Locational Analysis of Filling Stations in Portharcourt Local Government Area, River State, Nigeria Using GIS Approach

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Abstract— *The rapid growth of urbanization has created greater demand for vehicles, which results in more fuel consumption and has given rise to the establishment of filling stations in other to satisfy those needs. A petrol filling station is important but meanwhile it is a hazardous facility, so special attention is paid on its location. The paper is aimed at location analysis of filling stations in Port Harcourt local government area of rivers state using GIS approach through acquisition of primary and secondary datasets of the study area, creation of a functional spatial database and spatial attribute queries that will aid in the location analysis of filling stations in compliance with petroleum safety rules and regulations. The result shows that About 7 filling stations were located close to residential buildings, 14 out of 38 filling stations do not have adequate fire extinguishers, 14 filling stations have its pumping machine close to the road and 15 filling station lie in electricity high tension right of way. It is recommended that the regulating bodies should frequently inspect these filling stations to ensure that all the safety measures are properly observed and equipments are put in place.*

Keywords— Database, Geographic Information System (GIS), Petrol Stations, Spatial query.

I. INTRODUCTION

Petrol filling stations are no doubt an important facility but can be harmful and dangerous. The petroleum sector faces several challenges. Such challenges include: propagation of substandard petroleum dispensing and storage sites which pose environmental health and safety risks, diversion of petroleum products destined for export into the local market by dishonest business people to evade tax and a control of the market by a few companies among others (ERC, 2013). Other problems include road accidents, pollution, fire accidents etc.

In Port Harcourt, Rivers state, Nigeria, road accidents and traffic congestion have been common because of the long queues caused by motorist who wants to purchase products. These are sometimes as a result of the fact that most of these filling stations are sited less than 15 meters away from the roads, starting from their first pumping machine.

II. STUDY AREA

The study area is Port-Harcourt local government area of Rivers State, Nigeria. It has an area of 360 sqkm (140sqmi), with a population of 1,382,592 (2006 Census). It is located between latitude 4^0 $39^{'}$ $45^{"}$ and 4^0 $50^{'}$ $00^{"}$ and longitude 6^0 $56^{'}$ $15^{"}$. 6 and 7^0 $7^{'}$ $32^{"}$.

III. METHODOLOGY

The methodology used in this paper is shown in figure 3

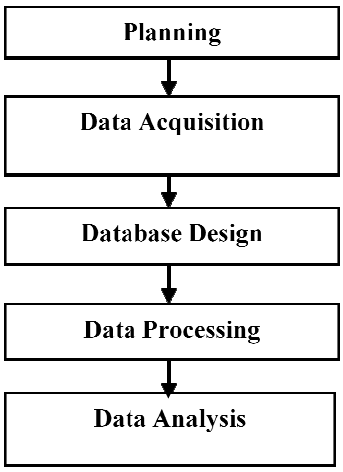

Fig.3: Flowchart of Methodology Adopted

3.1 Data Acquisition

The data used for the research is grouped into two main classes; primary and secondary data sets.

A. Primary Data Set

The primary data set used for this paper included the following:

i. GPS recording/co-ordinates: The entire filling stations in Port Harcourt metropolis were coordinated using the GPS GARMIN 76CSX.
ii. Attribute data: This includes non spatial descriptive information of filling stations

B. Secondary Data Set

The secondary data set used for this paper included the following:

i. Map of Port Harcourt showing road network, towns was obtained from the Ministry of Lands, Survey and Urban Planning, Port Harcourt Rivers State.
ii. Map of Nigeria showing Rivers State
iii. General information about the study was obtained from journals, network, newspapers, and publications.

3.2 Database Design

The creation of a structured, digital database is the most important and complex task upon which the usefulness of the cadastral information system depends. Database design is the process of producing a detailed data model of a database (Hernandez, 2012). The design phase consists of three levels (Kufoniyi, 1998):

a) Conceptual Design
b) Logical Design
c) Physical design

a. Conceptual Design

Conceptual design is the first step in database design where the contents of the intended database are identified and described. It deals with the identification of the basic terrain objects together with the spatial relationship that exist among them. It is human-oriented, often partially structured, model of selected objects and process that are though relevant to a particular problem domain. Conceptual design is carried out independent of the software and hardware that will be used to implement the database.

b. Logical Design

This is another stage of the database design in which all the real world entities conceptualized were modeled into the real world using logical design. It is the representation of the conceptual design to reflect the recording of the data in the computer system using a relational database management system (RDBMS) (Effiong and Alagbe, 2012). In this phase, the entities, their attributes and their relationships were represented in a single uniform manner inform of relation in such a way that would be no information loss and at the same time no unnecessary duplication of data.

c. Physical Design

This involves the translation of the real world entities into the computer compactable forms of the chosen structuring model such as relational, geo-relational, network, and hierarchical. For this project, relational (table) method was used due to its easy implementation and management.

All geospatial and non spatial (attribute) data were structured and actualized to form a database in a format acceptable by the implementing software and hardware. Thus, point, line and polygon layers were created for spatial objects on the digital map. Attribute data needs of the database were also structured as shown in the following tables.

3.3 Data Processing

The map of the study area was scanned and then exported to ArcGIS 10.2 for georeferencing and digitized, so that spatial analysis can be performed. These data were processed and queried to provide useful information for planning and monitoring.

3.3 Data Analysis

GIS packages can perform a variety of analysis which include classification, spatial search, buffering, overlay operation, spatial query and display, proximity analysis etc. for the purpose of this research, spatial queries was performed to provide information that will aid in the monitoring of petrol filling stations across Port Harcourt Rivers State.

IV. RESULTS

The results obtained are discussed in the following subsections:

4.1 Query to Determine Filling Stations That Is 50m Close To Residential Area

This query is structured to determine the filling stations that are 50m close to residential as shown in fig 4.0

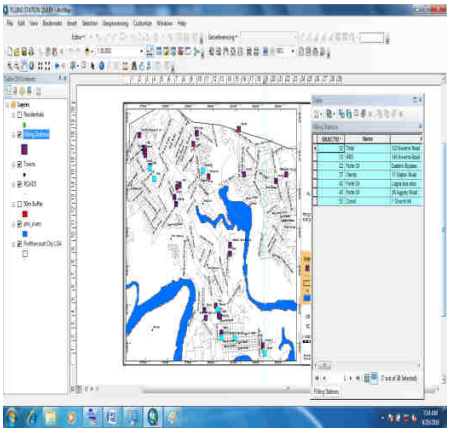

Fig.4.0: Query results showing Filling Stations That Is 50m Close To Residential Area

the result shows that about 7 filling stations are close to residential which are three Forte Oil stations, Oando, Conoil, Mrs And Total. This implies that they did not meet the depertment of petrolleum resources crittera which states that filling sation should be sited 50m away in all angles of the build up area to create a buffer zone for the residential house.this is important as will help to prevent collateral fire outbreak.

4.2 Query to Determine Filling Stations without Fire Extinguishers

This query is structured to determine the filling stations without fire extinguishers incase of fire out break as shown in fig 4.1

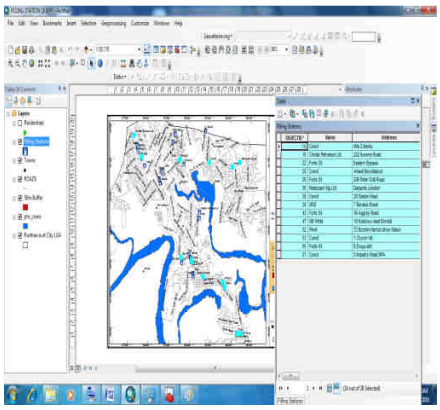

Fig.4.1: Query result showing filling stations without fire extinguishers

The result shows that 14 0ut of 38 filling stations do not have fire extinguishers. Fire extinguisher should be kept handy this is important as it helps to combat fire during fire outbreaks.

4.3 Query to Determine Filling Stations with Pumping Machines that are close to the edge of the Road

This query is structured to determine filling stations with first pumping machines that are less than 15m to the edge of the road as shown in fig 4.2

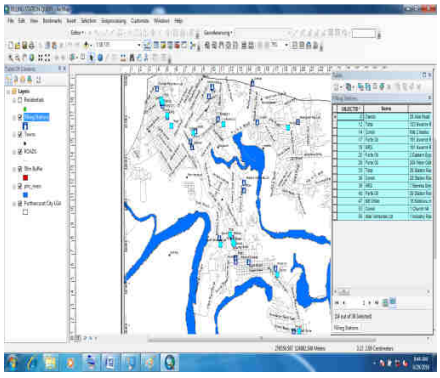

Fig.4.2: Query result showing filling stations whose first pumping machines are less than 15m to the edge of the road

The result shows that about 14 out of 38 filling stations have their pumping machine less than 15m to the edge of the road which is against the department of petroleum resources criteria which states that "The distance from the edge of the road to the nearest pump will not be less than 15 meters". This query is important as it will help to reduce traffic congestion and accidents due to long cue of vehicles who want to buy fuel.

4.4 Query to Determine the Filling Stations That Lie Within Electricity High Tension Right Of Way

This query was structured to determine the filling stations that lie within the electricity high tension wire right of way as shown in fig 4.3

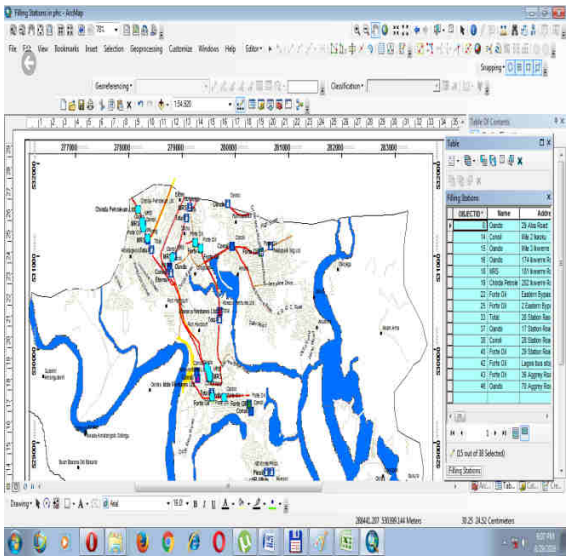

Fig 4.3: Query result showing filling stations that lie within electricity high tension right of way

it was observed that about 15 filling stations lie within electricity high tension right of way e.g. Oando filling station has the highest number of filling station (a total of 6) followed by Forte Oil (a total of 5) which lies within electricity high tension right of way. This implies that Oando and Forte oil filling stations are at a greater risk.

V. SUMMARY & CONCLUSION

This research was made possible through the conversion of the analogue base map to digital format. Features were digitized into different themes and their attributes were processed through the creation of GIS database by using the Arc GIS 10 software. GIS as a tool in this research paper was able to demonstrate its applicability in the mapping and assessment of filling station in Port Harcourt local government area of rivers state and Nigeria at large, these will provide useful information that can aid decision makers and researchers in future.

VI. RECOMMENDATION

Based on the findings of this research paper, the following recommendations are highlighted.

1. Filling stations that are close to residential buildings and public facilities should be closed. This is as a result of fire explosion which can cause loss of life's and properties.
2. Filling stations that do not have fire extinguisher handy should be closed until adequate fire extinguishers are bought.
3. The regulating bodies should frequently inspect these filling stations to ensure that all the safety measures are properly observed and equipments are put in place.

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