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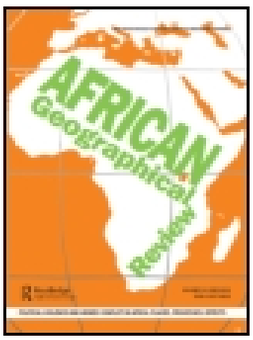

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Emergency fire response in Ghana: the case of fire stations in Kumasi

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Recently, Ghana has been plagued by increasing and disastrous fire emergencies, yet little research exists on Ghana's fire response system. This paper examines the emergency fire response system in Kumasi, Ghana's second largest city. We use spatial analysis to evaluate the geographic distribution of existing fire stations and their service areas, and identify coverage gaps based on specified response times. Our results show that large portions of the Kumasi Metropolitan Area are underserved, a situation that partly explains the huge losses in property and lives during recent fire outbreaks. Efficient location of fire stations using simple location–allocation models can help to improve response to fire emergencies and reduce the cost of fire outbreaks in African cities.

Keywords: Ghana; population health; emergency response system; GIS

Introduction

Urban fire outbreaks are a recurrent and costly problem in Ghana. From a total of 1986 fires in 2006 (Aziz, 2007), Ghana recorded a total of 2201 fire outbreaks in the first quarter of 2013 alone, with an estimated US $8 million in property damage (Appiah, 2013). Market sites have suffered the most frequent fire outbreaks. For example, the Accra Kokomba market fire of April 2014, destroyed over 5000 stores rendering more than 700 persons homeless (Kwawukume, 2014). In Kumasi, which is considered the largest open air market site in West Africa (Storr, 2008), about 300 shops were razed down in February 2014, leaving more than 500 traders jobless (Dapatem, 2014).

The complete loss of the Central Medical Stores (CMS) in Tema in 2015 (Laary, 2015) is an excellent example of the financial and human health costs of Ghana's urban fires. CMS provided storage for imported drugs and medical equipment used throughout the country. At the time of the fire, it contained drugs purchased by the Ghana Ministry of Health for distribution throughout the country as well as donated drugs and supplies from international partners in anticipation of the Ebola outbreak. The total loss of contents, estimated at $65 million (Laary, 2015) meant, not only a huge disruption in the supply chain for maintaining population health, but also the loss of important medical

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records and supplies. Such disasters affect the cost as well as operational capabilities of the health and pharmaceutical sectors.

Despite the frequency, severity and cost of these fire outbreaks, little scientific research exists on the problem. In fact, Ghana's fire outbreaks have been attributed to criminal acts such as arson (Andoh, 2016), political sabotage (Ayarkwa, Danso, & Adinyira, 2010), smoking (Abu, 2013), improper use of electrical appliances, gas leakage, over-frequent power outages (Abdulai, 2014), and even witchcraft. The Ghana National Fire Services (GNFS) is widely blamed for poor fire response. Some have defended the GNFS and attributed blame to overcrowding in the markets which makes movement of fire trucks and personnel extremely difficult. GNFS enumerates many challenges including inadequate numbers of personnel and poorly equipped fire trucks, unreliable water supply, poorly located or non-existent fire hydrants, and outdated emergency communication infrastructure.

A significant reduction in the number of fire outbreaks and the corresponding damages will require a multi-faceted approach. Educating the public on fire prevention and enforcement of building regulations and zoning laws are important steps that can reduce fire outbreaks. In the event of a fire, effective control depends on the ability of the GNFS to respond within the shortest possible time with the right equipment (functional fire trucks with fire retardants etc.), and well trained personnel with access to timely information regarding location of fires. Thus, the geographic distribution and coverage of fire services is vital. Yet, this has received the least attention.

The most important study to date in this regard, Forkuo and Quaye-Ballard (2013), identified the optimal route from existing fire stations to any fire event in the Kumasi Metropolitan Area (KMA) as well as the closest fire hydrants. By allowing queries to locate the closest fire hydrants, the study provided one important tool for improving fire response in Ghana. However, it did not evaluate the efficiency of the current system of fire stations in terms of geographic coverage. For example, we are unable to know which sub-metro areas are unserved or under-served by the existing system or where to locate additional fire stations to improve the system. This is the gap we seek to fill. We examine the geographic distribution of the existing system of fire stations in the KMA and evaluate the spatial coverage for each fire station under predefined response times. We show the areas which have coverage as well as those that lack coverage. Taken together with the Forkuo and Quaye-Ballard (2013) study, these two studies provide vital information for improving the efficiency of the system of fire stations to ensure effective emergency fire response in Ghana.

Study area and methods

The Ashanti region experienced the highest frequency of fire outbreaks in Ghana from 2011 to 2013 (Figure 1). Kumasi, the regional capital and second largest city of Ghana, has an estimated population of 2,035,064 and an annual growth rate of about 5.4% (Ghana Statistical Service 2012). The Kumasi Metropolitan Area covers a total of approximately 115.4mi^2, and is the most populated and industrialized among all the 27 districts of the Ashanti region. The major economic activities occur at the Central Business District (CBD), the Central Market (the largest open air market in West Africa) and the Adum Shopping Center.

We used a GPS to determine the exact locations of the existing six fire stations to include in the Geographic Information System (GIS) (Table 1) which consisted of street

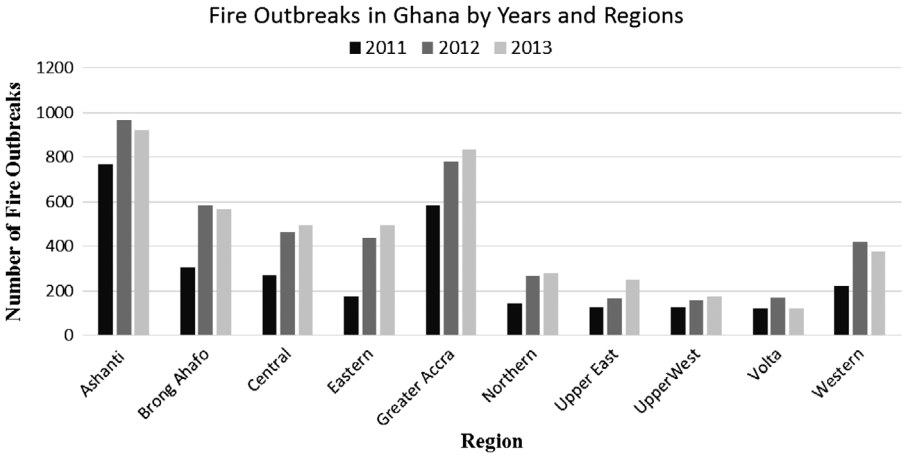

Figure 1. Frequency of Fire Outbreaks in Ghana.
Note: GNFS 2014.

Table 1. Coordinates of fire stations in the Kumasi Sub-Metro.

Fire station	Sub-metropolitan area	*X*	*Y*
Kumasi Regional Headquarters Fire Station	Asokwa	656,651.6422	735,184.56
Kumasi Metro Fire Station	Oforikrom	656,639.8371	739,294.381
KATH Fire Station	Bantama	651,386.6887	740,578.783
Magazine Fire Station	Suame	651,775.3263	743,259.521
Manhyia Fire Station	Manhyia	653,203.6898	741,142.298
KNUST Fire Station	Oforikrom	657,583.7702	739,118.338

centerlines, boundaries of the 10 sub-metropolitan areas, land use/cover, and population and housing data from the 2010 Census (Ghana Statistical Service 2012). After classifying the land use into built-up, grass, water, bare ground, and forest, we overlaid it on the study area. We used geospatial analytical methods to assess the current locations of fire stations and their coverage in the KMA, and to determine which parts of the metropolis are un(der)covered within pre-defined standard response times. This became the service area for fire service coverage. Subsequently, we completed a cross-sectional analysis based on the following response times: 4, 5, 8, 10 and 15 min.

The stipulated target response time for the GNFS is 4 min:

> According to the GNFS operational standards and International Association of Fire Fighters Guidelines (IAFF), response time includes turn out time and drive time to fire emergencies. Turn out time begins when GNFS is notified of fire emergency and ends when the appropriate firefighting apparatus and fire men leave the fire station to the fire scene and takes a maximum time of one minute .The drive time to fire emergency scenes also begins when appropriate firefighting and fire men leave the station and ends when they arrive at the fire scene and takes a maximum time of three minutes. Therefore according to GNFS and IAFF, the total response time to fire emergencies is four minutes. (Ghana National Fire Service, 2013)

However, this can be affected by travel difficulties due to crowdedness and traffic congestion. For our analysis, we used the 4 min response time; it is not only the GNFS target, but the standard of the National Fire Protection Association (NFPA) from fire departments in the USA (Flynn, 2009). The remaining standard response times (5, 8, 10, 15 min) were used to illustrate differences in coverage particularly in the face of the current traffic conditions in Kumasi.

To determine the service areas covered by the current system of fire stations for these response times, we used 9.32 mph as the speed limit. According to Ghana's Department of Urban Road Report of 2004, the average speed limit during the peak period in KMA is 9.32 mph. This was used to calculate impedance in minutes for use in the network analyst. This provides a worst case scenario given the narrow roads and chronic traffic congestion in the city.

We used the network analyst in ArcGIS environs to determine the service areas – a region around any fire station that encompasses all accessible streets that are within a specified impedance – and the percentages of built-up areas covered by each fire station for the different response times for each sub-metropolitan area. Thus, the % of built area covered by a fire station is given as:

$$\frac{\text{Service area of each fire station in a sub metro} \times 100}{\text{Total built area of that sub metro}}$$

Results

Distribution of fire stations in the Kumasi Metropolis

Figure 2 and Table 2 show the current geographic distribution and number of fire stations in the study area. Only 5 of the 10 sub-metropolitan areas have fire stations. These are the Manhyia, Suame, Asokwa, Oforikrom, and Bantama sub-metros. While each sub-metro area has only one fire station, the Oforikrom sub-metropolitan area has two – KNUST and the Kumasi metro fire stations which are approximately .6 miles apart.

Interestingly, most fire stations are located in the central and eastern part of the study area away from the more populous areas. Surprisingly, the most populous sub-metropolitan area according to the 2010 population and housing census, Asawase, (Table 3) does not have a fire station. Apart from the regional headquarters fire station which is located in the central part of the Asokwa sub-metropolitan area, all the fire stations are located close to the outskirts of each sub-metropolitan area. Assuming that the original fire stations were located centrally with regard to the sub-metropolitan areas they serve, the city and its sub-metros may have grown spatially in ways that the original planners did not anticipate.

The explanation for this configuration of fire stations lies in the historical growth of KMA. The Kumasi metro and KNUST fire stations are both located in the older part of the city centered on Adum. Peripheral expansion began from the most central location (Adum) particularly towards the north and west. As a result, the distribution of population within the 10 sub-metros is skewed towards the Asawase, Manhyia, Bantama, Kwadaso, and Suame sub-metropolitan areas (Ghana Statistical service, 2010 National Population census). Regardless of the explanation, the current configuration of fire stations makes it difficult to cover the city effectively and may produce unnecessarily much higher response times and a greater risk of loss in the event of a fire outbreak.

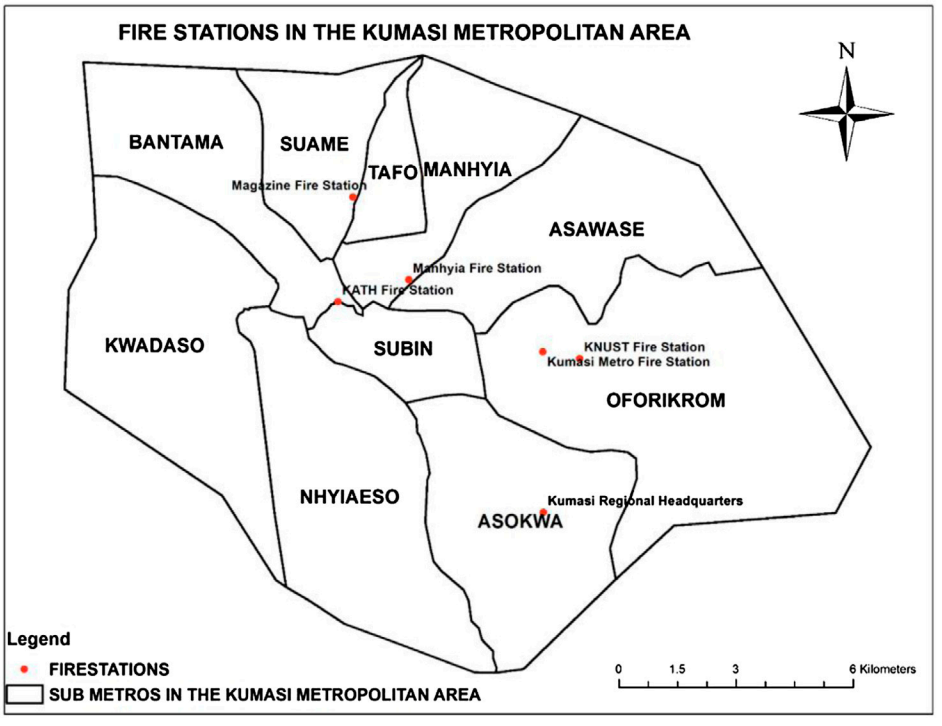

Figure 2. Fire station locations in the Kumasi metropolis (Source: Author).

Table 2. Number of fire stations in each sub metro in Kumasi Metropolitan Assembly.

Sub-metropolitan area	Number of fire stations
Asawase	0
Asokwa	1
Bantama	1
Kwadaso	0
Manhyia	1
Nhyiaeso	0
Oforikrom	2
Suame	1
Subin	0
TAFO	0

Underserved areas

Figure 3 shows the service areas covered by the fire stations under the various predefined response times.

From Table 4, the four-min response time set by the GNFS is seen as an unattainable goal given the current configuration of fire stations. In fact, none of the sub-metropolitan areas is totally covered under that standard. Kwadaso and Nhyiaeso have 0% coverage while Subin has only .9%. Except for Tafo sub-metropolitan area with

Table 3. Population by sub-metropolitan area.

Sub-metropolitan area	Total population
Kwadaso	251,215
Nhyiaeso	134,488
Subin	174,004
Asokwa	140,161
Oforikrom	303,016
Asawase	312,258
Manhyia	152,225
Tafo	146,024
Suame	161,199
Bantama	260,474

Notes: Ghana Statistical Service (2012). 2010 Population & Housing Census. *Summary Report of Final Results.*

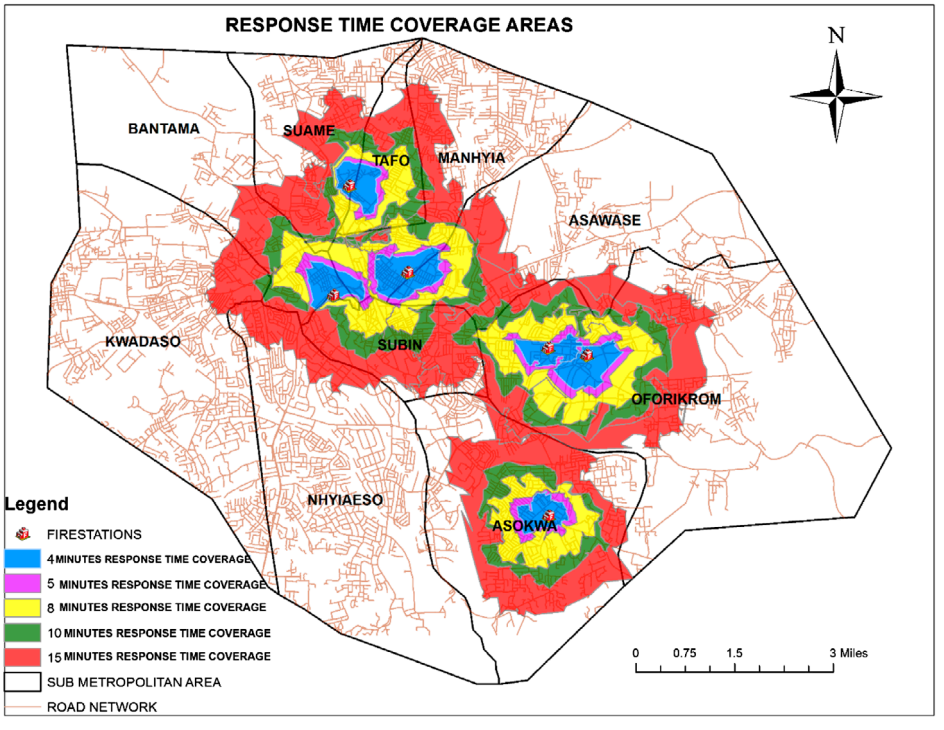

Figure 3. Service areas of fire stations in the study area (Source: Author).

12.3% of its area covered, the remaining sub-metros have less than 15%. Thus, with the current setup, the GNFS is completely unable to meet its set goal of responding to fire outbreaks within a four-minute standard response time.

As expected, notable improvements in coverage occurred with increasing response time (Table 4). For example the total area covered by the fire stations for Manhyia sub-metropolitan area was 8.94% for a response time of 4 min but increased drastically to

Table 4. Percentage of total built area served under the pre-defined response times.

Sub-metropolitan area	4 Min	5 Min	8 Min	10 Min	15 Min
Asawase	4.07	4.87	10.45	16.62	34.4
Asokwa	3.94	13.2	18.77	25.5	57.2
Bantama	5.01	5.9	12.26	19.6	50.9
Kwadaso	0	0	0	.5	6.6
Manhyia	8.94	18.94	25.71	45.22	75.3
Nhyiaso	0	0	0	0	9.1
Oforikrom	5.25	11.8	25.64	43.49	72.1
Suame	1.8	2.78	6.69	10.22	19
Subin	.9	8.42	20.51	46.25	64.3
Tafo	12.3	16.98	35.26	52.1	79.3

75.3% for a response time of 15 min. Similarly, the area served in Tafo sub-metropolitan area increased drastically from 12.3% at 4 min to 79.3% at 15 min.

Despite these improvements in coverage with increasing response times, no sub-metropolitan area reached a 100% coverage even at 15 min. The Nhyiaeso, Subin, and Kwadaso sub-metropolitan areas are the most poorly served under the given scenarios. Nhyiaeso, for example, is only covered by the KATH fire station when the response time is 15 min. Even under that scenario, only 9.1% of the total built area for that sub-metropolitan area is covered. Table 4 shows that the remaining sub-metropolitan areas including Manhyia, Tafo, Subin, and Oforikrom have only partial coverage under a response time of 15 min.

Discussion

The current location of fire stations in the Kumasi Metropolis hinders effective and timely fire service response. This could, at least partially, explain the huge losses of lives and property whenever fire outbreaks occur. The limited number of fire stations as well as its poor configuration definitely increases the response time and, relatedly, fire damage and human health costs. By identifying the gaps in coverage, this study provides insights for improving the services. For example, new fire stations could be sited in the areas with poorer coverage or volunteer fire services could be established in the areas currently with no coverage.

However, this does not address the many challenges facing the GNFS – including shortage of skilled personnel and state-of-the-art technology, malfunctioning water hydrants, poor road networks, and poor address systems. Improving the geographic distribution of fire services without improving the fire service infrastructure is probably inadequate; it must be coupled with effective infrastructure, trained personnel, and communication systems. Until these questions are addressed satisfactorily, residents will continue to face huge losses from fire outbreaks.

While these findings may not necessarily reflect exactly what pertains in other major Ghanaian and African cities, we suspect that they mimic the reality of service coverage in most African cities, and thus can provide a framework for evaluating the efficiency of emergency response in such settings. Because most African cities are growing very rapidly and existing infrastructure is unable to cope with the new growth, the rapidly growing, unregulated and under-serviced urban areas constitute high-risk locations for

emergencies, disasters, and disease. Deficits of urban infrastructure amidst rapidly escalating demand for these resources contribute to chronic emergencies and humanitarian crises (Zetter & Deikun, 2010). The lack of effective preparedness for multiple hazards, not just fire, and limited mitigation measures compound the vulnerabilities of urban populations. Such over-rapid urban growth, slumurbanization, is considered a health hazard and humanitarian disaster threat (Patel & Burke, 2009) because of a greater potential of endemic and epidemic diseases with global health implications. Thus shifts in planning and programming, based on solid research particularly of the spatial patterns of population change in large African cities is necessary.

Conclusion

Timely response to fire emergencies depends on several variables including efficient location of fire stations. We have demonstrated that poor geographic distribution of fire stations in KMA probably affects fire response. Our findings suggest the need for additional fire stations in all the sub-metros, and can be used to determine which sub-metro should be prioritized for siting a fire station. We have also demonstrated that simple applications of Geographic Information Systems can lead to improved and well-structured emergency response for Ghana and other developing countries, and have implications for global health.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Abdulai, A. A. (2014). Frequent fire outbreaks in Ghana: Let's use preventive methods to deal with it. Retrieved from https://www.modernghana.com/news/518518/frequent-fire-outbreaks-in-ghana-le.html

Abu, J. (2013, March 18). Smoking is number one cause of fire outbreak in Ghana. *Ghana News Agency*, Monday.

Andoh, D. (2016). 12 Busted for role in Central Medical Stores fire as Arsonist is on the run. Retrieved from http://www.graphic.com.gh/news/general-news/57340-12-busted-for-role-in-central-medical-stores-fire-as-arsonist-is-on-the-run.html

Appiah, S. 2013. First quarter of 2013, fire outbreaks galore. Retrieved from http://www.modernghana.com/news/470789/1/first-quarter-of-2013-fire-outbreaks-galore.html

Ayarkwa, J., Danso, A. K., & Adinyira, E. (2010). Incidence of domestic fire outbreaks in Ghana: Causes and prevention. *The Ghana Surveyor, 3*, 7–20.

Aziz, A. (2007). *Fire service records 1986 fires*. Daily Graphic online, February 2007. Retrieved from http://www.graphic.com.gh (May 4, 2012), p. 20.

Dapatem, D. (2014). Fire renders 500 jobless at Kumasi Central Market. Retrieved from http://www.graphic.com.gh/news/general-news/18404-fire-renders-500-jobless-at-kumasi-central-market.html

Department of Urban Road. (2004). Report on Urban Planning and Traffic management studies. Kumasi.

Flynn, J. D. (2009). *Fire service performance measures*. Quincy, MA: Fire Analysis and Research Division, National Fire Protection Association.

Forkuo, E. K., & Quaye-Ballard, J. A. (2013). GIS based fire emergency response system. *International Journal of Remote Sensing and GIS, 2*, 32–40.

Ghana National Fire Service. (2013). Performance audit report of the Auditor-General on the preparedness of Ghana National Fire Service (GNFS). Retrieved from http://www.ghaudit.org/gas/site/reports/download_report/495

Ghana Statistical Service. (2012). *2010 Population & Housing Census*. Summary Report of Final Results.

Kwawukume, V. (2014). 700 Displaced by fire at Konkomba Market. Retrieved from http://www.graphic.com.gh/news/general-news/21362-700-displaced-by-fire-at-konkomba-market.html

Laary, D. (2015). Ghana: Medical supplies estimated at ¢237 million lost to fire. Retrieved from http://www.theafricareport.com/West-Africa/ghana-medical-supplies-estimated-at-c237-million-lost-to-fire.html

Patel, R. B., & Burke, T. F. (2009). Urbanization – An Emerging Humanitarian Disaster. *New England Journal of Medicine, 361*, 741–743.

Storr, V. H. (2008). The market as a social space: On the meaningful extra economic conversations that can occur in markets. *The Review of Austrian Economics, 21*, 135–150.

Zetter, R., & Deikun, G. (2010). Meeting humanitarian challenges in urban areas. *Forced Migration Review, 34*, 5–7.