A GEOGRAPHIC INFORMATION SYSTEM APPROACH TO POST INCIDENT ANALYSIS OF THE JAMAICA FIRE BRIGADE EMERGENCY OPERATIONS

(Kingston and Saint Andrew Division)

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Abstract

The Jamaica Fire Brigade is the agency responsible for the protection of lives and property in the event of fire emergencies. They are often unable to carry out their responsibility effectively, primarily due to resource constraint. This situation sometimes leads to the loss of lives and property. Sadly, during the period January 2004-December, 2012, 851 persons lost their lives as a result of these emergencies.

This paper explored the benefits which Geographical Information System (GIS) have on Post Incident Analysis in emergency management; placing emphasis on Planning, Preparedness, Recovery and Response. The objectives of this research are; locate high risk areas, identify the spatial location of Malicious False Alarm, identify areas that have sufficient hydrant coverage, provide GIS educational aid for fire prevention officers.

The benefits of this research are; an improved community education program in hot spot areas, targeted mitigation measures as it relates to bush and rubbish fires and also provide an assessment for the management of emergency personnel.

The research objectives were achieved through a combination of geo-processing tools in ArcMap software which included point density, kriging and spatial analysis tools such as buffering and weighted overlay. The results obtained highlighted the important role that GIS has in the management of Emergency Operation within the Jamaica Fire Brigade.

Introduction

The Jamaica Fire Brigade responded to 18,711 emergency calls in 2009, 14,425 of those were genuine fires and in 2010 a total of 14,040 emergency calls came in, 10,263 of the calls were genuine fires (Jamaica Fire Brigade, 2013). The demand for emergency service from the JFB far outweighs their ability to effectively deliver the important service to many communities. The fire fighters through their limited resources have worked tirelessly to reduce the number of fatalities; injuries and collateral damage over the years, but the lack of geospatial aids hinder them from achieving their objective.

The Fire Service in Jamaica was established in October 1871 with the formation of the Kingston Fire Brigade, a timely response to the spate of large fires which had ravaged sections of the city's residential, industrial and commercial developments. The first sub-station to be established was located in Half-Way-Tree in the 1930s and later the addition of York Park in November 1944 (Jamaica Fire Brigade, 2001). The Kingston and Saint Andrew (KSA) Fire Brigade was established primarily for the protection of lives and property within the limits of Kingston.

The Jamaica Fire Brigade of today is a Statutory Body within the office of the Prime Minister's Department of Local Government. The Brigade is governed by a board of directors which sets broad policy guidelines, which are then implemented by the Commissioner who has the operational command of the Brigade. The Brigade is divided into the Operations Branch and Administrative Branch, with each branch headed by a Deputy Commissioner. The Deputy Commissioner in charge of Operations has overall responsibility of the Brigade in firefighting and rescue operations (Jamaica Fire Brigade, 2001).

The Jamaica Fire Brigade is responsible for the protection of lives and property in the event of an emergency. However they are often unable to carry out their responsibility efficiently and effectively, which unfortunately sometimes results in the loss of lives and property. Statistics obtained for the period 2004-2009, from the Fire Prevention Department of The Jamaica Fire Brigade, showed that residential and commercial fires resulted in $ 18.81 billion worth of damages. During this same period 247 persons lost their lives (182 adults, 65 children), 10,961 persons were left homeless, (6,864 adults, 4,097 children) and 684 injuries occurred (109 Fire Fighter, 424 adults, 151 children) (Jamaica Fire Brigade, 2013).

The Project Area

The population as at 2012 is 2,711,476 for the entire island of Jamaica and 666,041 for the parishes of Kingston and Saint Andrew. The population sample of Kingston and St. Andrew (figure 2) has a ground area of 456.6 Square Kilometres while Jamaica (figure 1) has a total ground area of 10,991 Square Kilometres (Statistical Institute of Jamaica, 2013). The physical environment consists of flat lands on the plains to steep lands in the rural sections of St. Andrew. The communities with relatively flat lands are where the housing density is at its greatest, these constitute the urban centers where the greatest amount of emergency incidents originates.

Figure 1 (Map of Jamaica)

Figure 2 (Map of Kingston and St. Andrew)

The use of GIS in Fire Service

Johnson (2000) made the point that one of the most powerful tools provided by a GIS is the ability to geocode individual incidents and displays those incidents on jurisdictional base maps. Fire agencies can use geocoded data to make decisions about the need to purchase and assign additional extrication tools and to strategically position brush fire fighting units or other specialized units for optimal response. Fire prevention requirements and other mitigation strategies can be determined through GIS incident analysis. Incident data can be readily examined by GIS analyst and deployment adjusted accordingly, GIS also provides the ability to quickly query the database and perform what-if scenarios. The tools have eliminated the need to wait while paper maps are produced, allowing real time problem solving by staff officers (Johnson, 2000).

The role of GIS in Disaster Management within the Caribbean

The Caribbean is comprised of small island developing states; these islands have their unique sets of challenges with respect to disaster management. The uses of GIS in disaster management within the region by public and private entities are not well documented and limited literature has been published.

This view is supported by research conducted by Opadeyi (2009) of the University of The West Indies (UWI), St. Augustine, Trinidad. Dr. Opadeyi studied the use of GIS Tools and Technology amongst Caribbean Disaster Emergency Response Agency (CDERA) member states at the Seismic Research Centre based in Trinidad.

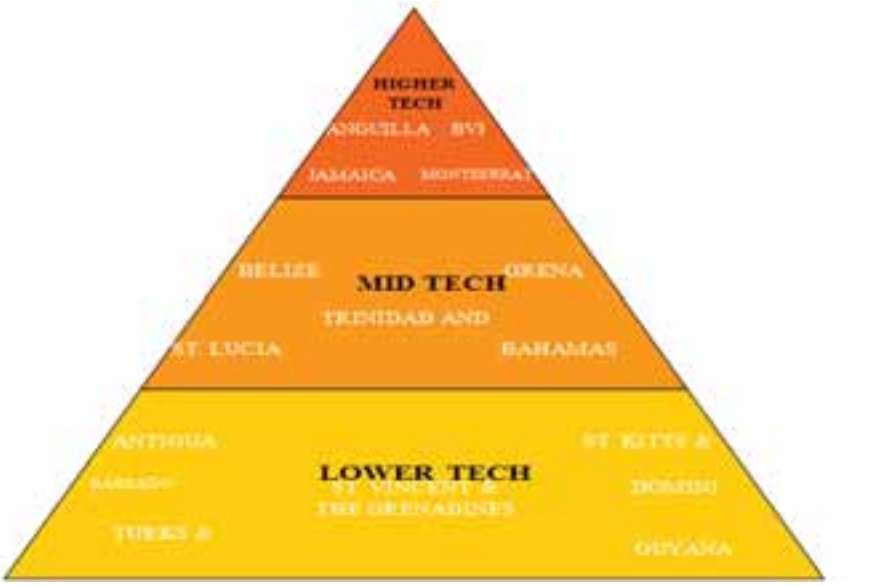


Figure 3 (Results from ICT assessment in CEDRA participating states Source: Opadeyi, 2009)

Opadeyi (2009) deduced the classification shown in figure 3, whereby the use of GIS by public entities for the management of disasters is limited across Caribbean territories. Jamaica ranked in the top tier amongst Caribbean islands; this is useful justification for the application of the findings of this research in the Jamaican environment.

Application of Post Incident Analysis in Emergency Response

Post Incident Analysis (PIA) is important to limit the time it takes to respond to an emergency. The PIA of all events must be very critical to realize the optimum benefit of the experience (Oliver, 2003).

A PIA allows fire fighters to obtain a more global perspective of the emergency operations and not just the area which they physically participated in. Fire departments should understand that no event is too small for a PIA. Poulin (2006) found that fire crews linger at the scene of an emergency to discuss what happened, how and why decisions were made, and how operations could be more effective in the future.

Methodology

The focus of this research is to investigate the use of GIS in Post Incident Analysis. The main data set used in the GIS are the incidence reports, this secondary data is a compilation of emergency responses by the Jamaica Fire Brigade during period January 01, 2010 to December 31, 2010. Figure 4 shows the method by which the stated objectives were achieved.

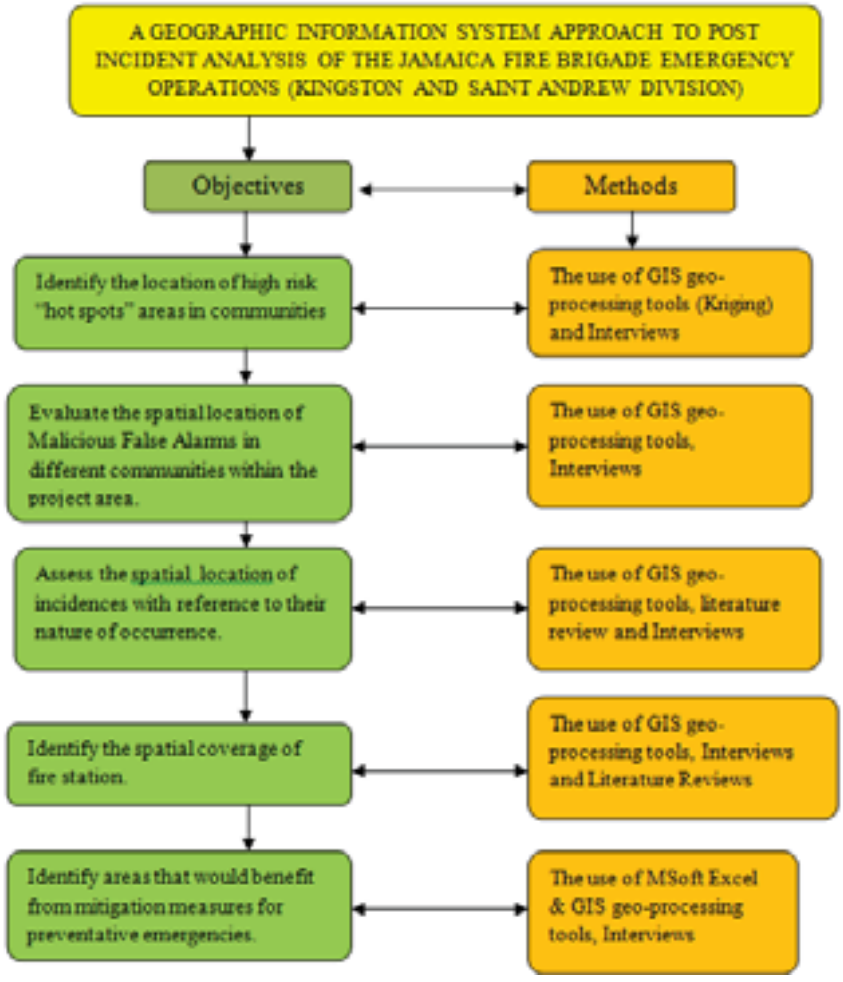


Figure 4 (Methodology)

The main data being analyzed within the GIS was acquired as secondary data from the records office of the Jamaica Fire Brigade. The primary data collected for the research was obtained from interviews conducted with members of the JFB.

The compilation of secondary data for this research was created without the use of Global Positioning System (GPS); this method was not used because of financial limitation and unavailability of resources. The descriptive process of how the secondary data for the project was geo-referenced will appear obsolete to geospatial professionals, however it proved to be very efficient in geo-referencing the existing data.

Conceptual Plan

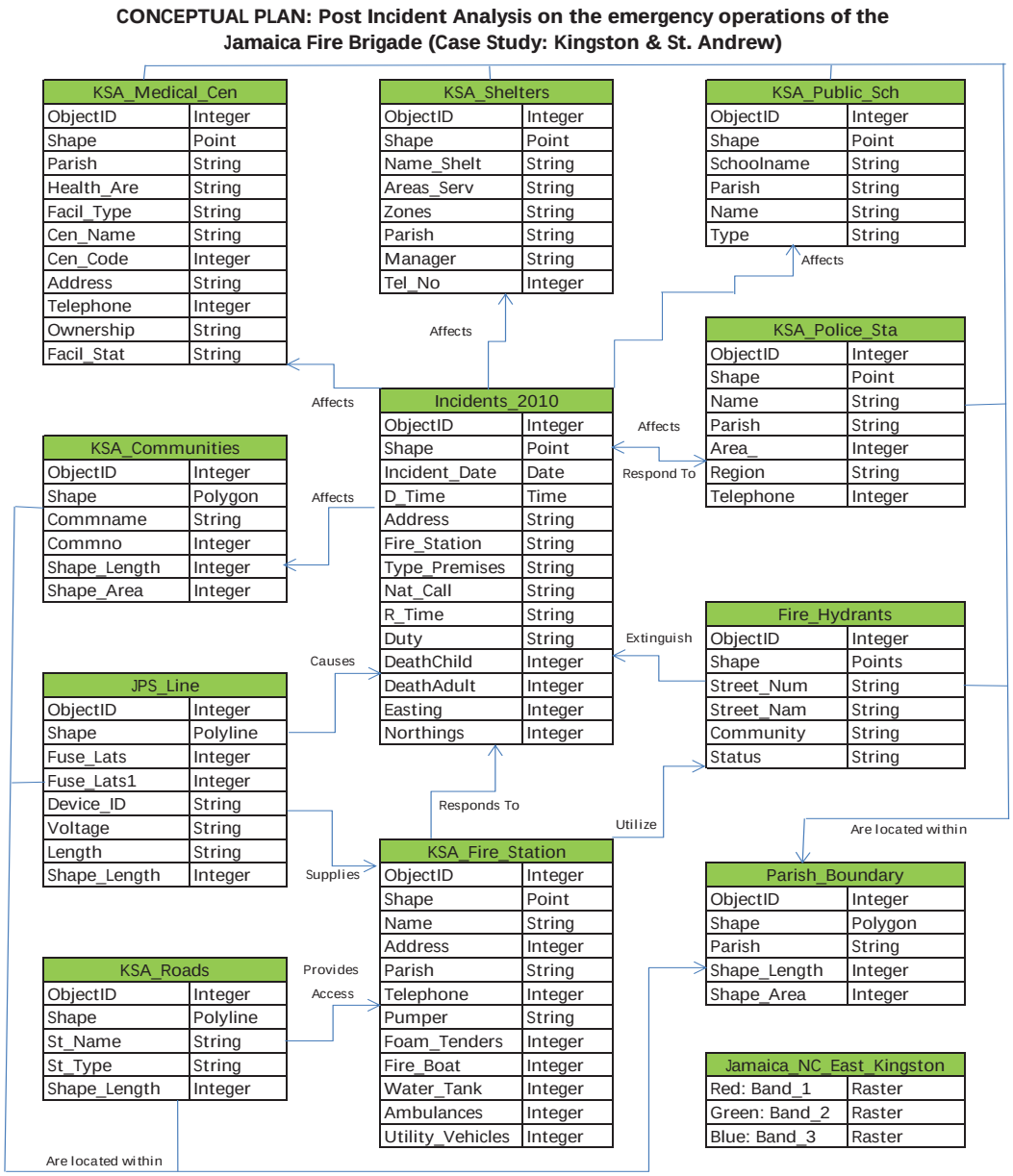


Figure 5 (Conceptual Plan)

The conceptual plan in figure 5 outlines the topological relationship between data set such as fire hydrants and their attributes such as status in the project area. The data sets shown here were imported into the geo-database inside the GIS software ArcMap for analysis.

Data Gathering for Secondary Data

The data gathering process began at the registry located at the Jamaica Fire Brigade operational command station on Orange Street. The registry records and stores all incidents which the JFB responds to, whether they are genuine or none genuine. They also provide fire reports to the general population and provide press releases to the different media houses.

The information obtained from the registry was not in a digital format, they were written descriptions of the events which took place during the incidents which includes the unit responding, the station, the departure time, the location, type of incident and the time the unit returned to the base station.

The data obtained was entered into a Microsoft Excel spread sheet; upon completion of this task each of the incidents was then geo-referenced by using the address for each incident. The process used to accomplish this task was the use of the National Land Agency IMAP web application software (www.nla.gov.jm/map.asp).

The National Land Agency IMAP was used to locate the street address, which also provided local grid coordinates in the format of Easting and Northing reference to the Jamaican Datum of 2001. The diagram in figure 7 outlines the methodology used in the project to acquire secondary data; it also shows the processes that the data went through before the creation of the geo-database in ArcMap.

The software allowed the researcher to search for locations through street addresses, scheme names and road names. This option reduced the time it would have taken to otherwise drive around and physically visit each incident site and log the coordinates for that position with a GPS device or conduct data editing in the ArcMap software. The data editing process in ArcMap involved loading the Microsoft Excel spread sheet into the software and selecting each incidents and then locating them on the geo-reference ikonos satellite image dataset in ArcMap.

This process would have been very time consuming and would also require that one has a very keen knowledge of the entire project area of Kingston and St. Andrew. The use of local street map courtesy of Esso service stations and Shell service stations was of great use in trying to locate some of the road names which proved difficult to locate using the IMAP software.

Figure 6 (IMAP software)

There were instances where the street names were pointing to the wrong direction across town. For these instances the existing street maps were used as a check and reference, to adequately locate the correct address on ground and then the coordinates taken from the IMAP software.

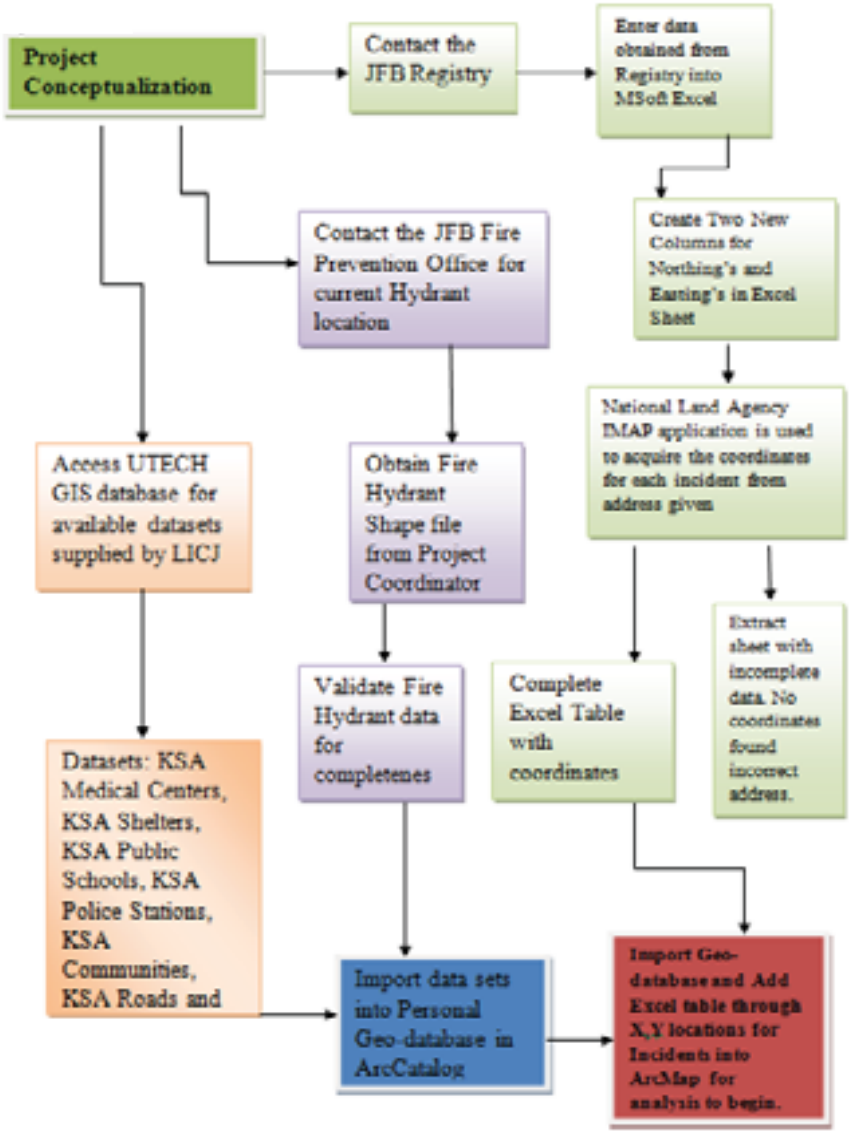


Figure 7 (Methodology for data acquisition)

Other challenges with the data that occurred during the geo-referencing process were

- The address given by firefighters did not exist, which seemed to have been a blunder on their part when they were recording the address location on site. Instances of incorrect spelling in addresses were noted and corrected.
- There was an instance where an officer stated that a fire occurred at the intersection of Duke Street and King Street in downtown Kingston.

This location is impossible since both roads runs parallel to each other in their entire length, therefore they will never intersect.

- Street name given does not exist on any maps

The incidents that had these data validity issue were placed into a separate Excel sheet and since the GIS can only process data that have geographical coordinates, these were omitted from the database.

Geoprocessing

Figure 8 below, shows how a model is used in GIS to achieve the task of spatially locating the areas that have adequate hydrant coverage. The data model used three data sets Incidents, Hydrant location and KSA communities.

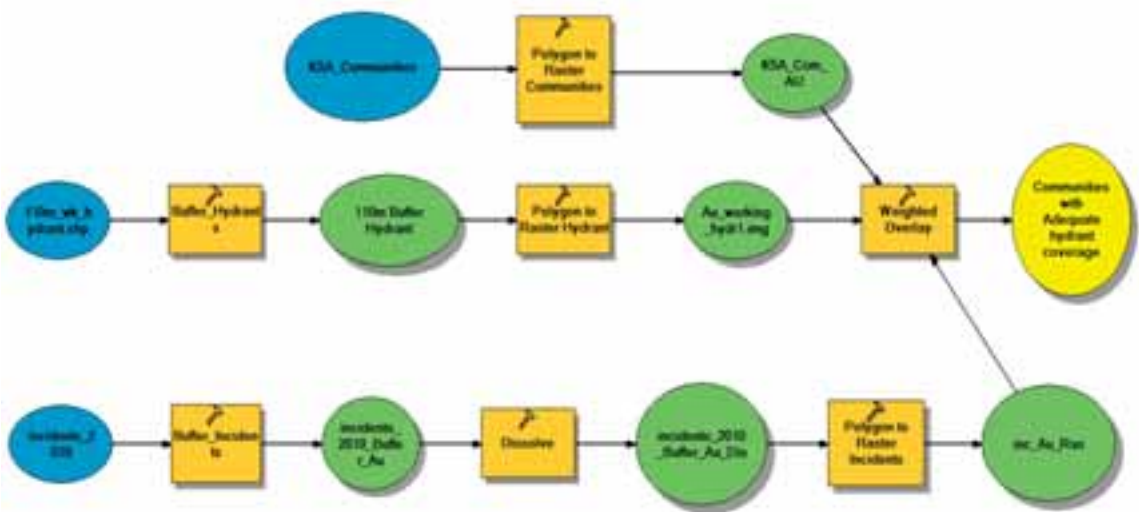


Figure 8 (Model to determine communities with adequate hydrant)

Locating Hot Spot

The use of geo-processing tools such as the kriging assisted in achieving the desired objective of indentifying areas with the highest incidence occurrences "Hot Spots".

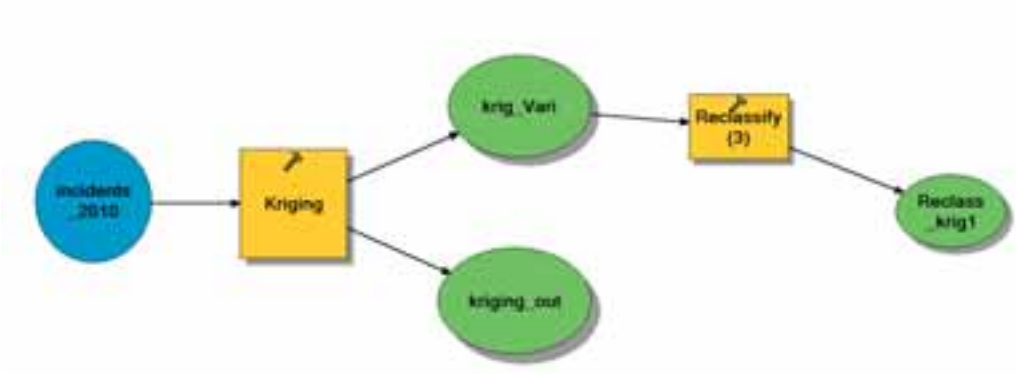


Figure 9 (Model to locate Hot Spot areas)

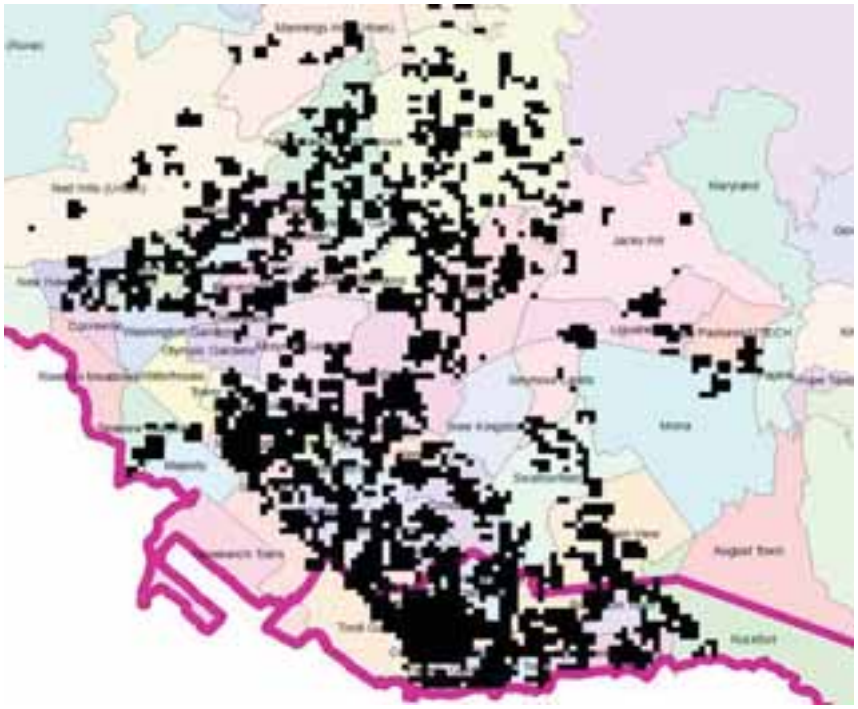
Results

Figure 10 highlights the spatial location of medical centers in relation to the "hot spot" areas which have the most reported incidents in Kingston and St. Andrew over the research period January 1, 2010 to December 31, 2010. The majority of incidents were largely concentrated in the densely populated areas of the parishes which are the urban centers.

The rural section of the parish of St. Andrew hardly depicted any emergency activity taking place; this is evident for Brandon Hill, Mount James, sections of Lawrence Tavern and Irish Town. However, some incidents such as bush fires were reported for these regions which have a large farming community with densely vegetated environments.

In figure 11 the map shows the spatial location of "safe spot" in communities with adequate fire hydrant. The areas highlighted in black represent those areas in the communities that have incidences occurring and have sufficient hydrant coverage to assist the fire fighters in emergencies. This is however not the case for the majority of the communities of Kingston and Saint Andrew. The map shows a visual representation of what exist in many of our communities which are inadequately serviced by functioning fire hydrant. Incidents were occurring in areas where the nearest hydrants were miles away from the scene of the incident.

Figure 10 (Incident hot spot in red and Medical Centres)



It is however important to note that in some of these areas where there exists no fire hydrants, the communities themselves lack the supply of the precious commodity of potable water. The installation of fire hydrants is directly dependent on a number of factors, some of which are external to the JFB. One such factor is the National Water Commission providing pipe water to these areas which would support the function of the fire hydrant (Williamson, 2012).

Figure 11 (Map showing hydrant coverage)

The JFB faces many challenges in its daily operations, however one such challenge they could do without is the large number of prank calls to the emergency hotlines. Prank calls classified as Malicious False Alarm (MFA) for the period under review is represented in figure 12. The locations of these calls are overlaid onto the different communities in which the incidents are reported to have occurred.

The locations were documented by the JFB personnel who responded to the call. The physical locations of the MFAs are the address at which the emergency vehicles are directed to and in some cases these are not necessarily the address where the calls originated from. The spatial locations of MFAs are densely distributed in the lower income communities and sparsely distributed in other areas where the income strata of residents are much higher.

This is evident for areas such as Central Down Town, Franklyn Town, Rose Town and Hannah Town which are showing a cluster of occurrences when compared to more affluent communities such as Jacks Hill, Mona, Hope Pastures and the "golden triangle" area of Seymour Lands in the Parish of St. Andrew.

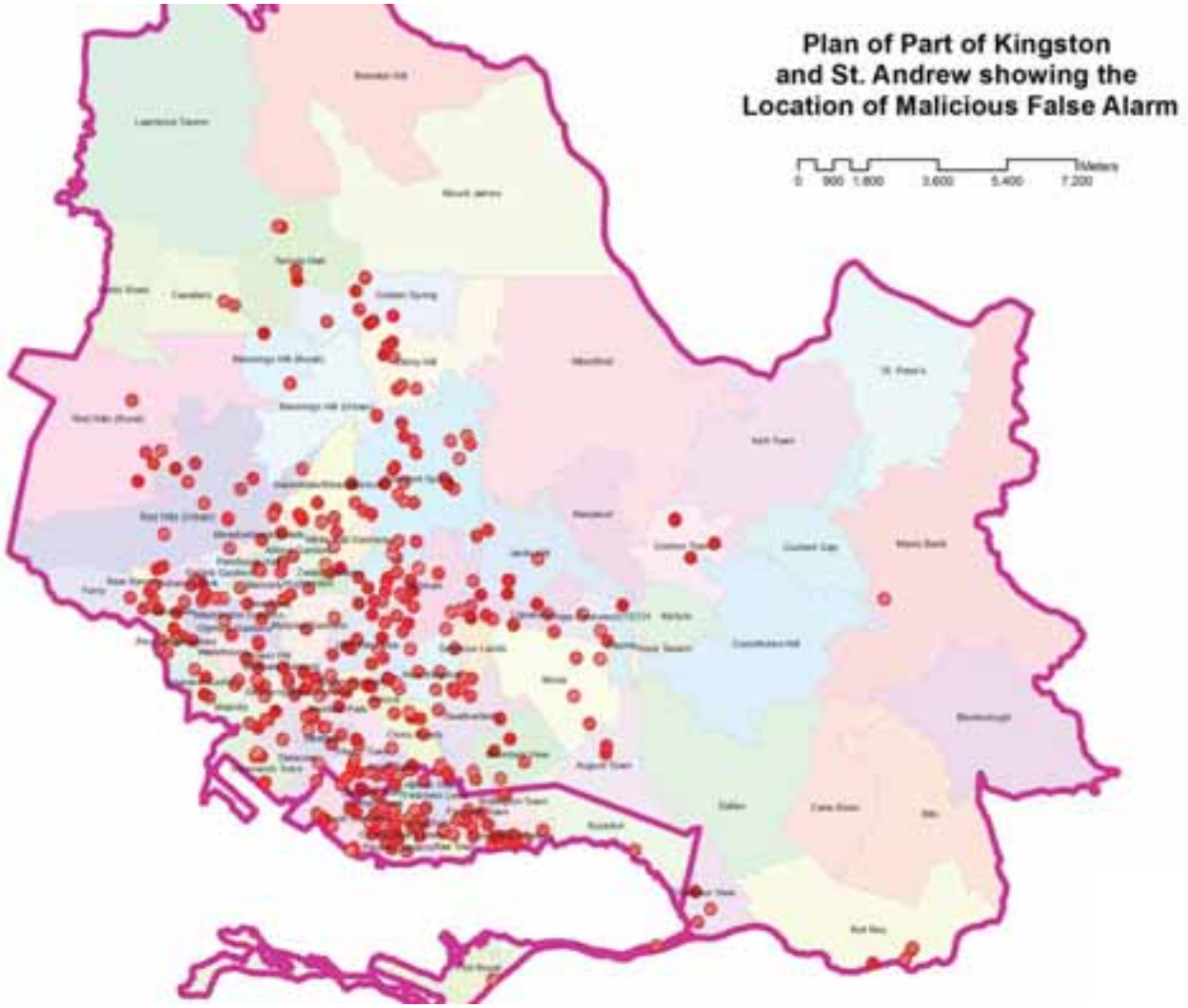


Figure 12(Map showing Malicious False Alarm)

Figure 13 (Nature and Location of Incident)

The spatial locations of incidences across sections of the Kingston Business District (KBD) were examined in figure 13. It showed the road names and nature of emergency response as documented by fire personnel.

The data presented in this map is a sample of the data for the wider business district and presents a good opportunity for post incidence analysis on the nature of emergencies and the different geographical location which are mostly affected. The occurrences of incidences in the urban areas are highlighted. This area is one of the most densely commercial areas in the KBD. Therefore, the potential for loss of personnel and commodity as a result of fire and smoke is an important consideration to the fire prevention officers and business operators in the area.

Figure 14 (Spatial location of Incidents and Fire Station Location)

The six fire stations and one fire boats which serve the KSA are besieged by the occurrences of emergency incidents throughout the year. The spatial locations of incidents in relation to fire stations in the division were examined in figure 14.

The communities that are furthest away from fire stations are exposed to a higher risk tolerance since the emergency units would take a longer time to reach those areas when compared to other sections of the urban landscape.

Conclusion

The fire service of today is very dynamic, it is not just fighting fires but providing emergency medical service, responding to motor vehicle accident rescue, fire prevention, and other nontraditional but important tasks which are vital to the community it serves. Balancing limited resources and justifying daily operations and finances in the face of tough economic times is a situation that is familiar to our emergency personnel across different jurisdictions.

Jamaica's emergency response agency the JFB suffers from limited resources such as; water trucks, ladder trucks and other necessary apparatus. In the present economic climate the availability of resources to the state agency will continue to be limited in the near future, therefore other less capital intensive measures will have to be explored.

One such measure is the use of GIS in the JFB daily operations, as illustrated in the results of the research. The creation of dynamic maps by GIS analyst potentially offers great benefits towards the overall function of the emergency response and planning. GIS can enable the Jamaica Fire Brigade to efficiently and effectively match demands for service. The results from the GIS allow the JFB to be aware of where the problems are. It also provides a visual means to proactively responding to an emergency and arranges mitigating measures with citizens group to build support on the ground.

The GIS system can also assist the JFB officers to understand an emergency better and provide an insight into the dynamics of a neighborhood including persons, events, fire hazards and hot spots for malicious false alarm. They will also be better able to identify risk factors including businesses, buildings, or other locations that are predisposed to fires. The use of GIS in their everyday operations will allow the department to document and map emergency incidents, thereby allowing them to generate incident reports and analyze trends in the data obtained.

GIS analyst will support emergency officers in developing more effective tactical approaches and deployment strategies. The results from this research can help in the prevention of those negative issues identifying by trend analysis, such as rubbish fires and MFA calls. Fire prevention officers working in the communities or investigators working a scene, already know generally where the emergency hot spots are located.

The system can model workflow and capture best practices. Thereby allowing analyst to determine what works and share it with others. The fire department can then build on their existing knowledge and experience collaborating with officers, investigators, and other state agencies such as the police to improve response times and management of emergency scenes.

The results presented and discussed throughout the paper can be beneficial to the operations of the JFB. The research objectives were achieved through GIS data analysis, data from interviews and statistical data. The benefits of the study can be classified into four major heading as purported by ESRI (2012). The four headings are; planning, preparedness, response and recovery. Preparedness provides for targeted mitigation in high risk (hot spot) areas of downtown Kingston, deployment analysis and training exercises for overwork staff located at the Half Way Tree fire station.

Response enables the JFB to improve response time through network analysis for navigation. assistance. The benefits of recovery can be used for damage assessment, logistics planning and infrastructure restorations. Planning will allow the JFB to carry out their mitigation measures in "hot spot" areas more efficiently and effectively.

The research examined data for the period January 2010 to December 2010; the data presented for other years may provide contradictory results or confirm the results of this project. Further research in this area would be encouraged to ascertain a year by year trend. It is recommended that the incident data be collected as a primary data with the use of a GPS device to map the geographical location to avoid some of the obstacles experienced during this research.

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