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Developing Geospatial Database For Emergency Response; A Case Study of Fire, Health And Security Facilities in Rivers State

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Abstract

Effective and efficient emergency management and response requires having the right information within the shortest possible time frame in order to save lives and property, this also involves the free flow of the right information in the right format, to the right person, in the right time to make the right decision. The aim of this research is to evaluate benefits of the use of Geoinformatics technology in emergency management to assist in planning and acting as a decision support system to Fire, Health and Security emergency managers. In this research, Rivers state fire stations were evaluated as a unit of emergency delivery system, the research examined the role of Geoinformatics in evaluating the performance of emergency fire service delivery based on response time and fire station distribution. Using ArcGIS Network analysis and an annual fire incident record from year 2000-2012, the study revealed that the functional fire stations operating in Rivers state were unable to cover the entire populated regions within 5 minutes response time. In the case of this research the primary question that was addressed was; "Does everyone have access to rescue services within five minutes of travel time?" The research concluded by proposing the location of three fire stations using location allocation tool to help reduce the burden of other fire station and ensured ninety five percent (95%) wider coverage and reduced response time. This research also recommended that more efforts should be channeled towards curbing the practice of illegal and crude ways of refining petroleum products in the state; hence the result of the partial correlation of the variables associated with causes of fire incidents in Rivers State indicates a huge influence of kerosene explosion. The nearest neigbour index **(RN) of 0.59** for Hospital indicates a clustered pattern of distribution of health facilities in Rivers State, hence there should be deliberate policies to ensure regular pattern of distribution which allows spatial equidistance to these facilities Due to the unavailability of current Population data the research was carried out using 2006 population data of the study area which do not extensively cover the remote communities This researcher suggested the following areas for further study; The spatial distribution of fire incident in Rivers state in relation to the underlying social composition of the population using derivative index analysis, the use of web based GIS for effective emergency responds could be a viable area to explore. The spatiotemporal location and relocation of stationary ambulance service in a bid to provide even service delivery within the city.

Key Words: Emergency, Database, GIS, Fire, Health, Security, Response.

1. Introduction

The recent growth of population densities and economic expansion has created greater concentrations of residential and commercial risks within the urban areas which result in frequent emergency and disaster situation that can lead to loss of life and valuable properties. Consequently there is a need for proper emergency planning and responds system. Emergency planning and management is a dynamic process of mitigating, preparing, responding, and recovering from any form of emergency situation. It's a critical segment of the society where governments, stakeholders' planners, managers and even the general public play a vital role in saving lives and property. Mapping makes intricate information instantly understandable in a way not achievable with text or tables by equipping managers with the tools for combining data from different sources and analyzing the likely way an event might affect an area. In emergency situations the place of GIS is priceless in coordinating efforts of involving agencies. The distinction between an emergency situation and a full blown disaster is a matter of scale which is a direct function of time. Whether an emergency manager is identifying the quickest and shortest evacuation routes during a disaster, or a fire, police and paramedic team is been called to a fire, crime and life threaten situation, or a civil engineer is carrying out a rebuilding attempt after a disaster, or an environmental analyst is assessing the likely impact of hazards of oil and gas exploitation such as oil spillages and land degradation as shown in figures 1.1 and 1.2 below, all of these individuals tasks involves spatial component as well as relevant spatial-related data and this data are conventionally handled with the help of Geographical Information Systems (GIS).



Fig 1.1: Imagery showing Location of Oil and Gas Well Heads in Rivers State.



Fig 1.2: Imagery showing Petroleum products spillage site in Rivers State.

This research is aimed at creating a geospatial database infrastructure which demonstrates capacity for effective planning, response and management of fire disaster in Rivers state. To achieve the stated aim, the following objectives were employed; Acquiring geometric and attribute data including aerial photo imagery of the study area, Designing a suitable database for the study area, Analyzing collated geospatial data for patterns, distribution, relationships, vulnerability, trends and spatial component, Identifying service coverage gaps or deficiency within the study area and closing the identified gaps, Determining the desired emergency routes, response time, new service area, closest facilities and new location allocation using arcGIS network analyst, Recommending relevant proactive and mitigation measures to enhance effective management of fire disaster in Rivers State.

Based on these facts above, this research study relied on geospatial data on the frequency of fire incidents in Rivers State and the resultant damages, injuries and deaths as shown in table 1 below.

Table 1: Casualties resulting from fire incidence (2000 to 2012).

Year	Number of fire Incidence	Number of Deaths	Number of Injuries
2000	99	12	22
2001	143	8	7
2002	100	3	7
2003	970	1	4
2004	115	7	13
2005	98	3	5
2006	116	10	7
2007	136	20	14
2008	176	17	27
2009	104	7	15
2010	108	3	7
2011	97	6	13
2012	93	148	80
TOTAL		245	221

Source: (Rivers State Fire service 2012.)

The study area is Rivers state, Niger delta region of Nigeria. It is located between latitude 4, 28,39N and longitude 6, 10,12E. It is bordered in the north by Imo and Delta states, Bayelsa state in the west, Abia state in the east, the gulf of guinea and the Atlantic Ocean in the south as shown in figure 3 below.

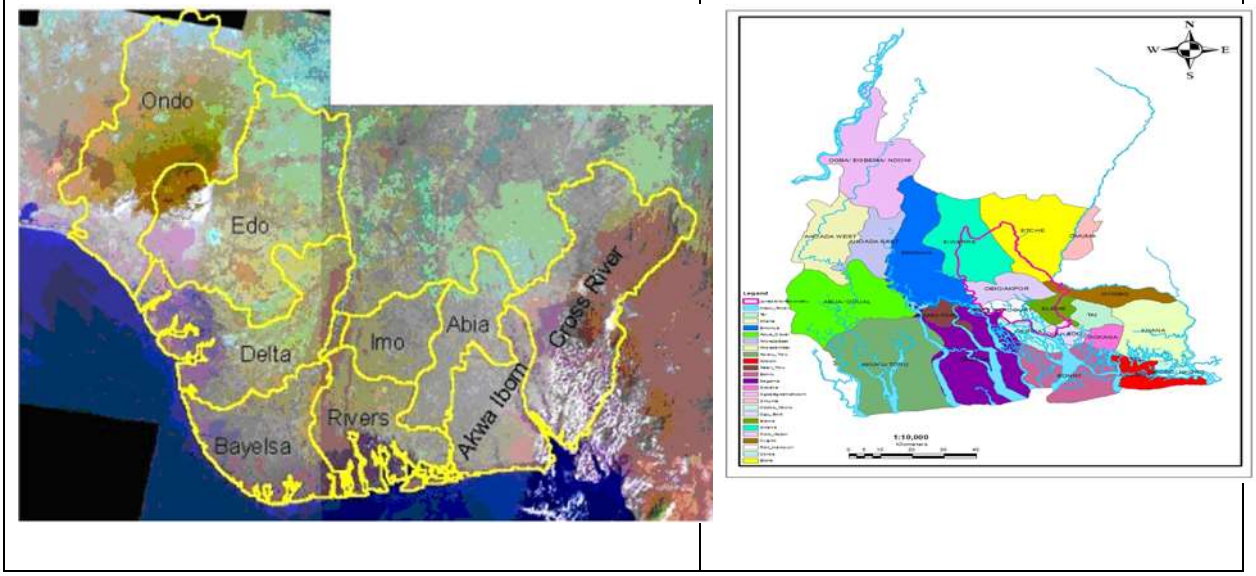


Fig 3. Imagery showing Rivers State and its bordering States and political map of Rivets state

Rivers State covers a landmass of about 1,077km2 with an estimated population of about 5,689,087 people (National Population Commission, 2006) Rivers State lies on the recent coastal plain of the eastern Niger Delta. Its surface geology consists of fluvial sediments which includes the recent sediments transported by Niger River distributaries and other rivers, such as Andoni, Bonny and New Calabar. These materials deposited as regolith overburden of 30m thickness are clays, peat, silts, sands and gravels. The depositional sequence exhibits massive continental sand stones overlying an alternation of sandstones and clays of marginally marine origin, but eventually grading downwards into marine clays. Sands, by far form the largest group of rock types in Rivers State, while mud constitutes all the polluted brackish waters of the riverine areas. However, peat constitutes the various vegetal and animal remains that lie in bogs and shallow pits. The gravel and pebbles form the last unit of the subsurface rock type, and are usually found at the base of the river channels.

2. Research Method

2.1. Softwares used:

ArcGIS is one of ESRI software product developed to provide GIS solution to numerous spatial related problems. The ESRI ArcGIS product comes in various packages such as ArcGIS for Desktop, ArcGIS for Mobile, ArcGIS for Server and ArcGIS Online, this study made use of ArcGIS Desktop. ArcGIS Desktop is a comprehensive, integrated and scalable system designed to perform various GIS analysis ranging from simple to complex analysis such as mapping, data management, geographic data analysis, editing and geoprocessing functions. ArcGIS Desktop software suite is made up of three applications that work together to give ArcGIS Desktop its powerful analytical capability. These three applications are;

ArcMap- use for mapping and data manipulation, ArcCatalog- for data management, Arctoolbox- for data conversion, modelling, and spatial analysis.

Table 2. GIS Desktop Extensions

S/N	ArcGIS Extensions	Uses
1.	ArcGIS 3D Analyst	For powerful and advanced visualization, analysis and surface generation tools that manage and analyze data in 3D realistic perspective
2.	ArcGIS Spatial Analyst.	Used as a spatial modelling and analysis tool that query maps to derive new information, create maps and analyze raster and vector data set.
3.	ArcGIS Network Analyst.	Provides solution to transportation and service location problems.
4.	ArcGIS Schematics.	Help to Visualize and manage linear physical and logical (economic and social) network through an automated schematic representation of geodatabases.
5.	ArcGIS Tracking Analyst.	For space and time based visualization analysis
6.	ArcGIS Geostatistical Analyst	As a tool for statistical modelling, data exploration and probabilistic mapping. Serves as a tool to create a valid statistical prediction of event

2.2. Data acquisition and source

2.2.1: Map of study area:

The map of Rivers state, the study area with its local government Area population was produced Esri shape file from image data of Rivers state surveys department.

2.2.2. Fire incident data:

The study made use of primary fire incidents and the data used was acquired from the Rivers state fire service statistics report for 2000-2012. The primary fire incidents for Port-Harcourt and greater Port-Harcourt region of Rivers state was digitized from the entire Rivers state fire service primary fire incident statistics report, (2000- 2012).

2.3. Database design

This process consists of two phases. These are:-The design phase and the construction or implementation phase

The design phase however consists of the view of reality together with three other steps, namely, Conceptual design, Logical design, Physical design, View of reality.

Reality refers to the phenomena as they actually exist, including all aspects which may and may not be perceived by individuals. The view of reality in this study refers to the Roads, Police stations, the Rapid Response Squads, Hospitals, Federal Road Safety Commission

office and the FRSC operating locations, as well as Rivers State Fire Service station. The design and construction phases of spatial database are illustrated in figure 4 below.

Facilities

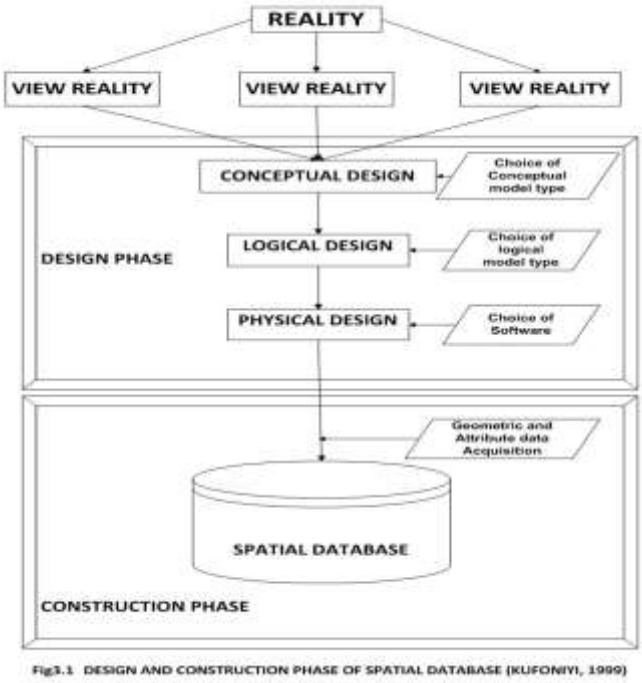


Fig3.1 DESIGN AND CONSTRUCTION PHASE OF SPATIAL DATABASE (KUFONIYI, 1999)

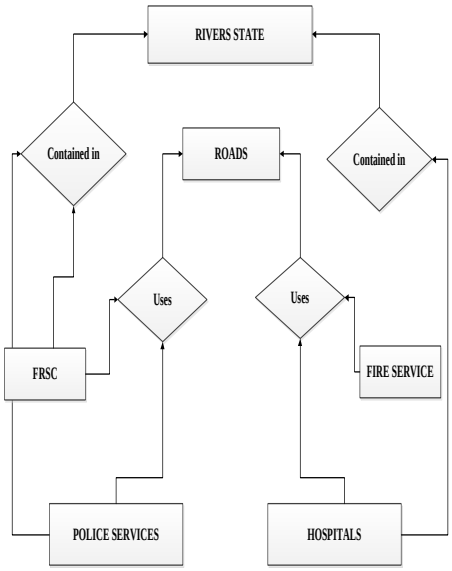


Fig. 4. Entity Relationship diagram for Fire, Health, and Security Facilities

2.3.1: Entity Relationship Model

In this research roads are classified as linear features while the Service Centers – Police stations, Hospitals, FRSC office and their operating locations as well as State Fire Service Station are regarded as point features as shown in figure 5 below.

This phase of abstraction is to form a conceptual model. Here, the basic entities, their spatial relationships, together with the attributes of the entities are identified as shown in figure 5 below.

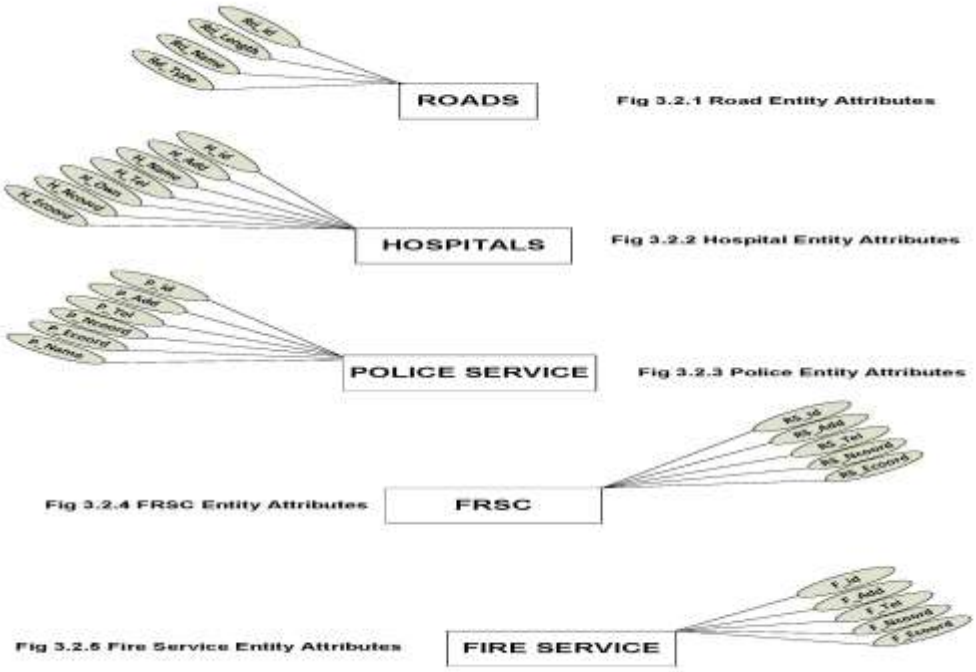


Fig. 5. Entities and Attribute data schema

The data collated for fire incidence in Rivers state was plotted in Microsoft excel to generate a bar graph showing the frequency of occurrence over the years as shown in table 3 and figure 6 below.

Table 3. Rivers state fire service primary fire incidence records (2000-2012)

Year	Number of fire Incidence	Number of Deaths	Number of Injuries
2000	99	12	22
2001	143	8	7

2002	100	3	7
2003	970	1	4
2004	115	7	13
2005	98	3	5
2006	116	10	7
2007	136	20	14
2008	176	17	27
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TOTAL		245	221

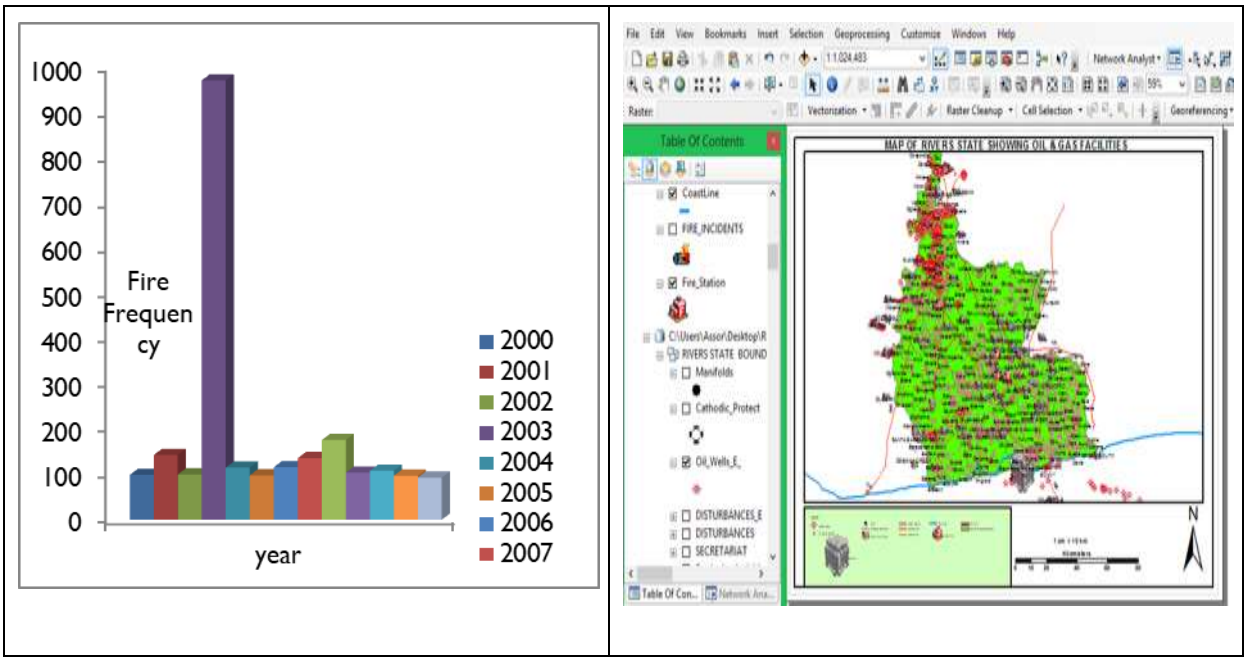


Fig. 6 **Locations of Oil and Gas facilities in Rivers State and** Rivers State fire service Primary Fire incidence graph

Fire Station

2.3.3. Fire stations data:

The fire stations for the entire Rivers State fire service authority was acquired in ESRI shape file format through image digitizing from the Rivers State surveys department. Using the obtained base map, the selected fire stations were digitized to obtain its spatial information

required. These selected fire stations were digitized in ArcGIS 10.1 software. It was created as a separate shapefile and added as a layer within the GIS environment.

1.3.4. Road network data: The study made use of the Integrated Transport Network (ITN)

Layer for Rivers state acquired from digitizing an orthorectified image data of the study area as shown in Fig.7 and 8 below.

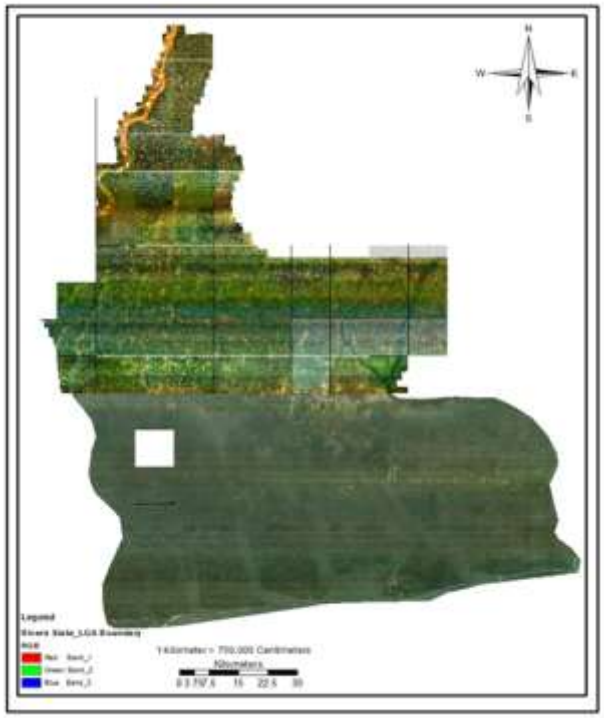


Fig. 7 Ortho-photo map of the study area (Rivers State)

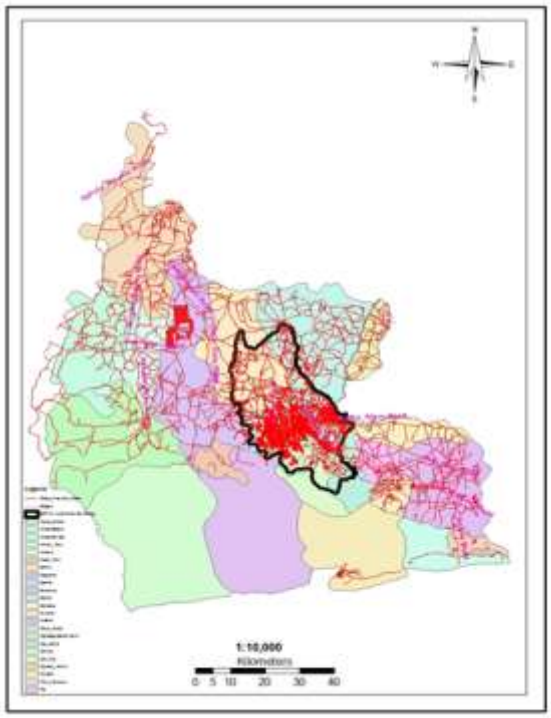


Fig. 8 Rivers State Integrated Transport Network (ITN)

2.4: Geostatical Data Analysis Techniques

2.4.1: Correlation Analysis

Correlation analysis was performed using the data on the major causes of fire incidents in Rivers State include; Deaths and injuries from fire Incidents (X1), Spill from petroleum products (X2), Electrical current sparks (X3) and Domestic Kerosene explosion(X4).

Total number of Deaths and Injuries from fire Incidents (X1) is the independent variable while the data on the major causes of fire incidents; spillage of petroleum products (X2), Electrical current sparks (X3) and domestic kerosene explosions (X4) were the dependent variables. The influence of these dependent variables on the independent variable (Deaths from fire incidents) was investigated through partial correlation analysis as shown in table 3.3 below.

The inter-correlations between these variables were obtained through the Spearman's Rank relation,

$$\mathbf{rs = 1(\frac{6\Sigma d^2}{n^3 - n})} \qquad \textbf{equ (1)}$$

Where;

r12.34 = 0.40, r13.24 = 0.55, r14.23 = 0.50, r23.14 = 0.40, r24.13 = 0.11, r3412 = 0.33.

Table 3.3: Correlation Analysis of the Causes of Fire Incidents

Year	Amount of Deaths (Independent Variable)	Causes of fire incidents (Dependent Variable)		
	X1	X2	X3	X4
2000	99	32	6	26
2001	14	40	10	10
2002	10	22	20	14
2003	23	55	5	5
2004	7	64	16	12
2005	3	18	8	6
2006	10	42	12	8
2007	20	51	13	11
2008	17	69	13	13
2009	7	41	4	8
2010	3	64	15	9
2011	6	56	6	7
2012	148	51	8	21

The partial correlation analyses between the independent and dependent variables are as follows;

r12.34 = 0.40, r13.24 = 0.55, r14.23 = 0.50, r23.14 = 0.40, r24.13 = 0.11, r34.12 = 0.33.

The multiple correlation analyses between the independent and dependent variables using the multiple correlation coefficients expressed in terms of partial correlation coefficient for the variables using the expression;

1- $R1.234^2 = (1-r1.12^2)\ (1-r1.234^2)\ (1-r1.132^2)\ (1-r1.1423^2)$……equ (2)

R = 0.81

The nearest neigbour index **(RN) of 0.59** for Hospital and **1.17** for Police Station indicates a clustered and regular distribution of health and security facilities in Rivers State. A test for the significance of the result at **0.05%** confidence level confirmed a significant difference between the distribution of health and security facilities and a random pattern.

Hospital

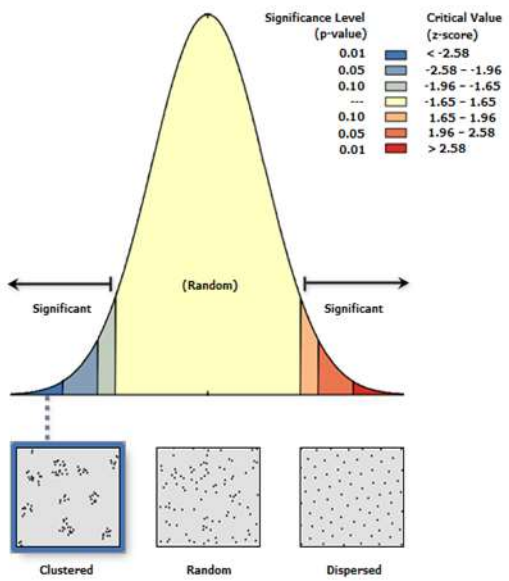


Fig. 9 (a): Clustered pattern of Hospital distribution in Rivers State

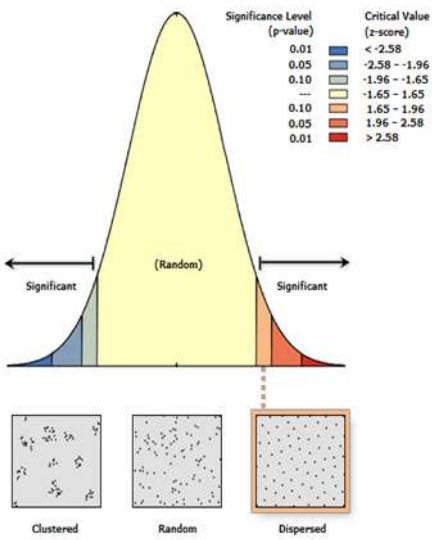


Fig. 9 (b): Dispersed pattern of police post distribution in Rivers State

Average Nearest Neighbor Summary

Observed Mean Distance: 483.303249 Meters

Expected Mean Distance: 812.700117 Meters

Nearest Neighbor Ratio: 0.594688

z-score: -9.899513

p-value: 0.000000

Dataset Information

Input Feature Class: HOSPITAL

Distance Method: EUCLIDEAN

Study Area: 430633924.762798

Given the z-score of -9.90, there is less than 1% likelihood that this clustered pattern could be the result of random chance.

Police Station

Average Nearest Neighbor Summary

Observed Mean Distance: **1765.339249 Meters**

Expected Mean Distance: **1498.737755 Meters**

Nearest Neighbor Ratio: **1.177884**

z-score: **1.894736**

p-value: **0.058127**

Dataset Information

Input Feature Class: POLICE_STATION

Distance Method: EUCLIDEAN

Study Area: 278530642.458345

Given the z-score of 1.89, there is less than 10% likelihood that this dispersed pattern could be the result of random chance.

Graph indices such as Connectivity, Alpha, and Cyclomatic Ratios where obtained from road network data of Rivers State using the expression;

Cyclomatic Index (μ) = e – v + g **equ (3)**

Connectivity Index (c) = $\frac{\mathbf{e}}{\mathbf{1/2(v-1)}}$ **equ (4)**

Alpha Index (α) = $\frac{\mathbf{e-v+g}}{\mathbf{2v-5}}$ **equ (5)**

Where; (e) is the number of edge in the road network

(v) is the number of nodes in the road network

(g) is the number of sub graph in the road network

Connectivity Index (c) = 0.3, Cyclomatic Index (μ) = 3, Alpha Index (α) = 0.8

3.4.2. Spatial Analysis

The ArcGIS spatial analyst extension provides a wide range of powerful spatial modelling and analysing tool which can be used to derive new information from existing data set, query maps, and analyze cell- based raster data. One of the spatial analyst techniques used for this study is the density analysis technique. Density analysis is used to measure the quantity of an input data set (line or point) that is distributed throughout a geographical space. It shows where point and line features are more concentrated within a specific area of study.

3.4.2. Network Analysis

ArcGIS Network Analyst offers a Flexible and friendly graphical user interface operating environment and tools alongside its powerful functionality accessible in the geo-processing environment which can be used for modelling and scripting in other to solve problems such as: Finding the shortest routes to and fro facilities, Determine service area coverage of a service or facilities based on distance and travel time. Optimum location of services and facilities, Create a travel cost matrix from a facility or service to all destinations, Find the closest facilities within a given area, Create a route direction for fleet of vehicles, Perform Point-to-Point transportation Routing .

ArcGIS Network Analyst uses the Dijkstra's Algorithm to solve various routing Problem and this algorithm was developed by Edgar Dijkstra in 1959. (ESRI 1992) states that "Dijkistra's algorithm is a recursive algorithm which assumes that the shortest route between any two points will be no greater than 1.25 the Euclidean distance between the two points".

Distance Criteria: The route is generated by taking only into account the location of the fire incident. The volume of traffic, speed and road characteristics is not considered in this case.

Time Criteria: The total drive time and speed in each road section is considered here and it is given as (The total reflex time (time between convey and actual fire fighting)

This study made use of the following Network Analysis tools, New Closest facility analysis, New Service (Drive-time analysis) and New Location- Allocation.

3.5: Network Analysis Tools used

(a) Closest Facility problem: The closest facility solver calculates the distance (in terms of time and cost) of driving between facilities and incidents or vice versa and determines which facility is closest to incidents. The closest facility solver displays the best routes between facilities and incidents, records their travel costs, response time and driving directions as shown in figure 10 below.

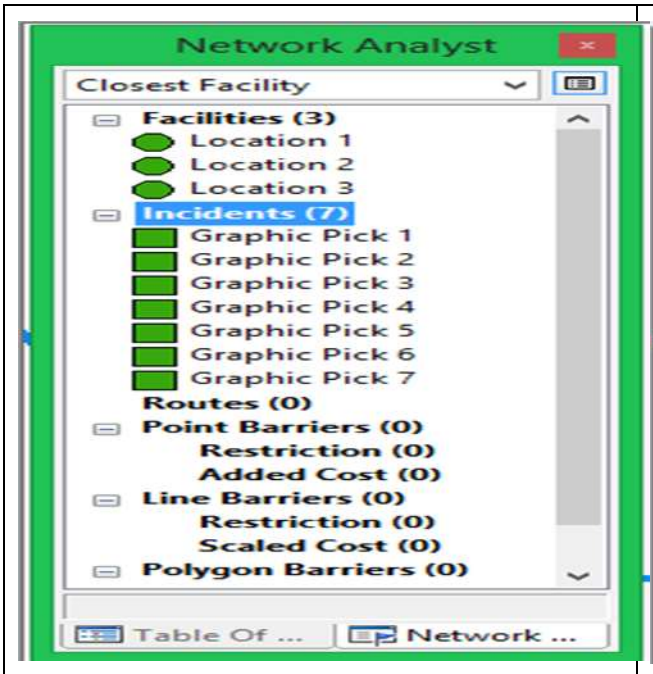


Fig 10 Closest facility Tools.

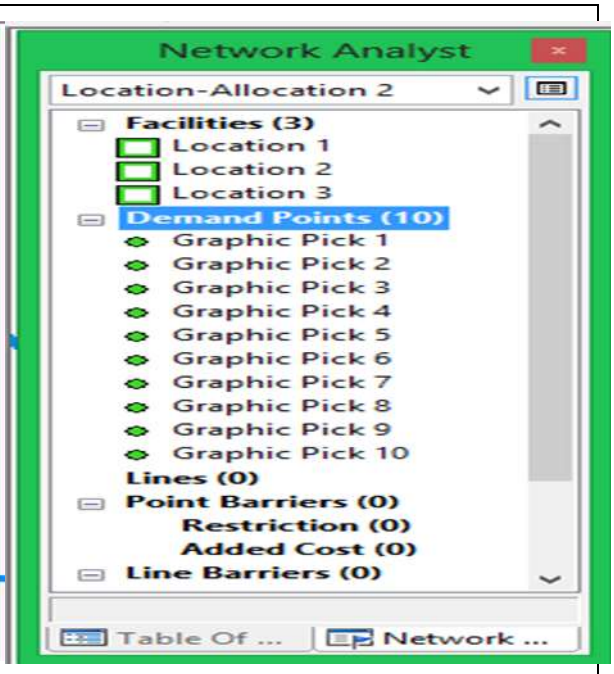


Fig 11 Location Allocation Tool use

(b) Service area (Drive time polygons):

Service Area helps to determine the service coverage extent of a facility within specified impedance thus Service areas created by Network Analyst also help evaluate accessibility by exposing any deficiency in facility service coverage within a given time and area.

(c) Location- Allocation

Location-allocation is a modelling technique, integrated into ArcGIS Network analysis to help solve problems of equating facility supply with demand using sets of criteria's and constraints (Church and Revelle, 1974). The location-allocation tool as shown in figure 3.9 below, determines the best location(s) of a service or facility with the aim of serving more population in the most effective and efficient manner.

2.6 Data Analysis.

Spatial Analysis

The kernel density (KD) function: evaluate the amount of events across a given surface by calculating the overall quantity of fire cases located within a given search radius from a target point and assign weight to them representing high and low incident point or areas.

Network Analysis

3.6.1: Closest fire Facility:

This is performed in order to determine the closest fire station to recorded fire incident given a 5 and 10 min response time.

3.6.2: Service area.

This tool assessed the Rivers state fire station coverage using 5 minutes drive time polygon in relation to population concentration and fire incident occurrence within the study area. This was achieved using the Rivers state fire station Standard of 5 minutes attendance where there is high population density. The results as shown in fig.3.12 and fig.3.13 indicate that eight local government areas of Rivers are densely populated, however fall short of the 5-minutes fire service coverage of the public and private fire facilities leaving the inhabitants of the regions more vulnerable to fire incidents.

However, the 5-munites fire service coverage of both the public and private fire facilities within Rivers State combined gave a spatial coverage of over 60% of the total area as shown in Fig. 3.16.

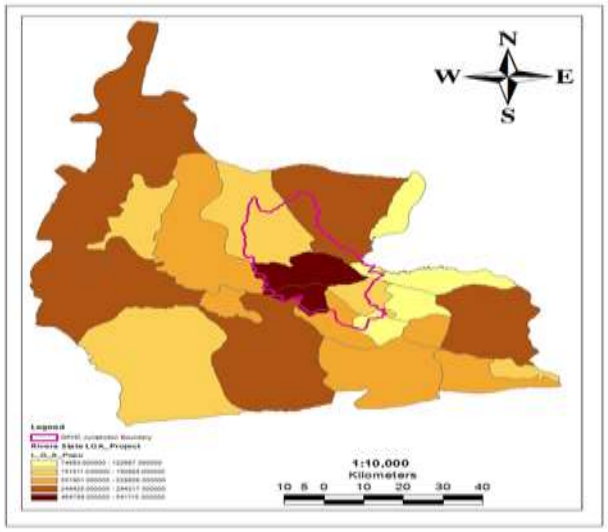


Fig. 12 Rivers State population concentrations showing fire services demand points.

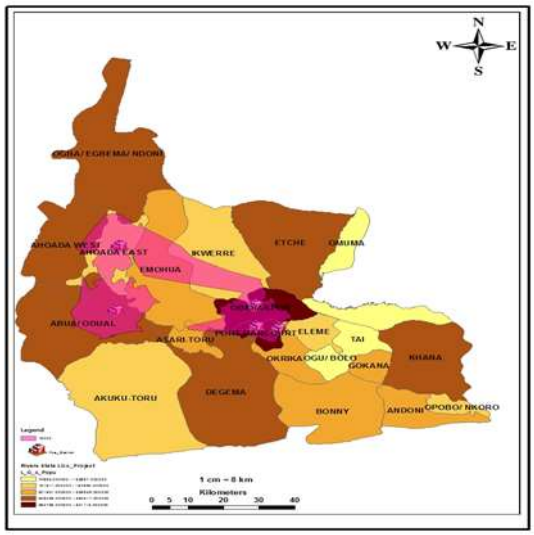


Fig. 13. 5 Kilometer Fire service coverage for public Fire facilities in Rivers State.

3.6.3: Location-Allocation.

Criteria used in selection of candidate site for a new fire station. The role of GIS in Fire station Location studied in the literature section of this work reviewed international standards and various case studies regarding the process and spatial requirements of sitting a new fire. It looked at the rational approaches as well as quantitative and qualitative methods of fire station location such as multi-criteria evaluations, performance evaluation and mathematical models. The following three (3) potential candidate sites were selected to perform optimum location- allocation analysis see table below.

Table 3.5 (a): Chosen location for new fire station and population demand points

Candidate Location	Site Name	Site Address
Location 1	Vacant site located at Kpokpori,	Ogba/Egbeme/Ndoni L.G.A
Location 2	Vacant site located Onne Eleme	Eleme L.G.A
Location 3	Vacant site located at Finima, Bonny	Bonny L.G.A.

Running the location Allocation analysis based on the above listed criteria, using the road junction from the (ITN data set) as demand points which is known to be directly proportional to population concentration in an urban area. The following results were obtained as shown in table 4.6 below;

Table 3.5 (b): Chosen location for new fire station and population demand points

Candidate Location	Site Name	Site Address	Eastings	Northings
Location 1	Vacant site located at Kpokpori, north of Omoku.	Ogba/Egbeme/Ndoni L.G.A	2401110.988	598972.516
Location 2	Vacant site located Onne Eleme	Eleme L.G.A	294898.133	522615.371
Location 3	Vacant site located at Finima, Bonny	Bonny L.G.A.	293387.36	487855.408

Table 3.5 (c): Chosen location for new fire station and population demand points.

Candidate Location	Site Name	Site Address	No of Demand Points
Location 1	Vacant site located at Kpokpori, north of Omoku.	Ogba/Egbeme/Ndoni L.G.A	325
Location 2	Vacant site located Onne Eleme	Eleme L.G.A	58 6
Location 3	Vacant site located at Finima, Bonny	Bonny L.G.A.	244

The major purpose of this site selection analysis is to maximise coverage area in other to

reach as many demand point as possible. In order to determine the area of improvement in response time and coverage extent, the new fire station is added to the four (5) existing ones.

New service area

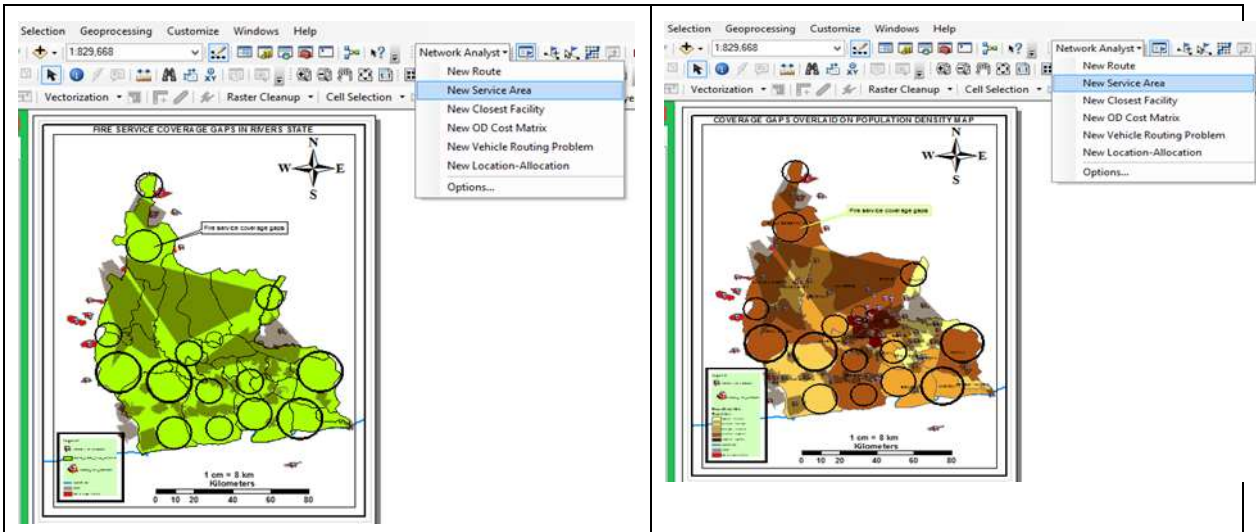


Fig. 14. 5 minutes Fire service coverage area gap of existing fire station and Comparing the 5 minutes fire service coverage and population demand points

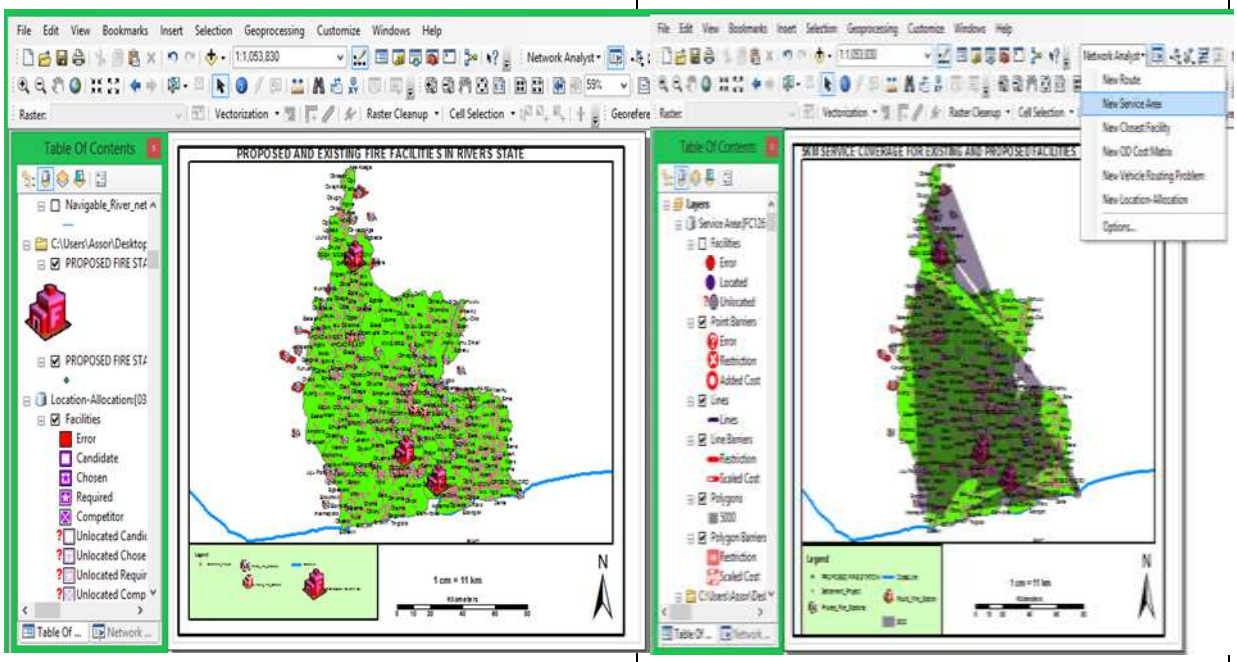


Fig. 15: Locations of Three (3) proposed fire Facility sites in Rivers State	**Fig. 16: New service area created from the proposed Fire Facility sites in Rivers State.**

3. RESULTS AND ANALYSIS

3. Results Presentation

The data for Rivers state fire incidence records reveals a high number of fire incidents in the 2003 as shown in fig. 3.3.4. This was as a result of increased illegal crude oil refining in Rivers state which eventually yielded low quality but highly inflammable petroleum products. The multiple correlation analyses between the independent and dependent variables using the multiple correlation coefficients expressed in terms of partial correlation coefficient for the variables using the expression;

$1\text{-}R1.234^2 = (1\text{-}r1.12^2)(1\text{-}r1.234^2)(1\text{-}r1.132^2)(1\text{-}r1.1423^2)$ **equ (6)**

R = 0.81

This result indicates a very huge combined influence of kerosene explosion, spillage of petroleum products and electric current sparks on the frequency of fire incidents in Rivers State, **(X1, X2, X3** and **X4).** TThepartial correlation analyses between the independent and dependent variables of **r12.34 = 0.40, r13.24 = 0.55, r14.23 = 0.50, r23.14 = 0.40, r24.13 = 0.11, r34.12 = 0.33.** A partial correlation coefficient of **r13.24 = 0.55, r14.23 = 0.50**, indicates a huge influence of both kerosene explosion and spillage of petroleum products on the frequency and deaths associated with fire incidents as shown in fig. 3.4.

The nearest neigbour index **(RN) of 0.59** for Hospital and **1.17** for Police Station indicates a clustered and dispersed distribution of health and security facilities in Rivers State. A test for the significance of the result at **0.05%** confidence level confirmed a significant difference between the distribution of health and security facilities and a random pattern as shown in fig 4.1 below.

The Connectivity, Alpha, and Cyclomatic Graph indices where obtained from road network as **0.3, 3, 0.8** respectively showing a maximally connected network of roads in Rivers state.

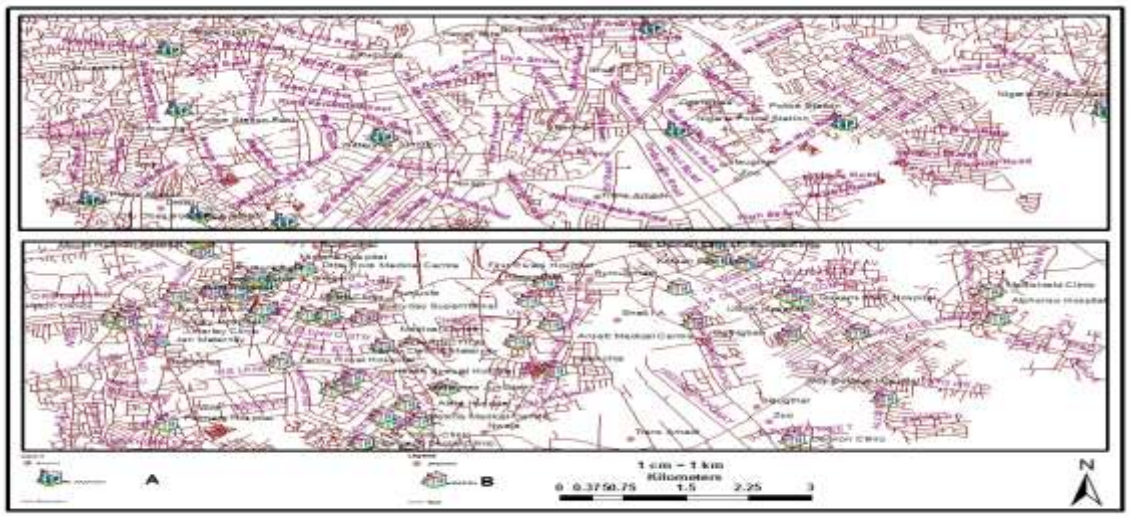


Fig 17. Distribution of Hospitals and Police Stations in Rivers State

3.2: Analysis of Results:

The Rivers State fire and rescue service is made up of 5 unitary authorities namely; Mile 1, Rumuodomanya, Ahoada, Degema and Borokiri stations. Rivers State was chosen as a case study because of its strategic location as the hub of oil and gas activities in the Niger-Delta region of Nigeria and importantly the economic heartbeat of Nigeria which consequently accounts for the current urban sprawl resulting to high level of fire risk from high rise buildings, shopping malls and high density population around urban center see Fig 8

Time is an important factor in fire fighting; the travel time a fire engine takes to get to fire incident from a fire station can be transformed to the shortest path between these two points. Here, the shortest path can show the shortest drive time between fire station and fire incident which is very significant to this study and this was calculated using ArcGIS 10.1 Network analysis and the results are shown fig. 4.2 (a), fig. 4.2 (b) and fig. 4.3 below.

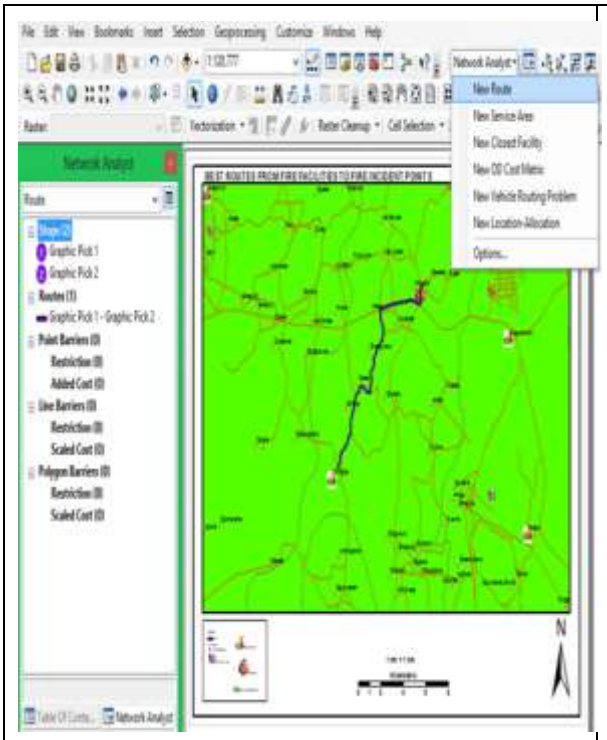


fig. 4.2 (a)

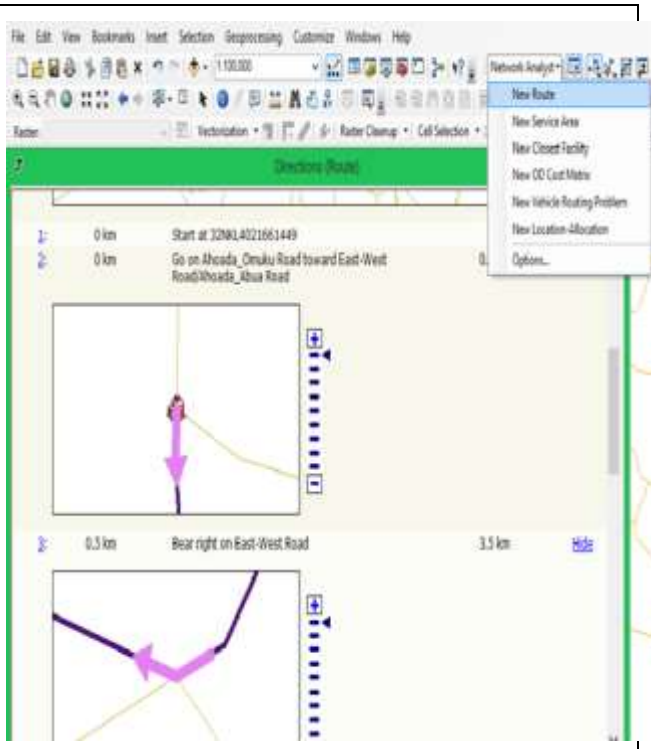
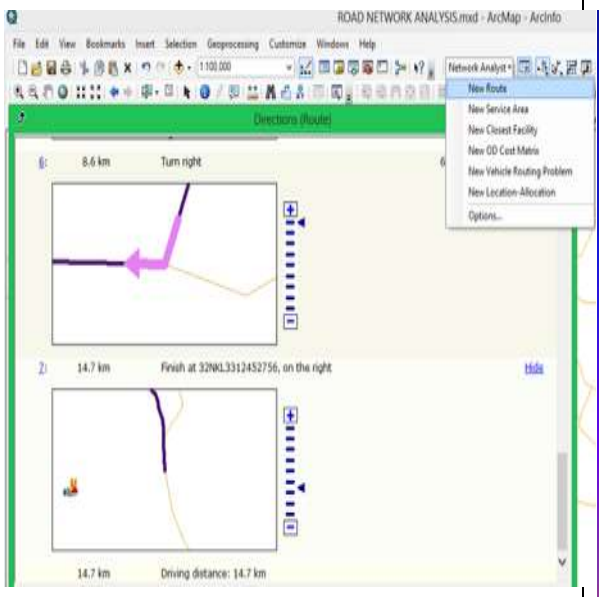


fig. 4.2 (b)



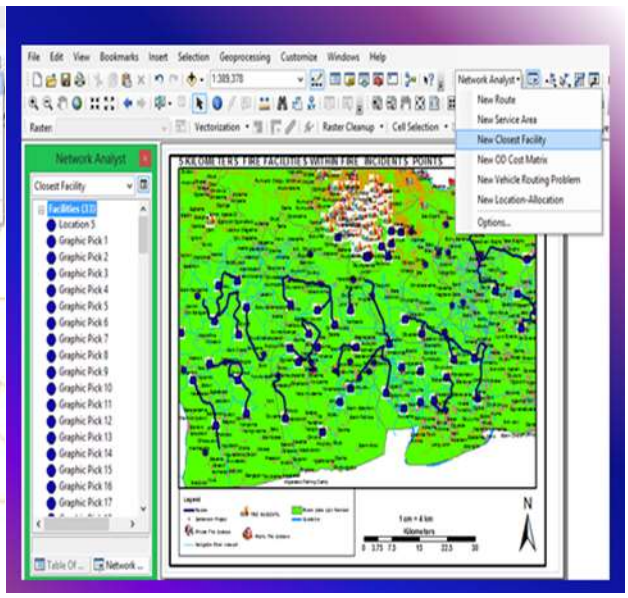


Fig 4.2: Best route between the fire station and fire incidents spots and Best route between the fire station and fire incidents spots

The closest facility analysis shows that the four fire and rescue stations operating in Rivers State where only able to respond to 82 within 5 minutes response time out of 103 fire incident recorded in year 2010 with a minimum and maximum distance of 0.6 and 4.2 miles respectively.

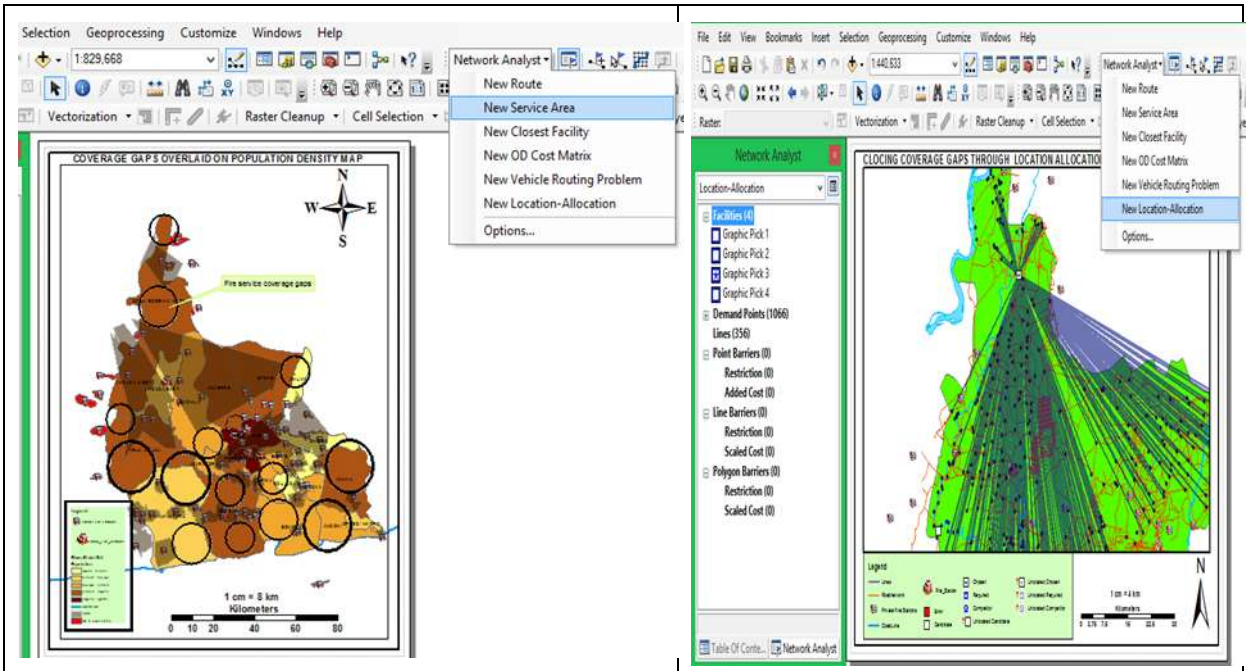


Fig.4.3: Closest fire facilities to fire incidents spots within 5 minutes response time and Fire service coverage gap and proposed candidate location at Kpokpori.

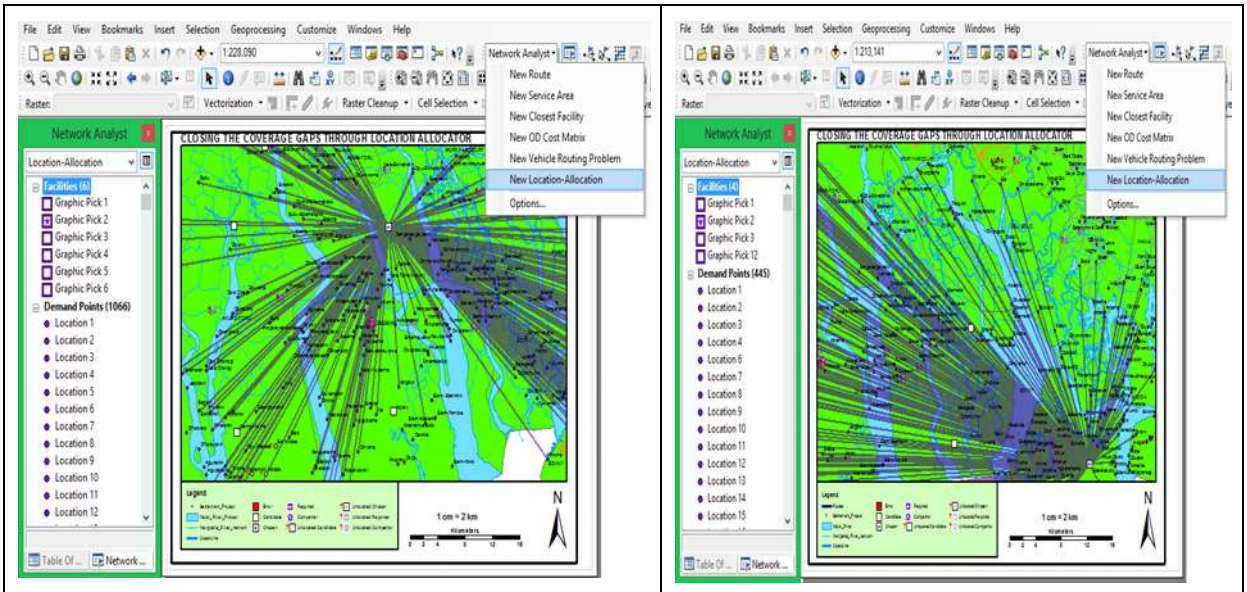


Fig. 4.5 : Demand point reached by the proposed candidate location at Onne in Eleme and Finiema Bonny.

The network road junction was used to represent population and demand point, loading the road junctions into the allocation analysis tool gave a total of 1,205 demands point for the entire study area fig. 3.20 & 3.21. The goal of the location allocation analysis tool is to choose the site that reaches more demand point within the region to be covered.

Table 4.1: Demand point reached by the proposed candidate location

Candidate Location	Site Name	Site Address	No of Demand Points Reached
Location 1	Vacant site located at Kpokpori, north of Omoku.	Ogba/Egbeme/Ndoni L.G.A	325
Location 2	Vacant site located Onne Eleme	Eleme L.G.A	586
Location 3	Vacant site located at Finima, Bonny	Bonny L.G.A.	244

5. CONCLUSIONS, RECOMMENDATION AND LIMITATIONS

5.1 Conclusions: The significance of GIS in emergency management arises directly from the benefits derived from integrating a technology designed to support spatial decision making into a field emergency management with a strong desire to address several critical spatial decisions. From the research it was revealed that everyone within the study area do not have access to fire and rescue services within five minutes of travel time and to solve this problem, the research using Location – allocation recommends the sitting of three more fire and rescue service station in kpokpori in the northern part, Onne in the eastern part and Finiema in the southern part of the state. .

The result of the partial correlation of the variables associated with causes of fire incidents in Rivers State indicates a huge influence of both kerosene explosion and spillage of petroleum products on the frequency and deaths associated with fire incidents. The nearest neigbour index **(RN) of 0.59** for Hospital indicates a clustered pattern of distribution of health facilities in Rivers State, hence there should be deliberate policies to ensure regular pattern of distribution which allows spatial equidistance to these facilities

5.3 Recommendation: we suggest the following for areas for further study; . The spatial distribution of fire incident in Rivers state in relation to the underlying social composition of the population using derivative index analysis, this will help to reveal if there is any correlation between fire incident and social status and consequently will help the government in planning for employment and provision of public facilities within the region. . The use of GIS to Assess ambulance response performance in Rivers State, and also the spatiotemporal locating and relocation of stationary ambulance service in a bid to provide even service delivery within the city.

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