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Utilization of GIS Techniques as Decision Support System for Location of Filling Stations in Minna, Niger State, Nigeria

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Abstract

The study demonstrated that spatial analysis with relevant socio-economic sources and physical parameter from different sources can be evaluated for the filling station sites planning. This has demonstrated the importance of Geographic Information System (GIS) application in predicting and determining of site criteria for filling stations facilities development, most especially in areas where there is land uses competition which requires consumer accessibility, sustainability, environmental safety, environmentally sensitive development solutions, etc. A stratified sampling technique was used to select the sample size and administration of the questionnaire. The data collected was analyzed using descriptive statistics such as frequency distribution, bar chart, pie chart and percentage and maps showing the sampled existing filling stations in the study area. The result shows the distribution of filling stations located across the study area. This study shows that GIS and multi-criteria analysis are essential tools to assist in correct siting to national planners and decision-makers in deciding the most appropriate filling stations location pattern to apply in Minna and its environs.

Keywords: GIS; filling stations; spatial distribution; location; distance

1. Introduction

A filling station is a place where petroleum products are sold for motorists or a place equipped for servicing automobiles (i.e. selling gasoline or making repairs. The following are some of the products and services rendered by most filling stations in Minna; premium motor spirit (PMS), diesel (AGO), engine oil, Liquefied Petroleum Gas (LPG), Kerosene (DPK), car wash and car repairs.

Filling stations are particularly hazardous workplaces which require to be licensed by Local Authorities because they store and sell a highly flammable liquid. Equipment failures

in filling stations or gas stations lead to accidents that pose significant threats to people and property. Therefore, before commercialization, safety standards for filling station need to be developed based on risk or locational analysis. In this study, the focus is on safety distance and the distribution pattern of filling stations in Minna and its environs. There are Ministries/Agencies responsible for this such as; Petroleum Products Pricing Regulatory Agency (PPPRA), Department of Petroleum Resources (DPR), The Petroleum Equalization (Management) Fund (PEF), Ministry of Petroleum Resources.

The position of Nigeria in terms of consumption of oil in the world as one of the biggest consumers of oil products in Africa with, about 40 million litres said to be consumed every day, because almost every home in Nigeria have generating set that work sometimes all day to power their homes, and most of these millions of generating set used in Nigeria run on petrol and/or diesel. Also, he said Nigeria is one of the biggest oil-producing nations in the world with substantial crude oil deposits around the entire South, South East, and South West region of the country, both tapped and untapped.

Khahro et al (2010) highlighted that, filling stations are associated with the high fire hazard, and improper locations of such services could lead to disastrous consequences during fire outbreak and resulting to pollution, loss of life and property. Two dangers are associated with petrol; fire hazard (which include; vapor leaks from appliances and gas cylinders as well as major hazards associated with loss of containment and rapid vaporization of tonnage quantities of the liquefied gas) and health risks(environmental pollution, terminal diseases and death can occur), since petrol is a highly flammable liquid, it must be stored, transported, and handled with care.

Minna is one of the towns faced with the action of the wrong sitting of filling stations in Niger State. The deliberate or intentional location of filling station in unsuitable sites within the Metropolis and environs might have highly increased the level of a disaster like fire, environmental pollution, diseases and untold hardship to its citizens. Apart from its adverse effect on the environment, the filling station also aids in worsening the already bad traffic problems in some parts of the town. Most of the places near filling station usually experience a lot of unfavourable conditions such as Fire/explosion, environmental damage, health effects (Exposure to them through use, accidental spillage or leakage, can result into health implication), pollution (such as noise pollution and water pollution). Also, where these stations fail to comply with the physical planning standards and indiscriminate parking of

cars leads to the reduction of the width of carriageway meant for efficient movement of automobile and pedestrians.

Previous studies related are spatial approach is very influential on regional planning by considering various aspects (Loidl et al, 2019). GIS application is very helpful planning related to safety on urban roads (Naboureh, 2019). GIS can formulate green spaces, public transportation access, and school distribution which is very effective for urban planning (Ma and Gopal, 2018). Adjacent station distance cause congestion in urban areas (Akilu, 2018). Geospatial analysis could help the government in deciding on a country's sustainable energy development strategy (Jahangiri et al, 2016).

The results of the above studies have not discussed the placement of filling stations in an area, even though this has become very important to improve population accessibility. The novelty of this research is the analysis of the planning of refueling stations using GIS. Based on the gap and problem of improper location of filling stations in Nigeria, Minna inclusive this, research was birthed to assess the distribution of filling stations in Minna city using Geospatial technologies (techniques) by looking at, the location and distribution pattern of the filling stations, to examine the conformity of the spatial location of filling stations to the physical planning standard and create maps that will help for decision support, planning and management purpose. The study demonstrated that spatial analysis with relevant socio-economic sources and physical parameter from different sources could be evaluated for the filling station sites planning.

2. Methods

The study was carried out within Minna Metropolis, located approximately between latitudes $09^0 25^{'}$N and $09^0 45^{'}$N, and longitudes $06^0 15^{'}$E and $06^0\ 35^{'}$E with an average elevation of 272 meters above the sea level. With an estimated population of 201,429 (NPC 2006). Minna shares borders with the following Local Government Areas; Shiroro LGA to the North, Wushishi LGA to the West, Gbako LGA to the South-West, Katcha LGA to the South-East and Paikoro LGA to the East as shown in page, is made up of settlements such as: Chanchaga, Shango, Maitumbi, kpakungu, Dutsen-Kura, Bosso, Maikunkere, Barkin Sale, Tudun Fulani, Keteren Gwari. The city is connected to neighbouring cities by road. Abuja, the capital of the country, is only 150 km away, is also connected by railroad to both Kano in the north and Ibadan and Lagos in the south which is also boarder by Ilorin city. Minna Airport serves the city. The maps 1, below show the study area.

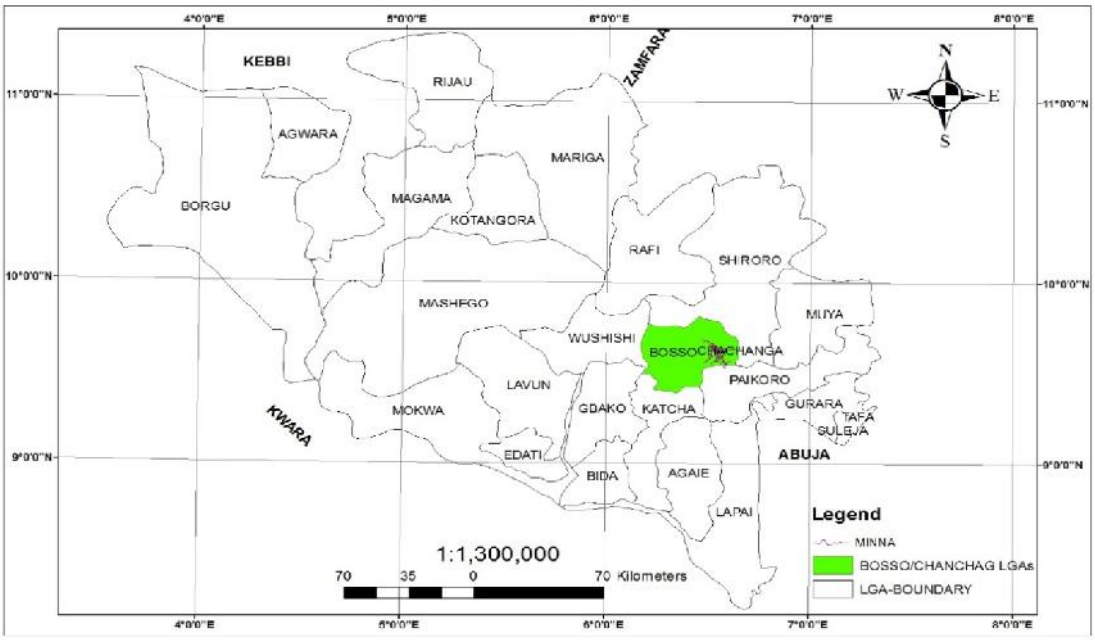

Figure 1. Location of the study area (Niger state)

The data for the research were sourced from two primary sources. These includes a personal interview/oral interview, distribution of the questionnaire. Use of GPS to get the appropriate location (longitude, latitude, i.e. X and Y) coordinate of each filling station points. These include the use of existing studies; textbook, journal, internet, technical reports, seminar papers, published and unpublished articles. The existing location of filling station from Ministry of Land and Housing Minna (Minna Master Plan, the standard of siting a filling station, and street guide map of Minna, satellite imageries of Minna. These include the location of filling station, the name of filling station, number of filling station, size of the filling station, radius, distance apart.

In the process of collecting data, different procedures were adopted such as physical observation, oral interview and administration of the questionnaire to the sampled filling station in Minna. Global Positioning System(Garmin etrex) was used to pick the coordinates (longitude and latitude) of each filling stations. In other to have unique information about the filling stations, stratified sampling technique was used to divide the area into four divisions (quadrants) A, B, C and D, of which 58 were sampled and 58 copies of the questionnaire were administered to the sampled filling station. The A quadrant comprises of Bosso (7 samples were taken), Tundu Fulani (6 samples were taken), River Basin (1 sample was taken), Maikunkele (3 samples were taken) and Numunyi (1 sample was taken). B quadrant comprises of Dutsen Kura (3 samples were taken), Keteren Gwari (1 sample was taken), Kpakungu (6 samples were taken), and Sauka Kahuta (5 samples were taken). C quadrant comprises Mobil (3 samples), M.I. Wushishi (3 samples), and Maitumbi (6 samples were taken). D quadrant comprises Tunga (10 samples), Tunga Goro (1 sample), and Chanchaga (2 samples). GPS was used to capture the x and y coordinate of the 58 sampled filling station.

In all we have 58 sampled filling station across the study area, with A quadrant 18 accounting for 31.03% of the entire total; B quadrant 15 (25.86%), C quadrant 12 (20.69%), and D quadrant 13 (22.41%) of the entire total as summarized in Table 1 below:

Table 1. Number of Sampled filling station

S/N	Quadrant	Sampled Filling Station	
		Number	%
1	A	18	31.03
2	B	15	25.86
3	C	12	20.69
4	D	13	22.41
Total		58	100

The topographic map of the area was imported into ArcGIS 10.3, georeferenced and each layer was digitized to create maps. The GPS points of filling station collected were converted through the GIS and displayed as the actual location on the maps. ArcGIS software was used to determine proximity analysis to find what is close or within a certain distance of one or more features, each Filling Stations were buffered from the built-up areas, double carriageway, single carriageway, and from the next Filling Station. The data collected were also analysed using descriptive statistics such as frequency distribution, bar chart, pie chart.

3. Results and Discussion

3.1 Identification and location of filling station

Table 2 below help to show the location of filling station, the x and y coordinate and each filling station name, fig 2 below also shows the actual location of the identified filling station as displayed on the map.

Table 2. Identification and location of the filling station

S/N	X	Y	Location of Station	Filling Station Name
1	9.661555556	6.523972222	Tudun Fulani	US KOKO
2	9.664277778	6.521	Tudun Fulani	Microclean petroleum Nig. LTD
3	9.668138889	6.515666667	Tudun Fulani	Muhabbat T. Global Resources Nig. LTD
4	9.685944444	6.474277778	Maikunkele	SolidMark Oil and Gas Limited
5	9.680916667	6.4855	Maikunkele	Mamman Danba Koko Nig. LTD
6	9.673027778	6.504527778	Maikunkele	Salihi International Company Limited
7	9.668944444	6.512333333	River Basin	Total
8	9.666722222	6.516833333	Tudun Fulani	Salihi International Company Limited
9	9.661611111	6.522083333	Bosso	Azman oil and Gas
10	9.658916667	6.525388889	Bosso	Garima Petroleum LTD
11	9.64825	6.536194444	Bosso	BD Petroleum Nig. LTD
12	9.647805556	6.536916667	Bosso	IP Oil Company Nigerial Limited
13	9.645805556	6.538555556	Bosso	Conoil
14	9.647361111	6.538416667	Bosso	KS Oil
15	9.647472222	6.538361111	Bosso	Abuhafsah Global Oil
16	9.61925	6.545833333	Mobil	Forte Oil (Fo)
17	9.617833333	6.546138889	Mobil	Total
18	9.613638889	6.547361111	Mobil	Mobil
19	9.595305556	6.561638889	Tunga	Total
20	9.595111111	6.561833333	Tunga	Azman oil and Gas
21	9.587111111	6.565083333	Tunga	Conoil
22	9.585222222	6.565722222	Tunga	NNPC
23	9.581444444	6.567166667	Tunga	Oando
24	9.58075	6.567527778	Tunga	Asios and Son Nig. LTD
25	9.578833333	6.568388889	Shango	Azman oil and Gas
26	9.553333333	6.580444444	Chanchaga	Conoil
27	9.541972222	6.581444444	Chanchaga	Conoil
28	9.554527778	6.58125	Tunga Goro	A.T.J Nig. LTD
29	9.57425	6.571888889	Shango	Oando
30	9.659305556	6.507611111	Numunyi	Pinochles Petroleum Nig. LTD
31	9.633083333	6.516611111	Dutse Kura Gwari	Nasafah Global Concept Pet. LTD
32	9.620722222	6.528083333	Opposite Kure Market	First El-Shabab Nig. LTD
33	9.607694444	6.529305556	Along High Court	Ofyelagyi Petroleum
34	9.605583333	6.530694444	Keren Gwari	Forte Oil (Fo) Service Station
35	9.596333333	6.526388889	Kpakungu	Aliyu Shaba Station
36	9.594277778	6.520277778	Gbaganu	Adamu Iliyasu Petroluem Nig. LTD
37	9.593916667	6.519333333	Chankwa	JIBECO Nig. LTD
38	9.584833333	6.508138889	Al-Bishiri	NNPC
39	9.585555556	6.509805556	Al-Bishiri	A.U.G Petroleum
40	9.5975	6.532166667	Kpakungu	Oando

41	9.601805556	6.553472222	Tunga	Southgate Investment
42	9.596166667	6.548361111	Tunga	Gajere Multiple Links Nig. LTD
43	9.595666667	6.548055556	Tunga	Umaru Salihu Koko Nig. (US KOKO)
44	9.584361111	6.549388889	Sauke Kahuta	Garima
45	9.584638889	6.548833333	Sauke Kahuta	Garisco Investment Limited
46	9.582638889	6.552555556	Sauke Kahuta	Mobil
47	9.580555556	6.561277778	By-Pass Sauke Kahuta	Total
48	9.579222222	6.561583333	By-Pass Sauke Kahuta	NNPC
49	9.581222222	6.563583333	Tunga	yebosoko Global Concept
50	9.593277778	6.574583333	M.I Wushishi	Jazu Oil and Gas LTD
51	9.594861111	6.574527778	M.I Wushishi	A.S Petroleum LTD
52	9.598222222	6.573833333	M.I Wushishi	TIJ Ahmed Nig. LTD
53	9.635111111	6.580444444	Maitumbi	A.A Erena
54	9.636555556	6.582694444	Maitumbi	Raheem Petroleum
55	9.637527778	6.583111111	Maitumbi	NNPC Murmusa
56	9.63825	6.586027778	Maitumbi	ANE Oil Nigeria LTD
57	9.635583333	6.579444444	Maitumbi	Conoil
58	9.634527778	6.579166667	Maitumbi	NNPC

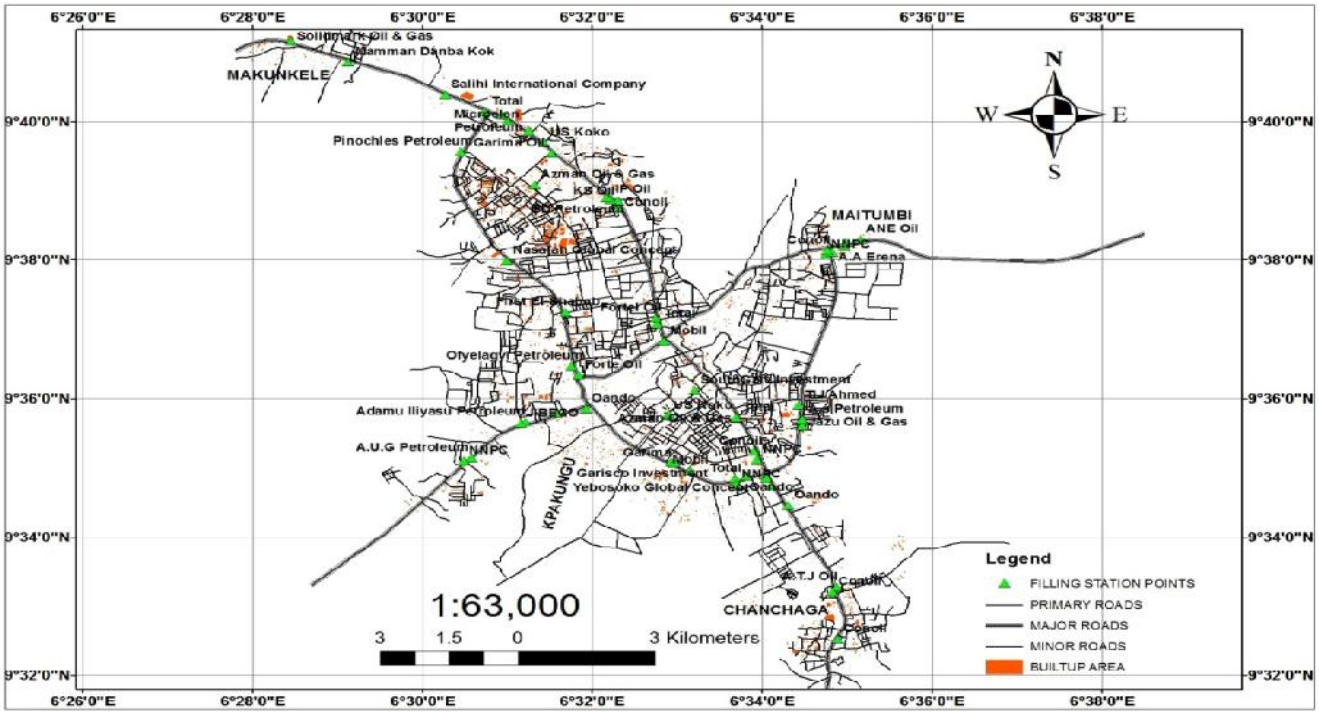

Figure 2. Location of filling stations

As shown in table 2 and fig 2 above, at of all the 58 (100%) filling station sampled; in term of location Tunga area has the highest number of filling station of 10 filling station accounting for 17.24% of the entire total, followed by Bosso area o of 7 filling station

accounting for 12.07% of the entire total, Maitumbi has 6 filling station with 10.34%, Tundun Fulani 4(6.90%), four areas like Maikunkele, Mobil, Sasuke Kahuta and M.I Wushishi area has 3 filling stations each with 5.17% each and areas like Chanchaja, Shango, Kpakungu, AL-Bishiri and Bypass Sauka kahuta has 2 (3.45%) each. Lastly, River basin, Tunga Goro, Numunyi, Dutse Kura Gwari, Opposite Kure Market, Along High Court, Keteren Gwari, Gbaganu, and Chankwa area has the least filling station of 1(1.72%) each.

3.2 The distribution pattern of the filling stations

In other to establish the distribution pattern of the sampled filling station, we decided to find their location on both sides of the road, buffer the filling at 450meter, 75meter, 50meter and 35meter. Table 3 below shows the number of the sampled filling station that could be found on each street/road both right and left. Bosso-Zungeru road carried the highest number of the sampled filling stations, 16 accounting for 27.59% of the entire total, followed by western by-pass road of 11 accounting for 18.97% of the entire total, the least is Keteren Gwari road of 2 accounting for 3.45 % of the entire total.

Table 3. Filling Station on both sides of the road.

S/N	Road Name	Sampled	
		Number	%
1	Bosso-Zungeru Road	16	27.59
2	Bosso-Paiko Road	10	17.24
3	Western By-pass	11	18.97
4	Eastern By-pass/M. I Wushishi Road	7	12.07
5	Bida Road	6	10.34
6	Keteren Gwari Road	2	3.45
7	Gwada Road	3	5.17
8	Shiroro Road	3	5.17
Total		58	100

As shown in Table 3 above, relating to filling stations on both side of the road; at Bosso-Zungeru Road there are about 16(27.59%) filling stations of the entire 58(100%) sampled, Bosso-Paiko road has 10(17.24%), Western By-pass has 11(18.97%), Eastern By-Pass/M. I Wushishi Road has 7 accounting for 12.07% of the entire total, Bida road with 6(10.34%) filling station, Keteren Gwari Road has 2(3.45%) of the entire total. Lastly on Gwada road and Shiroro road, there are 3(5.17%) each. On the issue of faulted and safe filling stations within and outside the buffer rings were discussed below.

The faulted and the safe filling stations that are within and outside 450m buffer rings identified based on the following divisions:

1. Division one: The faulted filling stations that are within buffer 450 rings are; Solid Mark Oil & Gas, Salihi International Company, Micro clean Petroleum, Salihi International Company, Muhabbat T. Global Resources, pinochle Petroleum, US Koko, Garima Oil, Azman Oil & Gas, Abu Hafsah Global Oil, and KS Oil.While the safe filling stations that are outside the buffer rings are; Mamman Danba Kok, Total, IP Oil, BD Petroleum, Conoil and Nasafah Global Concept.
2. Division Two: The faulted filling stations that are within buffer 450 rings are; JIBECO, Aliyu Shaba Station, A.U. G Petroleum, NNPC Gajere Multiple Links, US Koko, Garisco Investment and Garima.While the safe filling stations that are outside the buffer rings are; Forte Oil, Ofyelagyi Petroleum, Oando, Southgate Investment, First El-Shabab, and Adamu Iliyasu Petroleum.
3. Division three: The faulted filling stations that are within buffer 450 rings are; Azman Oil & Gas, and Conoil.While the safe filling stations that are outside the buffer rings are; Mobil, Conoil, Total, Total, Yebosoko Global Concept, NNPC, Oando, Asios & Son, Azman Oil & Gas, Oando, A.T.J Nig. LTD and Conoil.
4. Division four: The faulted filling stations that are within buffer 450 rings are; Forte Oil, Total, Mobil, Conoil and Raheem Petroleum. While the safe filling stations that are outside the buffer rings are; NNPC Murmusa, ANE Oil, A.A Erena, NNPC, TIJ Ahmed, AS Petroleum and Jazu Oil & Gas.

The faulted and the safe filling stations that are within and outside buffer of 75m rings were identified based on the divisions:

1. Division one: The faulted filling stations that are within buffer 75m rings are; Solidmark Oil & Gas, Salihi International Company, Total, Muhabbat T. Global Resources, Microclean Petroleum, US Koko, Garima Oil, BD Petroleum, IP Oil, Conoil and Nasafah Global Concept. While the safe filling stations that are outside the buffer rings are; Mamman Danba Kok, Salihi International Company, pinochle Petroleum, Azman Oil & Gas, KS Oil and Abuhafsah Global Oil.
2. Division Two: The faulted filling stations that are within buffer 75m rings are; NNPC, A.U.G Petroleum, Aliyu Shaba Station, Forte Oil, Ofyelagyi Petroleum, US Koko, Gajere Multiple Links, Garisco Investment, Garima and Southgate Investment. While the safe filling stations that are outside the buffer rings are; Adamu Iliyasu Petroleum, JIBECO, Oando and First El-Shabab.
3. Division Third: The faulted filling stations that are within buffer 75m rings are; Mobil, Total, NNPC Total, Azman Oil & Gas, NNPC, Asios and Son, Azman Oil & Gas, A.T.J Nig. LTD, Conoil and Conoil.While the safe filling stations that are outside the buffer rings are; Oando, Oando, Yebosoko Global Concept and Conoil.
4. Division Four: The faulted filling stations that are within buffer 75m rings are; Jazu Oil & Gas, AS Petroleum, TIJ Ahmed, NNPC, Raheem Petroleum, ANE Oil, Mobil, Total and Forte Oil and Conoil and A.A Erena are outside the buffer, making them the only safe filling station.

The faulted and the safe filling stations that are within and outside buffer 50m rings were identified based on the divisions:

1. Division One: Only Solid mark Oil & Gas, Mamman Danba Kok, Salihi International Company, Nasafah Global Concept, pinochle Petroleum and Azman Oil & Gas are safe in this division, others are within the buffer ring.
2. Division Two: Only Conoil filling station in Chanchaga, along Paiko road, is safe, while the rest of the sampled filling stations in this division are faulty.
3. Division Three: Only First El-Shabab Filling station in Dutsen Kura, along with western by-pass is safe, while the rests of the sampled filling stations in this division are faulty.
4. Division Four: None of the sampled filling stations in this division is safe; they were all because they are found within the buffer zone (ring).

The faulted and the safe filling stations that are within and outside buffer of 35m rings were identified based on the divisions:

1. Division One: Only Muhabbat T. Global Resources, KS Oil and Abuhafsah Global Oil are faulted, the rest of the filling stations in this division are all safe.
2. Division Two: Only A.U.G Petroleum is faulted; the rest of the filling stations are all safe.
3. Division Three: All of the filling stations in this division are safe from 35m buffer ring
4. Division Four: All of the filling stations in this division are safe from 35m buffer ring.

3.3 Conformity of the spatial location of filling stations to the physical planning standards

The table 4 below helps to confirm the spatial location of filling stations as it relates to physical planning standards, as weighted filling stations result by 450 m buffer away from other filling station, 75 m buffer away from building, 50 m away from the dual carriageway, and 35m buffer away from the single carriageway.

Table 4. Union/Integration of Filling station

S/NO	Filling Stations	450 m buffers away from other F/S	75 m buffers away from buildings	50 m buffers away from dual carriage	35 m buffers away from single carriage way	Weighted
1	Solidmark Oil & Gas	1	0	0	1	2
2	Salihi International Company	1	0	0	1	2
3	Salihi International Company	0	1	0	1	2
4	Microclean Petroleum	0	0	0	1	1
5	Muhabbat T. Global	0	0	0	0	0

	Resources					
6	Pinochles Petroleum	1	1	0	1	3
7	US Koko	0	0	0	1	1
8	Garima Oil	0	0	0	1	1
9	Azman Oil & Gas	1	1	0	1	3
10	Abuhafsah Global Oil	0	1	0	0	1
11	KS Oil	0	1	0	0	1
12	Mamman Danba Kok	1	1	1	1	4
13	Total	0	0	1	1	2
14	IP Oil	0	0	1	1	2
15	BD Petroleum	0	0	1	1	2
16	Conoil	0	0	1	1	2
17	Nasafah Global Concept	1	0	1	1	3
18	JIBECO	0	1	0	1	2
19	Aliyu Shaba Station	0	0	0	1	1
20	A.U.G Petroleum	0	0	0	0	0
21	NNPC	0	0	0	1	1
22	Gajere Multiple Links	0	0	0	1	1
23	US Koko	0	0	0	1	1
24	Garisco Investment	0	0	0	1	1
25	Garima	0	0	0	1	1
26	Forte Oil	0	0	1	1	2
27	Ofyelagyi	0	0	1	1	2

	Petroleum					
28	Oando	0	0	1	1	2
29	SouthGate Investment	0	1	1	1	3
30	First El-Shabab	1	1	1	1	4
31	Adamu Iliyasu Peyroleum	0	1	1	1	3
32	Azman Oil & Gas	0	0	0	1	1
33	Conoil	0	1	0	1	2
34	Mobil	0	0	1	1	2
35	Conoil	0	0	1	1	2
36	NNPC	0	0	1	1	2
37	Total	0	0	1	1	2
38	Total	0	0	1	1	2
39	Yebosoko Global Concept	0	1	1	1	3
40	NNPC	0	0	1	1	2
41	Oando	0	1	1	1	3
42	Asios & Son	0	0	1	1	2
43	Azman Oil & Gas	0	0	1	1	2
44	Oando	0	1	1	1	3
45	A.J.J Oil	0	0	1	1	2
46	Conoil	1	0	1	1	3
47	Forte Oil	0	0	0	1	1
48	Total	0	0	0	1	1
49	Mobil	0	0	0	1	1
50	Conoil	0	1	0	1	2
51	Raheem	0	0	0	1	1

	Petroleum					
52	NNPC Murmusa	0	0	1	1	2
53	ANE Oil	0	0	1	1	2
54	A.A Erena	0	1	1	1	3
55	NNPC	0	0	1	1	2
56	TIJ Ahmed	0	0	1	1	2
57	AS Petroleum	0	0	1	1	2
58	Jazu Oil & Gas	0	0	1	1	2

The only filling stations that have a suitable location according to the physical planning standard are Mamman Danba Kok and First El-Shabab filling station. The map also showed that only 3.4% of the sampled filling stations are located in a suitable location, while the remaining 96.6% of the total numbers of existing Filling Stations in Minna Petropolis and its environs are not located in suitable areas.

However, there is similar or relevant research done by various scholars on GIS application in filling station as decision support system tools. Emakoji and Otah (2018), worked on analyzing the location of filling station in Afikpo-Ebonyi State Nigeria against the laws/regulations guiding their establishment; their result shows that about 44.4% of the filling station did not meet the criteria of 15m minimum distance from the pump to the road,22.2% of the filling station was sited too close(lesser than 100m) to the health Centre. While 66.7% did not meet the criteria of 400m minimum distance to other stations located on the same roadside. Tah (2017) researched on location of filling stations within Kaduna Metropolis against the physical planning standards set by Department of Physical Planning (DPR) and Kaduna Urban Planning and Development Agency; his study revealed that there are about 228 filling stations within the 26 roads in the study area of which 74% owned by independent marketers, 18% owned by major marketer and 8% owned by NNPC. That about 86% of the filling station did not meet the standard of 100m from health care facilities. 84% did not meet the 400m minimum distance to other stations on the same road.

The essence was to check if it is in line with the Physical Planning Standards set by the Department of Petroleum Resource (DPR) and Kano Urban Planning and Development Agency, the research shows that there are about 214 filling station along the 43 roads in the

study area; the highest number of filling stations is located along Zaria, Maiduguri, and Kastina roads which are major high ways, but access road like Sabo Bakin, Zuwo, and Zungeru roads have the highest density of filling station per km^2 . However, about 96% of the filling stations meet the 15m from the road criteria; also 98% meet the 400m distance to the health centre. But the majority of the filling station did not meet the criteria of 400m from each other.

Peprah (2018), investigated the level of compliance to standards set by the Ministry of Energy, and Town and Country Planning Department on existing oil and gas station in Tarkwa Ghana, using multi-criteria decision analysis and GIS approach, the result showed that 75% of oil and gas operators compliant with the standard while 25% did notLastly. Mustapha et al (2016) studied the uses of Geospatial technologies to determine the distribution pattern and assess the level of conformity of the filling station against the Physical Planning standards by the regulating bodies in Illorin Kwara State. Their result shows that 225 filling stations in the study area are clustered in nature in terms of distribution. The 15m distance standard from the edge of the road was meant by 71.6% filling stations why 28.4% was not. In terms of 400 m apart, only 2,7% was in compliance while 98.7% was not.

Conclusively, from these above and in line with the research at hand, shows that about 89.7% of the total filling station in Nigeria did not meet the 400m apart criteria; the physical planning standards are not followed. This is a major problem in almost all the state in Nigeria, that is why the recommendation highlighted in this research work should be adhered.

GIS can be used to plan environmentally friendly cities (Jelokhani-Niaraki et al, 2019). Spatial analysis of a city's coastline will improve environmental capability (Dhiman et al, 2019). GIS helps effectively analyze the distribution of mobile networks in a city (Sacramento et al, 2019). Suburban areas related to urban problems are very effectively analyzed by GIS (Vaz et al, 2018). GIS can analyze the vulnerability of coastal areas and help the government in making decisions related to sustainable city development strategies (Maanan et al, 2018). The results of this study are better than the studies above related to the distribution analysis of filling station services. This will be very beneficial for the growth of the city and facilitate community access to services.

4.Conclusion

The study demonstrated that integration and spatial analysis with relevant socio-economic sources and physical parameter from different sources could be evaluated for the

interpretation of filling station sites planning. The spatial distribution pattern of filling stations in Minna was identified through the creation of a geospatial database for the sampled filling stations. The sampled filling stations were confirmed based on the physical planning standard gotten from the Ministry of Land and Housing Minna, to be correctly located and improperly positioned filling stations were also identified.GIS was integrated into siting of filling station in the study area, and the number of filling stations found in suitable location was identified. In conclusion, this study shows that GIS and multi-criteria analysis are essential tools to assist in correct siting to national planners and decision-makers in deciding the most appropriate filling stations location pattern to apply in Minna and its environs.

Conflict of Interest

The authors declare that there is no conflict of interest with any financial organization regarding the material discussed in the article.

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