Research Journal of Applied Sciences 8 (10-12): 461-469, 2013
ISSN: 1815-932X

GIS as a Tool for Effective Management of Fire Disaster: A Case Study of Onitsha Metropolis in Anambra State of Nigeria

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Abstract: The number of natural and human-made disaster is on the rise worldwide. Over the last few months, Nigeria has witnessed an astronomic increase in rate of bombing and other fire outbreak. Recently, a Dana plane crashed in Lagos, Nigeria killing about 152 passengers. Most of these passengers died as a result of the fire outbreak. The rates of fire outbreak have increased tremendously in Onitsha metropolis. This may be attributed to illegal electricity connection and lack of quick response by the fire service department to stop the fire at an early stage. Government has lost a lot of money in payment of compensation to victim of fire outbreak. The emotional distress on the victim of this incidence is unquantifiable and in some cases result to loss of human lives. Government in its effort to tackle this problem has invigorated the state fire service department to be able to tackle this challenge by providing new equipment for them. But how effective has this effort been able to solve this problem. GIS offers itself as an effective tool to manage this problem since it can graphically display features on the ground and be able to perform query on them. The analytical capabilities of GIS can detect the possible shortest route as well as model the housing pattern and location of important features, thereby providing a quick response to fire outbreak. This study discusses the application of GIS to effectively manage fire disaster in Onitsha metropolis. It explores the great potential of GIS in managing fire disasters through sample queries. The research recommends immediate increase in the number of fire stations in Onitsha.

Key words: GIS, fire, database, risk, Onitsha

INTRODUCTION

A disaster is defined as a serious disruption of the functioning of society causing widespread human, material or environmental losses which exceed the ability of an affected society to cope using only its own resources (EEA, 2006). Fire is a form of disaster that can occur anytime and anywhere and in some instances without notice (Eduputa, 2011). Fire occurs as a result of formation of a fire triangle which is composed of fuel, oxygen and heat. The occurrence may vary from one location and situation to another but in most cases is dependent on the scale, the nature of combustible materials and mode of occurrence, circumstances prevailing during the period of occurrence, the weather condition, the nature and direction of prevailing wind among other factors. Fire is considered a disaster depending on the intensity of the hazard event and the degree of vulnerability of the society. Fire outbreak in unpopulated area may not have the same effect as in a highly populated city like Onitsha.

Findings from Anambra State Fire Service Headquarter show that most of the fire disasters were caused by petrol tankers accident, illegal electricity connection and carelessness. For example, 32 persons that got burnt near Azare in Bauchi State in 2012. About 5 persons that died along Umunya to Enugu express in 2010, buildings that caught fire in Kano street near Onitsha main market in December 2006 were all as a result of fuel tanker accidents. Considering the high density and the large number of inhabitants combined with the accelerated urban development, urban cities run the highest risk of fire disaster. Table 1 presents a summary of fire incidents in Anambra State between 2005 and 2011, showing the number of fire incidents, deaths and damages incurred in millions of naira. These statistics confirm that fire disaster poses a serious threat to economic advancement and sustainable development especially in Onitsha. This has become a recurrent phenomenon. As a result, Anambra State Government established the State Fire service and Emergency Management Agency to effectively manage fire related problems. But how effective have these agency be enduring fire intervention process since they still adopt the conventional approach of fire fighting? Modern-day mitigation and management of fire are unimaginable without the tools of spatial

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Table 1: Report of fire statistics between 2005 to 2011

Fire service stations	Year of fire occurrence	No. of response calls	Fire accidents		Cost of damage (*f*) in Millions of US$	Property recovered (*f*) in Millions of US$
			Rescued	Dead		
Onitsha (Main Mkt)	2005 to 2011	259	5	6	181.97	18.20
Onitsha (Okpoko)	2005 to 2011	245	0	8	25.40	2.56
Nkpor	2008 to 2011	20	0	0	0.68	0.05
Amawbia	2005 to 2011	193	4	5	130.51	10.12
Ekwulobia	2006 to 2011	14	1	1	0.35	5.00
Nnewi	2005 to 2011	51	0	0	0.85	7.60
Government House-Awka	2005 to 2011	35	3	4	2.15	8.15
Ultra modern fire station (Agu-Awka)	2010 to 2011	0	0	0	0.00	0.00

ASFSH (2012)

technology. Spatial data information is very vital in disaster prevention and emergency aid. To guarantee for speed and efficiency of rescue operations all information should be available at a glance in the control units and in the mobile rescue units as well. In an emergency case not only the location of the event but many other information are needed, like, how many people are affected? Which road network is available? Can the location be reached by vehicles? Where are the most nearby fire station and hospitals located? How much and which kind of capacity do the hospital have? Does the nearby fire station have enough facilities to control the fire? Such and many other questions can be answered very quickly if and only if reliable spatial data are available in digital form and if the data are processed in a powerful Geographic Information System (GIS).

A GIS as a tool can be used by the fire service personnel to plan effectively for emergency response, determine mitigations priorities, analyze historical events and predict future events (Ejikeme and Igbokwe, 2011).

Disaster risk management and its components: Disaster Risk Management means the systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters (UNISDR, 2004). According to Lemmens (2005), disaster management involves many diverse activities. These activities can be grouped into five stages viz.: assessment, mitigation, preparedness, response and recovery. The first three activities are performed before the occurrence of disaster while the fourth and fifth take place during and after the occurrence of disaster, respectively.

Assessment: This involves inventorying (identification and recording) the sensitivity and vulnerability of a region to certain types of hazards. At this stage, the level of risks and danger to human life, environment and structures are considered and determined. The assessment will provide identification of development that will reduce risk rather than increase them thus establishing the culture of prevention.

Mitigation: This entails making necessary provisions to ensure that the region is less vulnerable to known risks and danger. Mitigation activities may include: landuse and planning; moving settlement away from areas susceptible to such risks and danger such as flood and storm areas and the establishment and enforcement of building codes, etc.

Preparedness: This involves planning of emergency aid, development of scenarios and monitoring systems and establishment of early warning system, public information and awareness of likely hazards, community involvement in disaster management programmes, establishment of disaster management and reduction at local, state and national levels and establishment of proper communication channels.

Response: This happens after the occurrence of the disaster which would have caused untold human suffering and damages to the environment. At this stage, rescue teams will attempt to save lives, injured people will be cured and nursed and relief will be supplied to traumatized survivors. This is the most sensational stage of disaster reduction and management system.

Recovery: This stage involves assessment of damages, rehabilitation, cleaning of the environment and social and economic reconstruction. It also entails the first three stages of disaster management process viz. assessment, mitigation and preparedness, all of which are central to strategic development aimed at preventing or minimizing the effect of future disasters. GIS plays a prominent role in all stages of disaster management ranging from pre disaster preparedness, to response and recovery activities.

Pre-disaster preparedness: In pre-disaster activities GIS provides a useful tool such as proximity analysis and

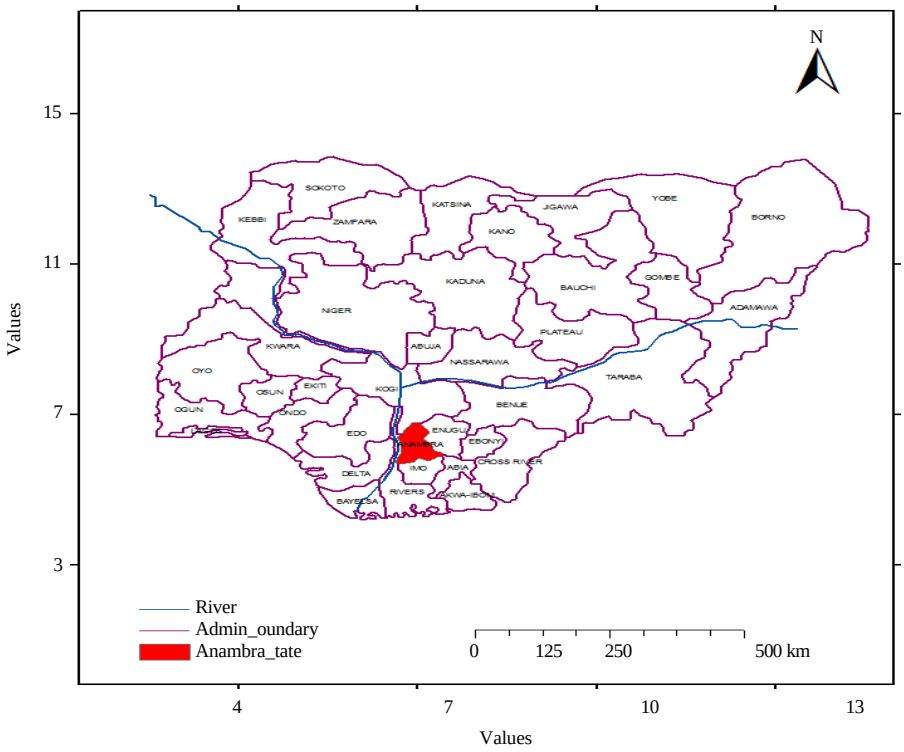

Fig. 1: Map of Nigeria showing Anambra State

network analysis in making informed decision in the organizing of emergency response tools for effective response during emergency. GIS at this stage is also useful in the mapping of the status quo which is an essential tool in restoring the environment back to its pre disaster condition. GIS can also help in identifying areas that are susceptible to fire outbreak such as markets and slum, thereby providing necessary measures in place to avert possible fire outbreak (Table 1).

Disaster management: GIS plays an important role in disaster management. It helps personnel and resources deployment, organize inventory of both human and resources in the disaster affected areas. It also helps in the organization of the evacuation of communities and modeling of the damage caused by disaster.

Post-disaster management: GIS is applied in post disaster management in remediation activity planning and assessment.

The study area: Onitsha urban area is located between latitude 06°02'56"N and 06°38'34"N and longitude 06°37'30"E and 06°59'30"E in South East Nigeria. Onitsha is the largest urban centre in Anambra State and is also a major commercial town east of the Niger. Onitsha is

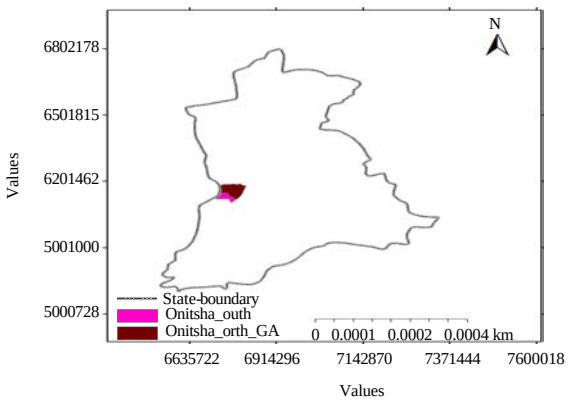

Fig. 2: Map of Anambra State showing Onitsha, the study area

heavily populated and attracts people from all over the country because of the commercial activities in the town. Onitsha main market is reputed to be the largest market in West Africa. The study area (Fig. 1-4) has two fire service stations; Onitsha (Main market) and Onitsha (Okpoko). The study area was segregated into zones: Awada, Okpoko, GRA, Odoakpu, fegge, enuonicha, low cost housing estate and Nkpor. Onitsha is also a major river port, located at the River Niger.

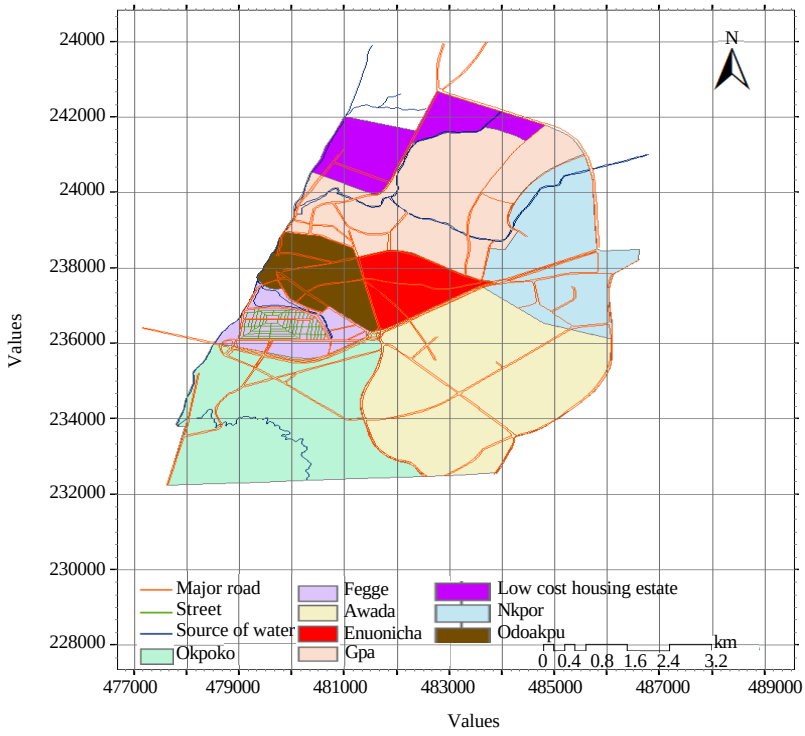

Fig. 3: Map of Onitsha metropolis, the study area

Fig. 4: IKONOS image showing the study area

MATERIALS AND METHODS

Data requirement: The data used in executing this project are:

- Onitsha metropolis street guide map
- Spatial locations of fire service station and some of the major markets
- Attribute data of fire service station including their distress call number, causes of fire incidence as well as statistical data on fire incidence that occurred from 2005 to 2011
- Location of major hospitals

Sources of data: Data were collected from primary and secondary sources. Attribute data of fire service stations were collected from the state headquarter, Anambra State Fire Service Department, Awka. Also, the street guide map of Onitsha metropolis was obtained from the survey department of the Ministry of Lands, Survey and Town Planning, Awka. The locations of the fire service station as well as some of the major markets and hospitals were obtained using Garmin 76S handheld GPS.

Data processing and analysis

GIS database creation: The Onitsha street guide map was scanned using AO scanner and saved in TIFF format. The scanned map was then imported into ArcGIS 9.3 Software where it was georeferenced and digitized. The geographic coordinate of the fire service stations as well as some of the major markets and hospitals were plotted into the digitized map. The attribute data of each of the fire service stations were then added. A composite map was generated from spatial data layers in the database as shown in Fig. 5. Spatial analysis were performed based on the composite map.

Identification of spatial and temporal fire outbreak pattern: To determine if there is a pattern to the fire incidence, their locations as well as causes of the fire

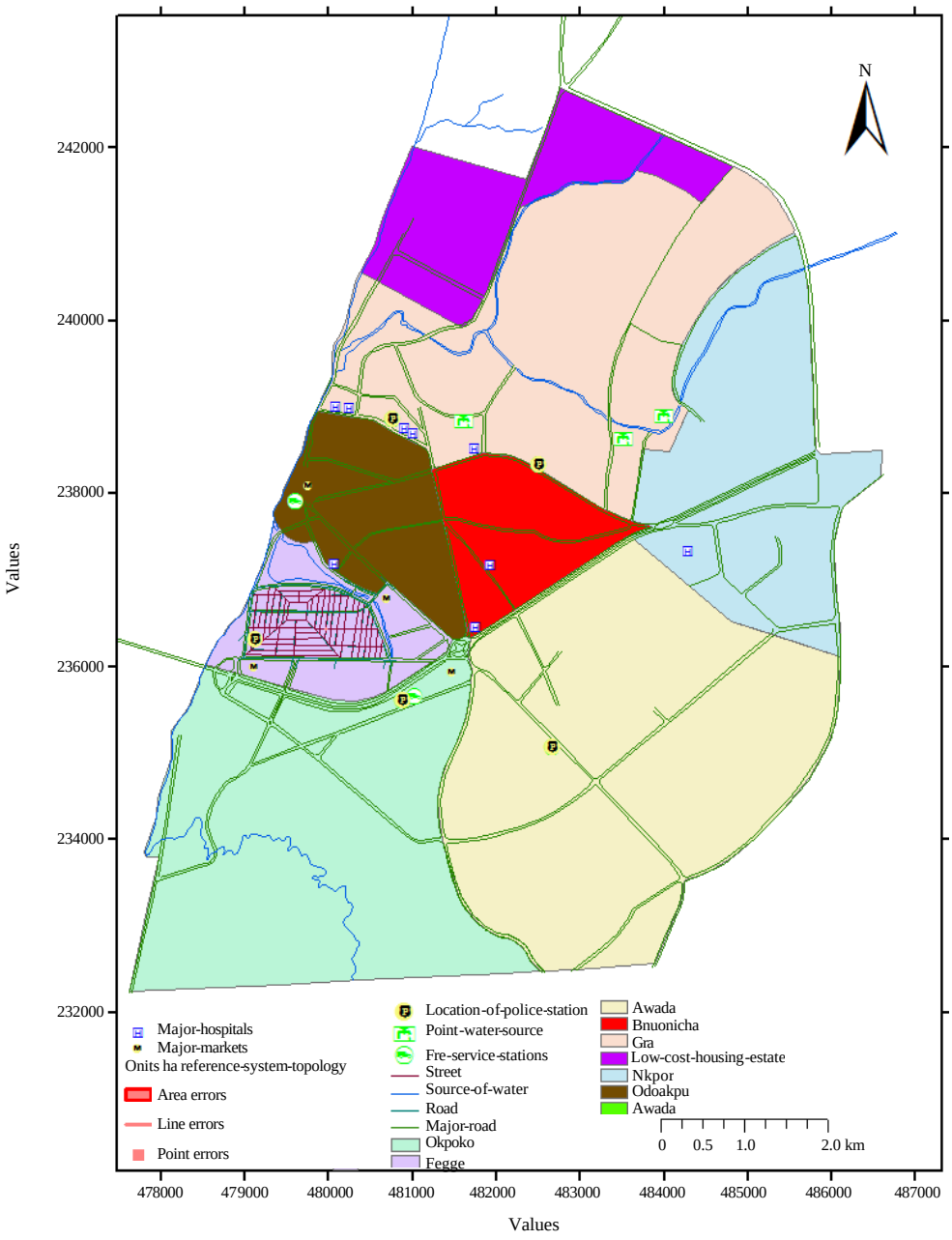

Fig. 5: Composite map of the study area

outbreak were utilized. The total number of fire incidence that occurred in each area was calculated in order to determine if there is a pattern to the fire disaster.

Association with demographic features: Certain characteristics of the area such as the housing pattern were analyzed to determine the association between the demographic characteristics of the area with the fire incidence.

RESULTS AND DISCUSSION

Results of the database queries were presented in the form of digital maps and attribute tables. Some of the queries are given.

Query 1: How many fire stations are located in GRA?

The result of this query (Fig. 6) showed that there is no fire station in GRA despite the fact that it is most suitable for location of fire station based on its nearness

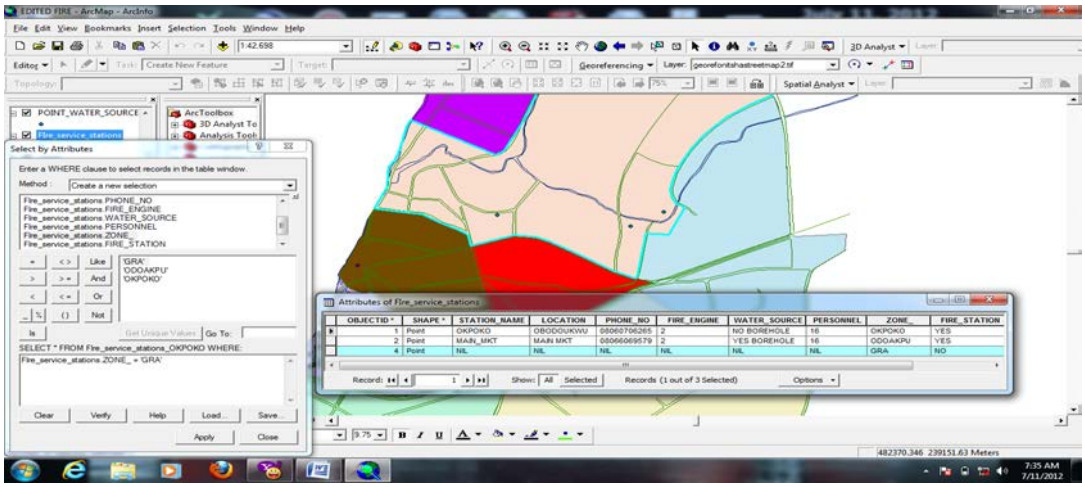

Fig. 6: Query result showing the number of fire station located in GRA

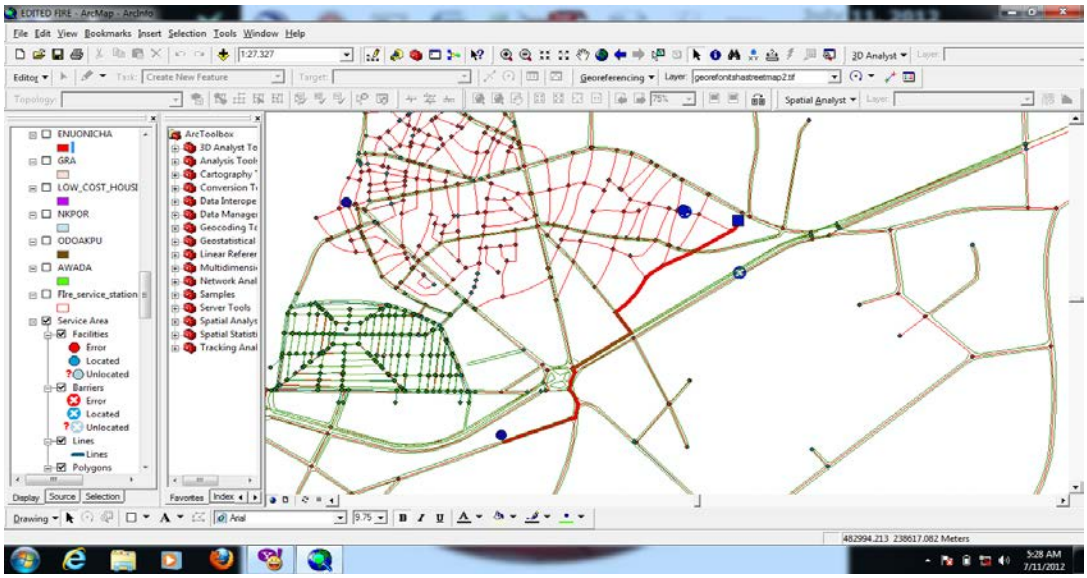

Fig. 7: Query result showing the shortest possible route from the nearest fire service station to the location of the fire outbreak that occurred at St. Stephens road

to source of water. The lack of fire station in GRA shows that there will be serious delays to get fire fighters from the other fire stations to come to the GRA in case of emergency.

Query 2: The fire service unit have been alerted of a plane crash at St. Stephen's road and needs to know the location and shortest possible route to the scene from the two fire service stations.

The query result Fig. 7 shows that the fire station located at Obodoukwu road in Okpoko Area is nearer to the fire incident scene. This is a network analysis to help fire fighters identify the shortest possible route from their station to a point of fire outbreak.

Query 3: What is the extent of coverage of the fire service stations at distance of 500 m?

The analysis in query 4 will assist government to determine the area covered by the fire service station as well as in taking decision on the best location to site a fire station. The result of this query is shown in Fig. 8

Query 4: Where is the location of police station at Fegge area?

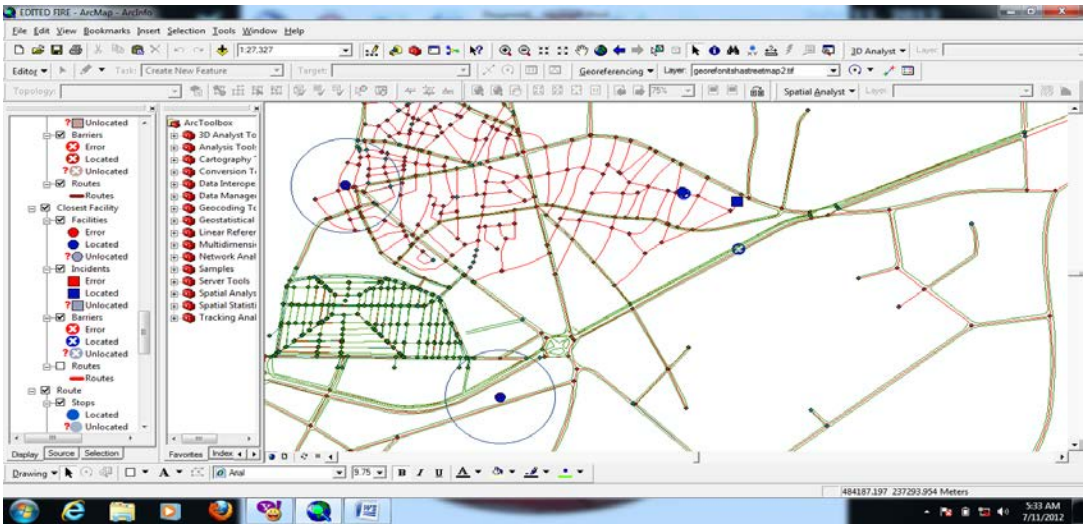

Fig. 8: Query result showing areas covered within 500 m by the fire service stations

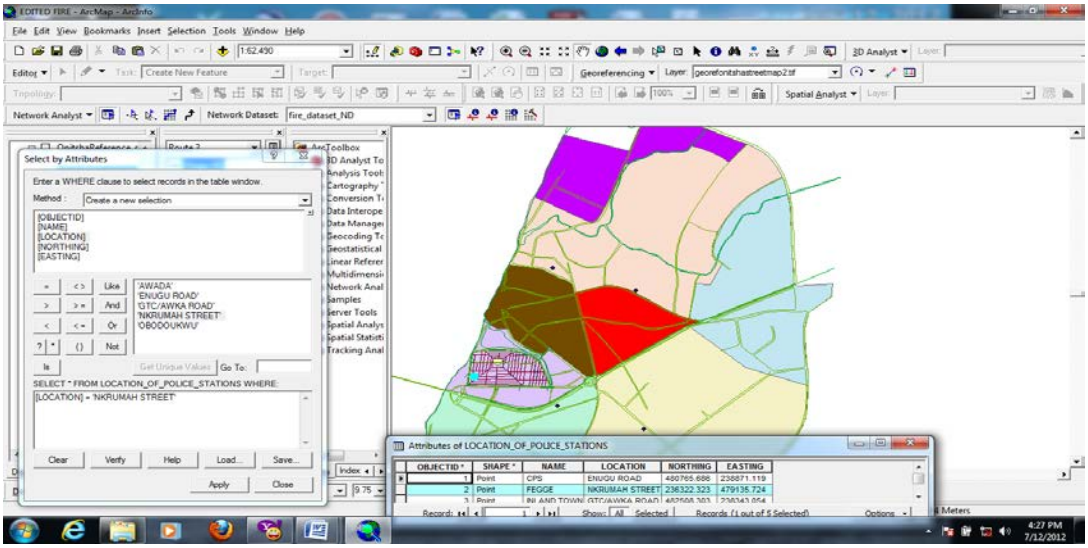

Fig. 9: Query result showing the location of police station located at Fegge area

The result of this query is shown in Fig. 9. This is a spatial search to identify the location of an existing fire station in a district of the city known as Fegge. The search will also help the government to confirm if the existing fire station is enough to serve the district.

Query 5: What are the attributes of the fire stations?

This analysis shows the attributes of the fire service stations such as their name, phone numbers, number of fire engines, personnel and most importantly their source of water.

The result of this analysis is shown on Fig. 10. This analysis will help the governement etermine he adequacy of facilities in a given fire station and to plan for possible upgrade of facilities.

Query 6: What is the shortest route between the loaction of the police stations and the fire service stations?

This query was carried out to identify the shortest route between the police stations and the fire service stations. This will ensure greater coordination among the police personnel and the fire service personnel. In fire emergencies, there is need for the security agency like the police to work closely with the fire service to ensure the protection of lives and properties. This analysis (Fig. 11) therefore is to identify the closeness of police stations to a fire station.

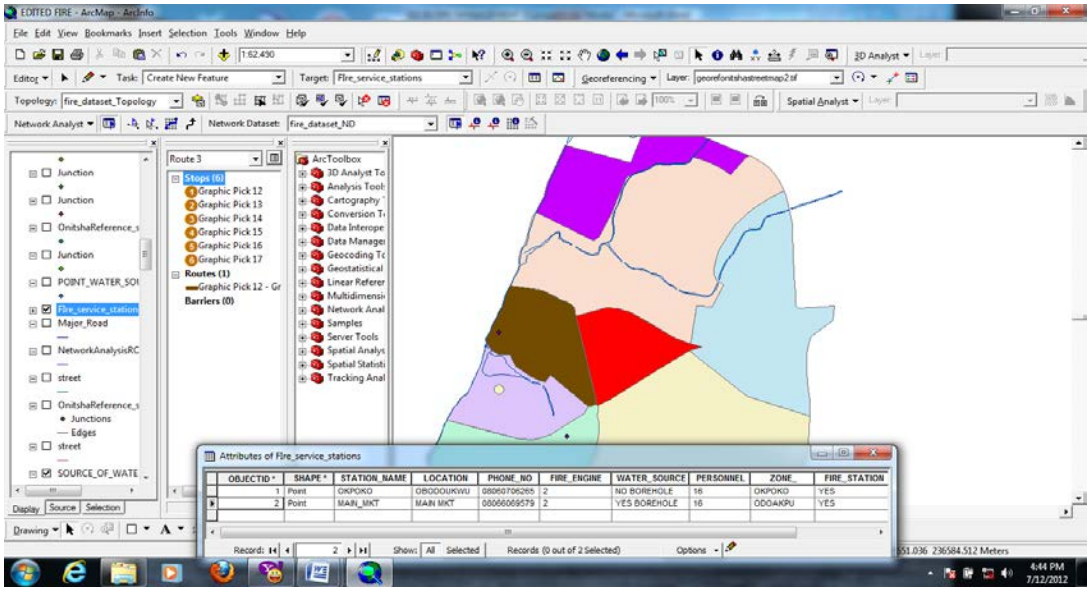

Fig. 10: Attributes of the fire stations vis-a-vis their sources of water supply

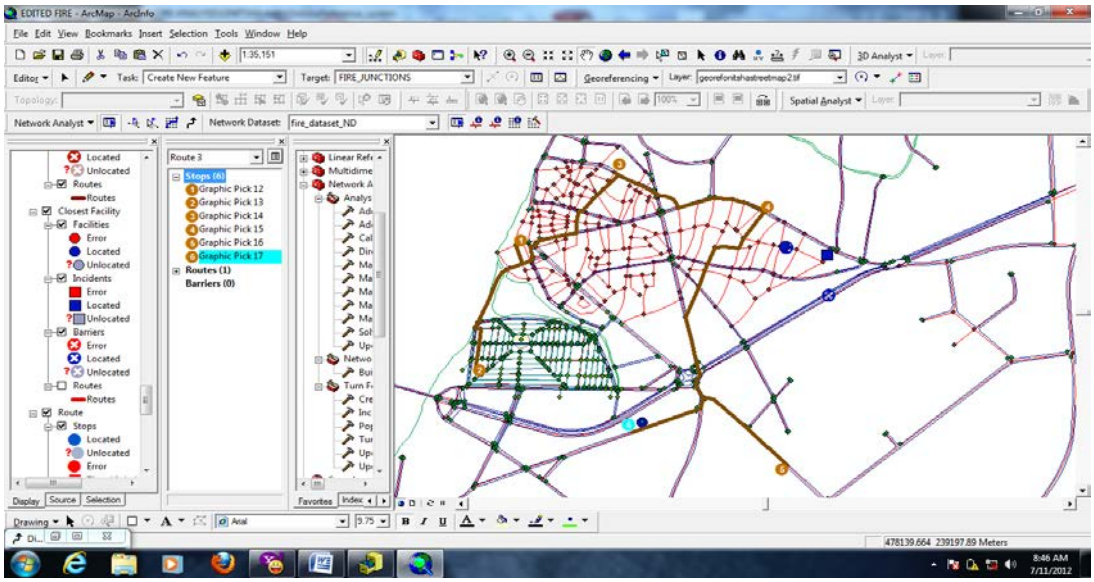

Fig. 11: Query result showing the proximity of police stations (point 2-5) to the location of fire stations identified as point 1 and 6

CONCLUSION

From the result of the analysis, it has been showed that GIS can be used to manage fire outbreak. Effective management of fire outbreak requires quick response. Since, fire incidence has location, GIS can be used to locate the possible shortest route to the fire location, thereby deploying personnel on time to quench the fire on time. Also, the attribute database of the fire stations can be used to know which fire service have the necessary facilities to effectively manage a fire outbreak. Proximity analysis also shows that the fire service stations were not centrally located for efficient access to other areas. Also, the source of water which is a major ingredient for fire fighting was not considered in the sighting of the fire station. Finally, from the statistical data obtained from the state fire service headquarter, Onitsha (Main Market) and Onitsha (Okpoko) has the highest number of fire

incidence. This could be attributed to the housing pattern of Onitsha city. The study shows that the number of fire stations in the metropolis is grossly inadequate.

RECOMMENDATIONS

In as much as GIS presents a wide range of options for addressing fire disaster management, it requires the commitment and cooperation of all stakeholders for its implementation. The following are recommended:

- The government should establish fire service station very close to the police stations and markets in Onitsha
- Nearness to source of water should always be considered while establishing fire service station since water is the major resource needed in extinguishing fire. Alternatively fire hydrants should be developed in different parts of the metropolis
- There should be a greater coordination among stakeholders such as the police, fire service unit, civil defense and other stakeholders in the implementation of emergency relief strategies
- There should be capacity building and retraining of fire service personnel on modern approach to fire-fighting and fire protection

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