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Site Suitability Assessment of Petrol Filling Stations (PFSs) in Oyo Town, Oyo State, Nigeria: a Geographic Information Systems (GIS) Approach

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Abstract:*In this study, a GIS was developed for PFS site suitability assessment. The standard criteria set for PFS siting by Oyo State Urban and Regional Planning Board (OSURPB) and the Nigerian Department of Petroleum Resources (DPR) were considered. The DPR criteria were incorporated to assess possible lapses in the local standards. The study is multi-dimensional, incorporating suitability, proximity and spatial statistical techniques. The results showed that, out of the 113 PFSs in the area, only 3, representing just 2.654 percent are in high suitability zone, 6 PFSs (5.309 percent) in in medium as well low and 98 stations(86.725 percent) in very low suitability zone. Considering the OSURPB criterion, 76 PFSs are at unacceptable distances to residential land use and as much as 102 PFSs considering the DPR criterion. Also, assessing the size of PFSs, 41 stations (39 percent) have the standard land area while 69 PFSs (61 percent) were deficient. Furthermore, only 6 stations, representing 5 percent of PFSs in the area have their dispensing pumps at least 15m off the road. More so, the assessment of the spatial pattern of PFSs in the area showed that the distribution of petrol stations are very clustered with less than 1 percent likelihood that the clustered pattern could be a result of random chance. In a nutshell, it can be concluded that most PFSs in Oyo town, considering both local and national siting standards are not suitably sited and also contravene planning standards. Also, the substandard requirements proliferated by the local planning authorities, who are defiant of the national standards undoubtedly increases the threats on the health and safety of users and residents in the vicinity of the PFSs*
Keywords:*Geographic Information Systems, Petrol Filling Stations, suitability assessment, siting criteria*

I. Introduction

The rapid growth of vehicular traffic in the country and subsequent increase in the number of PFSs along the motor-ways and also in towns and city roads as well as within settlements urges for a real need to control and manage the development of such activities. The rise in global population has outpaced and posed serious challenges on the government to provide the masses with the essential infrastructure as well as enact and enforce legislations on the people [1]. As the population increases, so does the number of automobiles, thereby creating the need for fueling services and consequently the construction of PFSs. A PFS is where petrol or other vehicle and machinery fuels are sold and where maintenance and minor automobile repair services may be conducted. It can also be defined as a facility where fuels and lubricants such as Premium Motor Spirit. Liquified Natural Oil, kerosene, Dual Purpose Kerosene, etc. for automobiles and other uses are sold [2].

PFSs, in as much as they should be located where they can be easily accessible, should be sited where they will pose little or no danger and congestion as much as possible. Over time, there have been concerns as to the over-provision and indiscriminate siting of PFSs in Oyo town and Nigeria at large. These fuels can give off flammable vapour at a very low temperature and thus suggests that there are high risks of explosion or fire if an ignition point is close. The health, safety and protection of the Oyo peopleis a major concern, thus the need to assess site suitability of PFSs in the area.

GIS has proven to be very relevant in solving spatial problems. It is a complex of software, hardware,databases, people, and procedures, all linked by computer networks, bringing together differentdata sets that may be scattered across space invery diverse data holdings from which relationships can be identified and decisions made [3]. 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 [4].

1.1 Statement of Research Problem

Urban centers have varying degree of vulnerability, depending on the level of development, coping capacity and the level to which effective development control strategies have been implemented. In most towns and cities of Nigeria, improper planning and contravening of planning standards have resulted to illegal

conversion of land-uses and haphazard development, thus the deliberate location of PFSs in unsuitable areas that are highly likely to cause hazards.

Oyo being an ancient town developed without a proper development plan and still suffers from non-adherence to planning laws. In a semi-urban environment like the area under study, PFS is a significant contributor to problems such as;

- Traffic disruptions as a result of inadequate parking space for tankers during offloading of products as well as due to the in and out flow of vehicles and indiscriminate parking along the station and other commercial activities in and around the PFS,
- Fire accidents due to the highly flammable nature of commodities sold in the stations and fire from fuel tankers enroute PFSs,
- Water pollution to underground water, as leakages might occur from the reservoirs as well as surface water runoff which wash spilled products to the nearest water body. Most people in the area source there water from hand dug wells. These wells can be at risk of pollution if a PFS is nearby because the aquifers are prone to pollution from leaking fuel reservoirs.

1.2 Aim and Objectives

The aim of the study is to assess site suitability of petrol filling stations in Oyo town. The objectives are as follows:

i. Identify, locate and collect spatial and attribute data of PFSs in the area.
ii. Assess PFS site suitability in the area considering standard siting criteria.
iii. Compare results derived from national and local PFSs siting standards.
iv. Evaluate the spatial pattern of distribution of PFSs in the area.

1.3 Significance of the Study

This study will assist planning authorities carry out necessary actions on already existing PFS that have contravened standards and are ill-sited as well as verify with ease and implement PFS 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 stakeholders in the urban planning, downstream petroleum industry and other related areas, for further research and decision making.

1.4 Study Area

Oyo is a town in Oyo State, Nigeria, The town has a population of 442,699 people, located within longitudes $3^{o}54'11.48''E$ and $3^{o}57'33.46''$ and latitudes $7^{o}48'18.79''N$ and $7^{o}52'41.07''N$. It is about 52km north of Ibadan, 166km to Lagos and 480km to Abuja. Oyo town and her suburbs are located in three (3) Local Government Areas (LGAs) namely: Atiba, Oyo East and Oyo West Local Government Areas. It is on the Trunk A Federal highway, North of Ibadan which links the Western part of the country to the northern part. The topography of the town is of gentle rolling low land rising to about 304m above mean sea level to the north of the town.It has an equatorial climate with dry and wet seasons and a relatively high humidity[5].

The scope of this study is limited to the area described as "Oyo Town" as shown and described in Fig.1. The town is dotted with petrol filling stations, few are owned by multinational marketers (referred to as major marketers) and most others owned by independent marketers. There are 113 PFSs in the town as at the time of this study with 7 still under construction. Most of the PFSs in the town have less than 5 dispensing pumps and products are readily available to the people except during cases of shortages. Fig. 1 shows the spatial location of all the PFSs in the area.

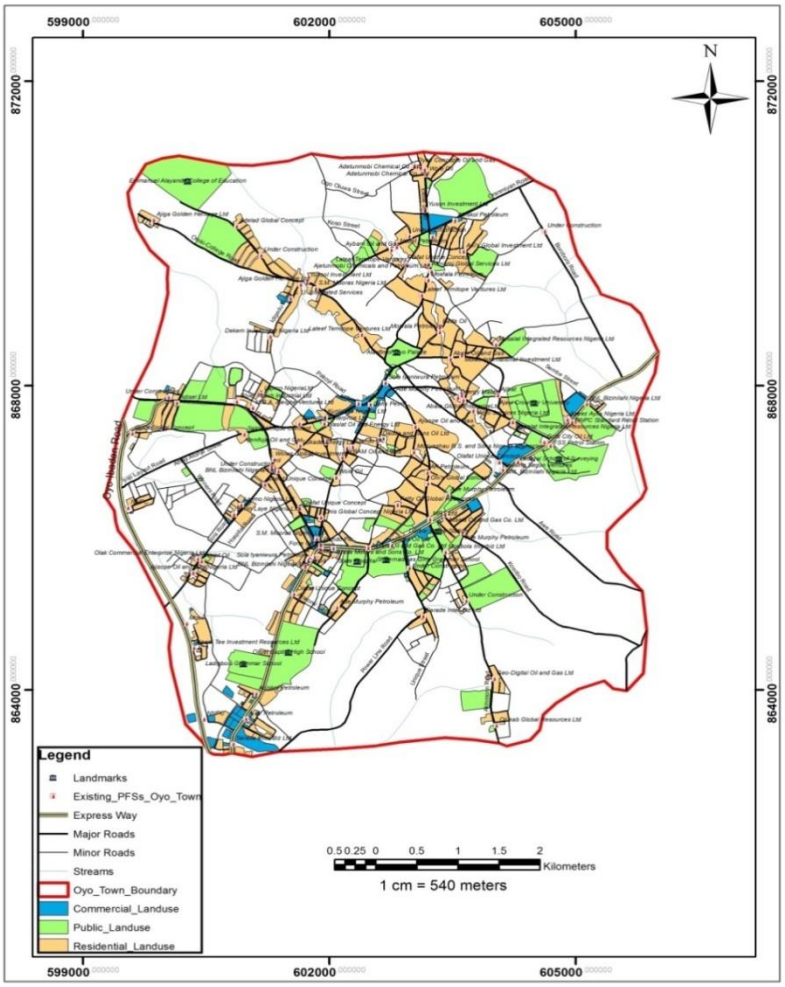


Fig. 1: Composite map of the study area.

II. Conceptual FrameworkAnd Literature Review

Land Suitability in this context is a GIS based process used to determine the appropriateness of a given area for a particular use. The basic premise of a GIS suitability analysis is that each aspect of the landscape has intrinsic characteristics that are to some degree suitable or unsuitable for the activities being planned. The results are often displayed on a map that is used to highlight areas of high to low suitability. A spatial suitability model typically answers the scientific question, "Where is the best location?"

2.1 Parametric Concept for Land Suitability Assessment

Land suitability analysis is a decision/evaluation problem concerning a number of parameters. Its assessment thus involves many factors that directly or indirectly control the ability of a part of land to adequately host a land use. Performing land suitability evaluation and generating maps of land suitability for a particular land use in an area would facilitate sustainable development. The parametric concept can be summarized into six steps as shown in Fig. 2, following the Food and Agriculture Organization (FAO) framework for land evaluation and procedures proposed by I. Sys et al in their work, 'Principles in Land Evaluation and Crop Production Calculations (1991)'[6].

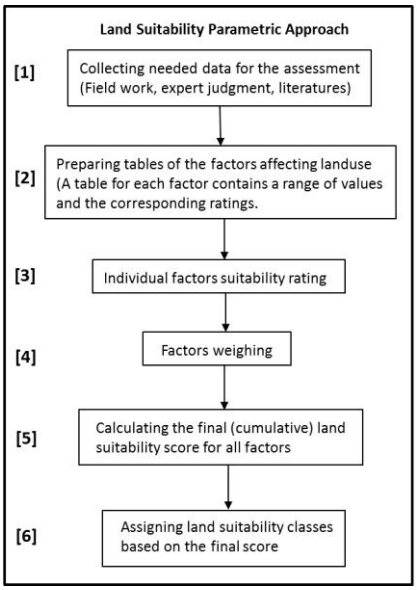


Fig. 2: Flowchart of parametric approach procedures (I. sys et al, 1991)

2.2 Issues on Regulations, Siting and Associated Hazards of Petrol Filling Stations in Nigeria

The problem of illegal siting of PFS does not end at the fires that might erupt at the stations but also include the dangers posed by the tankers that convey products to these stations, having to pass through these residential areas. Some break down on the narrow residential roads; there have also been cases of mishaps enroute the stations within the residential areas, causing product spillage and resultant fires engulfing neighbourhoods.

The DPR Head of Downstream Monitoring and Regulation was quoted by a national daily on why petrol stations are sited in illegal places. He accused the local town planning authorities in the various states of granting approvals for the siting of petrol stations in illegal locations, thereby jeopardizing the work of the DPR.He stated further that while the DPR only monitors the construction and operation of petrol stations, Town Planning Authorities approve where retail outlets are sited. "Thus if the local authorities have already approved sites that do not meet the requirements, problems arise"[7].

BobsonGbinije in his article, "DPR Filling Stations and Regulatory Lapses" buttressed that a drive through major cities and towns in Nigeria shows that the DPR does not comply with its own statutory requirements of the regulations guiding the establishment of filling stations, with petrol stations in Nigerian towns located neck-to-neck and back-to-back to each other within highly populated areas [8]. In his words;

> "the hazardous consequences of a conflagration in such areas are too gruesome to contemplate. It creates traffic bottlenecks and endangers the structures of residential buildings and their inmates. Most of the urban stations are bombs, cannonades and canon fodder's repositories waiting to explode, because of their proximity to each other. The statutory duties of the DPR because of its ludisbrastic approach have either been duplicated or taken over by State and Local Councils. Filling Station Operators/owners now pay all sorts of levies, taxes, fees, dues, fines, etc to states' Ministries of Environment, Environmental Protection Agencies, Local Government Revenue Sub-committees on Petroleum Products etc, ignoring the main aim of their commission"

The Operations Controller of the DPR blamed the Oyo State government for over 100 illegal filling stations in the state.Further in the same article, The Commissioner, Physical Planning and Urban Development of the state stated that there had been a three-year-old ban on major marketers of petroleum products in the state before this period. He said the ban was placed due to the marketers' consistent nonchalant attitude to the government's calls to desist from erecting illegal filling stations in the state. According to him several attempts had been made by the state government to ensure safety measures before siting filling stations[9].

An article published on a national daily titled 'They smile, Society bleeds' best buttressed the situation in Oyo town and most other Nigerian cities. The writer lamented that 'the mushrooming of fuel stations in residential areas across the country has assumed an alarming dimension in recent times, leaving the society with sad tales of carnage and losses as most of the stations violate town planning laws, thus endangering human lives and posing lots of environmental hazards to communities where they are located'[10].

Afolabi et al assessed the safety practices in filling stations in Ile-Ife, South-West Nigeria and concluded that a large proportion of stations in the area do not meet the minimum required standard for safety

and that filling stations owned or managed by conglomerates had better standards than those owned by Independent Petroleum Marketers [11]. In the same vein, Ahmed and Fabio did an over-view of the health risk and safety of petrol stations in Minna Town, Niger State, Nigeria. Amongst other findings, his study showed that most of the PFS in the area did not comply with laid down regulations [12].

In a developing country like Nigeria where the ability to cope with disaster is at its lowest ebb, preventive measures become imperative. The reasons of the Federal Government of Nigeria promulgating decrees e.g. the Environmental Impact Assessment Decree No. 56 of 1992 and the establishment of regulatory bodies like the Federal Environmental Protection Agency (FEPA) and the Department of Petroleum Resources (DPR) are to set standards and criminalize environmental offences such as the improper siting of PFSs.

There have been countless incidences of PFS fires lately in Nigeria, such as that of Mobil petrol station on ObaAkran Avenue, Ikeja, Lagos state [13], Jobayo filling station on Nwaniba Road, Uyo, AkwaIbom state [14], Okozak Petrol Station, Uzuakoli in Bende Local Government Area of Abia State [15], all in 2014 and the Conoil filling station, opposite Nigerian National Petroleum Coporation (NNPC) headquarters in the Federal Capital Territory, Abuja incidence in 2013 [16].

III. Methodology

To fully utilize GIS in the assessing the siting of PFS in the study, a good and suitable database needs to be designed. This is the process of declaring the features to be included in the database, taking into consideration the entities, attributes, their relationships and of course, the representation of those in an electronic database [17]. An Entity Relationship Diagram (ERD) was used to illustrate the functional relationships among entities identified in the study
(Fig 3).

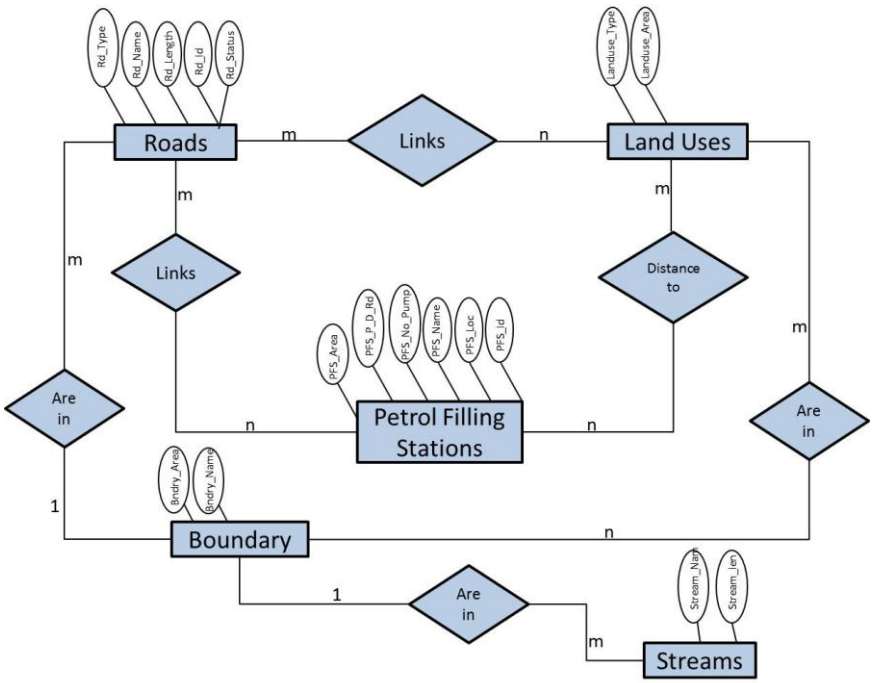


Fig. 3: Project ERD

The sources of data collected were essentially two, the primary and secondary. Existing literatures, OSURPB and DPR PFS siting standards, Landsat imageries(80cm resolution)to ensure coverage of the land use in high resolution, road map of the area and a Shuttle Radar Topographic Mission (SRTM) 1 Arc resolution Digital Elevation Model (DEM)incorporated in the suitability analyses in line with the siting criterion that stipulates that PFSs should be erected on level, rather than sloping sites, all constituted the secondary data. The primary data collected included PFS coordinates, attributes and details of existing land uses in the vicinity of PFSs.

As seen in Fig. 4, this study is multi-dimensional; combining different GIS analytical approaches to assess PFS site suitability in the area. The aim of this was to acquire multiple results that would emphasize different suitability issues.

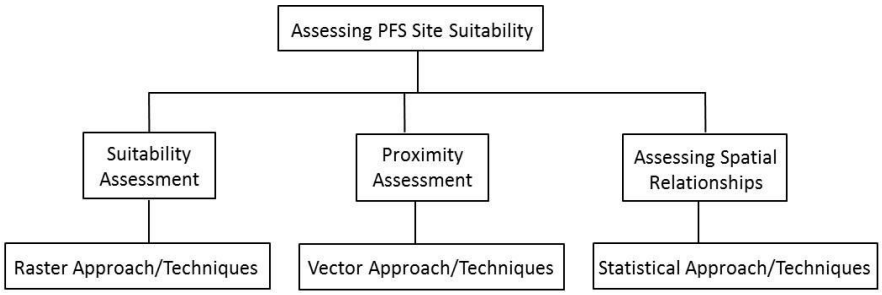


Fig. 4: Project analysis chart

This is a general suitability assessment of the study area adopted the land suitability parametric concept, creating a ranked result emphasizing different suitability zones. The weighted overlay process was applied considering the existing PFSs, topography, roads and the existing land uses in the areas around the PFSs. The result from the suitability assessment emphasizes the different degrees of land suitability for the siting of PFS's in the town, indicating areas in ranks of very low, low, medium and high suitability. Raster operations such as Vector to Raster, Reclassification, Euclidean Distance, Weighted Overlay and Raster to Polygon were used to evaluate general PFS site suitability in the area. The proximity approach adopted spatial analyst tools such as proximity and overlay to enable single and multi-criteria queries using the Select by Attribute Structured Query Language (SQL) to test the database created, selecting features based on location or spatial relationships.

Spatial Statistics tools were used to analyze spatial distributions, patterns and relationships. The Average Nearest Neighbour (ANN) tool for analyzing spatial distribution patterns was employed in this study. This tool evaluates if features or the values associated with features, form a clustered, dispersed, or random spatial pattern. To assess the spatial pattern, a null hypothesis was stated that PFSs in the area are randomly distributed. This hypothesis was tested using the results of the z-scores and p-values returned by the ANN pattern analysis tool. The values tell whether the null hypothesis can be rejected or not because it would indicate that rather than a random pattern, the features exhibit statistically significant clustering or dispersion.

The cartographic model in Fig. 5 reveals the step by step procedures of combining the acquired data to generate a product or a set of results as applied in this study.

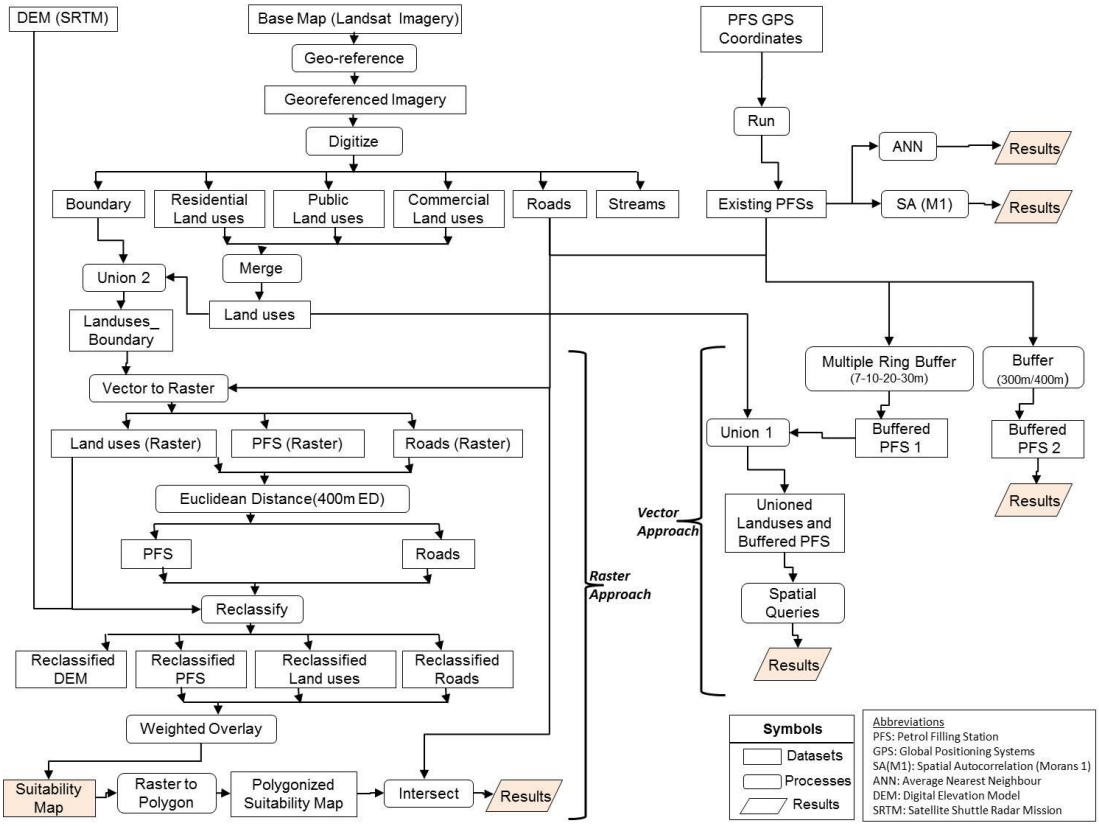


Fig. 5: Project cartographic model

3.1 Adopted Criteria for Assessing PFS Suitability

There are few similarities and disparities between thelocal and national criteria for siting of PFSs. The local criteria are those of OSURPB acquired from the Ministry of Physical Planning and Urban Development Oyo East Local Government Area and the National criteria are those of the DPR sourced from the organizations' official website [18]. To achieve the objectives of this research, the suitability guidelines of OSURPB and the DPR would be considered, and necessary comparisons would be made. Where the DPR and the OSURPB had similar criteria, only one of such was adopted. In other cases where two similar criteria had different parameters, both are assessed for comparisons to be made. The set of criteria adopted for this study include:

3.1.1 Oyo State Urban and Regional Planning Board

The planning requirements and guidelines for petrol filling stations siting according to the OSURPB in accordance with Section 49 (1) of their planning law (2011) are as follows:

a. PFS should have a minimum plot area of $1080m^2$and as much as a minimum of $3000m^2$for PFSs with up to 10 dispense pumps
b. PFS should have a setback of 7m from every dwelling house
c. Minimum distance between 2 stations along the same axis must be 300m

3.1.2 Department of Petroleum Resources (DPR), Nigeria

According to the DPR, suitability procedures and conditions for granting approval for the construction and operation of PFS in Nigeria, in compliance with the Petroleum Amendment Decree no 37 of 1997 safety rules and regulations are as follows:

a. The distance from the edge of the road to the nearest pump will not be less than 15 meters
b. A petrol station should be sited 50 meters away in all angles of the built-up areas to create a buffer zone residential land use. The buffer zone can be devoted to any non-residential land use.
c. Distance between one PFS and another will not be less than 400 meters.

IV. Spatial Analyses, Results And Discussions

Spatial analyses are the operations performed on spatial objects and data to find solutions to spatial problems.

4.1 Suitability Assessment

Theresult of the final weighted overlay analysis; the PFS suitability zones map is shown in Fig. 7. The dark green colour on the map represents areas of high suitability, the light green-medium suitability and the orange and red areas representing low and very low suitability zones respectively.

The results of the suitability analyses revealed that 3 PFSs, representing 2.6 percent in high suitability areas, 6 in medium suitability, 6 in low and 98, representing 86.7 percent in very low suitability areas.Tables 2, 3, 4 and 5 show the PFSs in different suitability zones. A summary of the results of the analysis is shown in Table 1. Figure 6 is a map of the PFS suitability zones and Figure 7, the suitability map.

Table 1: Suitability table

S/N	Suitability areas	Raster Value	Raster Count	Area Coverage (Hectare)	No. of PFSs	Percentage
1	High Suitability	4	2319	168.394	3	2.654
2	Medium Suitability	3	4004	290.751	6	5.309
3	Low Suitability	2	2740	198.968	6	5.309
4	Very Low Suitability	1	14383	1044.426	98	86.725
5	Total			1702.539	113	100

Table 2: PFSs in high suitability areas

S/N	**PFS Name**	**PFS Location**
1	Sola Iyaniwura Petroleum	Oyo-Ogbomosho Road
2	Ishola Motors and Sons Co. Ltd	Oyo-Ogbomosho Road
3	S. U. Integrated Services	Idigedu Road

Table 3: PFSs in medium suitability areas

S/N	**PFS Name**	**PFS Location**
1	A. A. Petroleum	Oyo-Ogbomosho Road
2	Total Filling Station	Oyo-Ogbomosho Road
3	FSS Petrol Station	FSS Compound
4	Waslat Oil and Energy Ltd	Iseke Road
5	Under Construction	Oroki-College Road

6	Ani's Global Investment Ltd	Oba Sabo Road

Table 4: PFSs in low suitability areas

S/N	PFS Name	PFS Location
1	Wole Oil	AbiodunAtiba Road
2	AK Petroleum	Ilaka Road
3	Lukade Energy Ltd	AbiodunAtiba Road
4	OandoPlc	AbiodunAtiba Road
5	Ajiga Golden Heritage Ltd	SakutuOgbegbe Road
6	Zamotun Enterprise Ltd	Sango Road

Table 5: PFSs in very low suitability areas

PFS Name	PFS Location	PFS Name	PFS Location
Sarade Inter-Biz Ltd	Oyo-Ogbomosho Road	AYBAM Oil and Gas	AbiodunAtiba Road
Olukab Global Resources Ltd	Akinmorin Road	Monyashau R.S. and Sons Nigeria Enterprise	Apinni Oyo Road
NNPC	Oyo-Ibadan Expressway	Ajenifuja Oil and Gas	Iseke Road
Abiskol Petroleum	Oyo-Ogbomosho Road	Gold City Oil Ltd	Oyo-Ogbomosho Road
Geo-Digital Oil and Gas Ltd	Akinmorin Road	Dauda and Sons Oil Ltd	Alaodi Road
Keem Tee Investment Resources Ltd	Oyo-Ibadan Expressway	Saklaj Unique Concept	Iyaji Layout Road
Mobil	Oyo-Ibadan Expressway	Oni's Global Concept	Oyo-Ibadan Expressway
Sarade Inter-Biz Ltd	Power Line Road	Ajisope Oil and Gas	Ilaka Road
Ade Murphy Petroleum	Chief AjeigbeAfonja Road	Musalat Integrated Resources Nigeria Ltd	Adikuta Road
Under Construction	Akinmorin Road	NNPC Standard Retail Station	Oyo-Ogbomosho Road
Olafat Unique Concept	Oyo-Ogbomosho Road	AzeezAyila Nigeria Ltd	Oyo-Ogbomosho Road
Ajisope Oil and Gas Nigeria Ltd	Ilora Road	Kunladeb Nigeria Ltd	Sango Road
Under Construction	Mabolaje Road	Virgo Services Nigeria Ltd	Baago Road
Conoil	Oyo-Ogbomosho Road	M.B.A. Ajeigbe Ventures Ltd	Oyo-Iseyin Road
Walat Oil	Ilora Road	Gofix Petrol	AbiodunAtiba Road
Olak Commercial Enterprise Nigeria Ltd	Ilora Road	BNL Bizinilahi Nigeria Ltd	Oyo-Ogbomosho Road
BNL Bizinilahi Nigeria Ltd	Oyo-Ogbomosho Road	Total	Pakoyi Road
MoribolaInterbiz Ltd	Akinmorin Road	Adisel Ltd	Oyo-Iseyin Road
Forte Oil Plc	Oyo-Ogbomosho Road	Silver Touch Industrial Ltd	Oyo-Iseyin Road
Assets Oil and Gas Co. Ltd	Oyo-Ogbomosho Road	AbataGlobalEnterpriseLtd	Adikuta Road
OandoPlc	Oyo-Ogbomosho Road	Energy Master	Adikuta Road
Fides Oil Ltd	Oyo-Ogbomosho Road	Under Construction	Oyo-Iseyin Road
S.M. Mooras Nigeria Ltd	AbiodunAtiba Road	Ajibat	Agunpopo Road
Ade Murphy Petroleum	Kosobo Road	Ade Murphy Petroleum	Adikuta Road
MRS Ltd	Oyo-Ogbomosho Road	LajimoNigeriaLtd	Idigedu Road
Onis Global Concept Nigeria Ltd	AbiodunAtiba Road	Sola Iyaniwura Petroleum	Sango Road
Assets Oil and Gas Co. Ltd	Oyo-Ogbomosho Road	Abebi Oil and Gas	Agunpopo Road
BintinLaye Nigeria Ltd	Ilora Road	Molab International Investment Ltd	Agunpopo Road
Olafat Unique Concept	Hospital Road	Musalat Integrated Resources Nigeria Ltd	Sembe Road
NNPC	Oyo-Ibadan Expressway	Dekem Investment Nigeria Ltd	Idigedu Road
Lajimo Nigeria Ltd	Ilora Road	LateefTemitope Ventures Ltd	Oroki-College Road
Fatty Oil Global Resources	Ajalasa Road Jabata	Mosfala Petroleum	Okeolola Road
Ade Murphy Petroleum	Ajagba Road	Bada Oil	Okeolola Road
Olafat Unique	Ilora Road	LateefTemitope Ventures Ltd	Asipa-

Concept			BaaleAgbeRoad
Oni's Global Concept	Ilaka Road	S.M. Mooras Nigeria Ltd	Oroki-College Road
BNL Bizinilahi Nigeria Ltd	Oyo-Iseyin Road	Ajiga Golden Heritage Ltd	Idigedu Road
BNL Bizinilahi Nigeria Ltd	Oyo-Ogbomosho Road	Yunsol Investment Ltd	Oroki-College Road
Under Construction	Oyo-Iseyin Road	Mosfala Petroleum	Asipa-BaaleAgbe Road
nil	Oyo-Iseyin Road	Ajetunmobi Chemicals and Petroleum Ltd	Asipa-BaaleAgbe Road
Blessing Segun Ventures	Orilota Road	LateefTemitope Ventures	Moses Awujeola Road
Olafat Unique Concept	Oyo-Ogbomosho Road	Almisroj Global Services Ltd	Asipa-BaaleAgbe Road
Aybam Oil and Gas	Oranmiyan Road	Olafat Unique Concept	Moses Awujeola Road
Nodat Petroleum	Oranmiyan Road	Wolag Global Investment	Oyo-Iseyin Road
Dee Dominion Intl Nigeria Ltd	Oranmiyan Road	Yusun Investment Ltd	BaaleAgba Road
MogbaraLewon Nig. Ltd	BaaleAgba Road	Wole Oil	Eleke Road
Under Construction	Mosadoluwa Road	Adetunmobi Chemical Co. Ltd	BaaleAgba Road
Adelad Global Concept	Oroki-College Road	Adetunmobi Chemical Co. Ltd	BaaleAgba Road
Abiskol Petroleum	Oranmiyan Road	Oyee Concepts Oil and Gas	Niresa Road
Ajiga Golden Heritage Ltd	Oroki-College Road		

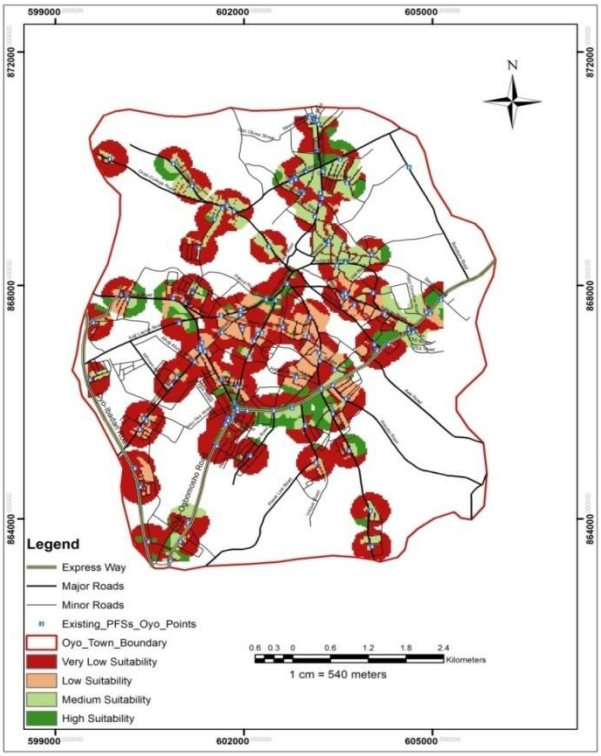


Fig. 6: Oyo town PFS suitability zones

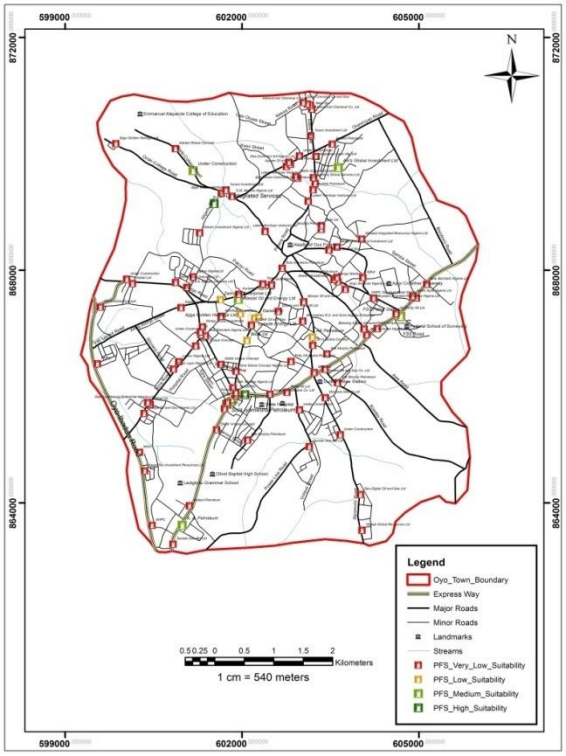


Fig. 7: Oyo town PFS suitability map

4.2 Proximity Assessment

This approach is more specific and criteria based. It aimed at assessing the suitability of existing PFS's in the study area with cognizance to the proximity of these stations to various land-uses, edge of road, other petrol filling stations and the size of these stations considering the given standard criteria..

4.2.1 Distance of Residential Landuses to PFS

OSURPB stipulated a minimum distance of 7 meters setback from every PFS and a dwelling house. The result of the query operation showed that 76 out of the 113 PFSs, that is 67 percent of PFSs in the area are

located 7m from residential land uses, with only 37 PFSs meeting the criteria, thus increasing the vulnerability of dwellers of these houses to PFS associated risks.

The PFS siting standard of the DPR was also considered to assess the distance of PFSs to dwelling places. The DPR stipulates a minimum setback of 50m from PFSs to Residential land uses. The result shows that 102 out of the 113 PFSs, that is 90 percent, are within 50m range from residential land uses, with only 11 PFSs meeting the criteria. The percentage here is higher than that derived using the OSURPB standard. It shows that more residential dwellers are actually vulnerable to possible PFS associated risks in the area.

4.2.2 Size of PFS

The result of the analysisassessing the land area of the petrol stations (Fig. 8) shows that 69 PFSs, representing 61% of the 113 stations have sizes less than the stipulated 1080m^2 and only 44 stations (39%) have the standard land area. These sub-standard sizes are not suitable to be used for PFS as they would pose problems to the PFS owners, users and commuters alike.

4.2.3 Distance of PFS pumps to the road

Thespatial queryrevealed that 107 of the 113, summing up to 95% of the PFSs have dispensing pumps very close to the roads (less than 15m) and only 6 petrol stations, just 5% of the 113 PFSs, adhere to the standard criteria. Some filling stations in the area have pumps just 1m from the road. See Fig. 9.

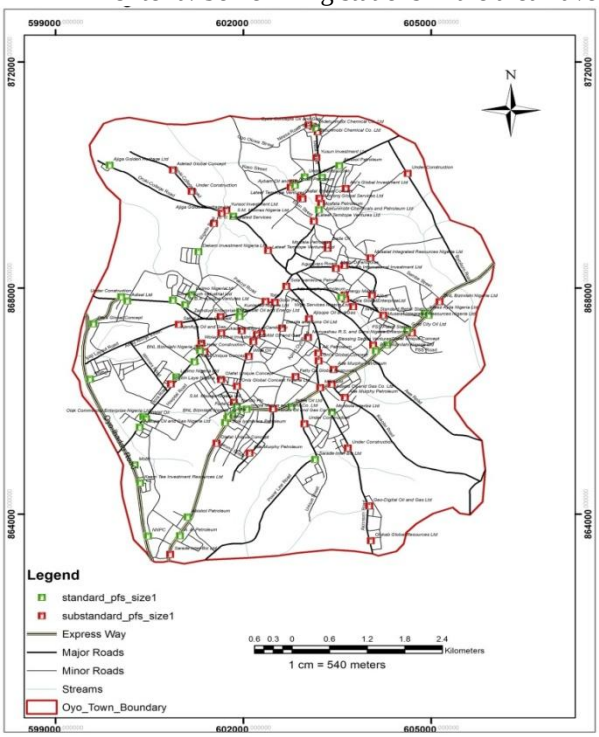


Fig.8: PFSs with standard and sub-standard land area

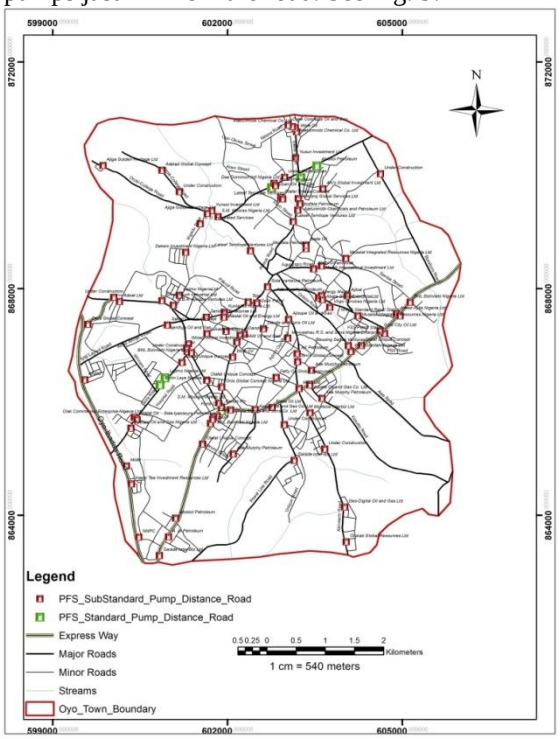


Fig.9: PFSs with standard and sub-standard pump distance to roads

4.2.4 Distance between two PFSs

The local authorities specified a standard distance of 300m as minimum interval between two PFSs on the same axis. The result of the 300m PFS buffer as seen in Fig. 10shows that only 4 PFSs on the same axis have an interval of at least 300m or more. Others are located at bottleneck, less than 300m to each other. The DPR on the other hand specified a standard distance of 400m as minimum interval between two PFSs on the same axis. The result of the 400m PFS buffer shows that only 3 PFSs on the same axis have an interval of at least 400m or more. Others are significantly clustered.

4.3 Assessing Spatial Relationships

The PFS feature was used to examine the nature of cluster of PFSs in the area. Fig. 11 shows the ANN pattern analysis result and summary. The z-score is given as -4.246473 and p-value 0.000022. These low values show that the pattern of distribution of PFSs in the area is significantly clustered. Also, the Nearest Neighbor Index is less than 1 (0.797187), a pattern that exhibits clustering. There is thus little probability that the features (PFSs) are randomly distributed. Since the spatial pattern is clustered and not random, the null hypothesis is rejected and the alternate accepted.

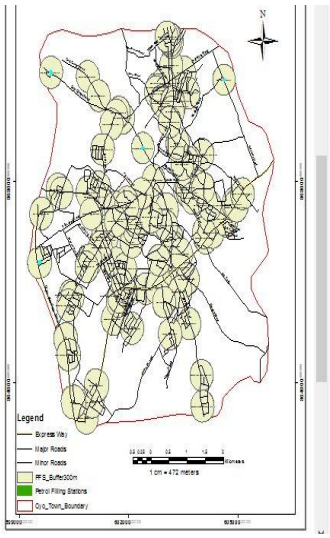
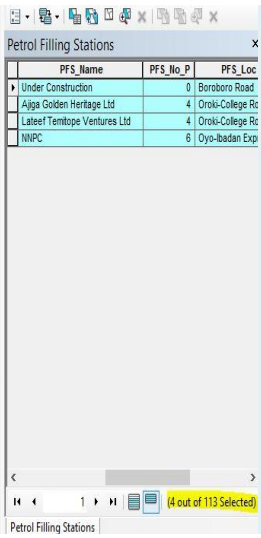


Fig. 10: PFSs with a minimum interval of 300m to any other PFS on the same axis



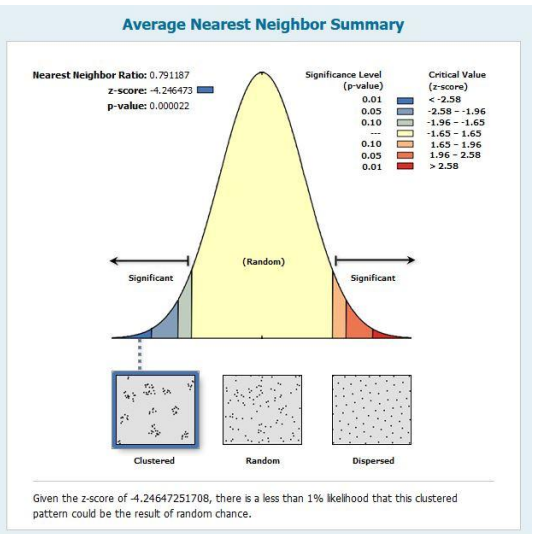


Fig.11: PFS spatial pattern in Oyo town using ANN

V. Conclusion

This study has demonstrated beyond reasonable doubt the use of GIS in attending to the spatial problem of PFS siting, applying various spatial analytical techniques in a multi-dimensional manner. Based on the study, PFFs in Oyo Town are haphazardly sited and as much as 86.7 percent of these stations evidently do not adopt standard planning criteria in selecting their sites or during the construction stage.

From the foregoing, it becomes imperative that a site suitability analysis should at all times be incorporated by the local authorities during town planning, especially for new developments and during policy and decision making as well as endeavor to approve all PFS plans before construction begins, supervise construction and punish offenders and PFS owners who contravene the standards in both their siting and construction phases. This will help nip the problems in the bud.

In addition, the DPR and the Local Town Planning Department should ensure that PFSs are properly sited in line with their stipulated siting criteria, as such; the results derived in this study can be adopted to reveal PFSs that contravene standards thus posing problems and possible risks to the Oyo people. Also, OSURPB should review their criteria of 7m setback from PFS to residential buildings as it exposes most Oyo residents to hazards associated with PFSs. The DPR criterion of 50m proves to be more acceptable.

In a nutshell, the results of the various analyses all point to the fact that PFSs are clustered at bottlenecks to each other, PFS pumps are at unacceptable distances to the roads, pari-passu with dwelling places, etc. These stations are existing already, thus, a proper Environmental Impact Assessment should be carried out by the authorities to assess the significant impacts the ill-sited PFSs could have on the environment and the ameliorative measures that can be employed to reduce the impacts if they must continue to exist in such places.

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