Spatial Distribution of Fire Service Stations and Service Area Coverage Analysis for Kaduna Metroplois

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Abstract – Fire is one of the most disturbing problems in urban areas, in Kaduna very large amount of property and lives are unfortunately destroyed by fire annually. GIS technology is a valuable tool in managing fire disaster. This research described the spatial distribution and service area coverage of fire service stations within Kaduna metropolis using GIS. Bing Satellite imagery of 5 meters resolution of the study area was processed and digitized. Handheld GPS was used to obtain locations of the fire service stations. Since response time to a fire incident from fire service station is crucial in managing fire disaster, the service area coverage analysis was used to determine the coverage area of each facility in 3, 5 and 10 minutes. The study shows the spatial distribution and attributes of the fire service stations within the metropolis and concluded by revealing the need for additional fire service stations since there are areas that cannot be accessed in 3 or 5 minutes from the fire service station, this will be able to service the entire metropolis in a maximum of five minutes drive time.

Keywords – Spatial Distribution, Fire Service Stations, Service Coverage, Fire Outbreak.

I. INTRODUCTION

Fire is a form of disaster that can occur anytime and anywhere and to some instances without notice (Edupta, 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 to another but in most cases is dependent on 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 hazards, events and the degree of vulnerability of the society.

Urban fire is one of the most common problems not only for developing countries but also for developed countries (Nisanci, 2010). Many fire hazards occur in informal settlements of urban areas affecting millions of people each year through loss of life, serious injury and loss of assets and livelihoods. While the growth of mega-cities and mega-risks like earthquakes capture headlines, far more lives in urban areas are lost to everyday disasters including dirty drinking water, poor sanitation and fires (Auran, 2006).

Fire outbreak in unpopulated area may not have the same effect in a highly populated city like Kaduna. The effect of a fire outbreak within the metropolis can have a devastating effect on lives and property.

As all other emergency cases, response to fires whose first aim is preventing loss of lives and recovering the loss with minimum harm is carried out by fire stations. Examining the locations of current fire stations in parallel with population exchanges and settlement movements or determining the exact locations in the case of opening new fire stations will reduce the response time at any possible emergency call case and accordingly reduce the loss of life and property (Challands, 2010). Although numerous studies related with medical first aid incidents about emergency response exist, limited number of studies is available on the subject of response to fires and locations of fire stations.

With all the challenges confronting emergency crews today, effective response requires good planning, risk management, comprehensive training, and intelligent deployment through preparation. GIS technology has become a powerful tool for improving all aspects of fire service delivery systems (ESRI, 2006).

In recent years, Kaduna state has witnessed series of fire outbreaks which have claimed lots of property and many lives in the process. The casualty is usually much because of the slow response time of the fire service department or lack of response to people's distress call at all.

Spatial distribution and service area analysis can address the challenges and reduce the losses from these fire disasters. There are incidences of fires burning for hours or even days before the state fire service department is informed.

II. AIM AND OBJECTIVES

The aim of this paper is to develop a spatial distribution and response system for fire service stations within Kaduna metropolis.

The objectives of this paper are:
1. Database Design for the study area.

2. Database creation and linking attribute tables to geometric data.
3. Distribution of fire service stations within the study area.
4. Ascertain the fire service coverage area within the study area.

- **Study Area**

Kaduna metropolis comprises of Kaduna South Local Government and Kaduna North Local Government. It is located in the North Western part of Nigeria. Kaduna lies between latitudes 100 20' N and 100 33' N and longitudes 70 45' E and 70 75' E covering an area of about 46, 053 sq.km.
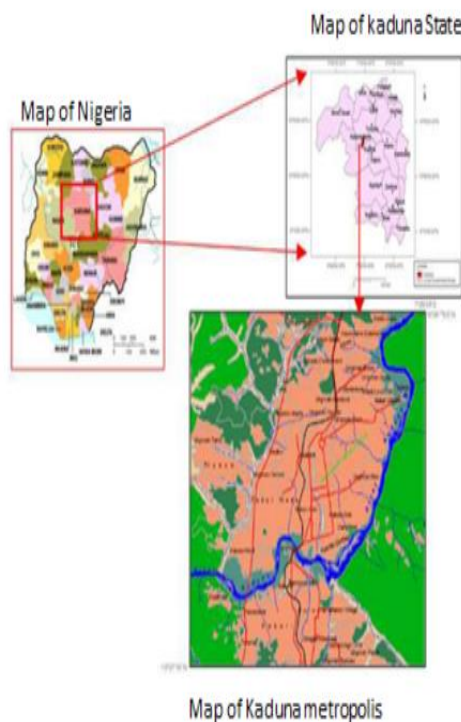

Fig.1. Map of the Study area. Source: (David,2008).

III. METHODOLOGY

1. MaterialS Used
The materials used are software, hardware and data.
2. Software and hardware used
The hardware used are:
- Laptop computer Microsoft Office.
- Handheld GPS (Garmin 76).
The software used are:
- ArcGIS v10.3 Desktop
- Microsoft Office.
The data used are:
- Bing Sattelite image
- Fire Service Station records

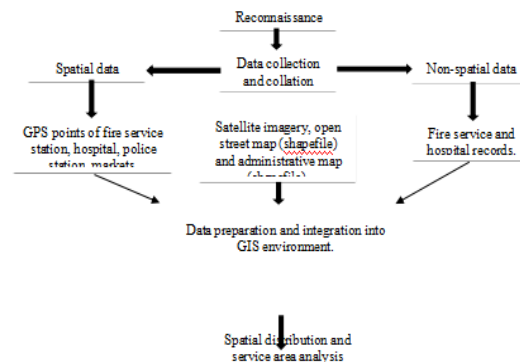The procedural steps used in the analysis of the datasets in this study are summarized in figure 2.

Fig.2. A flow diagram of the steps used in carrying out the research.

3. Reconnaissance
A general inspection was carried out on the study area by the observation of the satellite imagery in order to ascertain the scale of spatial data to be acquired. This also helps to know the extent of the study area.
Data collection and collation
Coordinate was collected for all the fire stations; such data was collected through physical survey of the area using Garmin hand-held GPS equipment.

4. Data preparation and integration
This involved summarizing the data into excel sheets which can easily be imported into ArcGIS. All datasets were converted to projected UTM WGS 84 zone 32N coordinate system and this was maintained all through. Each spatial data was typed into rows and columns and saved in .xlsx Microsoft Excel format. In a similar manner, all GPS data were also saved in tabular form for easy access and for further use in this study, satellite imagery was clipped to the exact study.

5. Network analysis:
Service area of fire stations : From network analyst toolbar, the network dataset created in ArcCatalog was added, the facility that will be the center for the service area was added too. New service area was then clicked from the network analyst window. Facilities in network analyst window was clicked, load facilities is now chosen. The service area parameters are set, solve button was then clicked on the network analyst toolbar. The result is then displayed.

IV. RESULTS AND DISCUSSION

1. Distribution of Facilites
There are 9 fire service stations. Out of 9 fire service stations, only one operates as state owned fire service within the metropolis, and that is Kaduna state fire service located in Kaduna south LGA. Others are owned by various institutions and do not render fire service outside their jurisdictions. They lie within Kaduna North and South LGAs. These are shown in figure 3.

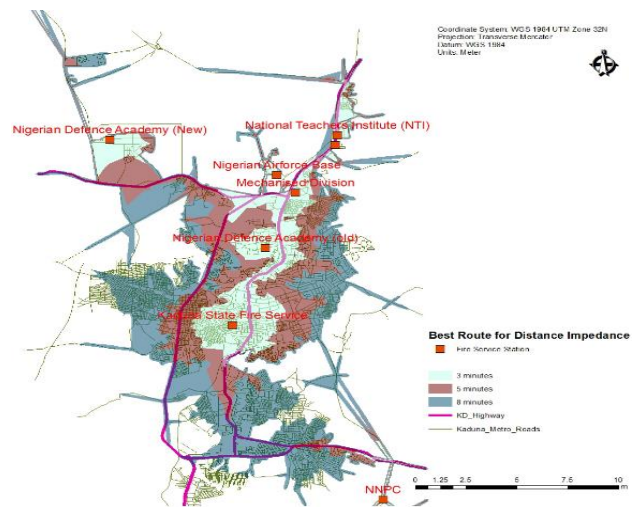Fig.3.The distributions of Fire Service Stations within Kaduna metropolis. Source. (Author's analysis).

Table -I: The description of number of fire fighters and vehicles of the fire stations.

S/N	NAME	NO. OF FIRE FIGHTERS	NO. OF FIRE FIGHTING VEHICLES
1	Kaduna State Fire Service	63	7
2	Kaduna Airport	5	1
3	Nigerian Defence Academy (old)	3	1
4	Nigerian Defence Academy (New)	5	2
5	Nigerian Airforce Base	7	2
6	National Open University of Nigeria	3	1
7	National Teachers Institute	3	1
8	Mechanised Division	3	1
9	NNPC	65	6

2. Source. (Kaduna State Fire Service).
In table 1, it can be seen that Kaduna state fire service has the highest number of vehicles (7) and 63 fire fighters. This is followed by the NNPC fire service with 65 fire fighters and 6 vehicles. This is as a result of their large scale service. Others have rear personnel and vehicles.

3. Service Area
The analysis of service area was carried out for fire Service Stations within the study area. This described the roads surrounding the fire stations can be at 3, 5 and 8 minutes. The result of the analysis is shown in figure 4.

Fig.4. A service area coverage for Kaduna state fire service at 3, 5 and 10 minutes breaks. Source: (Author's analysis).

It can be seen from figure 6 that at 3 minutes is shown in light blue color polygon, at 5 minutes break the coverage areas are shown in brown color, and the coverage area at 8 minutes are shown in dark blue colors. The areas that appears in green without roads are areas that cannot be accessed by any of the existing fire stations.

V. CONCLUSION

Geographical Information Sciences (GIS) has been applied in the spatial distribution of fire service stations within Kaduna metropolis. Therefore, findings were observed from the distribution of facilities, and service area analysis.
The findings shows the spatial distribution of 9 fire service stations within the the study area , it shows that there are areas in the metropolis that additional fire service stations need to be provided. One of the avenues of helping to achieve the objective is to design service areas for emergency services. The service areas were created based on response time. Identifying the service areas for each emergency service provides greater clarity the distance to different parts of the study area. In reality, the service areas provide an estimate concerning time to travel to different areas.

VI. RECOMMENDATION

1. It is recommended that the State Government should provide additional fire service stations within Kaduna metropolis.
2. There should be efficient access roads provided in markets, so that fire fighting vehicles can reach fire incidents locations in markets effectively on time.
3. Geographical Information System and mapping strategies should be employed by the Kaduna State Fire Service in order to reach fire incident locations on time and for efficient tackling of fire incidents.

REFERENCES

[1]. Auran,(2006). Summary report on the African Urban Risk Analysis Network. International workshop held on 7–9 March 2006 in Cape Town, South Africa.

[2]. Challands N (2010) The Relationships Between Fire Service Response Time and Fire Outcomes. Fire Technol 46:665–676.

[3]. Edupta, B.M (2011).Fire Prevention as an aspect of environmental Management in Nigeria. Tropical Built Environment Journal, V 1(2):141-148

[4]. ESRI (2006). GIS Technology and Applications for the Fire Service. Environmental System Research Institute. An ESRI White Paper.

[5]. Nisanci, R. (2010). GIS based fire analysis and production of fire-risk maps: The Trabzon experience. Academic Journals. V.5(9)