

GIS BASED SUITABILITY ANALYSIS FOR SITING PETROL FILLING
STATIONS IN ZARIA LOCAL GOVERNMENT, KADUNA STATE NIGERIA

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DEDICATION

This thesis is dedicated to my family, friends and colleagues, this thesis was made possible by your support, encouragement and motivation since from the beginning to the end.

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ABSTRACT

This study analyzed and assessed the Suitable site and distribution of petrol filling stations in Zaria Local Government based on the development standards set by Department of Petroleum Resource (DPR). The research used field surveys, GPS, remote sensing, and geographic information system (GIS) tools to locate and map the existing petrol filling station stations. The study located and mapped 56 petrol stations in the area. All analyses and mapping were carried out using ArcGIS 10.7 after the field data were processed in an Excel spreadsheet. A Multi Criteria Decision Analysis was performed in the research using weighted overlay tools. The distribution of the stations was calculated using the nearest neighbor method. The analysis clearly showed that the distribution of the petrol filling stations in the study area are clustered. The distances between petrol filling stations, the location of filling stations on the highway and the distances between filling stations to the nearest features were determined using the same technique. According to the survey, the listed petrol stations were all spread out along the highway on both sides. Additionally, it showed that only 3 of 56 gas stations met all of the development guidelines. The results of this study have also demonstrated the value of geospatial tools for managing and monitoring development in the built environment. Building ability to use the technology should be prioritized by relevant governmental agencies example Department of Petroleum Resource (DPR).

In order to prevent haphazardly siting of petrol filling stations in the area, the study recommended regular monitoring by the Department of Petroleum Resource (DPR) to assure complete compliance with the rules. Lastly, there should be proper planning in order to handle future road expansions.

ABSTRAK

Kajian ini menganalisis dan menilai tapak yang sesuai dan pengedaran stesen pengisian minyak di Kerajaan Tempatan Zaria berdasarkan Global Positioning System oleh Jabatan Sumber Petroleum (DPR). Penyelidikan ini menggunakan tinjauan lapangan, GPS, penderiaan jauh, dan alat sistem maklumat geografi (GIS) untuk mencari dan memetakan stesen stesen minyak sedia ada. Kajian itu menempatkan dan memetakan 56 stesen minyak di kawasan itu. Semua analisis dan pemetaan telah dijalankan menggunakan ArcGIS 10.7 selepas data medan diproses dalam hamparan Excel. Analisis Keputusan Pelbagai Kriteria telah dilakukan dalam penyelidikan menggunakan alat tindakan berwajaran. Pengagihan stesen dikira menggunakan kaedah jiran terdekat. Analisis jelas menunjukkan taburan stesen pengisian minyak di kawasan kajian adalah berkelompok. Jarak antara stesen pengisian minyak, lokasi stesen pengisian di lebuh raya, dan jarak antara stesen pengisian ke ciri-ciri terdekat ditentukan menggunakan teknik yang sama. Menurut tinjauan, stesen minyak yang disenaraikan semuanya tersebar di sepanjang lebuh raya di kedua-dua belah pihak. Selain itu, ia menunjukkan bahawa hanya 3 daripada 56 stesen minyak memenuhi semua garis panduan pembangunan. Hasil kajian ini juga telah menunjukkan nilai alat geospasial untuk mengurus dan memantau pembangunan dalam persekitaran binaan. Membina keupayaan untuk menggunakan teknologi harus diberi keutamaan oleh agensi kerajaan yang berkaitan contohnya Jabatan Sumber Petroleum (DPR). Bagi mengelak penempatan stesen pengisian minyak secara sembarangan di kawasan itu, kajian itu mengesyorkan pemantauan berkala oleh Jabatan Sumber Petroleum (DPR) untuk memastikan pematuhan sepenuhnya terhadap peraturan. Akhir sekali, perlu ada perancangan yang betul untuk mengendalikan pembesaran jalan pada masa hadapan.

TABLE OF CONTENTS

	TITLE	PAGE
	DECLARATION	iiii
	DEDICATION	ivv
	ACKNOWLEDGEMENT	v
	ABSTRACT	vvi
	ABSTRAK	vivii
	TABLE OF CONTENTS	viiiii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF ABBREVIATIONS	xii
	LIST OF SYMBOLS	xiixv
	LIST OF APPENDICES	xiv
CHAPTER 1	INTRODUCTION	1
1.1	Problem Background	1
1.2	Problem Statement	3
1.3	Research Goal	4
1.3.1	Research Objectives	4
1.4	Research Questions	5
1.5	Scope of Study	5
1.6	Study Area	5
1.7	Significant of Study	8
CHAPTER 2	LITERATURE REVIEW	9
2.1	Introduction	9
1.2	Definition of Terms	9
2.2.1	Location	9
2.2.2	Petrol Filling Stations	9
2.2.3	Suitability Analysis	10

2.3	Brief History of Petroleum industry in Nigeria	Error! Bookmark not defined.0
2.4	Concept for Location of Petrol Filling Station	Error! Bookmark not defined.1
2.5	Factors Used to Determine the Location of PFSs	Error! Bookmark not defined.5
2.6	Factors Used to Determine the Location of PFSs	Error! Bookmark not defined.7
2.6.1	Parameters to be adopted	20
CHAPTER 3	RESEARCH METHODOLOGY	21
3.1	Introduction	221
3.1.1	An Entity Relationship Diagram (ERD) used to describe the functional relationship among entities identified in the study area	22
	1	
3.2	Data Types, Sources and Collection	23
3.3	PFSs Data Collection	23
3.1.1	Global Position System (GPS)	23
3.4	Method of Data Analysis	25
CHAPTER 4	RESULT AND DISCUSSIONS	29
4.1	Introduction	29
4.2	The Spatial Location Location of PFS with their Condition	29
4.3	Spatial Distribution of the filling stations across the area	32
4.4	Average Nearest Neighbor Result	33
4.4.1	Mean, Median center and Directional Distribution Result	36
4.5	Distance between filling stations	37
4.6	Location of filling stations along the highway	40
4.7	Hotspot Analysis of filling stations within the area	42
4.8	Suitable Land for New Petrol Station	43
CHAPTER 5	CONCLUSION AND RECOMMENDATIONS	45
5.1	Research Outcomes	45
5.2	Contributions to Knowledge	46

LIST OF TABLES

TABLE NO.	TITLE	PAGE
Table 2.1	Department of Petroleum Resources (DPR) Guidelines	17
Table 4.1	Location of PFS with their Geographic Coordinates. Source: Field work, 2022	30
Table 4.2	Nearest neighbour analysis summary of the PFS	33
Table 4.3	Distance from Nearest Station	38

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
Figure 1.1	Map showing Zaria local of Kaduna state Nigeria	7
Figure 3.1	Entity Relationship Diagram (ERD)	20
Figure 3.2	Analysis process	20
Figure 3.3	GPS Specifications	23
Figure 4.1	Spatial distributions of petrol filling stations Zaria LGA	31
Figure 4.2	Average Nearest Neighbor Result	33
Figure 4.3	Spatial Pattern of Petrol Stations	34
Figure 4.4	Distance from nearest Station	35
Figure 4.5	Distance from Median Centre	36
Figure 4.6	Distance from Mean Center	36
Figure 4.7	Euclidean Distance from Highway	39
Figure 4.8	Distance from Highway to Petrol Station	40
Figure 4.9	Hotspot Analysis of Petrol Stations	41
Figure 4.10	Suitable Land for New Petrol Station	42

LIST OF ABBREVIATIONS

PFS	-	Petrol Filling Station
PMS	-	Premium Motor Spirit
LPG	-	Liquefied Petroleum Gas
LSA	-	Land Suitability Analysis
GIS	-	Geographical Information System
MCDM	-	Multi-Criteria Decision Making
DPR	-	Department of Petroleum Resources
NIS	-	Nigerian Institution of Surveyors
NIESV	-	Nigerian Institution of Estate Surveyors and Valuers
NIA	-	Nigerian Institute of Architects
PPPRA	-	Petroleum Products Pricing Regulatory Authority Petroleum Products Pricing Regulatory Authority
NITT	-	Nigerian Institute of transport Technology
OPEC	-	Organization of Petroleum Exporting Countries
NNPC	-	Nigerian National Petroleum Company
AHP	-	Analytic Hierarchy Process
EC	-	Expert Choice
GPS	-	Global Positioning System
SMCDA	-	Spatial Multi Criteria Decision Analysis
EIA	-	Environmental Impact Assessment
ROW	-	Right of Way
NNA	-	Nearest Neighbor Analysis
NNI	-	Nearest Neighbor Index

LIST OF SYMBOLS

A	-	area
d^-	-	mean distance
n	-	number
R_n	-	nearest neighbor index

CHAPTER 1

INTRODUCTION

1.1 Problem Background

A petrol filling station (PFS) is a place where motorists can purchase fuel products or have their vehicles serviced (i.e., selling gasoline or making repairs). Most filling stations offer the following products and services: premium motor spirit (PMS), diesel (AGO), engine oil, Liquefied Petroleum Gas (LPG), kerosene (DPK), car wash, and auto 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. (Yisa, et al. 2019). By definition, a petrol service station is a public facility where car gasoline (petrol, kerosene, diesel, etc.) and lubricants are sold. Furthermore, these fuels include large concentrations of toxic substances, which pose significant harm to human life and property. The expansion of gas stations is becoming a common occurrence in most of our state's urban areas. (S. A. Ogunyemi¹, et al. 2017) To get a thorough grasp of lands suitability analysis, it is frequently important to evaluate these occurrences within their specific geographical and environmental contexts.

Land Suitability Analysis (LSA) is a GIS-based process applied to determine the suitability of a specific area for considered use and distribution of future land uses. Petrol station site selection problem should be considered a complex multi- attribute decision problem. Petrol industry has been currently experiencing very intense competition. Alternative places for petrol stations are usually limited by some laws and regulations (Shabir Hussain Khahro 2017). Technological advancement in the

automobile industry has had a significant impact in the petroleum industry which has also trigger the building of petrol service stations (Petrol Filling Stations) at strategic locations to meet the demand of vehicular operations. (T 2017)

The rapid growth of vehicular traffic in the country and subsequent increase in the number of PFSs urges for a real need to control and manage the development of such activities. A PFS is where petrol or other vehicle and machinery fuels are sold and where maintenance and minor automobile repair services may be conducted. (Chukwudi G.Njoku 2015). The significant roles petroleum products play in any economy are well known. Chinambu (2012) acknowledged that, petroleum is a key driver of industrial activities. Besides the industrial development, the transportation sector is presumed to be the major consumer of fuel to facilitate mankind's movement patterns around the globe. (Thomas Kweku Taylor 2016)

Due to the availability of low-cost Geographic Information System (GIS) software with user- friendly interfaces, GIS application to spatial analysis has gained pace in recent years. There are numerous studies available on the locational study of petrol filling stations in metropolitan areas using GIS (Olasunkanmi 2017). GIS has proven to be very relevant in solving spatial problems. In a GIS environment, it is formulated as a Multi-Criteria Decision Making (MCDM) system. Different MCDM approaches are developed to combine factors in a suitability analysis of land for potential land uses and develop a generic suitability index. (Chukwudi G.Njoku 2015). GIS based multi-criteria decision-making techniques have been found useful to resolve such land suitability problems (Zolekar and Bhagat 2015).

In most large urban areas of Nigeria, there is high demand for land for socio-economic activities. This high land demand often results to land scramble and illegal

conversion of land uses, leading to haphazard development and the deliberate location of petrol filling stations in unsuitable areas that are highly vulnerable to hazard (Kaduna State Urban Planning Development Agency, 2009). Because engines are designed to run on petroleum products, and filling stations are where fuel is sold, increased car ownership resulted in increased demand for fuel and, by extension, fuel stations. Petrol filling stations have been discovered to be positioned near residential areas and, in certain cases, commercial and industrial operations. (Mshelia 2015)

1.2 Problem Statement

Petrol stations play a significant role as hubs of socioeconomic activity. Today, there are so many of them distributed throughout rural and urban regions around the world. Nevertheless, despite the significant roles that they play in our daily lives, they are at the root of a number of today's socioeconomic and environmental issues. In order to deliver petroleum products to petrol filling stations, tankers line up along roadways, which contributes to some of the current traffic accidents. In addition, it's common to see a long queue of vehicles waiting to purchase petrol outside of stations along roadways due to the small size and proximity of some stations to the road.

The lack of regulation and coordination of land-use activities along arterial highways in several of Nigeria's largest cities exposes the area to risks like traffic congestion, pollution, accidents, fire explosions, and other environmental issues. According to (Ayodele, 2011), Filling stations contribute significantly to traffic issues such as congestion, pollution, fire, and explosion in densely populated regions. The severity of these issues varies depending on factors including location, size, and proximity to a road, among others. When there is a fuel shortage, long lines of cars cause an overflow of vehicles onto the road, reducing the width of the carriageway intended for the efficient movement of cars and pedestrians. Communities close to filling stations experience a lot of noise, congestion, and other traffic-related problems. Traffic congestion is the outcome of such overcrowding and lengthy lines, which among other things results in delays, a loss of productive man-hours, an increase in pollution and energy consumption, and environmental damage. (Esther O. Akinsulire 2020)

Traffic clogs and accidents are frequently the results of this. The possibility of a fire starting exists due to the high flammability of fuel. All of these issues point to a fundamental flaw in the application of current development standards as well as their existence. Reports of the Department of Petroleum Resources (DPR) closing down petrol filling stations for not adhering to development regulations have surfaced over time. Additionally, numerous studies have been conducted to assess the locations and spatial distribution of petrol filling stations in many Nigerian towns. (Robert E. Ekpenyong, 2019) The findings of these studies are now available and can be used to plan and develop these towns. Unfortunately, according to the literature review, Zaria is not one of the towns or places where such research has been done. Zaria is an ancient town that was developed without a proper development plan and continues to be in violation of planning regulations, where poor planning and disregard for planning regulations have led to haphazard development, illegal land-use change, and the purposeful placement of PFSs in locations where they are very likely to create hazards and traffic as well.

1.3 Research Goal

The aim of the study is to assess the site suitability of petrol filling stations in Zaria Local Government, Kaduna State, Nigeria, using GIS techniques.

1.3.1 Research Objectives

The objectives of the research outlined as follows:

- (a) To determine the distribution pattern of petrol filling stations with respect to Department of Petroleum Resources (DPR) standards.
- (b) To analyse the sites of petrol filling stations to see if they adhere to the development guidelines set forth by the appropriate government agency.

- (c) To analyse the suitable locations for siting filling stations in the study area using geospatial tools and analyses.

1.4 Research Questions

The research questions for the study are outlined as follows:

- a) What are the requirements for development of petrol filling stations in Nigeria set by DPR?
- b) How are these petrol filling stations distributed within Zaria local government?
- c) What is the level of conformity of the filling stations to the standard?
- d) Where are the suitable locations for siting filling station in the study area?

1.5 Scope of Study

This research work is limited to GIS Based Suitability Analysis for Siting Petrol Filling Station in Zaria Local Government, Kaduna State Nigeria.

1.6 Study Area

The study area Zaria Local Government Area is located between Latitudes 10°56"N and 11°80'N of the equator and Longitudes 7°42'E and 7°53'E of the Greenwich meridian. Zaria is the second largest city in Kaduna State consisting of six districts, namely: Birni Da Kewaye (Zaria town and its environs), Dutsen Abba, Gyallesu, Tudun Wada, Tukur Tukur, and Wucicciri (the- nigeria.com, 2011). The study area is made up of thirteen (13) wards including; Anguwan Fatika, Anguwan Juma, Kaura, Kwarbia A, Kwarbia B, Limancin Kona, Dambo, Dutsen Abba,

Gyallesu, Kufena, Tudun wada, Tukur-Tukur and Wucicciri. Zaria covers a total land area of 563 km² with an altitude of about 762 meters above sea and Zaria is 156 km south-west of Kano, 84km north-east of Kaduna (Bello, Kibbon et al. 2021).

Headquarters of the Zaria Local Government Council and the traditional Zaria emirate, it is served by road and rail and by an airport just to the northwest. Zaria is an old walled town. Probably founded in about 1536, later in the century it became the capital of the Hausa state of Zazzau. Both town and state were named for Queen Zaria (late 16th century), younger sister and successor of Zazzau's ruler Queen Amina. Present-day Zaria has four main areas: the old walled town, inhabited by Hausa and Fulani peoples, which has numerous Islamic schools; the residential areas of Tudun Wada (which handles the old section's overflow) and Sabon Gari (the "African strangers' settlement"), which were established early in the colonial period; and the township for the non-African community. The old walls, the combined length of which is 15 miles (24 km), have eight gates, and a large market is still held on an ancient site. Zaria is the educational center of the northern states. Located at Samaru, 7 miles (11 km) west-northwest, is Ahmadu Bello University (1962), with its associated institutes of education, economic and social studies, administration, and health. Samaru is also the site of the Institute for Agricultural Research and Special Services (1924) and the Leather Research Institute of Nigeria. At Zaria are the Nigerian Civil Aviation Training Centre and a branch of the Katsina College of Arts, Science, and Technology. Zaria also has a commercial institute, a fine-arts school, and a school of pharmacy. There are several hospitals and a nursing school. Pop. (2005 est.) 847,000 (Britannica 2020).

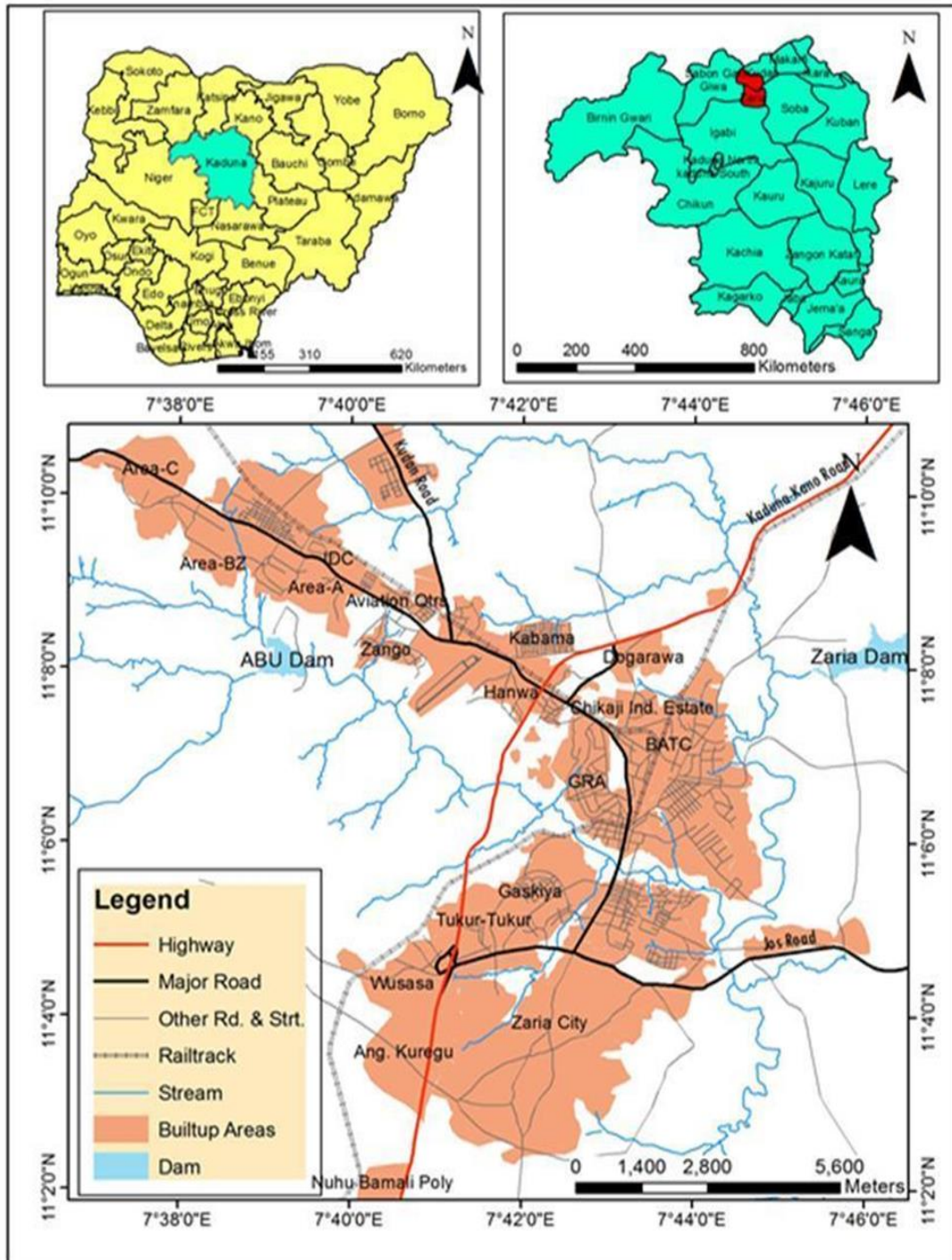


Figure 1.1 map showing Zaria local of Kaduna state Nigeria

1.7 Significant of Study

This research is extremely useful to both academics, private and public sector stakeholders in decision making. This research can be used by professional bodies such as The Nigerian Institution of Surveyors (NIS), The Nigerian Institution of Estate Surveyors and Valuers (NIESV), The Nigerian Institute of Architects (NIA), and others to keep an eye on the uncoordinated construction of petroleum filling stations near residential areas and other public buildings. Students studying professional courses in survey and geoinformatics, town planning, and real estate practice in the educational sector can use the findings of this study to conduct future research in the areas of housing, property development, valuation, and planning.

Also, this research will be of beneficial to the authority concern in regulating the siting of petrol filling stations i.e., the Department of Petroleum Resources (DPR), and the Petroleum Products Pricing Regulatory Authority (PPPRA) and also the Nigerian Institute of transport technology (NITT). While in the private sector, developers may be able to use this research to better understand the effects of petroleum filling stations on residential properties nearby. This research can be used by real estate developers to come up with viable strategies of siting/locating special purpose properties such as petrol filling stations without compromising the authority's standards.

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