Traditional Journal of Multidisciplinary Sciences (TJMS)

January-June 2023, Vol. 01, No. 01, [26 –39]

Published: 26th June 2023

https://ojs.traditionaljournaloflaw.com/index.php/TJMS

RESEARCH PAPER

Fire Risk Analysis of Dhaka South City Corporation (DSCC), Bangladesh

Fahim Jaman[1] Farabi Islam Pantha[2] Al Zabir Hasan[3]

[1] *Department of Civil Engineering, University of Asia Pacific, Dhaka, Bangladesh.*
[2.] *Department of Civil Engineering, University of Asia Pacific, Dhaka, Bangladesh.*
[3] *Department of Geography &Environment, Jagannath University, Bangladesh.*
**Corresponding Author* *fahimjaman.info@gmail.com*

ABSTRACT

Bangladesh has discovered numerous deadly hearth occasions that caused number of losses of life, injuries and economic losses. The excessive density of population and systems make the metropolis areas more susceptible to hearth danger. In this context, hearth incidents are very commonplace in Dhaka South metropolis organization (DSCC), especially in enormously densely populated regions. And as impact the vicinity of DSCC has to face a substantial economic loss in addition to fatality. The primary aim of the dissertation is to examine the functionality and ability of the fireplace station with recognize to the location of the DSCC and the modern-day fireplace incidents. There may be additionally a distinction within the use of the infrastructure. To mitigate such fire dangers at community degree, community participation is critical. The principal goals of this check can be based totally on chance of fire hazard in Dhaka South city agency (DSCC) wherein the aim will lead to gain the number one purpose via incredible method inclusive of secondary information, literature assessment and consultation. The information of fire incident was gathered from the relevant manipulate room of fire provider and civil protection from the three hundred and sixty-five days of 2016-2021. Distribution of fire incidents has been analyzed regular with one-of-a-kind land use classes and structure sorts. Assessment has been accomplished on the premise of populace call for and respective land use tendencies. The essential problems related to fire-fighting activities, recognized by the fireplace officials is first off the absence of constant water source to extinguish fire. Slim gets right of entry to avenue of a massive variety of homes is a few different difficult issues for the fireplace staffs. The findings of the research may moreover assist the respective authority to take necessary steps to enhance hearth-preventing facility to make certain higher fire protection.

Keywords: Fire Risk, Dhaka South City Corporation, Fireplace resilience, Firefighting

INTRODUCTION

Among non-herbal catastrophes, fire is a severe threat to urban populations, especially in densely populated areas. In addition to gravely harming houses and infrastructure and slowing down nearby financial activity, it may additionally bring about fatality.

One of the main risks in Bangladesh is hearth, in particular inside the city and business areas. There have been 21,601 hearth incidents recorded in 2021, with estimated losses of 2.183 billion Bangladeshi Taka (BDT), resulting in 219 fatalities and 570 accidents (BFSCD 2021). Every day fireplace incidences are growing in Bangladesh (Fig. 1). In assessment to rural settlements, urban settlements have a higher risk of fire because of higher population density, wealth awareness, and human interest (production, shipping, and provider) (Maniruzzaman and Haque, 2007). The city of Dhaka and its surroundings are where most people of occurrences take location. The 2 foremost reasons of fireplace incidents in Dhaka in addition to in Bangladesh are electrical quick circuits and fireplace from the burner (Islam and Adri, 2008). In step with Alam and Baroi's (2004), over 60% of fire incidents in Dhaka occur among noon and middle of the night, and the dry season (December to March) is the riskiest time of yr (almost two times as many hearth incidents occur at some point of this time than at some stage in the wet season). In Dhaka, neighborhoods with a mix of business and residential makes use of are greater prone to fire incidents. (Rahman and Islam 2019).

Year	Incident	Loss (crore)
2015	17488	856
2016	16858	240
2017	18105	257
2018	19642	385
2019	24074	330
2020	21073	246
2021	21601	218

[Source: BFSCD]

Table: Fire incident and the Economic loss in Bangladesh

Humans have used many strategies to reduce the harmful effects of hearth on human existence safety and property in order to make our network safer from the consequences of fireplace. Those hearth control techniques encompass establishing fireplace safety rules, making sure code compliance, and supplying fireplace protection for society at the legislative stage. They also encompass installing fire safety capabilities in homes to save your hearth ignition, manipulate hearth and smoke spreading, and control people's publicity to fires. Additionally, they encompass presenting fireplace emergency offerings for responding to and rescuing from fires.

Fireplace resilience objectives are to minimize the effects of a fireplace, which include any resulting losses in phrases of lives and money, to the finest volume sensible. Hearth resilience lessens these outcomes and may be regarded as a desire for a selection-maker, together with someone or a regulatory body that is located on the societal stage.

Providing fire protection measures that limit costs and resilience-associated outcomes may be seen on this angle as the answer to a rational selection-making predicament. Moreover, investments in lifestyles protection should no longer be considered in isolation from fire safety however instead extra comprehensively, thinking of a ramification of dangers and elements associated with human existence with the intention of reaching the greatest threat reduction that a society is prepared to pay for.

LITERATURE REVIEW

It has been reviewed to get knowledge of the modern-day kingdom of Bangladesh hearth carrier and Civil protection (BFSCD)-associated papers and moves. Moreover, numerous global norms observed via numerous nations have been examined.

Although the phrase *"fireplace threat"* has been around for a while, the definitions and the volume of the hazard posed by way of an unintended fire range across the literature. John M. Watts and John R. Corridor adhere to the Society of chance analysis's definition of threat inside the SFPE manual of hearth safety Engineering, which states that hazard is the opportunity of unintentional, unfavorable outcomes to human existence, health, belongings, or the environment. The definition of fireplace danger furnished by means of Brian J. Meacham in the equal literature is greater precise and reads as follows: *"hearth hazard can be viewed as the opportunity of an unwanted fireplace risk in an uncertain state of affairs, which might also set off loss or damage to the valued, normally in phrases of life, belongings, enterprise continuity, history, and surroundings, among different things."*

Dobbernack states that in ISO/PDTS 16732 there are two perspectives of fire threat:

(a) chance of a scenario: the chance is the combination of the possibility and the undesirable consequences of that particular situation. (b) threat of a layout alternative: the threat is the combination of the possibilities and effects of all of the scenarios with the layout. Even though the scope and definition of chance may additionally vary inside the literature, there are many key factors in commonplace to these definitions: undesirable bad results and likelihood of occurrence of such activities.

The occurrence of accidental fireplace is a random manner, and plenty of unknowns might motive such injuries. Consistent with Ramachandran (1999), *"The objective of fireplace protection/chance control is therefore to reduce risk to existence and belongings to very low tiers appropriate to a belongings owner and society at big."* He went directly to give an explanation for that chance evaluation, hazard reduction, and threat transfer are the three obligations that make up fire protection management. The method of hazard assessment includes figuring out numerous risk indicators, including the availability of combustibles and estimating how frequently fires originate in precise locations or compartments. Concerns about danger discount revolve across the advent and use of extra techniques to decrease the danger degree to an inexpensive trendy. Sooner or later, threat transfer entails buying the ideal hearth insurance policy and then transferring a portion of the fireplace loss to the coverage issuer.

The superiority of threat in our each day lives has led to an boom in take a look at on the nature of hazard. The Oxford Dictionary's definition of "risk" is "risk, threat of destructive effects, loss, and many others., or publicity to misfortune." The possibility that someone may additionally feel the consequences of danger is a common definition of danger (brief, 1984). Threat is described through the worldwide company for Standardization as the impact of uncertainty on goals, where a result is a departure from expectancies and goals would possibly encompass financial, fitness, protection, and environmental goals (BSI, 2009).

The Worcester Polytechnic Institute inside the america, under the route of Professor R.W. Fitzgerald, is wherein most people of the "building hearth protection Engineering technique" (BFSEM) became created (Wade and Whiting, 1997). A probabilistic risk assessment method is used on this shape of semi-quantitative hearth risk assessment method, however the results aren't taken under consideration. The method is designed to evaluate hearth protection beginning with mounted burning (EB), which includes a fire bursting from a waste paper basket. In terms of numbers, EB is called a fireplace with a flame size of 20kW, or around a 250 mm flame peak. Because many elements may additionally effect the early combustion characteristics of flames under 20kW, it is difficult to forecast their conduct (Fitzgerald, 2004, p. 21). It seems experience that EB will preserve so long as there's enough fuel and enough ventilation.

Threat degrees for a chance with a high frequency of incidence however a low result are corresponding to those for a hazard with a low frequency of occurrence but a excessive outcome. This is a way for standardizing numerous risks in order that they may be contrasted on an equal footing. Selection-making is substantially aided by way of the distinct information that the QRA gives on the character of the chance. Additionally, one of these method takes a complete technique to the examination of each occasion.

The two variables opportunity and effect ought to be recognized for every hazard in any procedure for estimating hearth risk if you want to determine the hearth threat. Three main strategies are used to evaluate the probability and effect of an event: engineering judgment, mathematical modeling, and earlier fireplace records.

Beyond evidence - past fireplace records and information provide a useful point of evaluation for the probability of a fireplace happening in various occupancies in addition to the seriousness of the ensuing results. In fact, that is a *"frequentist"* technique of chance estimate. However, so that it will use the information for risk computation, an in-depth fire information report ought to be furnished. Opposite to the United States, which has a automatic countrywide hearth Incident Reporting system (NFIRS), the local FSD most effective has access to the count number of fires and injuries as well as the categorization of fireplace reasons by way of classes and occupancy. The quantity of the hearth harm or the rooms wherein the hearth began aren't recognized. Which will offer additional hearth information records for future use of the QRA, it is possible that FSD has to in addition optimize the reporting gadget after putting out a hearth.

The eight warning signs linked to the fire supply, fire spreading, and evacuation at some stage in fire events had been used to research the fire hazard state of affairs inside the DSCC vicinity. The findings showed that not one of the structures had hearth hydrants, emergency exits,

or different hearth safety functions. There are many people living there. The majority of the systems lack interstices and are blended use. On the poles, electric cables are strewn round carelessly. The get entry to roads are quite congested. The complete Nimtoli region is still a fire threat problem, in keeping with an analysis of 8 signs. In Nimtoli, 32% of the place is at high chance of hearth, while 45% is at mild risk. The danger of fire in Bangladesh's urban areas can be drastically reduced by using following proper fireplace safety processes and safety inspections, routine maintenance of utility lines, raising residents' attention of hearth risks, efficiently imposing the Bangladesh national constructing Code (BNBC), and regulating buildings with blended makes use of.

Definition of risk

The method of danger evaluation includes identifying severa hazard signs, along with the availability of combustibles and estimating how frequently fires originate in precise locations or booths. Worries about hazard discount revolve around the introduction and use of extra methods to lower the risk stage to an affordable preferred. Sooner or later, chance transfer entails buying the correct fireplace insurance coverage after which moving a portion of the fire loss to the insurance issuer. The superiority of risk in our daily lives has brought about an increase in study on the character of hazard. The Oxford Dictionary's definition of "chance" is *"threat, threat of detrimental outcomes, loss, and so forth., or publicity to misfortune."* The possibility that someone may also sense the effects of risk is a commonplace definition of hazard (short, 1984). Danger is defined via the international organization for Standardization because the effect of uncertainty on dreams, wherein a end result is a departure from expectations and desires would possibly consist of monetary, fitness, protection, and environmental goals (BSI, 2009).

The British standards group (2001) defines hearth threat as the *"product of chance of incidence of a fireplace to be expected in a given technical operation or kingdom in a defined time, and effect or volume of damage to be expected on the occurrence of a fireplace".* Furthermore, the Society of fireplace safety Engineers (SFPE, 2005, 2007) defines "fireplace danger" as the capability for recognition of undesirable, adverse effects, in which fireplace is the risk which could induce the loss or damage to human existence, fitness, property, business continuity, historical past, the surroundings, or some aggregate of those.

RESEARCH METHODOLOGY

All research is conducted using a methodology that consists of several phases, each of which is designed in such a way that it aids the following step in concluding the study.

Therefore, a review of the existing fire risk assessment techniques available to practitioners will come first. The qualitative, semi-quantitative, and quantitative approaches are some examples of popular techniques.

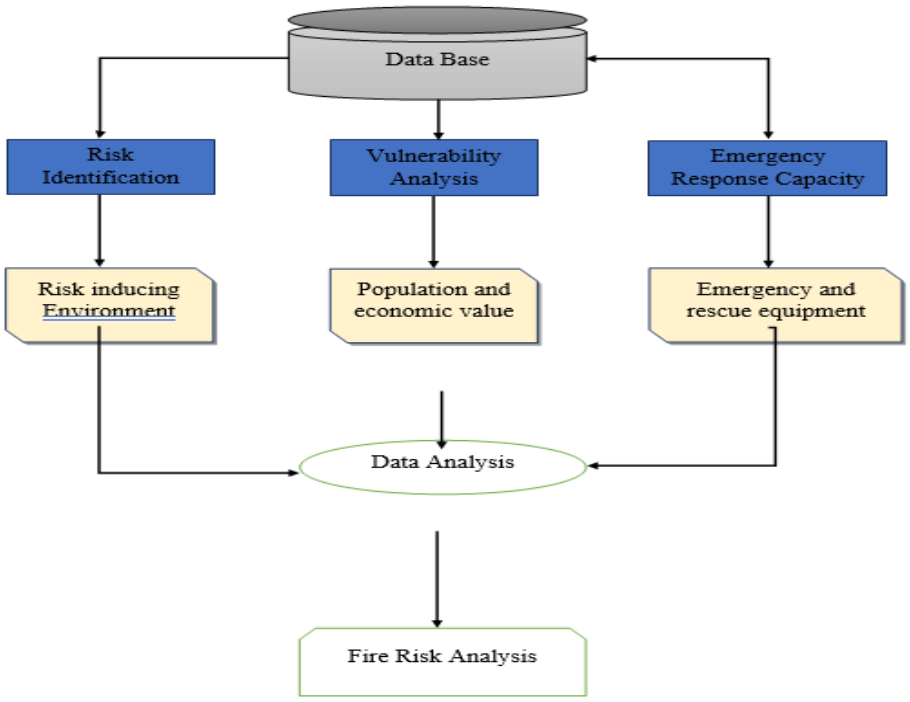
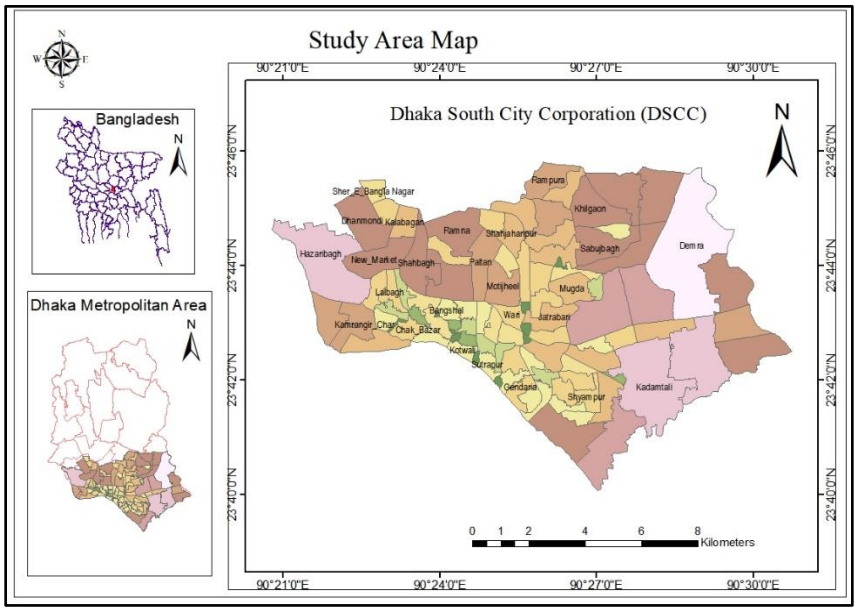


Figure: Methodology.

Dhaka South City Corporation

In the vicinity of latitudes 23°40' and 23°forty five'N and longitudes ninety°20' and 90°30'E lies Dhaka South metropolis corporation (DSCC). In line with the census of 2022, there are round 4,299,345 citizens dwelling in the Dhaka South city business enterprise (DSCC) area, which is made of 23 thanas and covers a place of approximately 109.251 rectangular kilometers.

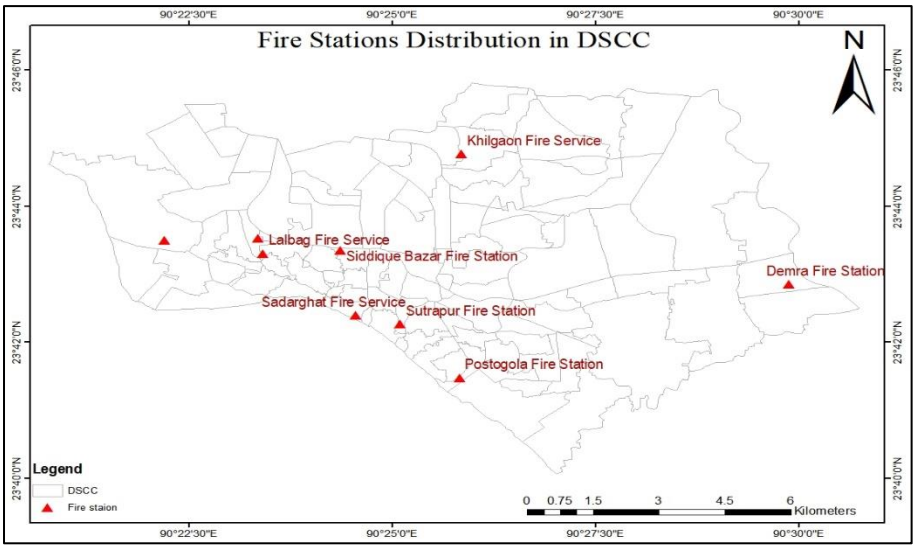


Map: Map of Dhaka South City Corporation (DSCC)

The town of Dhaka has grown in populace, form of systems, transportation offerings, industries, and many others. Due to this urbanization. And all of those occasions have added to the town dangerously near catastrophe. Alongside herbal catastrophes like floods, warm waves, earthquakes, and many others., guy-made risks like site visitors' jams, hearth occurrences, environmental pollution, and so on. Have elevated the vulnerability of city lifestyles. The maximum important of these man-made urban screw ups is the hearth event because it at once outcomes in the lack of lives and property.

Fire Stations in Dhaka South City Corporation (DSCC)

There are 9 fire stations in the area of Dhaka South City Corporation (DSCC) that is not enough to support the vast population of DSCC.



Map: Distribution of Fire Station in DSCC

Sources of fire in the area of DSCC

Within the city of Dhaka, short circuits in electric powered transmitters and wires on the side of the road are usual. Even though the fire that started out in the roadside electric powered infrastructure is normally positioned out earlier than spreading, it occasionally may additionally motive severe harm to the close by systems. Another vital supply of fireplace is a gasoline riser or fuel line leak at the side of the street. And that allows you to save catastrophic damage, the fireplace that began from a fuel supply desires to be managed properly. Of their observe, Alam and Baroi (2004) also found that a giant component (14%) of all occurrences involved fires at gasoline and electric infrastructure.

Fireplace INCIDENT inside the vicinity OF DSCC

The parameters of incident date, reaction time, place, purpose of incident, call of serving station, quantity of loss and recuperation because of incident are always referred to within the document e book of hearth stations. From the fireplace station record ebook, records on fire incidences for the years 2016 to 2021 have been collected, and a radical examine become

conducted. This bankruptcy has focused on the distribution of fireplace activities across numerous land use organizations and building kinds.

Hearth incident in the DSCC according to Land Use variation

The maximum inclined land use kind, in which the public of accidents arise, should first be decided in an effort to assure hearth safety. The locations of hearth occurrences are dispersed during various varieties of land use, and the frequency of incidents additionally varies amongst those types of land use (Haque, 2001). The land use sort of the structure isn't always in particular cited in the log e book of fireplace occasions; handiest the usage of the structure is mentioned. Consistent with the land use form of the detail place Plan (DAP), the shape of the land use kind has been determined from the information gathered on the use of the buildings.

Source of Fire	**Percentage**
Electric line	39.82%
Gas serving line	4.65%
Cigarette	14.78%
Coil/ Candle/Stove	18.52%
Chemical reaction	0.05%
Machine/Wielding	4.37%
Blast (Cylinder/ Boiler)	0.63%
Unknown reason	17.18%
Total	100%

Source: BFSCD, 2022

Table: Source of fire incident in the area of DSCC

Electric short circuits were discovered by Islam and Adri (2008) to be the primary contributor to fire incidents in the city of Dhaka for each year that data was gathered (from 2001 to 2007).

FIRE FIGHTING CAPACITY OF THE FIRE STATIONS OF DSCC

Every station must have a standard fire-fighting capacity to respond to fire situations effectively. This chapter evaluates the combined firefighting capability of the nine DSCC fire stations.

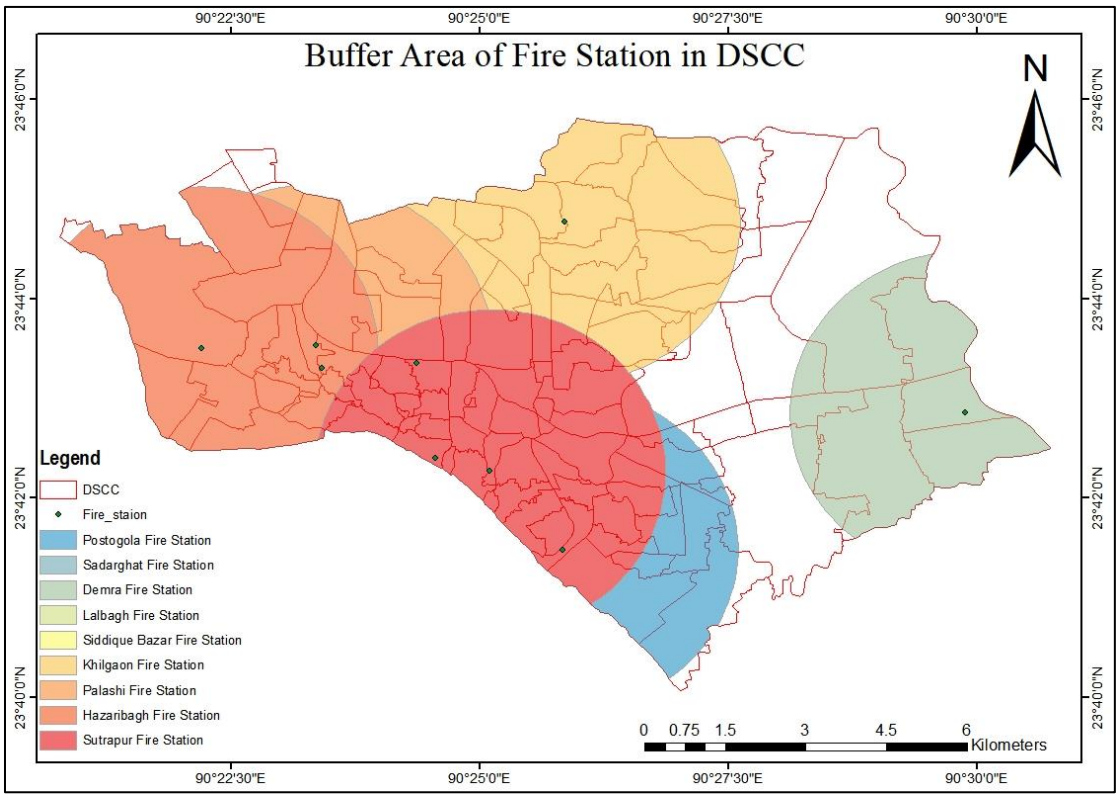
Capacity of Fire stations in the area of DSCC

The capacity to combat any fireplace situation is called having a fire-combating capability. Elements, along with spatial and non-spatial characteristics, can be used to evaluate this ability.

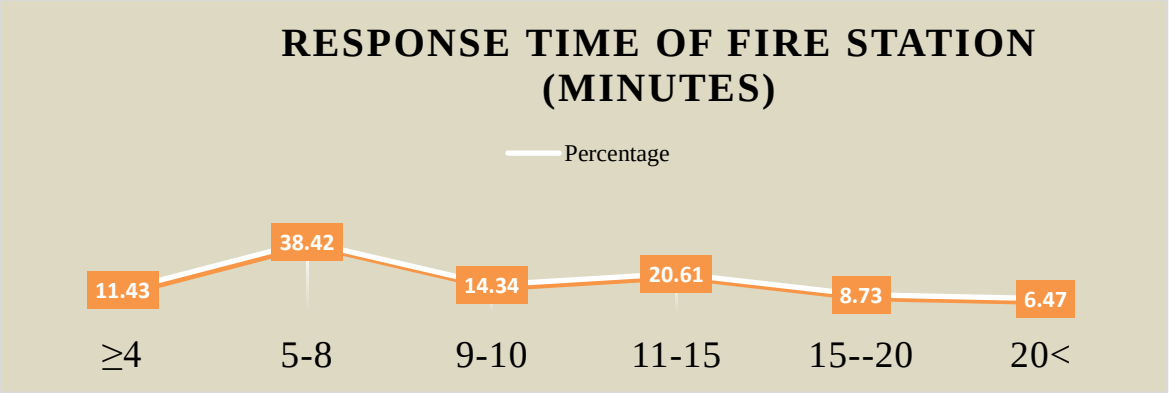
Spatial traits, including the populace serviced, carrier area requirements, and insurance vicinity, are basically related to wherein fire stations are placed. Contrarily, non-spatial characteristics include the capacity of the body of workers and the supply of hearth-preventing cars.

Coverage Area and Population Served

Every hearth station has a certain place beneath BFSCD rules, and it's far the station's responsibility to respond first to any fire occasion interior that vicinity. This area is known as the corresponding fireplace station's insurance location. Whilst the first station is not able to extinguish the fireplace, the close by stations join in to assist with the effort. A complete of 9 fireplace stations in DSCC are in charge of supplying help to the metropolis's four million citizens and a 109 sq. Km. Vicinity. The average insurance location per station is 25.17 square kilometers, and each station serves 4,77,705 human beings. In Bangladesh, there are no policies governing the quantity of the population serviced or the coverage region. As a result, the coverage vicinity and length of the serving populace of these 9 stations vary significantly from one another, as may be visible from the ability facts provided by way of 3 specific hearth stations.



Map: Km buffer area of the Fire Stations in DSCC



Source: BFSCD, 2022

Figure: Response time of fire stations in DSCC

Even though the firefighter response time is only 30 seconds, the crew cannot get at the scene of the event in time mostly owing to severe traffic congestion on their route. The fire authorities at the stations have highlighted this traffic congestion as one of the main challenges to effective firefighting. Only about half of the time, which is the worldwide requirement, could they get to the scene of the event.

Primary Findings and Recommendation

Predominant Findings

In this portion of the file critical findings of the studies have been highlighted. And, on the basis of the major findings, some tips have been given to make certain higher fire protection.

Fireplace Incident in DSCC

Using hearth incident statistics for the years 2011, 2012, and 2013, the distribution pattern of fire occasions inside the DMA has been evaluated. The pattern of fire activities at some stage in this term is as follows:

(a) The residential land use class (36% of all fireplace activities) has the best frequency. (b) In pucca constructions, nearly 60% of the stated occurrences befell. (c) The average financial loss related to fireplace events is BDT 12.79 lac, even as the average loss is BDT 7.60 lac in commercial land use classes. (d) regions with the best fireplace prevalence density (eighty-three to 104 incidents in step with zero.01 sq. Km.) are normally blended-use (38.46%) and business (25.68%) regions.

Fire Station of DSCC

The Bangladesh hearth carrier and Civil protection (BFSCD) now has 9 hearth stations to service the eight.9 million citizens of the 109.251 rectangular kilometer Dhaka South metropolis employer (DSCC) place. These stations' capacity has been as compared to some of worldwide requirements.

(a) The Environmental construction hints for Hyderabad Metropolitan development Authority kingdom that there should be a hearth station or sub-fire station inside a radius of 1 to 3 kilometers for each 2 hundred,000 inhabitants. Consequently, 28.26 sq. Km can be considered as the maximum insurance place (calculated as the size of a circle with a 3 km diameter). Nine fireplace stations inside the DMA have an average coverage region of 25.17 rectangular kilometers, and every station serves a mean of 4, seventy-seven,705 human beings.
(b) In keeping with NFPA and ICMA tips, 2,000 humans must be served for every energetic firefighter. The populace to lively firefighter ratio in DSCC is around 34,250.

Ensuring Water supply

Water is commonly the important thing factor needed to position out a fire. But, in most people of instances, in step with hearth-fighting professionals, a loss of water makes it hard to position out a fire speedy. They start by means of using the water that the water smooth has reserved earlier than searching out any other supply. Maximum regularly, they use water from a close-by WASA water pump or a close-by constructing's water reservoir. This work becomes easier if an adequate water flow may be guaranteed from the construction's production. The Bangladesh country wide constructing Code, 2014 (phase 4.2) states that roof gravity tanks or storage tanks have to be constructed in accordance with the code's necessities for every magnificence of occupancy, and fireplace suppression structures must be immediately connected to tanks if you want to provide the appropriate water float fee. Consequently, the ideal government ought to oversee powerful execution of the code to deliver the vital water tank for each building. Additionally, it will likely be especially efficient at putting out fires in structures where fashionable firefighting automobiles have difficulty coming into.

Proper land use zoning

Land use zoning is vitally crucial for hearth safety. Any constructing in a positive region must constantly maintain its occupancy magnificence. In step with the research, business and mixed-use zones are those that see the best quantity of hearth occasions. The danger of fireplace occurrences should be taken into account while granting acclaim for blended occupancy in this case. In keeping with the rules of the code, risky occupancy (J) is not permitted as a blended or separate occupancy with any other occupancy rating.

CONCLUSION

For the reason that fireplace is the most catastrophic urban disaster and may bring about a full-size lack of life and belongings in a fairly brief time frame, good enough attention has to accept to each location of development that may assist with the carrier. Human beings inside the network are becoming more aware about the causes and results of hearth events in current years. To help firefighting operations, hearth zoning, avenue layout design, and construction should be performed in accordance with requirements. The perfect authorities must make sure that these facilities are often maintained and inspected.

The maximum tough troubles for preventing fires within the present-day situation are the shortage of a strong supply of water and the constrained access to a big range of structures.

Therefore, it's far critical that the structure be built according to standards to ensure that water will waft from it within the occasion of a fireplace. On how to guarantee an herbal water supply inside the area, more look at can be executed. Additionally, thorough planning needs to be executed to location new fire stations whilst taking the need of the populace and the level of fireplace hazard into consideration, similarly to making sure that the modern stations have enough people and motors.

REFERENCES

Alam, M.J.B., and Baroi, G.N., "Fire hazard categorization and risk assessment for Dhaka city in GIS framework", *Journal of civil engineering (IEB)*, vol. 32 (1), pp. 35-45, 2004.

Anderson T., "Kernel density estimation and K-means clustering to profile road accident hotspots", *Accident; Analysis And Prevention*, vol. 41(3), pp. 359-64, June 2009.

BBS. *Population and Housing Census 2011, Community Report: Dhaka.* Bangladesh Bureau of Statistics, Statistics and Informatics Division. Ministry of Planning, Government of Bangladesh, Dhaka, 2011.

Delhi Citizen Handbook, Centre for Civil Society, New Delhi, 2006, Retrieved from ccs.in/sites/all/books/com_books/book_dch_2006.pdf on April 23, 2014.

DTCB, "Preparatory Survey Report on Dhaka Urban Transport Network Development Study (DHUTS) in Bangladesh", Dhaka Transport Coordination Board, Ministry of Communications, Government of The People‟s Republic of Bangladesh, March, 2010.

ESRI, "GIS for Fire Station Locations and Response Protocol", ESRI, 380, New York St., Redlands, USA, January 2007.

FIG, "Rapid Urbanization and Mega Cities: The Need for Spatial Information Management," The International Federation of Surveyors (FIG), Copenhagen, Denmark, January 2010.

FSCD Directorate, "Stakeholder‟s workshop on finalizing strategic management plan," Fire Service and Civil Defense Directorate, Ministry of home affairs, Bangladesh, 2013.

Hacıoğlu Ç., *Spatial requirements of fire stations in urban areas: a case study of Ankara*, M.Sc. thesis in Urban Design, Department of City and Regional Planning, Middle East Technical University, Turkey, 2010.

Haque Q. M. F., *Fire hazard modeling in Dhaka city using GIS*, MURP thesis, Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology, 2001.

Haynes H. J. G. and Stein G. P., "US Fire Department Profile 2013", National Fire

Islam Md. M. and Adri N., "Fire Hazard Management of Dhaka City: Addressing Issues Relating to Institutional Capacity and Public Perception", *Jahangirnagar Planning Review*, Vol. 6, pp. 57-67, June 2008.

Jahan, N., Islam, S., & Hossain md. I., *Developing fire risk index for chemical warehouse of old Dhaka*, BURP thesis, Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology, 2012.

Kent Washington City Center, "Urban Fire", 220 Fourth Avenue South, Kent Washington. Retrieved from kentwa.gov/WorkArea/DownloadAsset.aspx?id=8074 on November, 2015.

Landré M., "GIS in Response Time Analysis" *GIM International, Volume 22, Issue 2*, February 2008. Retrived from www.routeware.dk/download/gim-internationalroutefinder.pdf on February 2013.

Lin Y. P., Chu H. J., Wu C. F., Chang T. K., and Chen C. Y., "Hotspot Analysis of Spatial Environmental Pollutants Using Kernel Density Estimation and Geostatistical Techniques", *Int J Environ Res Public Health,* 8(1), 75–88, January 2011. Retrived from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3037061/ on June, 2015.

Liu N., Huang B., and Chandramouli M., "Optimal Siting of Fire Stations Using GIS and ANT Algorithm", *Journal of Computing in Civil Engineering, ASCE,* Vol. 20, No. 5, pp. 361-369, 2006.

Mahmud A. H., "Revised National Building Code to be Converted into Law", Dhaka tribune, Dhaka, 2014. Retrieved from http://www.dhakatribune.com/bangladesh/ 2014/aug/29/revised-national-building-code-be-converted-law on November 17, 2015.

Mahmud A. R., and Indriasarin V., "Facility Location Models Development To Maximize Total Service Area", *Theoretical and Empirical Researches in Urban Management, Special Number 1S,* April, 2009.

Monday C. C., "Optimal staffing levels for firefighter effectiveness and mitigation of firefighter injuries," An applied research project submitted to the National Fire Academy, Martinsville Fire Department, Martinsville, Virginia, 2000.

Moniruzzaman K.M., and Haque Q.M.F., "Fire Hazard in Dhaka City: A Case Study of the Service Area of Mohammadpur Fire Station", 2013. Retrived from www.bip.org.bd/SharingFiles/journal_book/20130718121437.pdf on March, 2014.

Mornington peninsula fire protection policy, 2014. Retrieved from http://planning schemes.dpcd.vic.gov.au/schemes/morningtonpeninsula/ordinance/22_lpp11_morn.pd f on September 04, 2014.

NDMA, "*National Disaster Management Guidelines—Scaling, Type of Equipment and Training of Fire Services*", National Disaster Management Authority, Government of India, New Delhi, April 2012.

NFPA, *Fire Protection Handbook* (20th edition). Quincy, Massachusetts

NFPA, "About NFPA", Quincy, Massachusetts, USA, Retrived from http://www.nfpa. org/about-nfpa on June 20, 2014.

NFPA, "Document information pages (list of NFPA codes & standards)", Quincy, Massachusetts, USA, Retrived from http://www.nfpa.org/codes-and-standards/ document-information-pages on June 20, 2014.

NFPA, "NFPA Overview", Quincy, Massachusetts, USA, Retrived from http://www.nfpa.org/about-nfpa/nfpa-overview on June 20, 2014.

Parajuli A., Chand D. B., Rayamajhi B., Khanal R., Baral S., Malla Y. and Poudel S., "Spatial And Temporal Distribution of Forest Fires in Nepal", XIV World Forestry Congress, Durban, South Africa, September 2015. Retrieved from www.forestrynepal.org/images/publications/wfc2015_forestfirenepal.pdf on November, 2015.

Patton B., "Volunteer Vision: Obstacles in Maintaining a Volunteer Department", June 06, 2008. Retrieved from http://www.firefightingincanada.com/volunteers/ volunteer-vision-obstacles-in-maintaining-a-volunteer-department-2136 on August, 2015.

Protection Association, Fire Analysis and Research Division, Quincy, MA, November 2014. Retrieved from http://www.nfpa.org/~/media/files/research/nfpa%20reports/ fire%20service%20statistics/osfdprofile.pdf on November, 2015.

Roy, D., Islam, M. S., & Islam M. S., *Analyzing vulnerability of a community of fire hazard:A case study of ward 72*, BURP thesis, Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology, 2008.

S. Mollah and T. Khan, "Nimtoli Fire Tragedy- No lessons learned", The Daily Star, 64-65, Kazi Nazrul Islam Avenue, Dhaka, June, 2013. Retrieved from http://archive.the dailystar.net/beta2/news/no-lessons-learned/ on December 2015.

Sripramai K., Oikawa Y., Kanai M., and Katada T. "The Relationship between Local Government and Residents in Disaster Prevention Activity", (n.d.), Retrieved from dsel.ce.gunma-u.ac.jp/doc/n200.pdf on 13 March, 2014.

Tie-Nan G., "Fire Situation and Development of Fire Safety Science and Technology in China", Fire Safety Science–Proceedings of the Eighth International Symposium, pp. 111-124, International Association For Fire Safety Science, 2005.

TriData, "Oklahoma City Fire Department Fire Station Location Study", TriData, A Division of System Planning Corporation, Arlington, 2006. Retrieved from http://www.okc.gov/fire/fire_report.pdf on April 23, 2014.

UNDESA, "World‟s Population Increasingly Urban with More Than Half Living in Urban Areas", United Nations Department of Economic and Social Affairs, New York, 10 July 2014.

USA: NFPA, 2008. Retrieved from https://www.inkling.com/read/fire-protectionhandbook-2008-edition-volume-ii/chapter-13/responsetravel-time-standards on May 12, 2014.

Wang J. H., Sun J. H., Lo S. M., Gao L.J. and Yuen R.K.K., "Statistical Analysis on the Temporal-spatial Characteristics of Urban Fires under Typical Urbanization Features," Procedia Engineering, vol. 11, pp. 437- 444, December 2011.

Wang Z., Zhang X., and Xu B., "Spatio-Temporal Features of China‟s Urban Fires: An Investigation with Reference to Gross Domestic Product and Humidity", Sustainability, vol. 7, pp. 9734-9752, 2015.

Wikipedia, "Dhaka". Retrived from http://en.wikipedia.org/wiki/Dhaka#Geography_ and_climate on 14 September, 2015

Wing M. G. and Long J., "A 25-Year History of Spatial and Temporal Trends in Wildfire Activity in Oregon and Washington, U.S.A.", *Modern Applied Science*; 9(3), January, 2015. Retrieved from http://ccsenet.org/journal/index.php/mas/article/ viewFile/44150/ 24047 on November, 2015.

Wing M. G. and Tynon J., "Crime Mapping and Spatial Analysis in National Forests", *Journal of Forestry,* vol. 104 (6), pp. 293-298, September 2006.

Zaman A.K.M.H.U., Khan M.T.A., & Islam M.J., "Urbanization in Bangladesh: Present Status and Policy Implications", *ASA University Review*, Vol. 4 No. 2, 2010.