IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 23, Issue 7, Ver. II (July. 2018) PP 42-55
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

The Location of Fire Hydrants and Implications to Fire Disaster Management in Caliber, Cross River State, Nigeria.

[1]InahE. Okon*, &[2]Chukwudi G. Njoku
[1]Department of Geography and Environmental Science, University of Calabar, Calabar
[1]Department of Architecture, Cross River State University of Technology, Calabar
Corresponding Author:InahE. Okon

Abstract: experiences in Calabar with regards to knowledge, availability and effective use of fire hydrants isinconsistent with global best practice, hence the needfor this research. Data on the locations of existing fire stations,hydrants and the road network of the city were acquired. Additionally, 620 questionnaires with a success rate of 90.3 percent were acquiredfrom residents. About 385 respondents were sampled within a diameter of 150m of the hydrants and 235 without. Different scenarios of location and access to service were analyzed using descriptive and spatial statistical techniques in a Geographic Information System (GIS). Results revealed that 75 percent of respondents perceive the Fire Department as incapable of effective fire disaster management (FDM). Furthermore, about 83.5 percent of the respondents lack knowledge of the existence of fire hydrants in their vicinity. Spatial analyses in relation to service area showed that the availability and location of fire hydrants in the area violates all known international standards. Also, the spatial cluster analysis depicted statistical significance in spatial dispersion of the existing hydrants. The study revealed gross inadequacies in the location of fire hydrants, its effective use for FDM and recommended locations for future planning of fire hydrants and the best routes from fire stations to hydrant locations. It further recommends public enlightenment for FDM to reduce the damages accrued from fire outbreaks in Calabar.

Keywords: Fire hydrants; fire disaster management; service area; best route; spatial dispersion.

Date of Submission: 22-06-2018 Date of acceptance: 09-07-2018

I. BACKGROUND TO THE STUDY

The world has witnessed an alarming increase in the frequency and severity of disasters.A global overview by Swiss Re (2016) stated that there were a total of 353 catastrophe events in the world in 2015 out of which 198 were natural disasters and 155 man-made. Evidences show that most cases of disasters are fire incidences which occur due to anthropogenic factors, coupled with a near absence of efficient disaster mitigating approaches like the use of fire hydrants in our cities. Disasters have catastrophic effects upon the community and community life in the countries exposed to disaster. Considering especially the last ten years, damage caused by disasters decreasedin developed countries with the help of the precautions taken, in contrast to developing countries such as Nigeria where the reverse remains the case due to lack of or inadequate sectorial integration with the relevant disaster risk management agencies before, during and after disaster (UN, 2009; EM-DAT, 2010). Most cities in Nigeria cannot cope with the continuous geometric increase in rural-urban migration; this has resulted into un-regulated and haphazard development of suburban and peri-urban areas. In the event of fire incidences, access to these un-planned areas remain a mirage as the populace is left hapless.Factors which continue to exacerbate disasters can be reduced or mitigated with an effective disaster and emergency management (DEM) approach, which should be considered as an integrated system before, during and after disaster occurs. Integrated DEM includes all valuable resources of all disaster types and emergencies related to the phases of DEM. Integrated definition of DEM means all social, economic, political and cultural factors are taken into account. All organizational and communication methods for implementation of integrated model are determined according to policies of each country and disaster zones (Bhugra, 2005; GRSP, 2007; Vakis, 2006).

Fire has been said to be a very good servant, but a very bad master. This is because, as long as fire is under our control, it serves a lot of useful purposes, but once it goes out of man's control, it creates a lot of destruction. However, despite the presence of fire safety measures, the occurrence of fire accidents is oftentimes inevitable. Fire disaster occurs in every part of the world where humans dwell. Cross River State and Calabar Metropolis is no exception. There have been countless incidences of fire outbreaks in Calabar in the past years, most of which caused significant damage before being effectively controlled.

Fire hydrants are important municipal installations, placed at strategic positions to assist in putting out fires during an outbreak. There are above-ground connections that provide access to water supply primarily for the purpose of fighting fire and alternatively for some other municipal activities such as construction works and other outdoor water needs. Every hydrant has one or more outlets to which a fire hose may be connected. To provide sufficient water for fire-fighting, hydrants are sized to provide a minimum flow-rate of about 945 liters per minute. The need for fire hydrants developed with the advent of underground water systems in the 1600's after installation of hollowed-out log pipes in England. As cities grew, so did their water systems and also the need for a more effective fire management system.Water is the most cost-effective fire suppressant and the fire hydrants gained more importance as fire departments and tax payers alike realized that strategically placed, high-capacity hydrants can significantly reduce the impacts of fire hazards (Madehow, 2016). In Calabar however, the data provided by the Cross River Water Board Limited (CRSWBL) showed that there were only 11 hydrants serviced by the Board in the Metropolis. While it is the responsibility of CRSWBL to provide water for the hydrants, it is the duty of the Fire Departments (the Federal Fire Servicestationed at Margret Ekpo International Airport and the Cross River State Fire Service stationed at Mary SlessorAvenue) to manage and utilize the fire hydrants.

Today, it is not just enough to have functional fire installations such as the fire hydrants. The major bane for achieving an effective Fire Disaster Management (FDM) in Calabar is accurate geo-data (Samadi, et al, 2009; Ware, 2003). Since GIS can analyze intensive data volumes and is highly effective in responding to spatial queries, it can be used in the analysis of data concerning urban fires. When the cost-benefit results of GIS are compared with economic losses that occur as a result of fire, it can be argued that GIS provides a relative economic solution. In practice, the formation of fire analysis for urban areas is not common. Similarly, studies based on GIS supported fire analysis are very limited. The non-existence of spatial geo-data, maps and a holistic spatial assessment of FDM by the relevant fire service agencies in Calabar hasled to complexity in response phase and hampers coordination between actors involved in FDMin the Metropolis.

Calabar Metropolis is the capital city of Cross River State in the South-South region of Nigeria. It comprises of Calabar Municipality and Calabar South Local Government Areas. There are 22 Wards in both LGAs, 10 in the latter and 12 in the former. It was the capital of the Southern Protectorate of Nigeria until 1904 and one of the earliest seats of Local Government Administration in the then Eastern Region up to 1952 (Wikipedia, 2016). It lies between longitudes $8^0 18^1 00^{11}$E to $8^0 24^1 00^{11}$E and latitudes $4^0 54^1 00^{11}$N to $5^0 04^1 00^{11}$N (figure 1). It is bounded by the Calabar River to the west, Great Kwa River to the east, Odukpani LGA to the north and the creeks of the Cross River as it empties into the Atlantic Ocean in the South. Calabar Metropolis had a population of 328,878 in 1991 according to the National Population Commission (NPC, 1996). In 2006, the population of the area amounted to a total of 375,196. With continued development of the City, the projected population for 2016 was given as 450,000 approx. Under the Koppen-Geiger climate classification, the metropolis' climate is classified as tropical. Like other tropical areas, rainfall is significant in most months of the year and the short dry season has little effect. The average annual temperature is 26.1^0C and the average annual rainfall 2750mm (climate-data.org, 2016). The wet season lasts between April and October while the dry season spans from November to March of the following year.This has implication to emergency fire outbreaks and subsequent mitigation and management which this study seeks to investigate.Human and economic losses from disasters remain a menace to the national economic life. The damage caused by disaster is unquantifiable; and varies with the geographical location, climate and the type of earth surface or degrees of vulnerability. These influence the mental, socio-economic, political and cultural state of people in the affected area, thus leading to economic imbalance and instability to the country at large. Yet, government only plans when there is disaster, refuting preparedness and preventive mechanisms. This paper advocates that emergency management at local level will facilitate safety and protection of lives and property which is a fundamental function

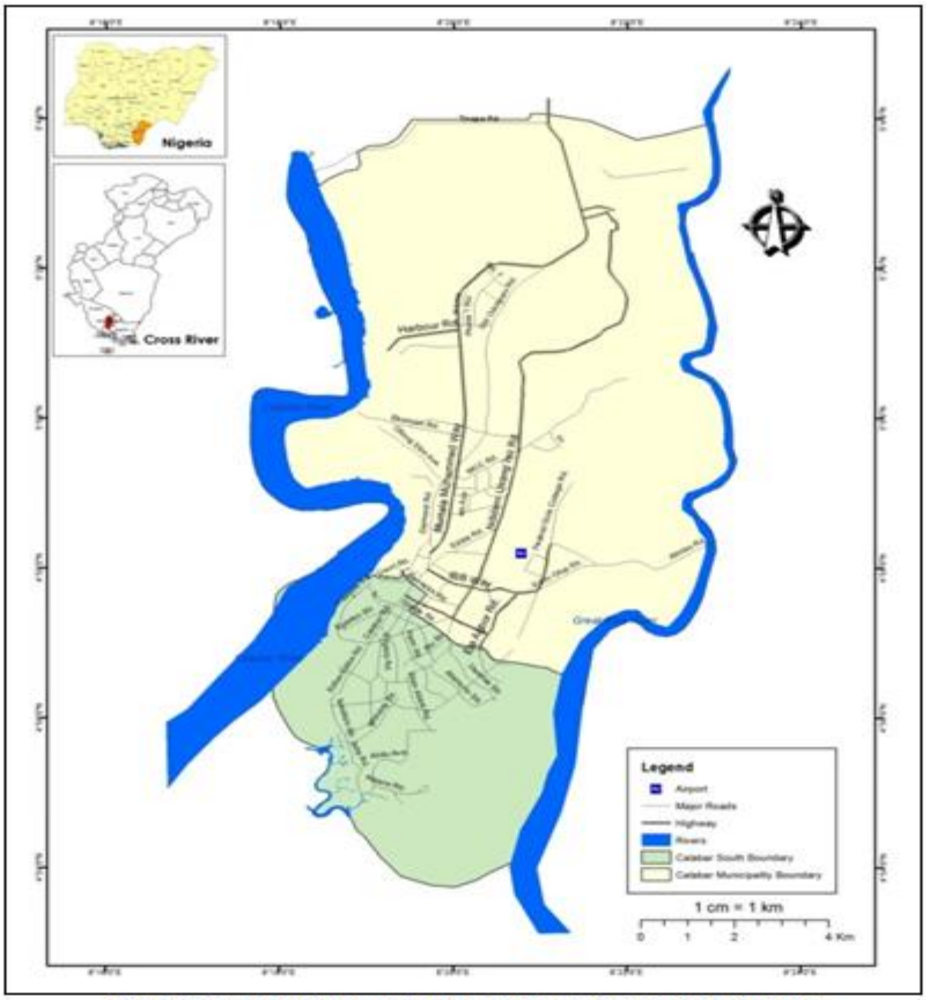


Fig 1: Calibre metropolis, insert: Cross River and Nigeria.

of government at any level; and of course, the above statement justifies the rationale and philosophy behind its need and importance at local level. It further highlights the lapses in the preparedness of the emergency management agency in the study area in lieu of the provision of fire hydrants which are proven installations for effective FDM in cities today.

II. PROBLEM IDENTIFICATION

The State Emergency Management Agency (SEMA) of Cross River in January 2016 reported that no fewer than 61 people were displaced and 98 Million Naira worth of property damaged by fire outbreaks within 6 months in Cross River communities (Africa News Circle, 2016). There have been series of fire incidences recorded in Calabar Metropolis such as: the Watt Market Fire, BedwellRoad axis in April 2014 (The Nation, 2014); the Appeal Court fire in 2011 which destroyed unquantifiable historical documents (Vanguard, 2011); the Central Bank of Nigeria fire incidence in March, 2016, which destroyed property and claimed some lives (Punch, 2016); and a host of other fire disasters in the area. It is worthy to note that in all these fire incidences, fire hydrants in all its effectiveness for fire disaster management were not put to use because of its unavailability or non-functionality for areas where they were present.

The fact that fire disaster is a pronounced problem in Calabarcannot be over-emphasized. The clustering of buildings in some residential areas makes it a cry for one, a cry for all whenever there is fire outbreak. The cry is inevitable because fire disaster does not only destroy the originating building, but it most times engulfs several others. Typical of this scenario was the outbreak of fire at Number 1 Atekong Street off Big Qua Town Hall, Calabar (figure 2a) which occurred in November, 2015. The fire originated in a single room apartment and spread to the entire compound and every household was raised by fire. The residents wept sore and it was pathetic that the fire could not be managed and thus a resultant loss of their propertyand valuables. Incidences like this put a question on the effectiveness of the fire departments in the city and emphasize the need for fire hydrants in every community.

There are 2notable fire stations and only 11 fire hydrants in the city, all of which are said to be functional. Figure 2b shows the fire hydrant at Margaret Ekpo International Airport. However, for a city as the size ofCalabar, 11 hydrants is incredibly too small to cater for fire emergency situations. It is not just enough to have fire hydrants. Their locations are also of paramount importance. A distance of 150m has been stipulated by different individuals and organizationsas the average distance that must be allowed between two hydrants (State of Oregon fire code, 2007; Aydinoglu, Demir and Yomralioglu, 2011). The existing hydrants in the city evidently can only cater for a very small fraction of the population. For example, based on projections, Calabar with a population of 529,362 in2015 covers a land area of 137.039km^2 and has 11 fire hydrants., This is in comparison with the city of Portland in Oregon, USA with a population of 632309 in 2015 and a land area of 376km^{2}having a total of 16,000 fire hydrant installations (The City of Portland, Oregon, 2016). What is obtainable in the city of Portland is no different from the situation in most other developed climes. This comparison discloses the worrisome deficit of fire hydrants in Calabar and its counterparts in this part of the world.

With these developments therefore, it is pertinent to point out that incidents of fire disaster management in the Metropolis calls for urgent attention by the appropriate authorities to curtail the occurrence and damages accrued from fire outbreaks in the area. There are questions bothering around this research including the need to know the locations and distribution of fire hydrants in the area; the coverage area within the metropolis serviced by fire hydrants; the perception of residents toward FDM and fire hydrant within the study area; the best routes from fire stations to fire hydrants for optimal FDM; and where hydrants can be located to effectively cater for fire emergencies. Also, in Calabar, little or nothing has been empirically studied on FDM in the past years. Particularly, there is no known study that assessed the presence, location and distribution of fire hydrants and its implication for FDM. The use of GIS techniques which were adopted in this study for spatial decision making with regard to hydrants and FDM in the area has also not been adopted by researchers in the past. It is against this background that this paper is to evaluate the location of fire hydrants and its implication to fire disaster management in Calabar. specific objectives include to: assess the location and distribution of fire hydrants in the Metropolis; evaluate the perception of residents to fire disaster management and fire hydrants awareness in the area; examine the service coverage of fire hydrants in the Metropolis considering stipulated standards; determine the best routes from fire stations to hydrants in the area for optimal emergency management in the area among others.

Fig 2a: Fire-ravaged building at number 1, Atekong Street off Big Qua Town hall.
Fig2b: Fire hydrant at Margaret Ekpo International Airport, Calabar.

III. LITERATURE REVIEW

Although there has been a global awakening on fire disaster management, empirical literatures with recent issues, especially as regards to the use of fire hydrants for FDM were lacking within the scope of this study. Pasha (2006) studied ‘challenges faced by emergency service providers on road network in Hyderabad city. An integrated GIS based prototype system to design routes of ambulance on road network, such as it finds proximity to accident location on the road network and locates the nearest ambulance to accident site using the real-time technologies. This system showed the fastest route from the nearest ambulance to accident point and finally to the nearest hospital. In a similar research, Chevalier et al (2012) attempted an integrated GIS approach to locate fire stations in Belgium. A multi-scale GIS analysis which included risk modeling approach was used to determine the optimal location and allocation model giving consideration to victim queuing and staffing problems. The system was holistically designed to enhance effective and efficient management of fire-station locations and allocations. Further, Nisanci (2010) adopted GIS through effective spatial data storage and query to produce dynamic fire maps. Fire data base was formed using GIS and carried out an analysis of fire hydrant location. The system was used to determine the optimum distribution of hydrant, location of fire stations, classification of fire regions according to fire type and the establishment of region specific early intervention plans. Additionally, spatial queries were performed and pixel-based risk maps were produced. Eric, Forkno and Jonathan (2013) in their study used a GIS based fire emergency responds system in Ghana, so that Ghana National Service can identify the optimal route from its location to any fire incident. They estimated a model on optional route taking into cognizance; distance, time, road network intervening opportunities. The result of their study reveals that there were insufficient numbers of fire hydrants in the areas where fire is always intensive and the distribution of these hydrants was not compatible with regulation.

In Nigeria, Oladokun and Emmanuel (2014) worked on urban market fire disasters in Ibadan, Nigeria, assessing how damage can be minimized based on a Fuzzy Logic Model Approach. They acknowledged that frequent fire disasters in crowded urban business and market structures have become a major concern to Nigerian urban planners. Analysesof their results showed that the fuzzy logic safety model provides a good planning and management tool for urban renewal schemes aimed at reducing fire related disasters in Nigerian cities.Ogundele, Arohunsoro, Jegede and Oni (2013) also evaluated the operations of emergencies and disaster management agencies in Ekiti State, Nigeria. They collected data using questionnaire, personal observation and oral interview from a total sampling of 1,600 respondents. Results from their study showed amongst others that theEkiti State Emergency Management Agency (ESEMA) does not have enough capacity to meet the level of performance responsibility which could support effective disaster management and suggested creation of urban search and rescue through space applications and information technology.In view of the reviewed literature, it becomes obvious that GIS is an indispensable tool in FDM and must be adopted in Calabar for research and policy making as has been adopted in other places. The problem of ill-capacity for the government in Nigeria to manage fire effectively has been buttressed.

IV. METHODOLOGY

This research adopted the mixed method of research which comprises both qualitative and quantitative approaches (Creswell, 2003). Data acquired for the study includes objects such as the location of fire stations and fire hydrants as well as fields which comprises of the 2016 population of Calabar Metropolis, road network data of the city and a 2015 Landsat Satellite imagery covering the Metropolis.These data were acquired from both primary and secondary sources. The questionnaires administered and the coordinates of fire stations made up the primary sources while the secondary means encompassed existing official and unofficial statistics from publications including journals, articles, thesis, books, conference papers, etc. the 1991 and 2006 census data from the NPC and road network data obtained from the Office of the Surveyor General of Cross River State was used., The coordinates of fire hydrant locations from CRSWBL, ground-troothed with a handheld Global Positioning System (GPS) and satellite imageries acquired from Google Earth Professional software were also used in this study.

A total of 620 respondents were sampled within the metropolis. To determine the sample size, the population of the metropolis in 1991(328,878) (NPC, 1991) was projected to 2015 (529,362) using the World Bank (2015) population annual growth rate of 2.54 percent for Nigeria. Further, using Smith (2000) sample size methodology, a least sample size of 384 was derived. However to make the sample size adequate for the sample population, more than one sample was taken from each sample location, as such, an additional 236 respondents were sampled giving a total of 620. Furthermore, to derive results that represent the existing situation in the area, 35respondents were purposively sampled randomly within a 150m diameter of each of the 8 fire hydrants in the Municipality and 35 for each of the 3 hydrants in Calabar South, thus a total of 385 samples within a 150m diameter of all the 11 fire hydrants. Additional, 185 respondents were selected randomly outside the 150m coverage in the Municipality while 50 respondents were sampled outside same coverage in Calabar South. The 150m diameter was adopted sinceit is the least area-coverage a fire hydrant must service as given by stipulated set standard (references).

Data analyses for this research integrated descriptive and spatial techniques. Tables, charts and maps were used to visualize the results obtained.Specifically, the nearest neighbour multi-distance spatial cluster analysis (Ripley's K-Function) spatial statistics tool was adopted. This spatial statistical technique is a step towards making inferences from the stated hypothesis.The K-function determines whether features or the values associated with features, exhibit statistically significant clustering or dispersion over a range of distances (ESRI, 2013). Also, the mean center and standard distance were used to measure the spatial distribution of fire hydrants within the city. The later identifies the geographic center (or the center of concentration) for a set of features while the former measures the compactness of a distribution, providing a single value representing the dispersion of features around the center (ESRI, 2013).

Further, the ArcGIS network analyst tool was introduced. This tool allows for solving common network problems, such as finding the best route across a city and identifying a service area around a location.

The network analyst toolwas used to determine the areas within the metropolis that are served and not-served based on the State of Oregon, United States of America (USA), fire code (2007) standard. This stipulates that the average acceptable standard between 2 fire hydrants should be 152m. This also conforms to the distance of 150m quoted by Aydinoglu, Demir and Yomralioglu (2011)for the least level risk zones such as residential and commercial areas which are mosttypical landuses in Calabar.Same 150m was also specified for residential areas in urban and rural developed neighborhoods by the Carpinteria-Summerland Fire Protection District Prevention Bureau, California, USA (2007).Concentric service areas depicted with Euclidean polygons were created to show how accessibility varies from the fire hydrants with impedance (stipulated 150m standard for each hydrant coverage area). Also, the best route analyses showed the routes most suitable for the fire trucks to arrive at the hydrants considering mileage from the fire station to the hydrant point closest to the fire during an emergency. The location of the fire stations, hydrants and road network dataset were used for this scenario.

Finally, as a recommendation, locations were proposed for proper siting of fire hydrants in lieu of a more effective emergency fire disaster management in the metropolis. This was achieved by creating 150m grids, covering the study area and overlaying it on the acquired satellite imagery. Afterwards, at least one hydrant point was carefully placed strategically within the grid guided further by the Carpinteria-Summerland Fire Protection District Prevention Bureau, California, USA (2007) recommendations thus:

i. Irrespective of 150m distance stipulated, additional hydrants may be required at intersections and near driveways serving buildings at risk such as petrol and gas stations and industries.
ii. Regardless of the 150m hydrant spacing, fire hydrants shall be located such that all points on streets and access roads adjacent to a structure are within the distances.
iii. Fire hydrants shall be required on both sides of the roadway whenever a roadway is a major highway or thoroughfare and where a center median strip exists such as MurtalaMuhammed Highway and NdidemUsang Road.

Likewise, the Good Engineering Practice (2004) fire protection document specified that fire hydrants be situated so that they are readily accessible and provide the coverage required for the fire flows anticipated, recommending that fire hydrants should not be installed in lanes that are difficult to access such as unpaved surfaces and minor roads and most importantly, before siting of fire hydrants, consultation with the community is mandatory as individual communities may have more stringent requirements.

V. DATA ANALYSES, RESULTS AND DISCUSSIONS

Geographic distribution of existing fire hydrants in Calabar metropolis

Data acquired from CRSWBL and subsequent ground troothing showed the spatial distribution of the functional fire hydrants in Calabar (Table 1). Furthermore, figure 3a showed that there are 2 fire stations in the city: the FFS station at the Margret Ekpo International Airport; and the CRSFS station at Mary Slessor Avenue.The mean center and standard distance which are measures of geographic distribution which identified the centre of concentration of fire hydrants in Calabar, the later measured the degree to which the hydrants are concentrated or dispersed around the geometric mean center. The few hydrants in the city were assessed and the result as displayed on figure 3b depicted that the hydrants concentrated and centered within the Municipality with a mean centre location of 426401.72E, 549966.67N. The values derived from the statistics also indicated a standard distance of 1948.01m. Therefore, if the government considers siting another fire station, this location would be most suitable with regards to the proximity to fire hydrant installation.

Test of Hypothesis

The nearest neighbour multi-distance spatial cluster analysis (Ripley's K-function) spatial statistics tool was adopted for this analysis. The K-function determines whether features or the values associated with features, exhibit statistically significant clustering or dispersion. The output in Table 4 shows the result of the analysis. However, 8 of the 10 number of distance bands adopted (the number of times to increase the neighbourhood size and analyze the dataset for clustering) depicted higher values for the expected K than the observed K. In this scenario, the situation is said to depict a dispersed distribution. Otherwise would have been the case if the observed K values were larger than the expected K values for a particular distance, at which point, the distribution would have been said to be more clustered than a random distribution.

The result is also symbolized with a graph (Figure 4) where the expected result is represented by a blue line while the observed results will be by a red line. Deviation of the observed line above the expected line indicates that the dataset is exhibiting clustering while a deviation of the observed line below the expected line indicates that the dataset is exhibiting dispersion (ESRI, 2013). Decisively, following results returned by the analysis, the null hypothesis is rejected and the alternate accepted that the spatial dispersion of fire hydrants in Calabar metropolis is not statistically significant. This is because the few hydrants located in the city have shown to be significantly spatially dispersed. A much dispersed pattern like this for an area as large as the metropolis means insufficiency in the number of hydrants installed to cater for FDM. A clustered pattern would most likely be suitable for effective DEM in the area since fire hydrants are expected to be installed at near intervals all over the city.

Table 1: Locational attributes of fire hydrants in Calabar

S/N	CRSWBL ID	Eastings	Northings	Location	Status
A	H74	427536.881	551645.578	CRSWBL Complex	Functional
B	HD01	424756.744	547911.220	Calabar Road by Nelson Mandela Street Junction	Functional
C	HD02	424746.881	547943.578	Calabar Road by Clifford Lane Junction	Functional
D	HD03	425877.881	550408.578	Federal Secretariat	Functional
E	HD04	426815.353	549886.007	Opposite Ecobank, Ediba Road (Marian Market)	Functional
F	HD05	424927.192	547390.985	Chamley by King Duke Street Junction	Functional
G	HD06	426142.665	550335.854	Atekong by Kadana Street Junction	Functional
H	HE8	427640.881	551294.578	CRSWBL Complex	Functional
I	HE9	427461.881	551254.578	CRSWBL Complex	Functional
J	HI131	426786.213	552346.927	Old Odukpani by Johnson Ishie Road Junction	Functional
K	HA01	427767.583	549246..919	Margaret Ekpo International Airport	Functional

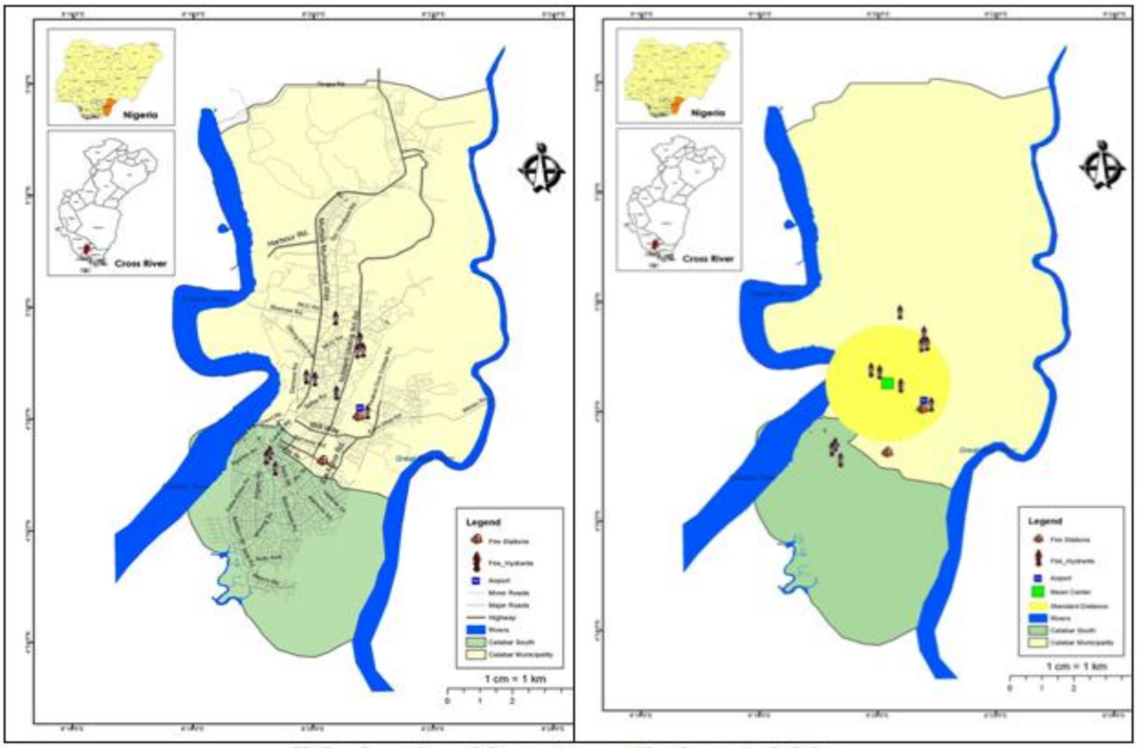
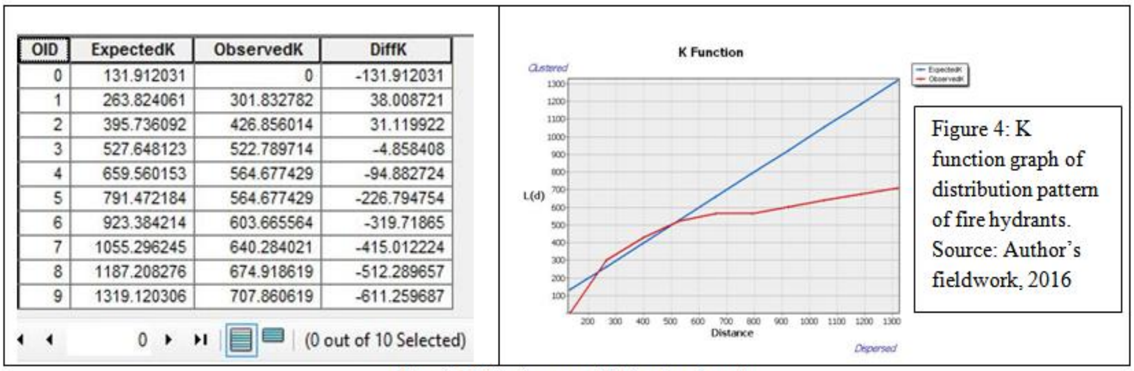


Fig3a: Location of fire stations and hydrants in Calabar
Fig3b: Mean center and standard distance of fire hydrants in Calabar



OID	ExpectedK	ObservedK	DiffK
0	131.912031	0	-131.912031
1	263.824061	301.832782	38.008721
2	395.736092	426.856014	31.119922
3	527.648123	522.789714	-4.858408
4	659.560153	564.677429	-94.882724
5	791.472184	564.677429	-226.794754
6	923.384214	603.665564	-319.71865
7	1055.296245	640.284021	-415.012224
8	1187.208276	674.918619	-512.289657
9	1319.120306	707.860619	-611.259687

Figure 4: K function graph of distribution pattern of fire hydrants. Source: Author's fieldwork, 2016

Fig 4: Multi-distance (K-function) result

Socio-economic characteristics of respondents

Socioeconomic characteristics of residents involved in the study are conceptualized as the social standing or class of an individual or group, often measured as a combination of educational attainment, income and occupation (American Psychological Association, 2016). This constitutes study demographics such as the location, position in the family, household size as well as age and sex differentials of respondents in the metropolis. The data from the field survey indicates that 155 and 465 respondents representing 25 and 75 percent were sampled in Calabar South and the Municipality respectively. The higher sample in the Municipality is informed by the presence of more fire hydrants in the area. About 61 percent of the respondents sampled were husbands (heads of households) while 32 percent were wives. The household size analysis revealed that 62 percent of the households had between 4 to 6 persons, 32 percent had 0 to 3 and only 6 percent had more than 7 persons as size of household. Furthermore, the details of the age distribution of the sample population were also given.A good percentage of persons sampled were adults as only 8 percent were aged between 13 to 19 years of age. A total of 28 percent is 31 to 45 while 24 percent is 46 to 60 years of age. Also, 65 percent of respondents sampled were male while 35 percent were female. The surveyfurther reveals that 40 percent of respondents were into business, 49 percent, public servants, 3 percent, Clerics and 8 percent, dependents. Details on the income of respondents showed a larger population represented by 44 percent who earned 31000-50000 Naira monthly. Literacy level can also be said to be high in the area as only 18 percent had some form of informal education. The other 82 percent had different levels of formal education.

Perception of residents to fire disaster management and fire hydrant awareness

Details of fire disaster and fire hydrant awareness in Calabar are shown in Table 2. It was revealed that 67 percent of respondents affirmed that there had been fire outbreak within their vicinity in the past decade while 33 percent were not aware of any such incident. On the opinion of the respondents about the ability of CRSFS and the FFS to manage fire effectively, 75 percent of respondents did not believe the Fire Departments were up to the task. 19 percent were quite convinced while 6 percent were indifferent about the Fire Departments' capabilities. To further buttress the effectiveness of the Fire Departments, a larger population of 49 percent perceive their capacity to be very poor, another 42 percent think its poor, 8 percent think they are effective and only 1 percent think the CRSFS and FFS are very effective. TheTable further revealed that a huge chunk of respondents represented by 84 percent do not have the emergency contact of the Fire Departments while only 16 percent attested to having the number. Considering the nature of fire hazards, it was expected that people had emergency numbers so that they could call for help when needed. Further, 16.5 percent were knowledgeable of what a fire hydrant is while 83.5 were not. Also, 97 percent were not aware of any hydrant installation in their vicinity, some because they are not knowledgeable of what it was and other because they never sighted it around while only 3 percent were well aware of fire hydrant installations around them. After educating most of the respondents on the importance of fire

Table 2: Fire Disaster Management and Hydrant Awareness in Calabar

S/N	Fire Disaster and Hydrant Awareness	Frequency	Percentage
A	Fire Incident withinVicinity in the Past Decade		
	Yes	416	67
	No	204	33
B	IsCRSFS and FFS Capable to Manage Fire Effectively?		
	Yes	120	19
	No	462	75
	Not sure	38	6

C	Perception of CRSFS and FFS Capacity		
	Very poor	302	49
	Poor	262	42
	Effectively	48	8
	Very effectively	8	1
D	Emergency Contact of CRSFS		
	Yes	102	16
	No	518	84
E	Awareness of Fire Hydrant Installation in the Vicinity		
	Yes	102	16.5
	No	518	83.5
F	Knowledge of What a Fire Hydrant is		
	Yes	18	3
	No	602	97
G	Necessity of Fire Hydrant Installation		
	Yes	486	78
	No	82	14
	Not sure	52	8

Source: Author's fieldwork, 2016

hydrants, 78 percent saw the need for fire hydrants installations, 14 percent still insisted it wasn't necessary while 8 percent were indifferent.

Service coverage of fire hydrants

The service area around each fire hydrant in the metropolis was determined using the ArcGIS Network Analyst extension. A network service area is a region that encompasses all accessible streets and aids to evaluate accessibility. Concentric service areas show how accessibility varies with impedance. This analysis helps to illustrate how much land, how many people, or how much of anything else is within the neighborhoods that are served and otherwise. The impedance specified for the analysis is 150m, which is the stipulated diameter a fire hydrant is supposed to service.Figure 5 shows that there is a huge deficit in the service of fire hydrants in the metropolis. Visibly, only a small fraction of the metropolis is serviceable by the existing hydrants. The 2 hydrants on Calabar road (D and G) and two of the installations in the CRSWBL complex (H and I) satisfied the set standard. The other few hydrants are more than 150m apart. An area calculation of the coverage of the served and un-served areas showed that only 1.1 percent of the Metropolis is serviceable by the existing fire hydrants while 98.9 percent is not within serviceable range. More so, 11 fire hydrants are no doubt incapable of effective fire disaster management in the city.Further analysis attempted to prescribe locations for siting fire hydrants to adequately cater for fire emergency needs of themetropolis.

Best routes for optimal emergency management

Solving a route analysis means finding the quickest, shortest, or even the most scenic route, depending on the impedance you choose to solve for. If the impedance is time, then the best route is the quickest route and if the impedance is distance, then the best route would be the shortest path. In whichever case, the best route is that which has the lowest impedance. For this study, the distance impedance was used to show the best routes from the fire

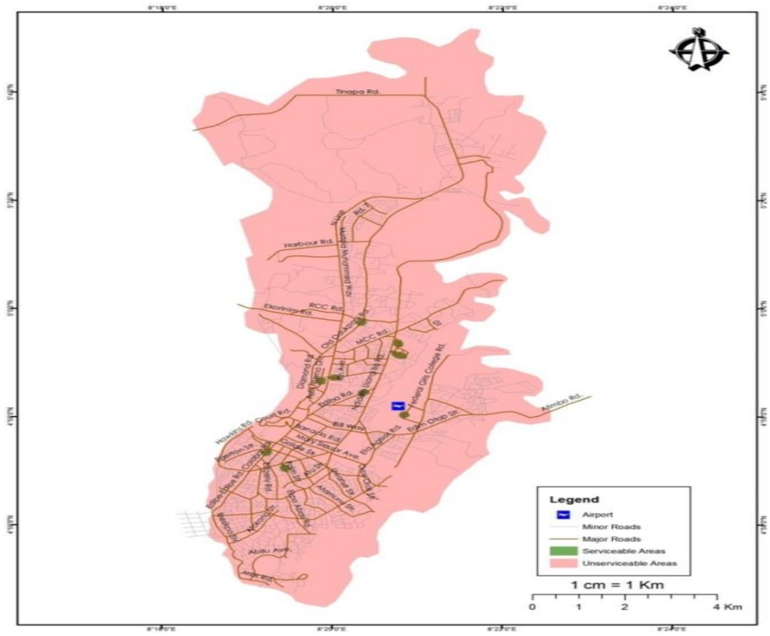


Fig 5: Service coverage of fire hydrants in the metropolis

stations to the fire hydrants during an emergency. The best route query was done from the FFS station in the MargretEkpoInternational Airport to the hydrant points around CalabarRoad, the installations in and around the Federal Secretariat, those in CRSWBL complex and the singular one at Old Odukpaniby Johnson Ishie Road Junction. The query ignored the hydrant point at the airport because of its close proximity to the FFS station. The best route analysis was also executed from the CRSFS station to the afore-mentioned hydrant locations. The total driving distance from the fire stations to the hydrant locations are given. As such, in a case of fire within the vicinity of the hydrants, the installations can be put to good use where the fire trucks can arrive at the scene in time.Effectiveness of the intervention during a fire disaster is directly linked with instant access to the fire, thus the best route analysis.

Best Route from CRSFS Station, Mary Slessor Avenue to Fire HydrantsA to J

The directionsdepicted inFigure 6a describes the best route from the CRSFS station to fire hydrant F located at Chamley by King Duke Street Junction. The total driving distance is 1613.4 m. The best route from the CRSFS station to fire hydrants B and C located at Calabar Road is also shown in Figure 6b. The total driving distance to hydrants B and C is 1901.9 m.

To access the fire hydrants D, G and J in due time in order to manage a fire hazard, the fire truck from the CRSFS station must follow directions depicted on Figure 7a, a total driving distance 6032 m to hydrant J. On this same route, driving distance from CRSFS Station to fire hydrants D and G is 3818m. During a fire emergency around the fire hydrants E, A, I and H, the fire truck from the CRSFS station must follow directions portrayed on Figure 7b**, a** total driving distance of 4757m.

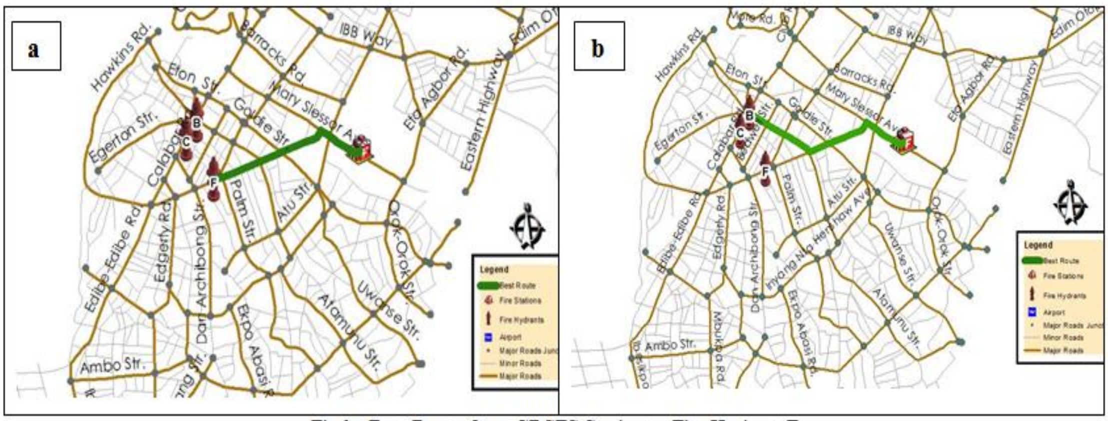


Fig6a: Best Route from CRSFS Station to Fire Hydrant F
Fig6b: Best Route from CRSFS Station to Fire Hydrants B and C

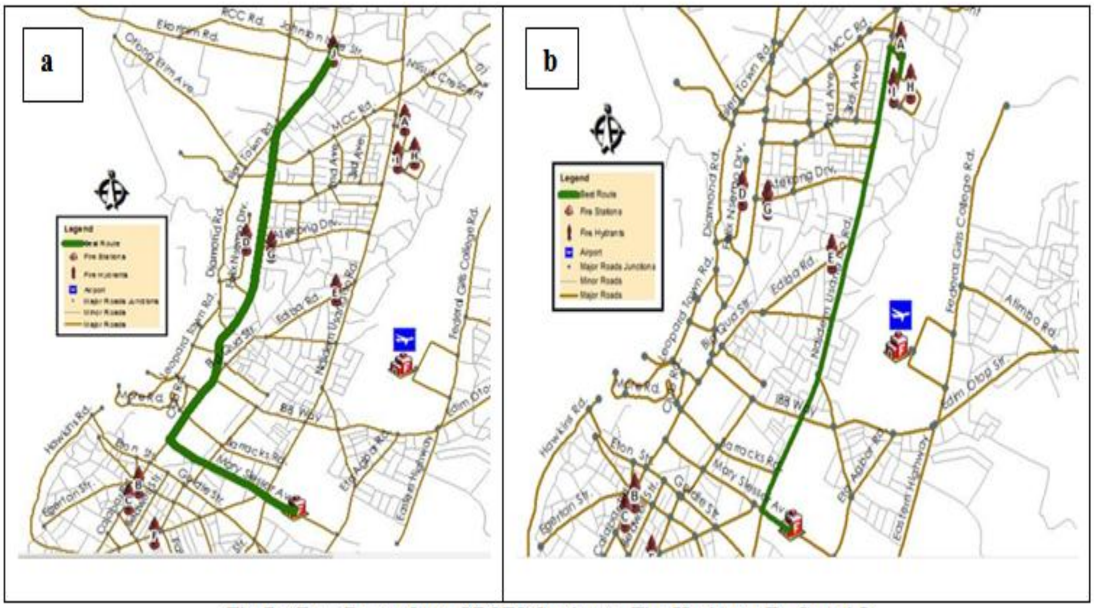


Fig 7a: Best Route from CRSFS Station to Fire Hydrants D, G and J
Fig 7b: Best Route from CRSFS Station to Fire Hydrants E, A, I and H.

Best Route from Margret Ekpo International Airport FFS station to Fire HydrantsA to J.

Figure 8ashows the best route from the FFS station to fire hydrant F located at Chamley by King Duke Street Junction. This route has a total driving distance of 4971.9 m. The best route from the FFS station to fire hydrants B and C located at Calabar Road is also shown in the directions depicted on Figure 8b, a total driving distance of 4683.2 m. To access fire hydrants D, G and J in due time to manage a fire hazard, the fire truck from the FFS station must follow directions represented on Figure 9a**.** The total driving distance to hydrant J is 7110.6 m and 497 m to hydrants D and G on this same route. To access fire hydrants E, A, I and H promptly, the fire truck from the FFS station must follow directions pictured on Figure 9b with a total driving distance of 5588.5 m.

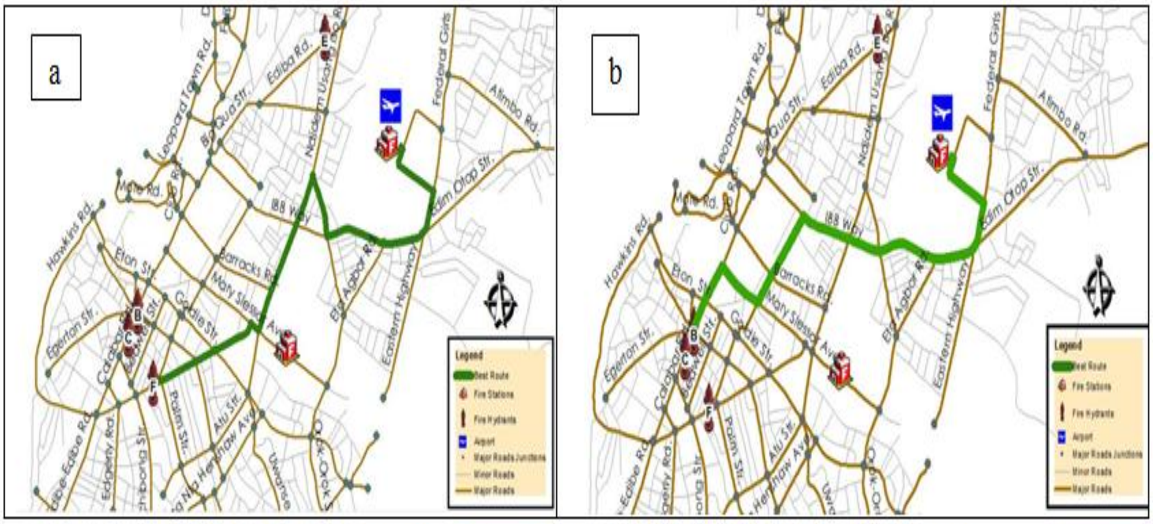


Figure 8a: Best route from Margret Ekpo International Airport FFS station to fire hydrant F.
Figure 8b: Best route from Margret Ekpo International Airport FFS station to fire hydrants B and C.

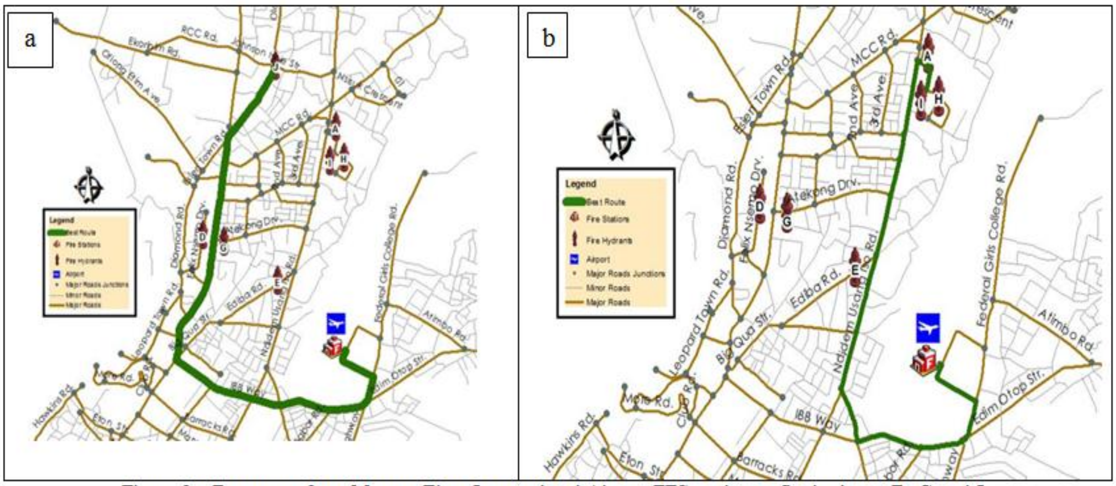


Figure 9a: Best route from Margret Ekpo International Airport FFS station to fire hydrants D, G and J.
Figure 9b: Best route from Margret Ekpo International Airport FFS station to fire hydrants A, I and H.

VI. RECOMMENDED LOCATIONS FOR SITING FIRE HYDRANTS FOR EFFECTIVE FIRE DISASTER MANAGEMENT

After a careful site selection analysis guided by standards stipulated in previous sections, a total of 950 locations where proposed for siting of fire hydrants in the metropolis. This implies that the city has a deficit of 940 hydrants for effective emergency fire disaster management to be achieved. 261 fire hydrants were proposed for Calabar South LGA and 689 for the Municipality. The figure for the former is expectedly larger because of its larger land area and the presence of more road networks, most of which are properly paved. Figure 10 shows the existing and proposed fire hydrant locations. This site selection however only considers areas that are built up and accessible by fire trucks. In event of an expansion and further development of the city, the number of fire hydrants needed would invariably increase to cater for emergency contingencies.

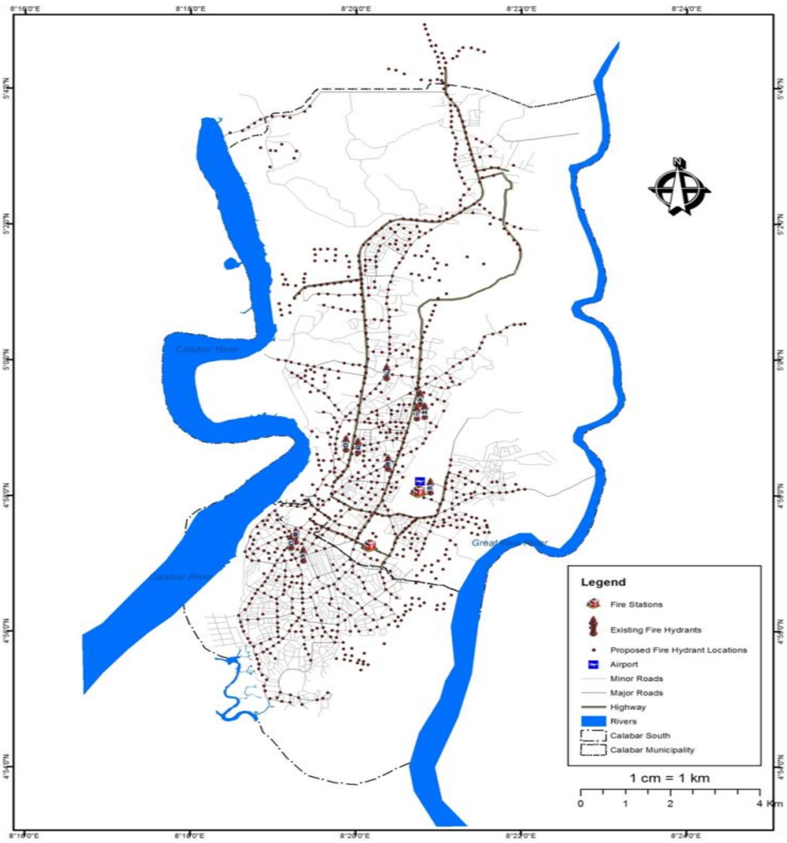


Figure 10: Existing and proposed fire hydrant locations in Calabar metropolis

VII. CONCLUSION AND RECOMMENDATIONS

This research focused on the assessment of the location of fire hydrants in Calabar metropolis and the implications of the installations to FDM in the area. The location of the fire service stations, the perception of residents to fire hydrants and the activities of the Fire Departments were also considered. This was informed by the gruesome effects of fire disasters on residents of the metropolis. Results derived from the study showed that there were 11 fire hydrants in the metropolis, 3 in Calabar South and 8 in the Municipality, all of which were said to be functional. An assessment of the spatial distribution of the hydrants exhibited centrality of the fire hydrants in the municipality and the nearest neighbour multi-distance spatial cluster analysis (Ripley's K-function) spatial statistical analyses aided to deduce that spatial dispersion of fire hydrants in Calabar Metropolis was statistically significant. Fire hydrants in the area are so few and dispersed and thus incapable of catering for disaster needs of the populace. With proper and adequate location of fire hydrants in Calabar, the risk accruable to fire disaster would be reduced and it is only then that the 11th goal of the SDG (making cities inclusive, safe, resilient and sustainable) can be achieved in the metropolis.

Further, it was revealed that fire outbreaks were somewhat frequent in the area as 67 percent affirmed occurrence in their vicinity in the past decade. Residents also showed to have given up on the government as 75 percent did not believe the fire departments were capable of managing a fire incidence in terms of quick response and quenching a fire. Thus 49 percent thought their services were very poor. Surprisingly, 84 percent of respondents did not have the emergency contacts of the fire departments, 83.5 percent were not knowledgeable of what fire hydrant installations were, 97 percent were not aware they had a few hydrants installed around the city, but 78 percent after some education of the need for fire hydrants deemed it a necessity to be installed around. A total of 155 respondents were sampled in Calabar South and 465 in the Municipality and most of the respondents were literate.

The service area analysis exposed a huge shortfall in the coverage of fire hydrants in the areas serviceable by the existing hydrants, since a diameter of 150m was stipulated as the standard coverage a fire hydrant must service. The result showed that 98.9 of the metropolis is not within the service area of the hydrants. To this effect, a site selection analysis was done to prescribe locations for siting fire hydrants, enough to cater for fire hazards in the area, after which 950 points were selected after considering standard criteria. The best routes for quick response of fire trucks from fire stations to existing hydrants for optimal FDM were also analyzed. The identified routes were the shortest paths in terms of distance impedance.

As a follow-up to the findings of this research, the following recommendations are made as a blueprint for improving overall FDM in the metropolis;

i. The Fire Departments must integrate GIS capabilities in planning and implementation stages of FDM. The service area and best route analyses are very vital examples of tools that can be adopted by the Departments.
ii. Sensitization of the public on fire disaster management; methods, applicable apparatus and equipment such as the fire hydrant should be frequently done so that residents can respond properly to fire emergencies before arrival of the Fire Department.
iii. The Fire Departments and other relevant agencies must as a matter of urgency install an addition of 939 fire hydrants in the area to sufficiently cater for fire disasters that might occur.

REFERENCES

[1]. African News Circle (2016). Fire Disaster Displaces 61, Destroys 98 Million Naira Worth of Property in Cross River- SEMA. Retrieved September, 2016 from www.africanewscircle.com/2016/01/24/fire-disaster-displaces-61-destroys-98m-worth-of-property-in-cross-river-/sema/

[2]. American Psychological Association (2016).Socioeconomic Status. Retrieved July, 2016 from www.apa.org/topics/socioeconomic status-status/

[3]. Bhugra, D., 2005. Cultural Factors and Disasters, WHO Conference on the Health Aspects of the Tsunami Disaster, 4- 6 May, Phuket, Thailand.

[4]. Carpinteria-Summerland Fire Protection District Prevention Bureau (2007).Fire Hydrant Spacing and Flow Rates.

[5]. Creswell, J. W. (2003). Research Design; Qualitative, Quantitative and Mixed Methods Approaches, Second Edition. SAGE Publications Inc. London

[6]. EM-DAT, 2010. The International Disaster Database [Data file]. Available from Centre for Research on the Epidemiology of the Disasters Web site, http://www.emdat.be/.Accessed August 13, 2016.

[7]. ESRI (2013).Multi-Distance Spatial Cluster Analysis (Ripley's K Function) (Spatial Statistics), ArcGIS for Desktop Help, 1995-2013.

[8]. ESRI (2013).How Standard Distance WorksArcGIS for Desktop Help, 1995-2013.

[9]. GRSP, 2007.Tools for Mainstreaming Disaster Risk Reduction, Global Road Safety Partnership.

[10]. Madehow (2016).Fire Hydrant.Volume 4.Retrieved September 2016 from www.madehow.com/volume.-4/fire-hydrant.html.
[11]. National Population Commission (2016). Nigeria Over 167 Million Population: Implications and Challenges. Retrieved May 2016 from http://www.population.gov.ng/index.php/84-news/latest/106-nigeria-over-167-million-population-implications-and-challenges
[12]. Ogundele, J.A., Arohunsoro, S.J., Jegede, A.O. & Oni, B.B. (2013).Evaluating the operations of emergencies and disaster management agencies in Ekiti State, Nigeria.Journal of Natural Sciences Research, Volume 3, No.15.
[13]. Oladokun, V. O. & Emmanuel, C. G. (2014) Urban market fire disasters in Nigeria: a damage can be minimized based on a Fuzzy Logic Model Approach. International Journal of Computer Applications. Volume 106, No. 17
[14]. Oregon Fire Code (2007).Fire Hydrants Locations and Distribution (Appendix C).
[15]. Punch (2016). Explosion Rocks CBN office in Calabar. Retrieved September, 2016 from www.punchng.com/explosion-rocks-cbn-office-calabar/
[16]. Smith, S. M. (2000). Determining Sample Size: How to Ensure you get the Correct Sample Size. Retrieved February, 2016 from http://success.qualtrics.com/rs/qualtrics/images/determining-sample-size.pdf
[17]. Swiss Re (2016).Natural Catastrophes and Man-made Disasters in 2015. Asia Suffers Substantial Losses. Sigma, No. 1
[18]. The City of Portland, Oregon (2016).All About Portland's Fire Hydrants. Retrieved September, 2016 from http://www.portlandoregon.gov/fire/article/321828
[19]. The Nation (2014). Fire guts Watt market in Calabar. Retrieved September, 2016 from www.thenationonlineng.net/fire-guts-watt-market -Calabar/
[20]. UN, 2009.Human and Economic Loss Due To Disasters, United Nations.UN/ISDR, 2007. Good Practices and Lessons Learned A Publication of the "Global Network of NGOs" for Disaster Risk Reduction, Building Disaster, International Strategy for Disaster Reduction. Retrieved August 15, 2016.
[21]. Vakis, R., 2006. Complementing Natural Disasters Management: The Role of Social Protection, SP Discussion Paper No 0543, Social Protection. Retrieved August 15, 2016.
[22]. Vanguard (2011). Fire guts Appeal Court, Calabar. Retrieved September, 2016 from www.vanguardngr.com/2011/12/fire-guts-appeal-court-calabar/
[23]. Wikipedia (2016). Portland, Oregon. Retrieved September 2016 from http://en.m.wikipedia.org/portland,_oregon
[24]. World Bank (2015). Population Growth: Annual Percentage. Retrieved July, 2016 from http://www.data.worldbank.org/indicatpr/sp.pop.grow?locations=ng

IOSR Journal of Humanities and Social Science (IOSR-JHSS) is UGC approved Journal with Sl. No. 5070, Journal no. 49323.

InahE. Okon "The Location of Fire Hydrants and Implications to Fire Disaster Management in Calaibaer, Cross River State, Nigeria..." IOSR Journal Of Humanities And Social Science (IOSR-JHSS). vol. 23 no. 07, 2018, pp. 42-55.