp. OBJ Complex	Functioning	230747	1065560
67.	Total	Chanchaga Road	Functioning	230779	1064180
68.	AYM Shafal	Opp. Mobil Roundabout	Functioning	230787	1064034
69.	Conoil	F‘ Layout Road	Functioning	230984	1063972
70.	Mobile	Bahago Drive	Functioning	230880	1063924
71..	Underconstruction	Bosso Road	Underconstruction	234322	1063557

72.	Underconstruction	Western bypass Road	Underconstruction	233148	1063888
73.	S. Turke	Western bypass Road	Functioning	230169	1065126
74.	Gingah Oil Investment LTD	Western bypass Road	Functioning	228350	1066556
75.	Ashrab Energy Investment LTD	Kpakungun Road	Functioning	228917	1068845
76.	Matrix	Kpakungun Road	Abandoned	228111	1063460
77.	Total	Kpakungun Road	Abandoned	227415	1061396
78.	Mbel	Kpakungun Road	Functioning	231378	1061106
79.	Danmarna	Kpakungun Road	Functioning	232714	1060104

Source: Researcher Survey 2018

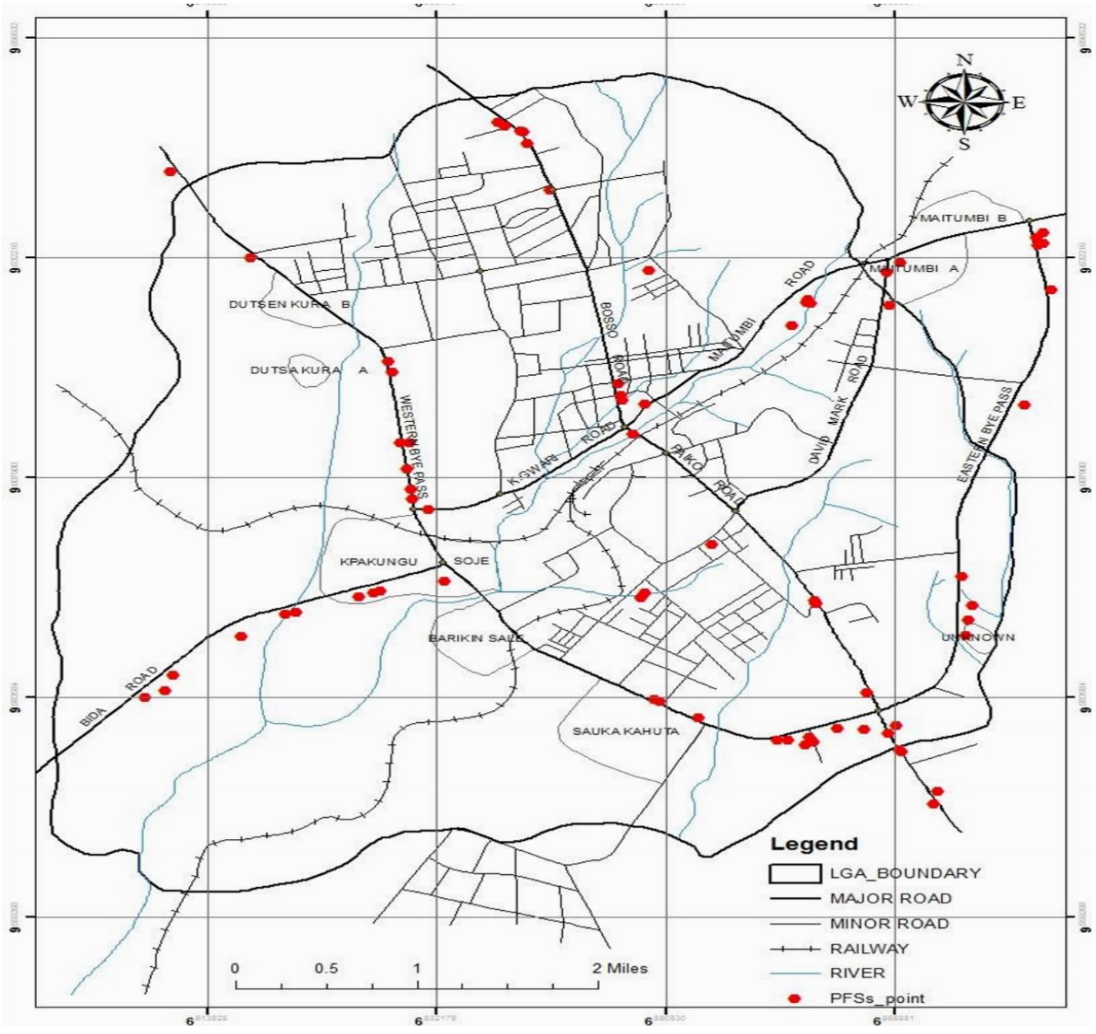


Figure 3: Spatial distribution of Petrol Filling Station in Minna Metropolis (Researcher Analysis, 2018)

Land area coverage of PFS

Illustrations and result analysis for land area coverage or size of PFS as seen in figure 4, reveals that 59 stations (representing 74.5%) of the 79 PFSs in the study area falls within the planning regulation of the DPR stipulation of 1089m^2 for PFS as 20 station (representing 25.3%) has less than the stipulated standard for PFS, thus increasing and posing problems to owners, user and other alike due to the unsuitable nature. The numerous nuclei theory like obnoxious facility location model that emphasis on desired facilities, postulates that siting of PFS have multiple development points from which its radiates, appears to be supported these data. However, one could argue that, among the 25.3% spread of PFS in the study area can cause environmental mishap.

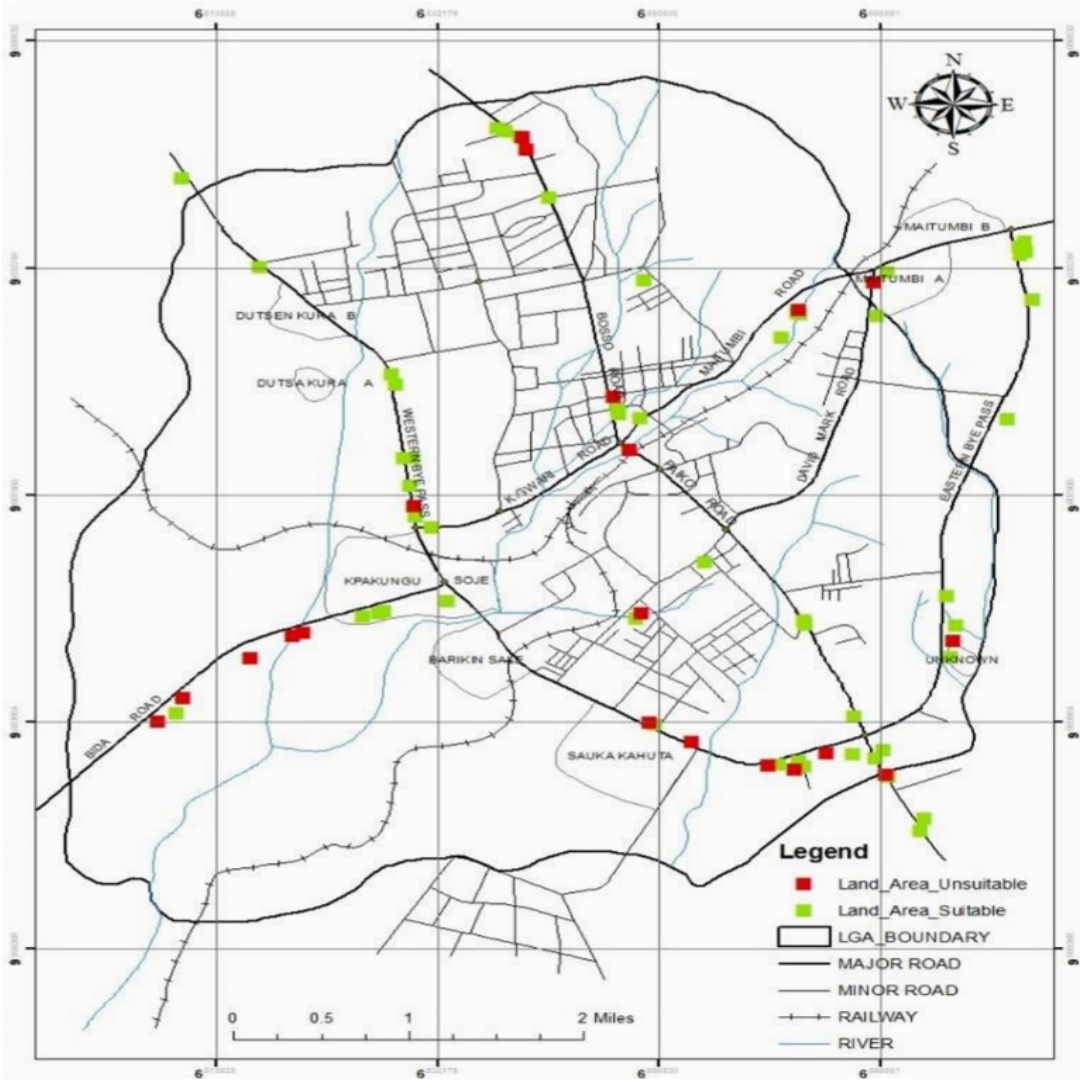


Figure 4: Standard and Sub-standard land area of PFSs
Researcher Analysis, 2018

Distance between Residential Land uses to PFS

Table 2, presents that are there more structure within the 50 metres radius of all petrol filling stations in Minna metropolis, of which it ranges from 77 (representing 32.1%) of six to ten metres and 3 (representing 1.6%) of twenty-one above metres, i.e. residential structures in the study share almost the same boundary with the petrol filling stations of which most do share such as 50 (representing 20.8%) of zero to five metres which is not in line with the regulation of DPR Decree 37of 1997 stating that PFS should be sited fifty metres away in all angles of built-up areas to create a buffer zone.

Table 2: Distance between the nearest Structures to PFS

Distance (m)	Frequency	Percent (%)
0-5	50	20.8
6-10	77	32.1
11-15	70	29.2
16-20	37	15.4
21- above	3	1.6
Total	237	100.0

Researcher computation (2018)

Figure 5: the outcome displays integration of planning regulation standard of 50 metres on which 90 percent of PFSs did not meet the criteria, thus increasing vulnerability of dwellers on risk associated with PFS. This further shows the non-adherence of developers and planning agency enforcement of standard.

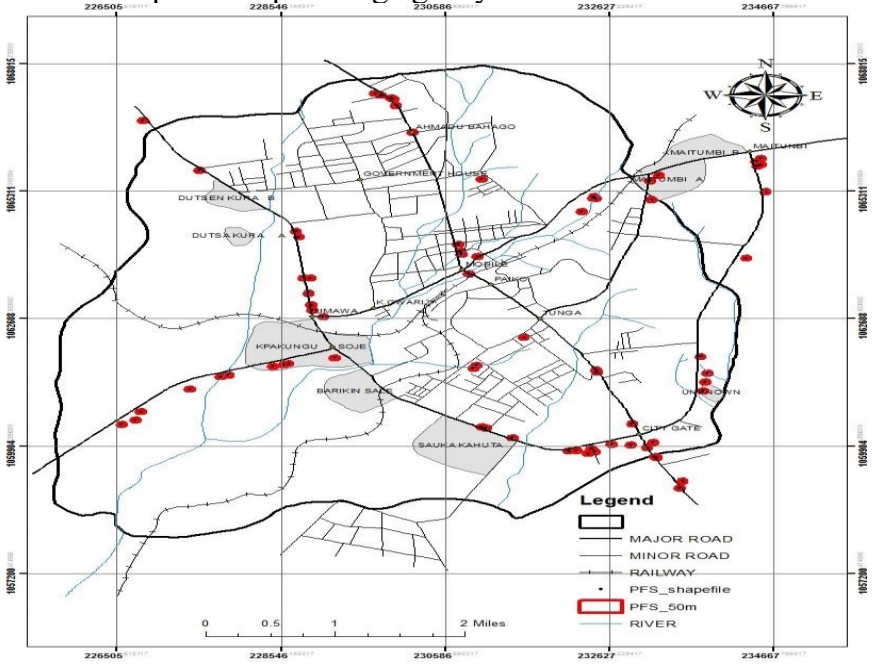


Figure 5: Buffer zone of 50 metre of PFSs to nearest structure

Researcher Analysis, 2018

Distance between two PFSs

The Department of Petroleum Resource act specified a standard distance of 400m as minimum interval between two PFSs on the same axis. The result analysis as integrate of the 400m PFS buffer as seen in figure 4.4 that only 12 (representing 15.2%) that falls within the range of DPR standard regulation as 66 PFSs (representing 84.8%) were below standard which implies that they are significantly clustered and can cause traffic gridlock under scarcity circumstances.

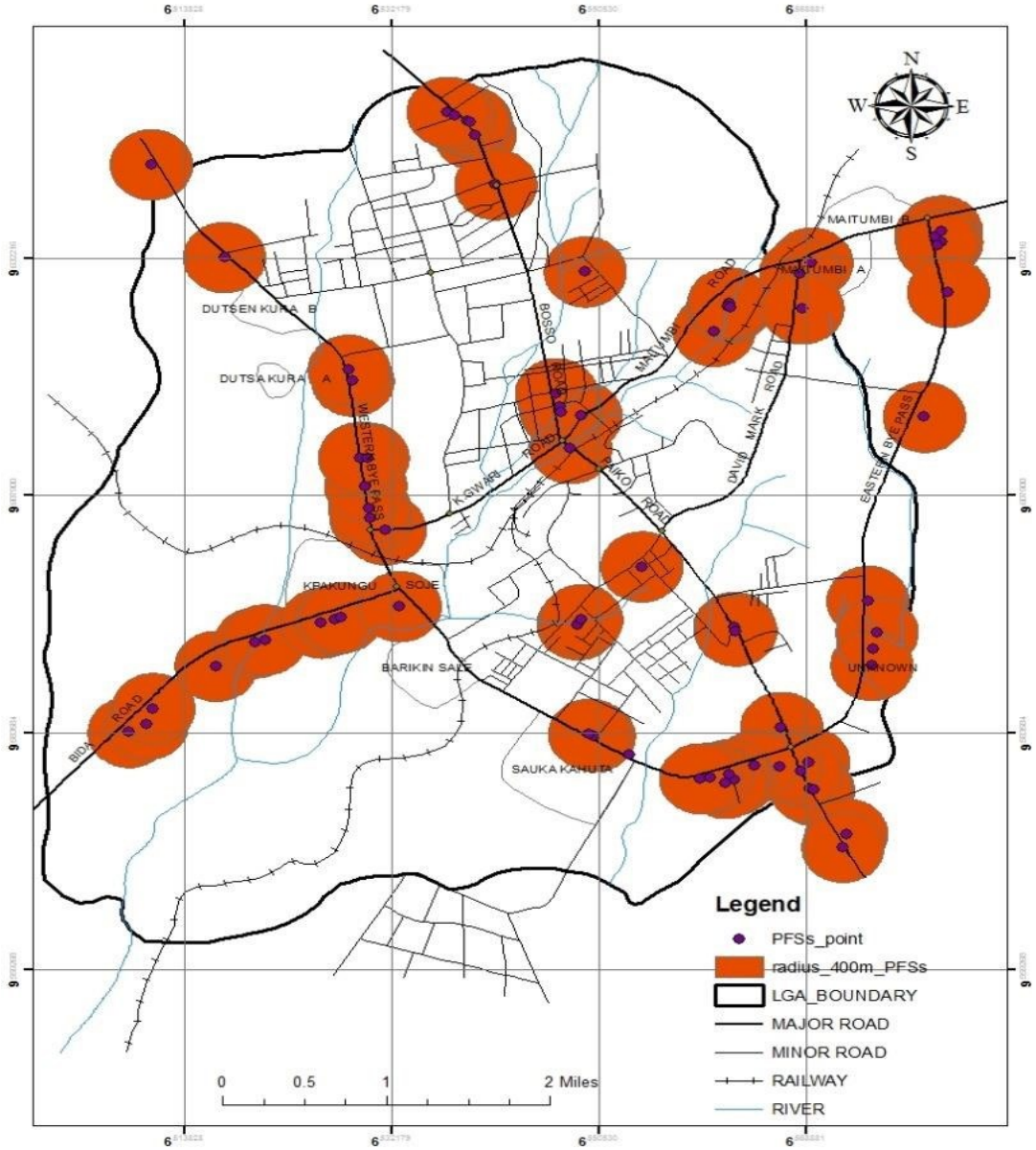
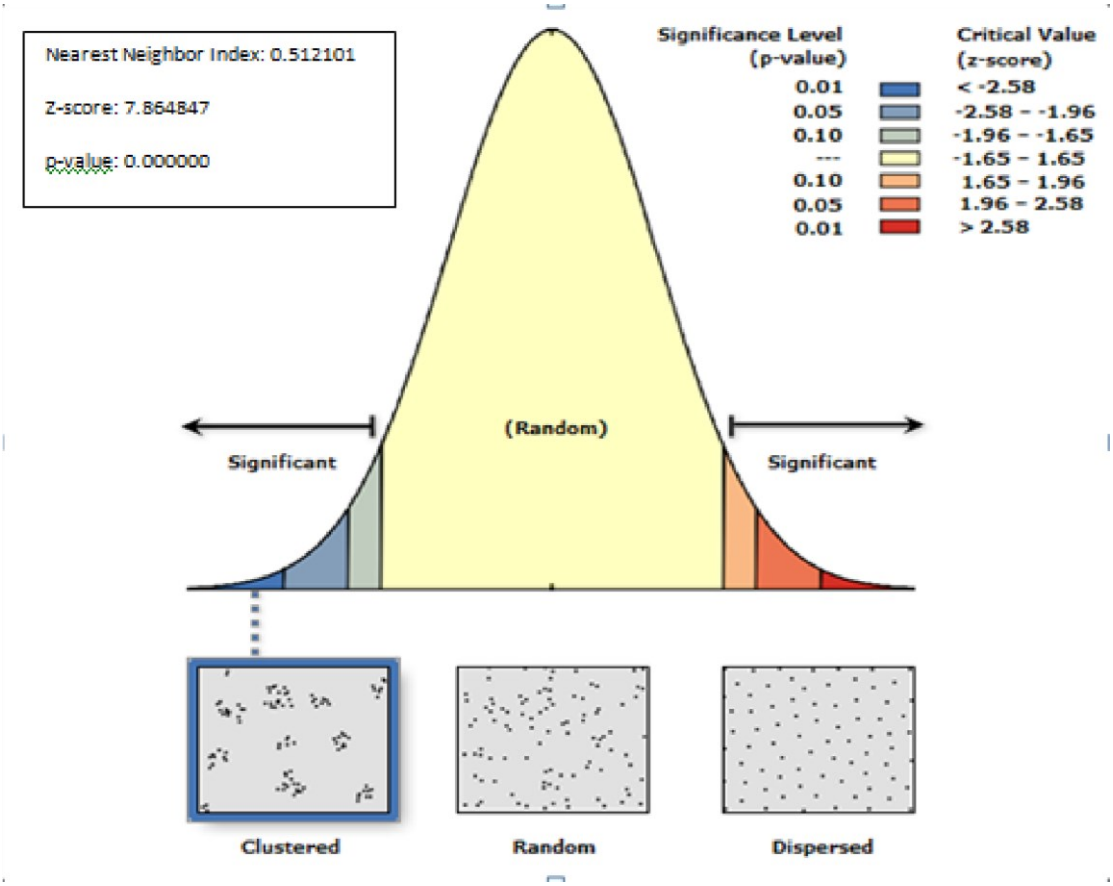


Figure 6: Buffer of 400m minimum interval between two PFSs
Researcher Analysis, 2018

Spatial Relationships on Pattern Distribution of PFSs

To determine the relationship of PFSs as to examine the nature of cluster in the area, PFS features were used. Figure 4.5 reveals the ANN analysis result as z-score is given as 7.864847 and p-value 0.000000; however the low value shows that the pattern of distribution of PFSs in the study area is significantly clustered. As the Nearest Neighbor index is less than 1 (0.512101), a pattern that reveals the clustering nature of PFSs as thus a little probability of that the features (PFSs) are randomly distributed



Given the z-score of -7.86484747678, there is less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 7: Spatial pattern of PFSs in Minna metropolis using Average Nearest Neighbor Researcher Analysis, 2018

CONCLUSION

From the foregoing, it is evident that all parameters for spatial distribution in the appropriateness of petrol filling stations are critically considered; little or none of the petrol filling stations in the study area will stand a chance of approval. It is also

important to note that their characteristics in terms of development hamper their functionality and are therefore an indictment of the agency responsible for managing spaces in the study area. The study recommends a moratorium on the approval of petrol filling station within the fully developed road corridors and other land use within the study area, as shown by the evidence that petrol filling station have greatly flouted planning standards the area. Certain standard discrepancies were spotted in the course of this study. For instance, while the DPR standard recommends a buffer of 50 meters and 400 meters from the nearest neighbor and other PSFs, respectively, which is in line with the Niger State Urban and Regional Planning Law of 1989 as amended in 2020. The study recommends that it should be made compulsory that a minimum of 400 m should be observed from one PFS to another so as to mitigate traffic gridlocks and increase convenience. It also recommends the need for more pro-activeness and effectiveness in the development control activities of the planning authority under whose jurisdiction the study area falls.

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