



Spatial Analysis of Gas Refill Stations in Owerri Metropolis Using Geographic Information System (GIS)

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Abstract

This study analyzed the location of gas stations in Owerri metropolis against the physical planning standards set by Department of Petroleum Resource (DPR) and Owerri capital city development authority (OCDA). Name and street addresses of the gas station were obtained from the Department of Petroleum resource (DPR) Owerri. Global position system Garmin 76X GPS was used to capture the locations of gas stations. Quickbird Imagery, street map, and boundary map was obtained from Imo State Ministry of Lands and Physical Planning and then imported to ArcMap environment of ArcGIS 10, integrated and georeferenced to the same coordinate system. The findings revealed that there are 27 gas stations located along 13 roads of the study area. There is a significant correlation between the number of gas station and the road hierarchy. The major roads like Port Harcourt road, Onitsha road, Aba road, Egbu road, Orlu road and MCC has the highest number of gas stations in the. The overall pattern of location of gas stations in the area is clustered and there is a significant difference between the pattern and random pattern at both 95 and 99% level of significance. Most gas stations satisfied the minimum 15m requirement distance from road (81%). Equally 95% of gas station met the minimum distance of 100 meter from the health care facilities. However many station had not meet the criteria of 400 meters minimum distance to other stations were located on the same road side and were not separated by any road or street. The researcher recommended that the regulatory agencies should take appropriate action which will ensure that gas stations operator comply with the standards.

Keywords: *Spatial Analysis; LPG Refill Gas Stations; Site suitability; GIS Suitability*

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Introduction

1.0 Background of Study

Filling stations, Petrol stations, Gas stations or Petroleum outlet is defined as that land, building or

equipment used for sales and dispensing of petrol or oil for motor vehicle or incidental thereto and includes the whole of the land, building or equipment whether or not the use as a petrol station is the predominantly use or only a part thereof. The

American heritage dictionary of English (2011) defines filling station as a place where gasoline and oil are sold and facilities are available for repairing or maintaining automobiles. Most of the filling stations sell petrol or diesel, some carry special fuels such as Liquefied Petroleum Gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane, while the rest add shops to their primary business (Ayodele, 2011).

Petroleum now doubles as a predominant source of Nigerian's revenue and foreign exchange. It has occupied a strategic place in Nigerian economy, accounting for as high as 78% gross domestic product and up to 90% of the country's total annual revenue and foreign exchange earnings (NBS, 2008). The petroleum industry in Nigeria is divided into two main segments, the upstream and the downstream sector. The activities such as exploration, production and delivery to an export terminal of crude oil or gas are referred to as upstream. On the other hands, activities such as loading of crude oil at the terminal and its use especially transportation, supply, trading, refining, distributions and marketing of petroleum product are referred to as downstream (Asada, 2013). Activities of filling stations or petroleum industry can be classified by type of actor or sector (Ehinomen and Adeleke, 2012). The actors in the Nigeria industry consist of both private and public organization. The public actors are the government agents and the functionaries such as the Nigerian National Petroleum Corporation (NNPC) and its subsidiaries, the Department of Petroleum Resources (DPR), the Petroleum Product Pricing Regulation Authority (PPPRA), among others.

While the private segments consists of both indigenous and foreign actor, the indigenous actors consists of independent marketers which numbered about 1000 in 1979, a year after formulating the act which established them but increased to 7948 in 2010 and they are competing with the foreign or multinational marketers (known as the major marketers) like Mobil oil Nigeria Plc, Oando Nigeria and African Petroleum Plc.

Liquefied Petroleum Gas (LPG) plants are facilities established to serve the public with sales of refill gas products, therefore, gas stations should be located not only where they are accessible but where they can be easily located by strangers. Specifically, refill gas station should be placed where they will not cause danger and congestion as much as possible. According to Abdulahi (2012), refill gas stations could be distributed rationally according to the size, spacing or distance and population to be served. However, in Nigeria, there are guidelines for location and operation of liquefied petroleum gas (LPG) plants. The issuance of licenses to all refill gas stations is vested with the Department of Petroleum Resources (DPR). It is the responsibility of DPR to determine whether or not an application is suitable for "Approval to Construct" (ACT) Petrol station. In urban cities where there is no proper coordination of development, petrol stations are one of the contributing factors of traffic, explosion and fire (Samuel, 2011). For example, in Owerri, some of the gas stations are too close to one another and no adequate set back from road, while others are too close to residential areas.

Maps are scales which are used for measuring of property and studying of location. Although maps may show objects with respect to attributes other than location, their principle purpose is to depict objects in terms of their location property. Location is seen as one of the property of objects which geographers consider central to their study and problems of understanding objects or phenomena which interest them (Lewis, 1977). Geographically, the term location is used to identify a point or an area on the earth or elsewhere and this may be through the use of absolute or relative terms. Location is said to be relative when it is described in relation to other point or area. An absolute location uses a specific pairing of latitude and longitude in a Cartesian coordinate grid (Abler, Adam and Gould, 1971).

Urbanization and the increase in urban population and the growth in the number of cars and other vehicle generate various kinds of demands, one of which is fuel. Harrison (1999) noted that a considerable amount of fuel cars are wasted due to the long urban path and unnecessary trips. He further observed that increase in vehicles triggers increasing demands for fuel, increase in urbanization and new technology leads to the demand for other petroleum products and by extension Liquefied Petroleum Gas station.

Since greenhouse gases are increasing and efforts are in place to reduce the effect to the barest minimum; gas stations are usually located close to the people for easy access. However, in siting of gas stations, the variables which are to be considered when selecting location for utility are proximity to population centers, distance from

neighboring stations, the easement of using existing utility and the magnitude of environmental pollution parameters (Alesheikh and Golestanic, 2011).

Geographic Information System (GIS) is defined as a set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes (Burrough, 1986). It is used to design service areas to meet specified criteria by integrating layers of information. The methods of analysis have been implemented in GIS to support the search for optimum locations for such central services as retail stores, hospitals, or fire stations. GIS techniques can be employed to enhance the location of infrastructures and assessment for proper distributions within a city (Oloko-Oba, Mustapha, Ogunyemi, Akintunde, Alaya, Badru, Ogbole, Popoola, and Samson (2016), and Abdullahi, (2012). Therefore, there is need for a study on the spatial analysis of the distribution and location of gas stations in Owerri Metropolis.

1.1 Statement of The Problem

In locating gas plants (gas stations), it is important to take some precautionary steps like locating them at a required distance from buildings, places of public assembly, public facilities such as markets, hospitals, and schools and areas of high traffic congestion and residential building (Odeh, 2017). And that, this consideration should be in accordance with the guideline provided by the Department of Petroleum Resources that the LPG filling stations should be located away from habitable areas, should be sited in an open ground and well ventilated areas, should be located along

main roads, that are safe for LPG transportation and should not be situated in close proximity to filling station (petroleum) (DPR, 2010).

1.2 Notwithstanding this, however, it is common to see gas stations located in the midst of residential houses or sharing the same premises with petrol (fuel) stations in Owerri metropolis. It is therefore against this background that the study examined the conformity of those gas station sites in relation to DPR standards.

1.3 Aim and Objectives

The study aimed at assessing the spatial distribution and conformity of LPG gas stations with DPR regulations in Owerri metropolis with the following objectives:

- i. To obtain the spatial coordinates of the various gas stations in the metropolis using GPS receiver;
- ii. To analyze the location of gas stations in Owerri metropolis against the physical planning standards set by DPR and OCDA; and

1.4 To assess the conformity of LPG gas stations with DPR regulations in Owerri metropolis.

1.5 Scope of the Study

This research focuses on the location analysis of gas stations in Owerri Metropolis which consist of 3 local governments (Owerri Municipal, Owerri North, and Owerri West. The location, distribution and patterns of the gas station will determine by the study, and the study will investigate the factors influencing the location of gas stations in the area. Also, the distance of the stations from the road,

hospitals and distance between station and its neighbours will be examined and compared with the standard of DPR and OCDA.

1.6 Significance of the Study

This study will assist planning authorities carry out necessary action in already existing gas station that have contravened standards and are ill-sited as well as verify with ease and implement gas station siting standards for those yet to be constructed. Also, not much research has been done on the subject matter in existing literatures. It will thus serve as guide for individuals, developers, the government and other shareholders in the urban planning, downstream petroleum industry and other related areas for further research and decision making.

1.7 Justification of the Study

The problem of indiscriminate location of liquefied petroleum gas (LPG) stations has become an alarming phenomenon in almost all Nigerian cities, and explosions associated with it have become recurring events across the country raising questions about public safety. The most recent of such explosions took place on Monday January 14, 2015 at Magodo, a suburb of Lagos (All Africa.com). Before the latest disaster, there have been other cases in Warri, Delta State, Badagry, Lagos State, Osogbo, Osun State, Owerri, Imo State and Nnewi in Anambra State. The lists of these explosions are not exhaustive. In view of the above development an intensive spatial analysis of location and distribution of liquefied petroleum gas (LPG) stations should be enforced so as to prevent and provide a qualitative urban environment for living, working and recreation.

Therefore, the study is relevant to Owerri

metropolis as a framework for the State Government and stakeholders. It will serve as guide for individuals, developers and stakeholders in the planning and approving of sites for liquefied petroleum gas (LPG) stations in the study area and Nigeria at large.

Literature Review

2.1 Introduction

This chapter focuses on the review of available literature relevant to the subject matter of the research. To address the theme, this chapter undertakes a review of literature or individual components of the central theme and combination of such individual components, as basis for developing the researcher's ideas on the general concept of the study. The reviews of literature, in addition, aims at providing detailed account of earlier studies in order to identify the gap that exists in the literature, which research attempted to fill. Literature from extant discipline such as location analysis, regional planning, spatial distribution, among others found useful for addressing the central themes were studied. In this study, emphasis was on previous writing on spatial distribution, location analysis, and distance between the location of gas station, distance to public facilities, distance from the road, urban and land value.

2.2 Location Analysis in Geography

“Locational” or “spatial analysis” or “spatial science” in human geography focuses on spatial organization, and its key concepts were embedded into the functional region – the tributary area of a major node, whether a port, a market town, or a city shopping centre. Movements of people, messages, and goods and so on, were organized through such

nodal centres. These were structured hierarchically, producing systems of places cities, towns, villages etc.

The concept of spatial arrangement followed fundamental principles developed by German geographer, Walter Christaller in the early 1930s, though it attracted little attention for two decades. Christaller's central place theory modeled settlement patterns in rural areas, the number and size of different places, their spacing, and services they provided – according to principles of least – cost location. The assumption was that individuals want to minimize the time and cost involved in journeys to shops and offices, and thus the needed facilities should be both as close to their home as possible and clustered together so that they can make so many purchases as possible on goods and services and as little as possible on transport. Christaller showed that this required hexagonal distribution of centres across a uniform plane (i.e., one that had no topographical barriers). With the smaller centres (providing fewer services) nested within the market areas of the larger.

Other works by non-geographers provided similar stimuli, as economists such as Edgar Hoover, August Losch (who produced a theory similar to Christaller's), Tord Palander, and Alfred Weber suggested that manufacturing industries be located to minimize both input costs (including the costs of transporting raw materials to a plant) and distribution costs (getting the final goods to market). Least-cost location was the goal, which could be modeled as a form of spatial economies. Efficient spatial organization involved minimizing movement costs, which was represented by an

adaptation of the physicists' classical gravity model. Dawson (2008) sees location analysis as a new vibrant, demanding and controversial concept, and doubted the emergence of location analysis even after seeing it as a new vibrant concept, he wondered what will be the outcome of the new concept and wondered if the concept will be a cuckoo in the nest or bring the long-sought aphrodisiac for our discipline. He further observed that the proponents appear to deride the traditional region-centered geography of schools and despise the literacy approach as inexact, ill-conceived, and out of tune with the development of service in general. The debate about the nature of the geographical individual has revealed that little attention has been given to the topological attributes of landscape elements.

Haggett (1965) suggested in his locational analysis in human geography that there lies a thin line between the social science and geometry bordered upon regional science, but in another development, Bunge (1966) opined that the locational approach may also be applied in biogeography and geomorphology. Bunge approved this broad definition of the field, for he notes in theoretical geography that all objects possess real relationships and shapes, and that any object may be viewed as part of a distribution.

Locational analysis has been in practice long before now, centuries before, people may have wondered in which area to live, where to build houses, villages, churches, and other facilities and they solved these problems using some sort of heuristic methods. However, location science formally began with Pierre de Fermat (1601 – 1665) who used to

tease his contemporary mathematician with tricky problems (Eisalt and Marinov, 2012). Among the pioneer in location analysis are Evangelica Torricelli (1608 – 1647) and Battista Cavallieri (1526-1597) who studied on basic Euclidean spatial median problem in early seventeenth century. However, Weber seemed to be the greatest of them all, hence his name appears most in the field of location science with formulation of the models in his book's appendix as observed by (Eisalt and Marinov, 2012; Sen Onden, Gokgoza and Sen, 2013). The breakthrough in modern quantitative location theory occurred in the mid-1960s, when Hakimi championed the epoch event which gave way to his path-breaking analysis of a location model on network, which, in today's parlance, is p-median problem (Eiaslt and Marinov, 2012).

2.3 Spatial Distribution

Spatial distribution is the arrangement of a phenomenon across the earth's surface, and a graphical display of such an arrangement is an important tool in geographical and environmental statistics. A graphical display of a spatial distribution may summarize raw data directly or may reflect the outcome of more sophisticated data analysis (Wikipedia 2010). Many different aspects of a phenomenon can be shown in a single graphical display by using a suitable choice of different colours to represent difference.

Belinda, Widya and Putu. (2016) suggests that the best criteria used for the determination of petrol filling station suitability (PFSS) location distribution in Surabaya. Four preference criteria were listed and these criteria are; Proper Landuse Selection (with 31.2% of influence rate),

Emergency Response Service (with 23.6% of influence rate), Vicinity Area Protection from Fire and Explosion (with 14.2%) and Water System Protection from Underground Storage Tank Leakage (UST) based on the weighted sum analysis. They divided the metropolis into three suitability regions: high suitability (53% of area) medium suitability (19% of area), and not appropriate (28% of area). The study was to assist in the proper siting of new stations and assess the location suitability of existing petrol filling stations in the area. They pointed out that the suitable petrol filling station siting must consider environmental safety criteria and attributes that will enable them to be located in a safe location so as to avoid unforeseen risk to people or the environment.

Mshelia, Abdullahi and Dawha (2015) suggest that for the environment to be properly managed and for the environment to be at its best, people and their needs must be placed at the forefront of concern so as to serve their physical, psychological, development, cultural and social interest equitability. That is, such attempt must be integrated, acknowledging all the element of the environments which are linked and interrelated taking into account the effects and decision on all aspects of the same environment and the people by pursuing the selection of the best practicable environmental options such as environmental health and safety, consequence of policy, programmes, project, process, service or activities for the purpose of overall environmental protection, conservation and safety of human life and property.

2.3.1 Overview of Liquefied Petroleum Gas (LPG) Stations

Jackle (1978) sees Filling stations as roadside facilities specially designed to sell gasoline and other products that automobile and others use. In addition, many also offer other minor repair services such as motor tuning and tyre alignment. Energy adequacy is universally recognized as a crucial parameter for the sustainable development of a nation. The constant increase in oil and gas demand requires the exploration, development and distribution of new energy source (Tavanna, Pidashti, Renney, Belaud and Behzadian (2014). Ambituumi, Amezega and Emescch (2014) had argued that Petroleum consumption has been on the increase in Nigeria since the early 1980s, this upward trend is crystal clear, as it is showing in the energy consumption data of 2006, 2007, and 2011 where petroleum products represent 53%, 67.3% and 68.5% respectively of the total energy consumed in the country (energy information administration 2012). Since principal function of the filling station is to supply the need for the automobile and the truck owner, and other commercial needs, its history is related to that of automobile. While the first passenger cars were sold in 1895, filling stations began operation in 1905 (Beckman, 1957).

However, Beckman is of the opinion that then, petrol stations were scanty and that specialized outlet which dealt only on gasoline and lubricant were not known and the motorist then purchased their products from retail stores and service establishments that sell petroleum product together with other business activities.

According to James (1953), the first fuel dispensing stores with underground tank appeared in 1910 and

even then, most pumps were adjacent to the stores. These specialized stores dealt only on sales of motor fuel and lubricant, this in return generated a large portion of revenue, there was also enough space for motorist to drive in and receive services. This innovation took motorist off the road, reduced traffic congestion and made the road free for other commercial and private user for ease of transportation.

Beckman (1957) and Pees (2004) noted that the first drive-in station was opened in Chicago by Standard Oil Company of Indiana in 1913. According to Pees (2004), Standard of Indiana, which was known as Standard Oil Co. Inc (Exxon Mobil, 2008), was the first specialized filling station. Both authors argued that the company (Standard of Indiana) opened a pump station for automobile in Minneapolis in 1911. However, the gasoline was pumped into cans and then poured into the vehicle's tank. Imperial oil had a service station in Vancouver, Canada, in 1908. Standard also opened a curbside station having a rotary pump in Rockford, Illinois, in 1914.

2.4 Liquefied Petroleum Gas (LPG) Station in Nigeria

The upstream petroleum sector is involved in the search for and production of crude oil and gas. It comprises such activities as; exploration, evaluation and appraisals, development, production and decommissioning (API, 1983; Charles, 1999). On the other hand, the downstream sector involves refining product, storage, transportation, distribution, and retailing. Filling stations are concerned with distribution and retailing of petroleum products with or without other business

attached to it.

The location and the siting of a filling station however need careful examination in regard to the control that requires to be exercised, the legal tools that may be required to enforce such control and the optimum conditions that should be created from the point of view of service to the general public. Filling station is seen as one of the paramount sources of traffic hazards generation, aestheticism reducing and potential fire causal agents (Ujjwal and Sokhi, 2006). This indiscriminate and uncoordinated zoning of stations in the public space is unhealthy to our environment, it is on the basis that States and Nations have to wake to the yearning of the public and laws and regulations to checkmate the siting and location of filling stations in the environment so as to minimize and reduce the risk associated.

In Nigeria the DPR is responsible for the registration and regulation in the downstream petroleum sector including the filling and liquefied petroleum gas (LPG) stations business. Other agencies involved are the State Ministries for Town Planning.

2.5 Department Of Petroleum Resources (Dpr)

In the bid to strengthen its control over the industry, the Nigeria National Oil Cooperation (NNOC) was established in 1977 and charged with the responsibility for both upstream and downstream activities in the sector. The NNOC also looked after Government's participation in the activities of the Oil Companies. In 1977, the Ministry of Petroleum Resources (which also had regulatory functions) and operates side-by-side with the NNOC, were

merged to form the Nigerian National Petroleum Corporation (NNPC). The NNPC combined the commercial functions of the defunct NNOC (that is, exploration, production, transportation, processing and oil, refining and marketing of crude oil and its refined products) with the regulatory function formerly exercised by the Ministry of Petroleum Resources. In the Ministry of Petroleum Resources, there is a Department of Petroleum Resource (DPR) which has four divisions; resource management division, inspections division, technical control division, and services divisions which also have three branches including economics, planning and statistics. The DPR's major tasks include the issuance of certificates as well as regulating the activities of filling stations (Proshare, 2013).

According to DPR (2010) guidelines, the procedure and conditions to be fulfilled before the grant of approval and license for the construction, modification, revelation of a liquefied petroleum gas (LPG) filling plant and AutoGas stations business, one has to submit;

- a. Three copies of the approved drawings showing the existing or proposed buildings on the site and the relevant distance to the roadways and adjoining properties, if any.
- b. Three copies of piping and instrumentation diagram (P I& D) of the gas filling plant and manufacturers data sheet of the storage tanks with codes and standards adopted in the design.
- c. A provisional approval letter and fire report by chief Federal/State fire

Officer or an officer authorized by him on his behalf, that he is satisfied with the proposed arrangement for the prevention of fire.

- d. A letter from appropriate town planning authority, authorizing siting of the liquefied petroleum gas filling plant at the proposed site. The town planning approved stamps on all design drawings is accepted.
- e. Three copies of memorandum and articles of association of the company and evidence that the company is dully incorporated by the Federal Ministry of Trade to deal in petroleum products.
- f. Tax clearance certificate for proceeding three years of application or tax exemption certificate for new company.
- g. An application fee, as may be determined by DPR, in Bank draft or certified cheque made payable to "Federal Government of Nigeria DPR Fee Account" is payable on submission of application.
- h. Three copies of codes, standards and specification adopted in the design of the tanks and auxiliary equipment.
- i. A copy of safety, health and environment (SHE) proposal for the proposal plant and environmental impact assessment report of the site.
- j. The regulation further provides that before operating a gas station some

physical planning standards must be satisfied. They include:

I. Construction Procedure

The regulations and condition governing the construction of liquefied petroleum gas (LPG) filling plant are as follows:

- a. Liquefied petroleum gas must be stored under pressure in vessels designed to withstand safely the vapour pressure at the maximum temperature construction of such vessels must be to an acceptable design code such as;
- b. The Nigerian standards organization approved standard on pressure vessels and liquefied petroleum gas containers NI S220/85
- c. American Society of Mechanical Engineers (ASME) boiler and pressure for use in the chemical, petroleum and allied construction, test and certification.
- d. The American Petroleum Institution Standards 2510 (2).
- e. The British standards (BS) 1500 Part 1, fusion welded pressure vessels for use in the chemical, petroleum and allied industries Pr BS

155000 for new vessels design, construction, test and certification.

- f. The installation/construction of piping, instruments and the plant must be carried out by an accredited DPR company.
- g. The materials used for the construction of the filling shed must be non-inflammable material.
- h. The filling shed must be open-sided for good ventilation.

The regulation further provides conditions necessary for licensing a newly completed LPG plant. They include:

ii Pre-license Inspection

On completion of construction works, the applicant shall notify the nearest DPR office and the following statutory/technical requirements shall be met or provided to facilitate pre-license inspection of the plan:

- i. A completed application form for the grant of LPG license.
- ii. Certification from Weight and Measures Division Federal Ministry of Commerce that the measuring equipment installed at the plant are calibrated satisfactorily.
- iii. Certification from Standards Organization of Nigeria (SON) that the gas tank meets specifications and is safe for the proposed purpose.

- iv. Final fire safety certification issued by Federal or State Fire Department.
- v. Mechanical teak tester
- vi. Gas detector
- vii. Warning notices and personnel protective wears for the plant operators
- viii. Gas tank and pipeline pressure test reports and certification. These facilities are to be pressure tested by DPR accredited company and witnessed by Director's assigned officer.

2.6 Imo State Ministry of Land, Survey and Urban Planning

The Ministry of Lands, Survey and Urban Planning was established and given the task of developing landuse policies and physical development of human settlement subject to enabling laws, including environmental concerns and building designs approvals (Punchng.com, 2016). The Ministry's other cardinal point of establishment includes advising the Government on land tenure issue, how to manage Government lands, properties and ensure that policies and development conforms to the landuse decree, Town Planning and Urban Renewal Strategies, necessary for effective performance of it services. The Ministry has an Urban Planning Board, a Landuse and Allocation Committee, Office of the Surveyor General, Mapping and Geo-informatics, Cadastral and Special Surveys, Processing of Title Document and Urban Administration Department.

In Imo State, the Ministry of Lands and Housing is also charged with survey of State lands, determination of landuse and control, compensations, housing policies and urban development. The OCDA (Owerri Capital City

Development Authority) is also mandated to oversee the development control in Owerri Capital City. Development control is a present tool for city management and growth that ensure orderliness, environmental friendliness, and improved city image.

The present functions of the agency includes provision of planning schemes for the State Urban Centres (master plans etc) providing planning permission/advice to the State Ministry of lands, Survey and Urban Development; development control (control use of land, granting building/development permits and monitoring); provision of amenities and convenience including recreational facilities, construction and maintenance of roads and drainages; designing of layouts for various purposes, and coordinating the effort of other major providers of urban infrastructure and services, utilities, and waste management etc.

2.7 Geographic Information System (Gis) For Location Analysis

Geographic information system (GIS) is defined as a set of tools for collecting, storing, retrieving at will, transferring, and displaying spatial data from the real world for a particular set of purpose (Burrough, 1986). The GIS application includes the use of design service areas to meet specified criteria by integrating layers of information. The integrating layers information methods of analysis have been implemented in GIS to support the search for optimum locations for such central services as retail stores, hospitals, or fire stations. Understanding the spatial distribution of phenomena that occur in space today constitute a great challenge to the elucidation of central questions in many areas of

knowledge. Due to the availability of low-cost Geographic Information System (GIS) with user-friendly interfaces, studies are becoming more and more common. To strengthen the system and achieve the aim of this technology, it is enough to have a database and geographic base (like a map of municipalities) and this is capable of presenting a colonial map that allows the visualization of the spatial pattern of the phenomenon (Ahmed, Mohammed and Idris 2013).

Chief among these studies includes Camille (2010), on location of petrol station in Abidjan with an aim of enabling motorist find nearest station using GPS. The findings of the study showed that GIS can allow consumers locate the station within the Central Business District and outskirts of the Abidjan easily without encountering any difficulty. A similar study was conducted by Ayodele (2011), in Kaduna metropolis that aimed at exploring the capacity of GIS based technology for locating filling stations. Emwendogo (2013) worked on the use of GIS in the management of information about service offered in petrol station in Mumbasa road, Kenya; the project is based on the integration of GPS and GIS technology for comprehensive database linked to digital map for efficient and effective management of information. Adsavakulchai and Huntula (2010) in Bangkok analyzed the optimum site selection of Natural Gas Vehicle (NGV) station using Geographic Information System which layers information system was integrated in a GIS environment for selecting best sites. These layers were concentrating on population size, road networks, vehicular population movement in and out of the area and

data for existing natural gas station existed in the area concern. The findings revealed that there are 76 filling stations in the area and the optimal District site location for NGV station Bangkok in Nongjok District about 50m from U-turn. The study concluded that GIS is a vital and necessary technology that must be included in site selection analysis, and that GIS must be one of the key factors to be considered in decision making such as gas station selection.

2.8 Liquified Petroleum Gas Station Distance to Public Building

Some airborne organic compounds such as benzene, which increases the risk of cancer, have been recorded at petrol station at levels above the average permissible levels for urban areas where traffic is the primary source of emission (Morales, Marta, Minarro, Ferradas, Carracena, and Rico, 2010). They further observed that it was relatively common to come across petrol stations surrounded by houses particularly in the urban areas. They further noted the effects of contaminants at petrol stations which are potentially harmful to health, and it can be inhaled from a building less than 100 metres away from service stations. Study showed that the air quality at petrol stations and in their immediate surrounding is affected by emission stemming from evaporated vehicle fuels (unburnt fuels from fuel loading and unloading operations, refueling and liquid spillage). The study argued that the minimum distance of 50m should be maintained between petrol station and housing and 100 metres for “especially vulnerable” facilities such as hospitals, health centres, school and old people’s homes.

Morales *et al.* (2010) further evaluated the extent to which petrol stations located in the South-East of Iberian Peninsula in Spain affect their surroundings. The level of typical traffic pollutants in the different part of the urban area of Murcia was measured and the quotient for the level of aromatic (benzene) and hydrocarbon (n-hexane) compounds at three petrol stations was calculated to find the distance at which the service stations stop having impact on the pump attendants. In the study, result and recommendation was that, the maximum distance of influence of close to 100 metres should be maintained, the study further indicated that, the average distance over which the contaminants have effects is around 50 metres. They however observed that the distance depends on the number of petrol pumps, the amount of fuel drawn from them, traffic intensity, the structure of the surroundings, and the weather condition.

They further noted that if the traffic in the area surrounded by the petrol station is intense, and exceeds the emissions from the station itself, pollution at the service station is “overlapped and goes unnoticed” over a short distance.

2.9 Compliance Of Gas Stations To Planning Standard

Ioş and Tudor (2011) examined the temporal changes in proximity of residential land use for filling stations in Bucharest suburb, Romania. Coordinates of the station were obtained and the digitization of the residential areas was performed using GPS, Aerial Photographs and Google earth imageries. Buffer zones were created in map to see the encroachments of residential areas. The results of the finding indicated that 21 gas stations were

located in residential areas and 39 gas stations were located in non-residential area.

However, the study was limited to buffer analysis and only one landuse (residential), distance of filling stations to other conflicting land like public building, hospital, schools, road network, population size, and vehicular population or movement were not analyzed by the researcher.

Ujjwal and Sokhi (2006) applied GIS technology for petrol station vulnerability assessment in New Delhi, India. In their study emphasis was placed on land uses within the 200m radius from each filling station. These were possible to identify using high resolution Ikonos image, and GPS were used in obtaining the coordinates of the stations. Stations were categorized based on vulnerability classes, which was density and population with 200 metres buffers. The study did not indicate the permissible requirement of inhalation by the petrol station attendants, the permissible requirement as per the duration one should work in the petrol station here was not stated, measures of mitigating the petrol station vulnerability were not spelled out. Hence, a further study is required to be carried out to research on the significant areas like health implication of those exposed to the hazardous effects of the petroleum products by inhalation.

The potential health hazards associated with petrol station on the life of the pump attendants was investigated by Nwanjo and Ojiako (2007) in Owerri, Nigeria. The study revealed that the pump Attendants from twenty filling stations were assessed in the area and another twenty individuals that were not exposed to its vapour were used as Control. It was revealed that that the rate of

exposure is directly proportional to the duration of the exposure. However, the study failed to investigate the role of distance in determining the concentration of these hydrocarbon compounds since not only pump attendants are exposed to vapour, but also the neighbors around the environment.

2.9.1 Gaps Filled by the Study

In Nigeria, many studies were carried out on the analysis of location of filling station in relation to Physical Planning Standards, example of these studies include Blamah *et al.* (2012) which looked at the locational impact of gasoline service station along Abuja-Keffi Road and environs in Karu. Though this study was carried out without involving GIS in the process, site reports submitted were used in assessing the location of the filling stations.

In the study, it was discovered that many stations in the area did not meet the standards set by the regulatory bodies. Abdullahi (2012) also realized that most filling stations in Agege Local Government Area of Lagos State did not see it as important to consider standards in sitting their station. Though the study did not apply GIS, rather Ayodele used GIS to show the spatial distribution which is the main aim of this research work, but nothing was done with regards to location pattern analysis. Also, there is scarcity of literatures on gas station analysis as literatures are mostly centered on petrol filling stations. This study would use GIS to identify the spatial pattern of the location of gas station in Owerri metropolis.

Materials And Methods

3.1 Introduction

This chapter discussed the study area, the materials

it focused primarily on the use of charts and frequency tables to show the distribution of filling stations.

Ayodele (2011) through the use of GIS concluded that 69.5% of the filling station in Kaduna did not align with the standard set by the Planning Authority. However, the actual method employed by study was not explained and those petrol stations that did not adhere to standards were equally not mentioned. Although ArcGIS software was used for the analysis, tools available for spatial pattern analysis such as nearest neighbor analysis and Kamel density analysis were not used in the study. In addition, there were no attempt to identify the factors consider in siting filling station in the area.

This study therefore focused on location analysis of gas stations in Owerri metropolis using GIS tools. Comparison of location to physical planning standards set by the regulatory bodies is employed to see the extent of compliance. Studies as available in the literature, from other Nigeria cities, like Kaduna, (Ayodele, 2011), part of Lagos (Abdullahi, 2012) and Karu in Abuja (Blamah *et al.*, 2012) were used as guide to ascertaining the compliance with the planning standards. Among the three, only used and the methods used to source and analyze the data collected for the study. The chapter is divided into sections. These are the study area, reconnaissance survey, types and sources of data, scanning, geo-referencing and digitilizing of the maps, detailed field work, data integration and data analysis.

3.2 The Study Area

Location

The study area, Owerri metropolis lies between latitude 5°31'N and 5°20'N and longitude 6°54'E

and 7°16'E. Owerri is made up of three local government areas namely Owerri municipal, Owerri North and Owerri West as shown in Figure 1.

It is bound by Mbaitoli in the North, part of Ikeduru on the Northeast, by Aboh Mbaize on the east and in the South by Ngor-Okpala, and Ohaji/Egbema in the West. River Otamiri, and Nworie bisect the area, creating the major landmark (Ukaegbu, Iwuji, Uche, Osumgboragu and Amangabara, 2017).

The climate and vegetation of Owerri are as found in the Southern part of Nigeria (Njoku, 2006). The study area is underlain by the coastal plain sands of the Benin formation which is late tertiary in age. It is rather deep, porous, infertile and highly leached. The soil in some parts consists of lateritic material under a superficial layer of grained sand. The soil would naturally be fertile but excessive leaching has removed much of the required plant nutrients. According to the 2006 Nigeria National Census, the study area has an estimated population of 401,873 inhabitants, with 211,298 males, and 190,575 females comprising about 32,000 households (NBS, 2008). The inhabitants are majorly traders few artisans, civil servants and farmers. The city has few commercial centers. Agriculture is likely to retain its relative dominance in some communities of the study area (Njoku, 2006).

3.3 Materials

The materials used in the research work ranged from software, hardware, equipment, list of gas stations and street maps.

3.3.1 Software and Hardware

- ArcGIS 10.0 Version

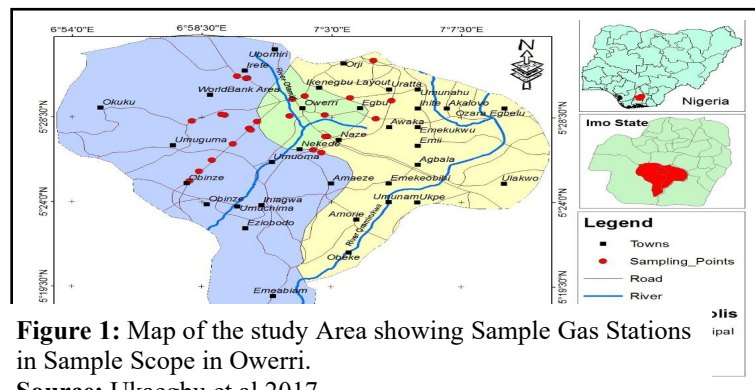


Figure 1: Map of the study Area showing Sample Gas Stations in Sample Scope in Owerri.

Source: Ukaegbu et al 2017

- Quickbird Imagery of 2013
- Excel Microsoft Office Application Software (2010)
- Computer hardware and related accessories like mouse, printer and scanner.

3.3.2 Equipment

Hand held Garmin 76X Models

3.3.3 Materials

- List of gas stations from DPR – Owerri Office
- Street Map of Owerri Metropolis
- Relevant texts
- Internet and related literatures

3.4 Methods Of Data Collection And Analysis

3.4.1 Reconnaissance

A preliminary survey was carried out to identify and document gas stations in the area. This acquainted the researcher with the knowledge of the area and provided a guide on how to source the data, types of data needed and preparation for the field work.

3.4.2 Types of Data

Data for the study were obtained from both primary and secondary sources. The primary data were obtained from direct field observations with a handheld GPS (Garmin 76X Model) device. The

GPS was used in obtaining the coordinates of the various gas plants in the study area. The secondary data were georeferenced data which included the street maps of the study area, the Geographical location and the list of gas stations and the areas the gas stations are located as well as literatures and other relevant texts used in the study

3.4.3 Data Sources

Data for the study was obtained from;

1. Imo State Ministry of Lands and Physical Planning and Owerri Capital City Development Authority (OCDA) where street maps of Imo State at a scale of 1:20000 will be sourced, Quickbird imagery of 2013 was integrated with street-map in order to produce the update street map of the study area.
2. List of gas stations was obtained from the Department of Petroleum Resources (DPR), a department under the Ministry of Petroleum Resources responsible for registration and regulation of filling stations and gas station in Nigeria. From the data gas station name, type and area (street) of location was identified. This served as a quick guide for verification and collection of the coordinate data using Global positing system (GPS).
3. Textbooks, journals from libraries and internet.

3.4.4 Scanning, Georeferencing and Digitilizing the Maps

Street map sourced was scanned, imported into ArcMap environment of ArcGIS 10.1 and then georeferenced using map to image georeferencing method. Quickbird 2013 image of the area was used as a slave image for the georeferencing.

3.4.5 Fieldwork

A simple checklist was compiled and used to source the detailed information on the gas station. Field visit was made to all the gas stations, and coordinates of the gas stations will be obtained using GPS (Garmin 76x model).

3.4.5 Software and Hardware

The software and hardware that was used for the work include:

1. Excel Microsoft Office Application of Microsoft Office software (2010).
2. ArcGIS 10.1 Version
3. Computer hardware and related accessories like mouse, printer and scanner.

3.4.6 Data Integration

In order for the goal of the study to be achieved, different sets of data were used. These include the gas station data sourced from DPR and field survey, landuse map and roadmap. These data were imported, georeferenced to the some coordinate and datum, and integrated in ArcGIS 10.1 environment for the analysis.

3.4.7 Data Analysis

Data obtained from the DPR was used for analysis with the aid of Excel Microsoft (2010) application to create simple database. Pattern analysis was done using spatial statistics tools in ArcMap environment

to identify the location pattern of gas stations in the area. A nearest neighbor analysis was used to compute the nearest neighbor index (NNI).

The nearest neighbor analysis according to Wough (2007) was initially developed by Clark and Evans distribution;

$\bar{d}$ = the mean distance between the nearest neighbours (km)

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

A = the area under study (Km²).

Comparison of location of the gas stations with standards buffer and proximity analysis was done in ArcMap. Buffer of 1.5 meter was created on the roads to identify stations that meet the criteria of fifteen 15metres distance from there to the road. Query by location was performed using selection menu in ArcMap environment.

Distance from the Road:

Physical planning standards set by DPR (2010), procedures guide for grant of approvals to construct and operate a petrol product retails outlet which stands at 15m from the road was used to ascertain the conformity between gas station and the nearest road and data query by location was made using ArcMap environment.

Distance between the Locations of gas station

The distance between stations in the area was determined in ArcMap environment using proximity operation of analysis tool.

Distance to Health Facilities

The distance between stations in the area and public facilities like school and hospitals, was determined using DPR standards operation and this was done

in 1954 to analyze the spatial distribution of plant species with the equation:

$$R_n = 2\bar{d}\sqrt{n}/A$$

Where R_n = the description of the

using ArcMap environment to check if the gas stations had met the required 100 meters minimum distance from public facilities as stated in the DPR operational procedures.

Data Analysis, Presentation And Discussion

4.1 Introduction

This chapter presents the analysis result and discusses the major findings of the research for the objectives stated at the first chapter to be achieved. The result is presented and discussed under five sub-headings namely, inventory and mapping of the gas stations, distribution pattern of the gas stations, factors governing the distribution of gas stations and comparison of the distribution of gas stations with physical planning standards set by DPR (2010) and adopted by OCDA (2017).

4.2 Inventory And Mapping Of The Gas Station

4.2.1 Inventory of Gas Stations by Area

The findings revealed that there are 27 (twenty seven) gas stations approved by DPR existing as at the time of the research. These gas stations are located along 13 (thirteen) roads in the area as shown in Table 4.2. However, the gas stations are not evenly distributed between the three local government areas that make up the metropolis as can be observed from Table 4.2. Owerri West has the highest number of gas station (13) followed by Owerri North (8) and Owerri municipal (4).

Further features of the location of gas stations are that they tend to be dominant on the areas with

higher population. As revealed by the research, the land use and land cover map as shown in Figure. 2, 3 revealed that built-up area occupied the highest area in the metropolis with about 18934.11 hectare making up a total of 35.36%. This showed that the city is fast expanding in built up areas. And development comes with high demands of basic service stations including the gas stations. It was also observed that secondary forest regrowth and farms in the area is the second largest land cover in 2019 showing that there are still areas on uncleared vegetation of about 12377.88Ha which is about 23%. However, the study revealed that the city has a cluster of built-up areas within Owerri municipal and hereby necessitating the decentralization of gas station to other part of the city centre like Owerri West.

Table 4.1: Land use land cover distribution

Name	Count	Area M ²	Area Ha	Area %
Forest vegetation	137532.00	123778800.00	12377.88	23.12
Farm vegetation	209315.00	188383500.00	18838.35	35.18

Source: Land Use Land Cover 2019

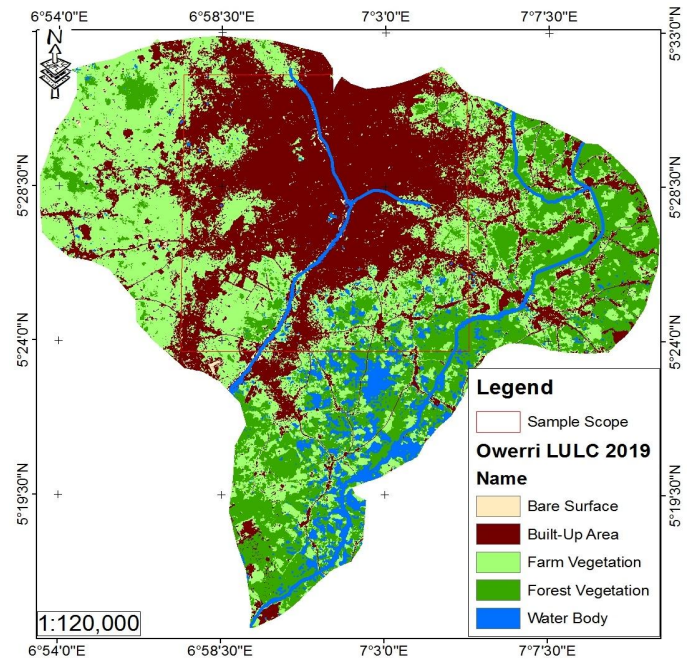


Figure 2: 2019 Land Use Land Cover map of the study area

Source: Land Use Land Cover 2019

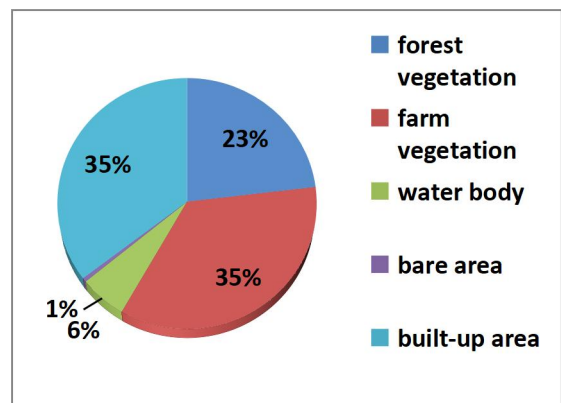


Figure 3. Land Use Land Cover Distribution Chart.

Source: Land Use Land Cover 2019.

Source: Field survey, 2019

Water body	34615.00	31153500.00	3115.35	5.82
Bare area	3093.00	2783700.00	278.37	0.52
Built-up area	210379.00	189341100.00	189344.11	35.36
Total	594934.0	535440600.00	53544.1	100.00

S/N	Names of Gas stations	Location	Proximity to Public Facilities (100m)	Poximity to road (15m)	Proximity to Nearest Gas Stations (400m)
1	Shore Link	Port harcourt road	C	NC	NC
2	Dutch Global	Orlu road	C	C	C
3	EbereLlinks	Bank road	C	C	C
4	Regime Gas Plant	Akwakuma	C	C	C
5	Dutch Global Station	Mcc	C	C	C
6	Halim 633 Energy	Toronto road	C	C	C
7	Chris Tee Investment	Egbu road	C	C	C
8	RegimeEenergy Service	Egbu road	NC	NC	C
9	EmpireEenegry	Aba road	C	C	NC
10	Jindu Global	Aba road	C	NC	NC
11	De Legend	Industrial cluster	C		NC
12	Robinochez Energy Nig Plc	Orji-Umudula	C	NC	C
13	Ebere Links	Item street, Mbari road	C	C	C
14	De Legend Plant	Poly road	C	C	C

15	Buttings and Tower	Port harcourt road	C	C	C
16	Ebere Links	Hospital road	C	C	C
17	EbereLlinks	Port harcourt road	C	NC	NC
18	Neetable Consult Limited	Poly road ne	NC	C	NC
19	Jindu global limited	Port harcourt road	C	C	NC
20	Juaku industrie	Onitsha road	C	NC	C
21	Regime energy service	Egbeada street	C	C	NC
22	A A Rano Oil and Gas	Onitsha road	C	C	NC
23	EbezinaGgasPplant	Km 5 ogbosisi rd umuguma	C	NC	C
24	Dutch Global Station	Port harcourt rd	C	C	C
25	Two LeaveGgates Global	Port harcourt rd	C	C	C
26	Chezon Daily Gas	Umuguma road	C	C	NC
27	CEENOL Resources Nig Ltd	Umuguma road	C	C	NC

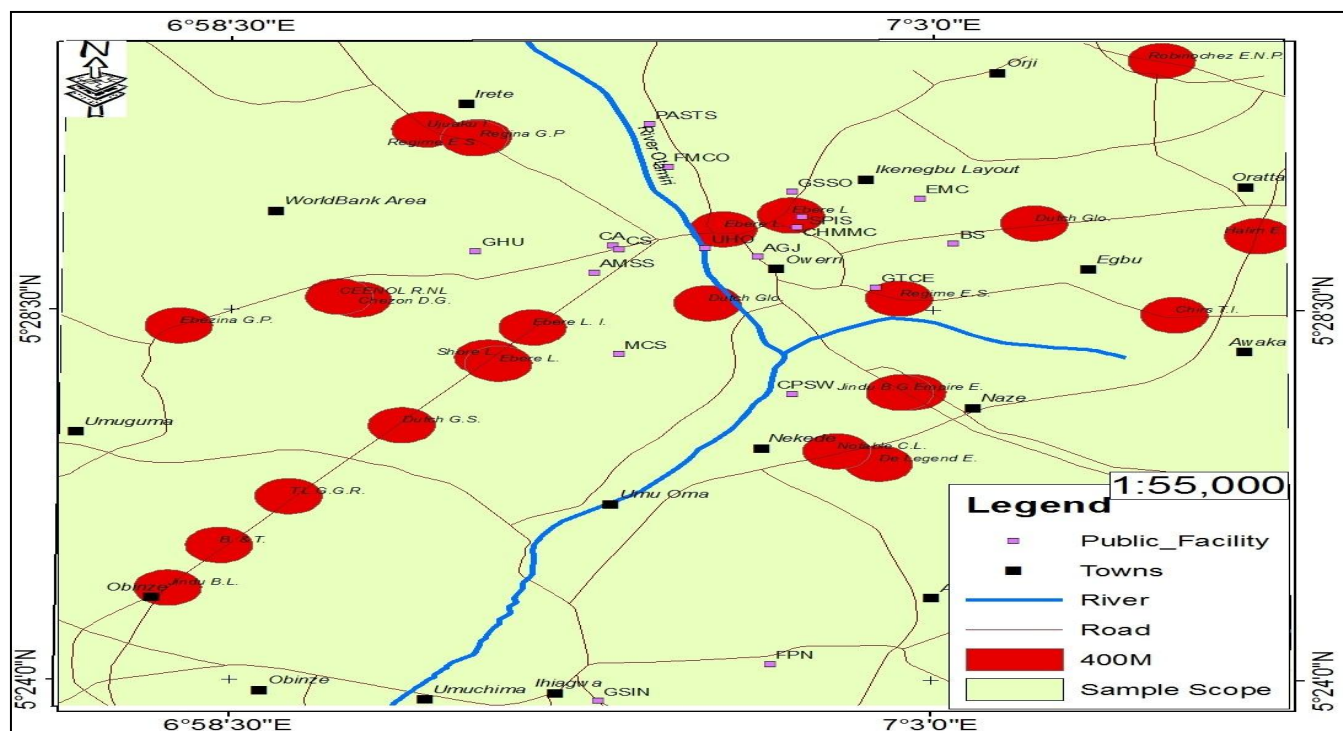


Figure 4. Map of the Study Area showing Sampled Gas Station in Owerri

SOURCE: Field survey2019

4.3 Pattern Of Distribution Of Gas Stations In Owerri Metropolis

Gas stations business is governed by many factors among which are accessibility, market, government policy, etc. This position is supported by Wough (2007) when he asserted that activities and events in geographic space tend to exhibit certain pattern. This pattern can be clustered, random or dispersed (Figure. 5, 6).

There are many methods of pattern identification; nearest neighbor analysis is one of them. The result of the analyses revealed that the pattern of distribution is perfectly clustered because the nearest neighbor index (R_n) value is less than 1 and Z – value is -15.87, less than 1.96. Also, there is a significant difference between the distribution of gas stations in the area and random distribution at both 95 and 99 percent because the p – value is less .001. However, it is important to note that

nearest neighbor analysis is just a technique that explained the distribution of phenomena but cannot explain the reason for the distribution, Wough (2007). The reason for clustered distribution of the gas and stations in the area may be linked to the fact that gas and petrol stations are located mainly on the roadside and research had shown that gas and petrol stations are mostly concentrated on major roads, and a typical example of this of distribution is experience in Owerri metropolis.

Figure 6. Gas Stations In Relation to 400m Distance to Nearest Gas Station

Source: field survey 2019

4.4 Factors Influencing The Distribution Of Gas Stations In Owerri Metropolis

Gas stations business has spatial dimensions due to the fact that it is done in a geographic space and that a place to be used for doing the business has to fulfill certain criteria. While DPR is responsible for clearing the site, issuing of license to operate and ensure standards are complied with, markets consider some factors in their choice of selecting

business location. Findings revealed that the following are factors the operators consider in selecting site to build a gas station:

- i. **Areas with high traffic flow:** This is one of the important factors considered in building a gas station. Marketers built their station along major roads that have heavy and continues traffic flow because they are likely to attract more customers. In other words, the more the traffic flow the more the gas demand.
- ii. **Convenience:** This is another factor consider by the marketers when choosing their business location. Even when heavy traffics are attractive, they also tend to build in a station away from traffic congestion where the prospective customers may find it convenient to stop by and do business. But they prefer where there is enough space for customers to come in and do business.
- iii. **Near Nodal Town/Junction:** Gas stations are also built close to nodal towns or junction because nodal towns are potential markets for gas stations. However, this is more applicable to peri-urban stations.

4.5 GAS STATION AND PHYSICAL STANDARDS

Gas stations business is regulated by DPR, a Department under the Ministry of Petroleum Resources saddled with the responsibility of registering and regulating the downstream petroleum sector. In addition, there exists

Owerri Capital Development Authority (OCDA) whose duty is to regulate all development within the metropolis of Imo State. Gas stations have to meet the planning standard set by these agencies for their business safety. This study correlates the planning standard (as discussed in chapter one) and current location of the gas stations in the area. This was achieved using proximity analysis tools available in ArcGIS 10.1.

4.5.1 Distance from Road

According to physical planning standard set by DPR (2010), the distance from the road to a gas station. Pump should not be less than 15 meter. Since gas station were represented as point of facilities and roads as line feature, a buffer of 15m was created on the road and data query by location was made in ArcMap environment. The query assisted with “selecting all locations that are completely within 15-meter road buffer. The result is presented in figure. 7 and figure 8.

The result revealed that nineteen (19%) of the stations did not meet the criteria of 15m minimum distance from roads as showing in Figure. 7, and 8). These stations include Ebere links, Port Harcourt Road, Jindu Best Global, Aba Road, Regime Energy Service, Egbu road, Ribonoches Energy Nig. Plc, Orji-Umudula Road, Ebezina Gas Plant Km5 Ogbosisi road, Umuguma, Ujuaku industries – Onitsha Road, and shore links Port Harcourt Road.

Figure7. Location of gas stations in Owerri

metropolis against the 15m standard distance from road

Source: Field Survey, 2019

4.5.2: Distance between the locations of Gas stations

Distances between stations in the area were determined in ArcMap environment using proximity operation of the analysis tool. The finding revealed that few gas stations in the study area are not in compliance with the set standard. This includes Chezon Daily Gas and CEENOL Resources Nig Ltd, Shorelinks and Ebere Links along Port Harcourt Owerri Expressway, Empire Energy and Jindu Best Global along Aba Road, De Legend Energy and Neetabel Consult Limited along Poly Road Nekede, Rano A. A. Oil and Gas and Regime Energy service along Onitsha Road.

In a nut shell more than one-quarter of the gas stations did not satisfy the standard of 400-meter distance from the nearest neighbor as shown in Figure. 9, 10 the gas station that had not satisfied this standard was found in most major roads. The highest number of those that did not meet the minimum standard of 400m distance between the locations of gas station was observed to be only 70% whereas 30% of the sampled gas stations were not compliant.

4.5.3 Distance of Gas Station to Health Facilities

According to the criteria set by the DPR gas stations are not allowed to operate adjacent to public installation like hospitals. In case they are to operate, the minimum distance of 100 meter has to be maintained. Thus, a buffer analysis was made to reveal the location of gas station in comparison to

their distance to the hospitals. The finding revealed that majority (25) making it 95% of the sampled gas stations in Owerri met the standards Figure. 11,12. while (2) stations making (5%) did not meet the set criteria by DPR.

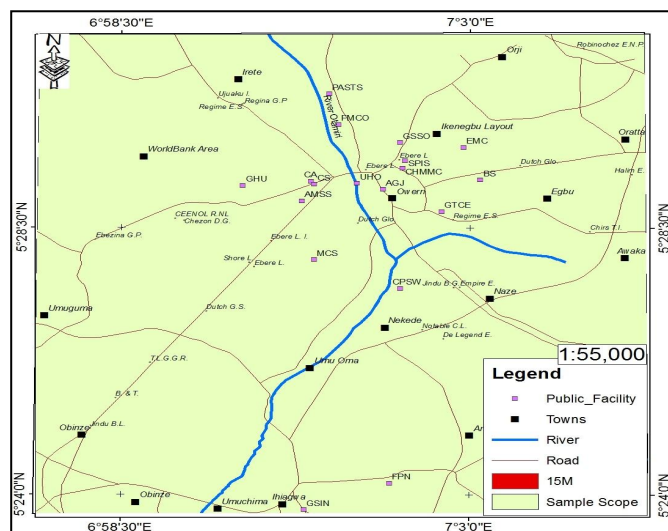


Figure 11. Distance of gas stations against public facilities

Source: Field Survey 2019

Summary, Conclusion And Recommendations

5.1 Summary Of Findings

The research analyzed the location of gas stations in Owerri metropolis and subjected the location to the physical planning standards put in place by the regulatory agency, DPR and OCDA. The research findings revealed that there are 27 gas stations currently operating in the area. The number of gas stations correlated significantly with road hierarchy. Major roads like Port Harcourt Road, Aba Road, MCC, Onitsha Road, Orlu road and Egbu have higher number of gas stations; however, the density of station per distance (in Km) is higher in major and access roads, about 79% of the gas stations are located along major roads, 13% along secondary

(minor) roads and 7% within residential areas.

Though the gas station exhibits linear pattern because they are sited mainly on roadsides where customers can easily get the product, the overall pattern of distribution is clustered with nearest neighbor value (R_n) of 0.3 (less than 1) and z – value of -15. There was significant difference between the observed pattern and the random pattern at both 95% and 99%. The level of significance at 99% is likely that the pattern is caused by chance. Though most of the gas stations satisfied the minimum requirement of 15 metre distance from the road (81%). Equally 95% of the gas stations met the minimum distance of 100 meter from the hospital, schools and other public facilities. However, many stations have not met the criteria of 400-meter minimum distance to other stations which are located on same roadside and were not separated by any road or street and this position is not supported by DPR 2010, which stipulated that gas stations should be separated by road or street.

5.2 Conclusion

This study was conducted in Owerri metropolis. The aim of this study was to analyze the gas station locations in Owerri metropolis using geographic information system based multi-standard analysis. Twenty-seven (27) gas stations found in Owerri metropolis distributed within 13 neighbourhoods, preliminary review created of gas stations in Owerri metropolis, which include the actual map, geographical status map, the directional distribution map, and google earth map and land use land cover map of the study area. Spatial analysis of the distribution of gas stations was performed through 3 basic standards.

The first standard is “the 100meters minimum distance between the location of the stations and facilities of services such as schools, hospitals, wedding halls, nursing homes, factories for 100 meters” showed that 25 gas station met this first standard, while the 2-gas station were in violation of the first standard. This is not supported by Morales et al., 2010 which postulated petrol and gas stations should be sited 100 meters away from public facilities.

The second standard “the 400metres minimum distance between the locations of gas stations against another gas stations”, indicated that 23 gas stations met the second standard, while 4 were in violation of the second standard of 27 gas station. This is against DPR (2010) guidelines which stipulated that gas stations should be sited 400meters away from another station.

The third standard “the 15meters minimum distance between the locations of gas station from the main road, counted from the outer limits of the station” showed that 25 gas stations met to the third standard of 27 gas stations.

Finally, the researcher found a direct correlation between population density and the number of stations in every neighborhood.

5.3 Recommendation

The study makes the following recommendations:

1. That there is a need for more studies on gas station especially issues related to site selection and optimization. Also issue like people’s perception on the location of the gas station can be investigated.

2. The distance of gas station to other public institution like churches and mosques has not been considered by this study; this can be area for future research.
 3. There is need to create comprehensive digital update for gas stations that can enable one access the site and in addition it could help the customers locate the gas station at ease.
 4. DPR should make it compulsory for the gas station operators when submitting their EIA report to include the geographic location of the site. This can be helpful in updating the spatial database for the gas station successfully.
- Gas stations are mostly located on some residential area as found by the study. Hence there is need to give priority for the siting of gas stations in residential areas and distance between the gas station and residential buildings should be strictly adhered to when giving license to operators.

References

1. Abdullahi K. (2012). Spatial distribution of Filling stations in Agege Local Government, Lagos State. Unpublished Research Essay Submitted to the Department of Geography, Bayero University, Kano.
2. Abler, R., Adams, J. S. and Gould, P. (1971). Spatial organization: The Geography's view of the world, Englewood cliffs, NJ: Prentice- Hall.
3. Adsavakulchai, S. and Huntula, C. (2010). Optimum Site selection of Natural Gas Vehicles Station in Bangkok using Geographic Information System. *Journal of Petroleum and Gas Engineering*, Vol. 1 (5), pp 89-94, Available Online at [http:// Wwww. Academic Journals. Org/ JPGGE](http://Www.AcademicJournals.Org/JPGGE).
4. Ahmed, M., Muhemmad, N., Mohammed, M., and Idris, Y. (2013). A Gis- Based Analysis of Police Station Distributions in Kano Metropolis. (IOSR) - JCE) volume 8, Issue 4 (Jan. Feb. 2013) PP 72-78 [www. Lose Journals](http://www.LoseJournals). Retrieved on 21st June, 2014.
5. Alesheikh, A. A. and Golestani H. A. (2011). GIS application in optimum site selection for gas stations. Geospatial world <https://www.geospatialworld.net/article/gis-applications-in-optimum-sites-selection-for-gas-stations/>(assessed 2nd April, 2017). Retrieved from on 28th August, 2019.
6. Ambituuni, A., Amezage J. and Emeseh E. (2014) Analysis of Safety and Environmental Regulations for Down-stream Petroleum Industry Operations in Nigeria: Problems and Prospects. *Elsevier Journal of Environmental Development*, 43-60.
7. American Heritage English language (2011). American heritage English language, fifth edition [Joseph P. Picket] – 10- cite/export close window cite. Published: Boston: Houghton Mifflin Harcourt.
8. American Petroleum Institute (API) (1983). Introduction to oil and gas production, Washington D.C. American petroleum institute.
9. Asada, D. The Petroleum industry in Nigeria joint operating agreements, memorandum of

- understanding, compensation and other issues in perspective. Retrieved from on 02/08/2019.
10. Ayodele, S. J. (2011). Spatial Distribution of Petroleum Filling Station in Kaduna North. Retrieved on 5th March, 2013 from www.srib.com/. Published at <https://www.researchgate.net/publication/317674028>. Retrieved on 27 July, 2019.
 11. Beckman, T. N. (1957). A Brief History of Gasoline Service Station. Edited by Brain Jones Retrieved on 27th March, 2019. Available Online at Faculty, Auinnipiac. Edu/ charm.
 12. Belinda, U. A., Widya, U., and Putu, G. A., (2016). Location analysis for petrol filling station based on stakeholders' performance and seismic microzonation. Published by Elsevier Ltd. (<http://creativecommons.org/licenses/by-nc-nd/4.0/>) procedia-social and behavioural science 227 (2016) 115 – 123 retrieved 9th October 2019.
 13. Blamah, N. V., Vivan, E. L., Tagwl, M. U., and Ezemokwe, I. U. (2012). Location Impact Assessment of Gasoline Service Stations along Abuja- Keffi road and Environment in Karu, Abuja, Nigeria. *Journal of Environmental Management and safety*, Vol. 3, No.5,(2012) 106- 123, available at www.cepajournal.com.
 14. Bunge, W. (1966). Gerrymandering, geography and grouping, geography review 56(2) 256-263. Doi 10. 2307/ 212882.
 15. Burrough, P. A. and McDonnell, R. (1986). Principles of Geographical Information Systems, Oxford: Oxford University Press.
 16. Camille L. W. K. (2010). Applied Gis in locations of petrol station in Abidjan City, cote d' ivoire Available online ieexplorleec. Orghxpls.
 17. Charles, C. (1999). The petroleum industry: A nontechnical guide, Tulsa: Pennwell constitution of the Federal Republic of Nigeria. 1999. (hereafter CFRN) section 20, 12, 33 and Criminal Code Act of 1916 Cap. C38 LFN 2004.
 18. Daily Mail Reporter (2011). Living near a petrol station is bad for your health” as fuel pollutants found to travel 100m [http:// WWW. Dailymail. Cs. UK/ health/ article-1354430 Petrol- station- having- 100m-garages-bad-health.html](http://WWW.Dailymail.Cs.UK/health/article-1354430/Petrol-station-having-100m-garages-bad-health.html) N jxzz3scuzbPIQ
 19. Dawson, A. H. (2008). “Eastern Europe: geography by David Turnock; the human geography of Eastern Europe. *Published in Geography Journals* 165, 35 (20080 p. 109.
 20. Department of Petroleum Resources (2007). Guide for Grant of and Approval to Construct and Operate Petroleum Products Retails. Issued by DPR, Ministry of Petroleum Resources.
 21. Eiselt H. A. and Marianov, V. (2011). Pioneering Developments in Location Analysis in formations of location analysis. *International Services in Operations Research and Management Science* vol. 155 edited by Elsel H. A. and Marianov V. Springer New York.
 22. Emwendogo, I. (2013) GIS in the Management of Information about Services offered in Petrol Station in Mumbasa Road, Kenya, University of Nairobi Kenya.

23. Energy Information Administration (2012) Animal Energy Review 2011; US Energy Information Administration, DOE/E/A- 0384.
24. Exxon Mobil (2008).“Our History” Exxon Mobil corp. archived from the original on 2008 11-12 Retrieved 2009-02-03.
25. Haggett, P. (1965) Locational Analysis in Human Geography. Edward Arnold, London.
26. Imo State Government (2017). Imo State official gazette; the Owerri Capital development authority, edict, Owerri Imo State Government.
27. Ioij C. I. and Tudor C. A. (2011). Temporal Analysis of Incompatible Land-Use and Land Cover: The Proximity between Residential Areas and Gas Stations in Bucharest Suburban Area.
28. Jackle, John A. (1978). “The American gasoline stations, 1920-1970” *Journal of American culture* 1 (fall, 1978): 520-542.
29. James M. (1953). The Texaco Story: The First Fifty Years 1902-1992. New York: The Texas Company.
30. Kolawale, I, S. Alaga, T.A Ogunyemi, S.A, Popoola, O.S. and Oloko –Oba, m. O. (2016). Street mapping of Ife metropolis, Osun State, Nigeria. *Journals of geographic information system*, 8, published online June 2016 in SciRes.
31. Lewis P. (1977). Maps and statistics. Methuen and Co Ltd London.
32. Morales, T., Marata, I., Minarro, D., Ferradas, F., Carracena, A., and Rico, J. (2010). Assessing the impact of petrol stations on their immediate surroundings, Elsevier *journal of environmental management* 91 (2010). 2754e2762 Retrieved on 31/08/2019.
33. Mshelia, M., Abdullahi, J. and Dawha, E. (2015). Environmental effects of petrol stations at close proximities to residential buildings in Maiduguri and Jere, Borno State, Nigeria. Vol. 20 No 4, pp. 1-8.
34. National Bureau of Statistics (2008). Nigeria Annual Abstract Statistics National Bureau of statistics, Nigeria.
35. Njoku J. D. (2006) Analysis of the Effect of Global Warming on Forest of South Eastern Nigeria using Remotely Sensing Data. PhD Dissertation, Geography and Environmental Sciences, Imo State University; Owerri 2006.
36. Nwanjo, Hu, Ojiako O. A(2007). Investigating the Potential Health Hazards of the Petrol Station Attendants in Owerri Nigeria. *Journal of Applied Science and Environmental Management*. Vol. II, No. 2.
37. Odeh Jameel El Fallet (2017). Spatial analysis of petrol stations in Khan-Younis city using geography information system (GIS) techniques.
38. Oloko – Oba O. Mustapha, Ogunyemi S. Akintunde, A. T. Alaga, R. A. Badru, J.O. Ogbole , Popoola O. Samuel and Samson A. Samson.(2016). Spatial distribution of primary schools in Ilorin West Local Government Area, Kwara State, Nigeria. *Journals of scientific research and report*. 9 (6): 1-10, published online June, 2016 in sci res.

39. Pees, S. T. (2004). “Whale Oil Versus the Other” oil history, Samuel T, published oil-industry history, volume 5, November 1, 2004 © 2012 petroleum history institute.
40. Proshare (2013). Petroleum statistics: Nigerian Economy retrieved on 04/04/2013 from <http://www.proshareng.com/news/14354>.
41. Samuel, J.A. (2011). Spatial location of filling stations in Kaduna, Kaduna: Retrieved on 5th August, 2017 from www.srib.com/samuelayodel1.
42. Sen A. Onden, I. Gokgoza T and Sen C. (2013). A GIS Approach to fire station location, Selection. Retrieved from www.academic.edu on 2nd March, 2013.
43. Tavana, M., Pidashti, M., Kennedy. D. T., Belaud, J. P., Behzadian, M. (2012). A hybrid Delphi SWOT Paradigm for Oil and Gas Pipeline Strategies Planning in Casplan Sea Basin. *Energy Policy*, 40, 345-360.
44. The Punch News (2018). Unsafe fuel/gas station locations in cities published on punchng.com. accessed 9th October, 2019.
45. Ujjwal, S. and Sokhi, B. (2006). GIS City Hazard Petroleum Station Vicinity Vulnerability Assessment. GIM International Vol. 20 Issues.
46. Ukaegbu, K., Iwuji, M., Uche, C., Osumgboragwu, I., and Amangabara, G. (2017). Spatial Assessment of Temperature and Land Cover Change as Climate Change Monitory strategies in Owerri, Nigeria. *Journal of Geography, Environment and Earth Science International II* (1): 1-9, 2017, ArticleNo JGEESi 34568 ISSN: 2454-7352.
47. Wikipedia(2010). Retrieved from <https://en.m.wikipedia.org/wiki/2010s> on 29th August, 2019. Released November 11:2010.
48. Wough, D. (2007). Geography; an Integrated Approach. Thomas Nelson and Sons, New York, U.S.A.