Risk Analysis for Recommendation of an Effective Fire Hazard Management System: A Study in Kolkata Municipal Corporation (KMC) Area, West Bengal, India

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***Abstract* - Urban fire is one of the most common and dangerous man made- hazards often causing massive damages to life and properties; however, can be manageable by taking preventive measures. It occurs frequently, particularly if the urban layouts are unplanned and congested. The study area is historically old, overcrowded and has emerged as an unplanned city due to haphazard growth since its establishment in the colonial era. The urban fire managers responsible for planning and implementation of urban fire prevention strategies usually work upon integration of fire protection systems along with various other aspects such as nature conservation, riparian zone management, preservation of aesthetics and urban heritage sites, etc. In Kolkata, the different land uses form a complex mosaic in the landscape and subsequently create varying degrees of fire hazards in the KMC area, particularly in the high density localities. Fire prone zones of the KMC area have increased dramatically, and data for the last ten years show that a substantial increase of fires which have caused huge loss of properties and a number of lives as well. So, development of a proper fire management system is very essential for the fire hazards of this cityscape. Geomatics, the new technological support of these days, may be immensely beneficial for management of the fire hazards, to a great extent. This paper is an attempt to explore the possibilities of application of Geomatics in fire hazard management in the KMC area.**

Keywards - Urban fire, man-made, hazards, land uses, high-density, fire management system, Geomatics,

I. INTRODUCTION

Fire management certainly demands experts with quick and effective communication skills to handle modern fire extinguishing equipments. Besides, for proper fire management it is very important to have knowledge about the fire history of the very areas. It is basically a record of the fire regime within an area since a useful time period (Delcourt and Delcourt, 1991). The main components of a fire regime include fire frequency, size, duration and intensity. Fire frequency can be defined as the average annual probability of a site being burnt or it is the number of fires that occur within a given time period of the interval between fires. The impacts of fire can range from destroying the local flora, fauna as well as human lives and monetary loss, to instances where fire can pass through an area without having much of an effect, depending on environmental conditions, fuel loading, and fire tolerance of the flora and mobility of the fauna (Larsen, 1997). Although fire hazard is not geographically limited to an area, yet it occurs more frequently in urban areas, where the man-land ratio is usually very high, and the nature of land use land cover (LULC) ,(Anderson et al. 1976, Jensen 2007, Tang, 2012) permits fire to spread quickly, especially in the unplanned towns and cities (Ghosh, 2018).

Fire management is concerned with 3P system. These are: (b) **p**ointing at the exact location where fire event has occurred, (b) **p**ro tection against fire and (c) **p**revention of fire. Pointing of the exact fire location indicates the identification of the fire victim place, and its demands the classification the character of the building, i.e. industry, hospital, school or residential area. Then the next important step is the selection of the shortest route with nearby water sources. Fire protection highlights the identification of the character of the concerned fire. The fire is classified as **A**,

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B, **C**, **D** and **K**, based on type of substances (https://**en.wikipedia.org**/wiki/**Fire_class**). The **A** type of fires involves with ordinary combustibles, such as paper, trash, some plastics, wood etc. The main characteristics of such materials are that they leave an ash after the fire. The **B** type is associated with flammable gas or liquids such as propane, oil and gasoline. The **C** type of fires is involved with electric components, whereas the **D** type concerns with metal, such as aluminum, magnesium, beryllium and sodium. Finally, the K type is involved with vegetable or animal cooking oil/fats (**www.femaliapsaapty.org**).

There is a code name for the use of fire extinguishers. It is called '**PASS**', i.e. P for **P**ull the pin of the extinguishers, **A** is to aim at the base of the fire, **S** is to squeeze the handle and **S** is for sweeping the fire. A fire man should have knowledge about the anatomy of fire extinguishing tools. It contains a metal body, discharge liver, discharge looking pin and seal, carrying handle, discharge hose, data plate, pressure gauge, discharge and discharge orifice. Every fire extinguisher contains a color coded label that indicates the class of fire for which it is meant for. Traditionally, water has been the most common fire extinguishing ingredient. Afterwards it has been used in combination with certain chemicals, but it is not fit for all types of fires. For instance, water is not usable against B, C or K types of fires. CO_2 is also a common fire extinguisher and it is environment friendly as it removes oxygen from the fire. Another important fire extinguisher is dry chemical, called mono ammonium phosphate. This chemical is non-conductive but can be mildly corrosive if moisture is present. Sodium bicarbonate ($NaHCo_3$) is another dry chemical, but effective for B and C fires. Potassium bicarbonate is a dry chemical used in B and C types of fires. The dry chemicals are usually used in laboratories, garages, offices, hospitals, homes, oil companies, etc. Halotron, an improvised variant of halon, may be useful for computer rooms, telecommunication areas, theaters etc. Foam is an important extinguisher which helps to prevent A and B types of fires, mainly used in homes, workshops etc. Type D fires burn at high temperature and because they contain metals, they react violently with water, air and other chemicals. Class D extinguishers contain produced metal, such as copper or sodium, chlorine, and sand. Produced copper extinguishes fires fueled by lithium and lithium alloy metals, while sodium chloride work best for fires involving uranium, powdered aluminum, magnesium, potassium and sodium (Voelkert, 2009). The principal components of an effective fire management system are described below (Fig.1).

Fire Alarm/ Reporting

(Fire brigade office)

↓

Task- I: Identification

1. Identification of location of fire event.
2. Identification of water Body (nearest) as well as land use pattern.
3. Identification of the class of fire (A, B, C, D & K).

↓

Task- II: Selection

1. Selection of the shortest route.
2. Selection of fire engines according to road type.
3. Selection of appropriate fire extinguishers.

Fig. 1: Flow Chart of a Fire Management System

GIS based software applications may serve as a powerful tool for effective fire risk assessment and management. Analysis of the hazard is a complex task as many factors can play important role in the occurrence of the disastrous event. Therefore, the analysis requires a large number of input parameters, and techniques of analysis. The increasingly available RS data and GIS techniques during the last decades has created opportunities for a more

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detailed and rapid analysis of FSM. The proposed research work can be used to create elaborate and effective FSM for the KMC area.

II. The Study Area

The KMC is located at 22^0 $82^/$ N of latitudes and $88^0 20^/$ E of longitudes, and is one of the oldest urban centres developed by the British. The city was not developed in a planned way, so is has a complex city character which has resulted in a number of human and environmental problems including fire hazard (Pal and Ghosh, 2014). It is situated on the left bank of the River Hugli. The study area experiences tropical climate having alternate warm wet summers and cool dry winters.

Kolkata is a pioneering city in India in terms of industrializations, and also one the most important cities of the country to serve the national economy, polity and culture. It is characterized by a large number of migrants perhaps due to communal harmony and political stability (Basu and Sil, 2000). Due to growth of population the land use pattern has been changing with the shrinkage of water bodies to be replaced by the ever increasing residential, commercial as well as industrial and institutional areas. It is very important to have clear knowledge about the physical structure of the city to reach quickly to the fire-affected places. The city of Kolkata may be conveniently divided by into two clear segments: (1) the relatively older parts of the city located in the central and northern parts, and (2) the peripheral built up areas in the east, south and south-western parts. These two areas have different urban characters. The older parts are characterized by poor urban infrastructure, although having close proximity to the CBD. On the other hand, the 'outer crescent of the city', exhibits planned urban development with primarily residential built up areas (Dhar, 2013). It seems difficult for the quickest arrival of the fire fighters at the five affected places in Kolkata because road space is very less in the city, but vehicular density (about 500 vehicles/ km) is very high, which often creates traffic congestion in the major roads (Chakrabarty and De, 2017).

In general, there is an individual fire extinguishing system is almost every apartment, hospital, industry and other installations against small fires at the nascent stage. But, unfortunately there is major infrastructural lacking and communication gap between fire events and their management especially for the large scale fires. In many cases it is noticed that the department of fire and emergency services is not properly informed. Sometimes narrow roads do not permit to enter the big fire engines, and very often fire fighters have to fetch water from distant places.

III. Objectives and Methodology

Literatures of Geography on fire hazards are somehow limited. However, a number of studies, mainly by the scholars of other disciplines, have been done on the hazard and its consequent disasters in the different parts of the world. Melesse et al (2007) have discussed about the remote sensing sensors that can be applied for environmental resources mapping and modelling. Lentile et al (2006) have used remote sensing technique in assessment of fire hazard as an effective technology with the assertion that it has great potential for scientists and managers seeking to map, predict and assess the ecological effects of fire. De Vliegher and Basigos (1995) have prepared fire hazard modelling using remote sensing and GIS with a case study in Greece. Picotte and Robertson (2010) have at attempted to test the accuracy of remote sensing technology in forest fire damages.

The Federal Emergency Management Agency, the USA (1999) has prepared a comprehensive profile of the urban fire problem in the United States of America. Ghosh Dastidar (2012) has discussed in detail the AMRI hospital fire tragedy of December 9, 2011. Paul and Ghosh (2014) have analysed the fire incident of AMRI hospital, which was a very shocking incident for the people of Kolkata.

The main objective of this paper is to produce a proper guideline of fire system management (FSM) for the KMC area. It is important to have easy access to the fire-affected place as soon as possible. A sound knowledge such as, clear idea about the correct location of the place, character of the fire and its distribution, availability of water, accessibility of the victim place, character of road, etc. should be well integrated. All these can be well represented by some accurate maps. A sound data base and pictorial representation of such data under Geomatics can help us to construct a strong infrastructure for the purpose. Secondly,

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it is necessary to acquire a clear knowledge about the modern fire extinguishing equipments and also the capacity to reduce the casualty by quick rescue operation. The present study is an attempt to focus on: (a) the investigation of actual and potential fire hazard prone areas of the KMC, and (b) construction of GIS data base and generation of thematic maps to study the risks and management strategies of the hazard. Thus, the methodology includes: (a) Preparation of fire zoning map of the KMC area based on fire frequency; (b) Identification of the class of fire situated within the fire zone as well as water body; (c) Preparations of road maps according to their width and also produce the alternative road during the traffic congestion, applying different shade of colour. Geospatial analysis techniques are used (Vliegher and Basigos ,1995;Tang, 2012; Raskar-Phule and Choudhury, 2015; Papnoi et al., 2017, Ghosh, 2018) to process the collected data (both spatial and non-spatial) to represent various parameters. Network analysis for FSM has been prepared and a large scale LULC map (Anderson et al. 1976) (Table-1) has been prepared with the help of the base map (R. F. 1: 25 000, NATMO). In this urban fire hazard and risk analysis, however, fire-load of specific industry has not been taken into consideration. Intensive field survey, e.g. per building and per industry, is beyond the purview of this study. The currently available ward wise demographic data have been used for the analysis. Floating population in cities has not been considered for distribution over the land use (built-up area).

Table 1: Remote sensing data products used in the study

Sl. No.	Data Type	Resolution (m)	Source	Year	Data Format	Application
1	LANDSAT- (MSS, TM, ETM+)	15/30	USGS	2016	Raster	Urban LULC Map
2	ASTER	15	USGS	2001-2015	Raster	Preparation of the images
3	IRS- (LISS-III + PAN, LISS-IV, IRS-P5 PAN AFT+ IRS P6 L4MX)	2.5/5.6	USGS	2001-2014	Raster	Identification of the inland water bodies
4	Geo Eye	0.5	Google Earth	2005-2018	Raster/vector	Identification of the location of fire event, networks analysis

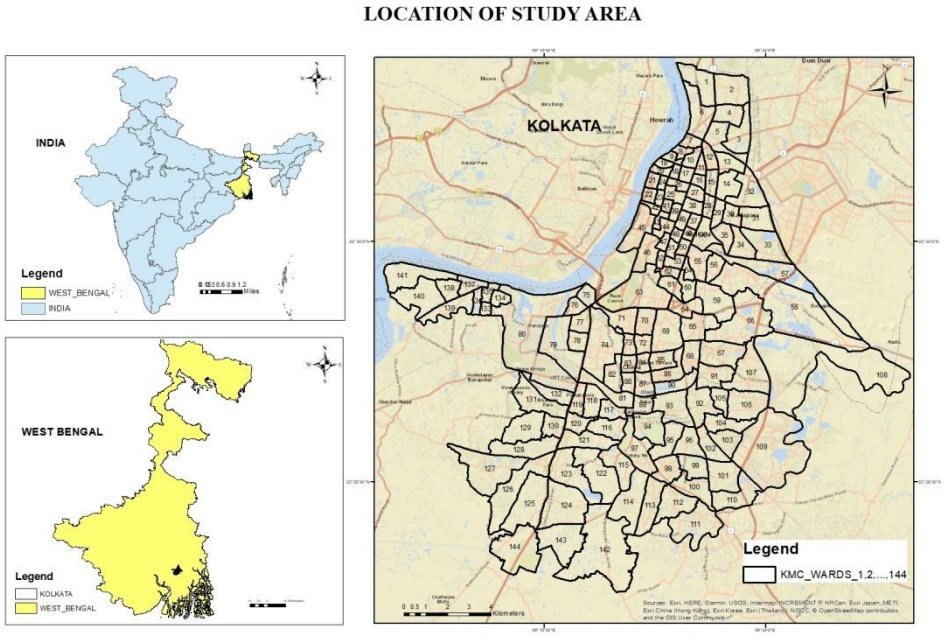

Fig. 2. Location of the Study Area

IV. Analysis and Discussion

A. Fire events in the KMC area during 2006-2018

The fire events during the period of 2006-2018 do not show any specific trend. The maximum number of fires (41) occurred in 2012, whereas the minimum number of fires (1) took place in the previous year, 2011. The frequency trend shows two sets of

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occurrences first (2006-2011), the distribution trend is 22, 16, 23, 14, 3, and 1; and the second data set (2012-2018) shows the trend as 41, 27, 2, 11, 2, 3 and 6. In this series the maximum number of incidents fire was in 2012, and it was followed by the fire frequency of 27 in 2013. The fire events were not evenly distributed in the KMC area during this time period. The most vulnerable was ward no. 32 followed by 34 and 62 (Fig. 3).

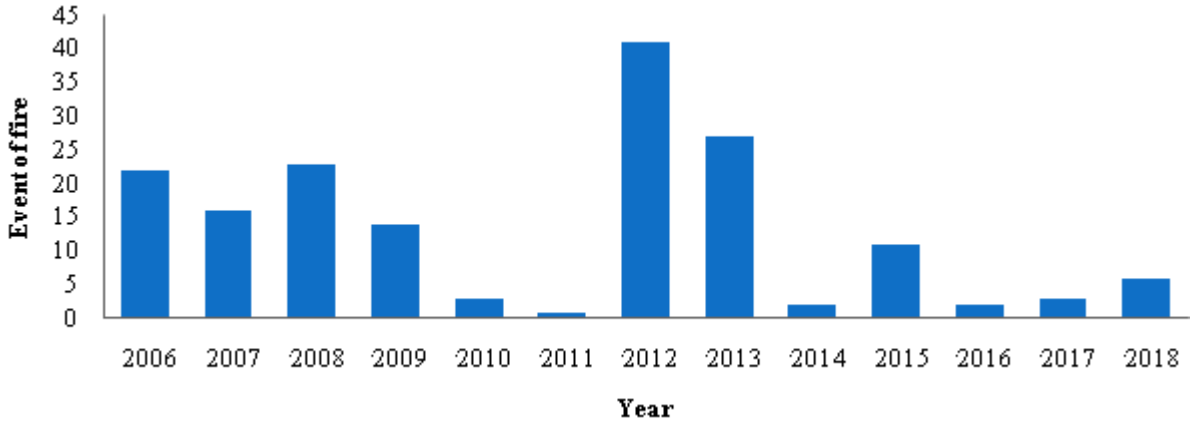

Fig.3: Frequencies of Fire events in the KMC area (2006 to 2018)

It is not very uncommon that there were two fires in the same year, such as in ward no. 32 (2006, 2012), ward no. 61 (2009) and ward no. 62 (2012). There were many wards which experienced only single fire event. The fire events in hospital only were four (2.28% of the total), but it had a great impact on the society. The victim hospitals included SSKM Hospital (in ward no. 93 with A-type fire) in 2012, Amri Hospital (ward no. 66 with A -type fire) in 2011, Chittaranjan Cancer Hospital (ward no. 85, C- type fire) in 2014, and Kolkata Medical Collage and Hospital (ward no. 39, C- type fire) in 2018 (Fig. 4).

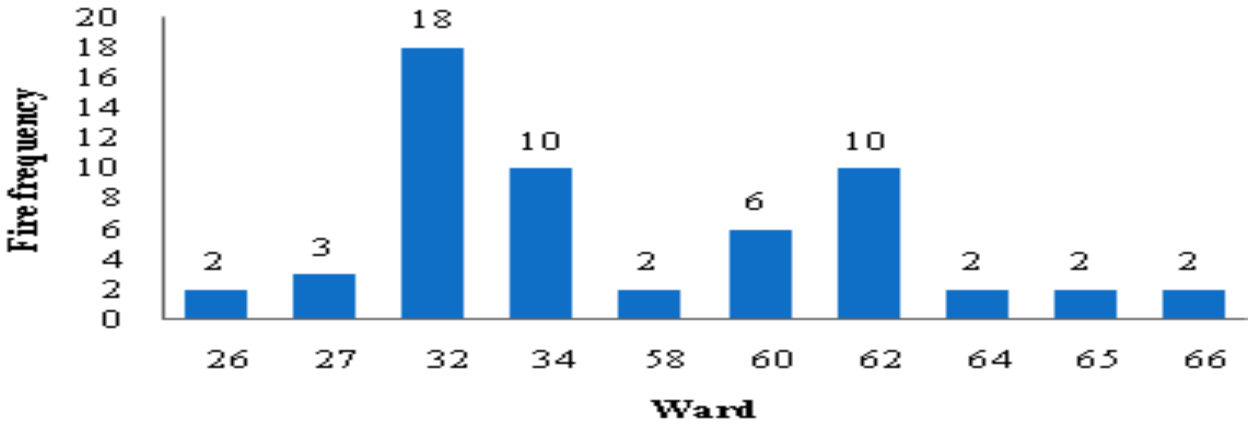

Fig.4: Ward wise Fire Distribution of Fires in the KMC area

From the fire zoning map (Fig.5), we can delineate the fire prone areas of the KMC into four zones, i.e. zone- I: 0 fire, zone- II: 1-4 no. of fires, zone-III: 5-9 no. of fires, zone- IV: 10-14 no. of fires for the time period of 2006-2018. Under the KMC area, 50.69% wards belongs to Zone-1 (0 fire events), which lies mainly in the south and western parts of the city (Table II).

. **Table 2**: Distribution of wards in different fire prone zones

Fire Zones	Ward Numbers of the KMC	Total	In Percent
Zone-I	1,4,5,8,12,14,17,23,24,28,30,36,41,47,48,51,52,68,72,73,74,75,76,77,79,83,84,85,86,87,89,91,93,94,95,96,97,98,99,101,103,104,109,110,111,112,113,114,115,116,117,118,119,120,121,122,123,124,126,127,129,130,132,134,135,139,140,141,142,143,144	73	50.69

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Zone-II	2,3,7,9,10,11,13,15,16,18,19,20,21,25,26,27,29,31,33,35, 37,38,39,40,42,43,44,45,46,50,53,54,55,56,57,58,59,61,63,64,66, 67,69,71,73,78,80,81,82,88,90,92,100,102,105,106,107,108,125, 128,131,136,137,138,	65	45.13
Zone-III	34,60,65	3	2.08
Zone-IV	6,22,32,62	4	2.77

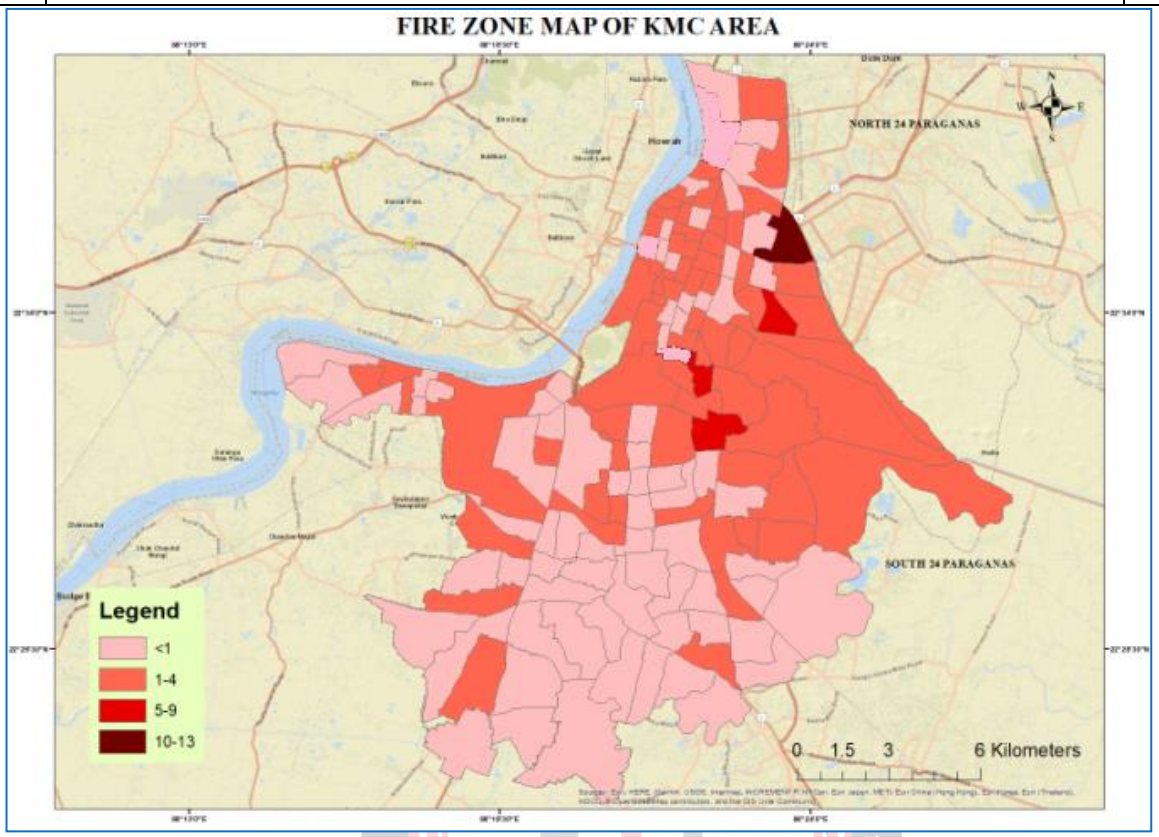

Fig.5: Fire Zone map of KMC

Source: Prepared by the authors

B. Distribution of the types of fires

Correct information about the source and type of fires helps the officials of fire service to get prepare themselves properly. This preparedness would save the valuable time and fulfill the purpose of this emergency service. The maximum fire type found is A**,** followed by C and B in the KMC during the time period of 2006-2018. The total occurrences of A type fires were 79 (i.e. 45.14% of the total), the C type fire were 55 (31.42%) and the B type fire were 31(17.71%). Occurrences of the D type and K type fires were very rare, but not uncommon. Thus, it is clear that, most of the fire events had taken place from common sources such as ordinary combustibles, flammable gas and also form electric components. Notwithstanding the complex character of the KMC area, the D and the K types fires are not very common (1.71%).

(a) Industry and Chemical Hazards

Kolkata and its surroundings have been a hub for traditional industries since long past. The locations of major polluting industries in West Bengal are concentrated mainly in and around Kolkata. The predominant chemical industries around the city are ceramic kiln, boiler, foundry, rolling mills, acid fumes, tannery, etc. Major concentration of industries is in the northern side of the city. There were a total of 46 industrial fires taken place during the above-mentioned period. The total industrial area of the KMC is 3.85% which has been concentrated into fifteen boroughs, surrounded in all sides except the north and northwest. Total numbers of industrial fires in the KMC during 2006- 2018 were 46 (26.28% of the total). Industrial fires mostly occurred in ward no. 32, followed by ward no. 62 (39.04%) and ward nos. 34 (8.69%), 65 (6.52%) 61 (6.52%), 64 (4.34%), 60 (4.34%), and 27 (4.34%).

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(b) Residential area and slum area with map

The city has witnessed 30 residential fires during the above period with the main fire types of A, B, C, and K. The numbers of A type fires were 18, the C type were 10, the B types were 6, and only one K type fire was reported in 2015 at ward no. 54. The total residential area, including slum areas, of the KMC area is 57.76% and there were 30 events of fires that took place in the residential areas. The residential fires (with the share of the total in parenthesis) mostly occurred at ward no. 32 (16.66%), 34 (10%), 35 (6.66%), 62 (6.66%), and 60 (13.33%).

(c) Fire in Hospitals

Within the KMC area there are about 62 well known hospitals where thousands of patients and their companions used to go for treatment. Unfortunately these important places are also not secure in the sense of fire event as the city has experienced different life threatening fire events in hospital during the recent past. Among them four events are significantly memorable as discussed earlier.

(d) Fire in Market Areas and Shopping Complexes

The fires of such type are mostly common in the KMC area, which mostly damage property. The market area and shopping complexes are mostly vulnerable because in market area people are seldom aware about fire-safety process and a market usually maintains the minimum fire safety norms. The important markets in the KMC area are: Sir Gurudas Market (ward no.30), Sir Charles Allen Market (ward no.18), Ultadanga Municipal Market (ward no.13), Manton Super Market (ward no. 130), Bakultala Market (ward no.128), Santoshpur Municipal Market (ward no.106), Ramlal Municipal Market (ward no.106), Kalitala Bansdroni Municipal Market (ward no. 113), Gorba Municipal Market (ward no.59), Jiban Mohan Ghosh (ward no.112), Baba Haat (ward no.138), Jabbar Haat (ward no.138), Binod Chamaria & Brothers (ward no.42), Ganesh Properties Pvt. Ltd. (ward no.43), Bangur Charitable Trust (ward no.43), Kolay Properties Pvt. Ltd. (ward no. 50), Charu market (ward no.89), New market (ward no.46), Gariahat market (ward no.68), Maniktala market (ward no.15), etc.

The fire types in the market area and shopping complexes are A, B, C and D. The total number of A type fire is 43 (58.90%), B (23, 31.5%), C (6, 8.21%) and D (1, 1.36%) during 2006-2018. A clear idea about this type of fires has been gathered (Fig.6) through intensive field work during this time period.

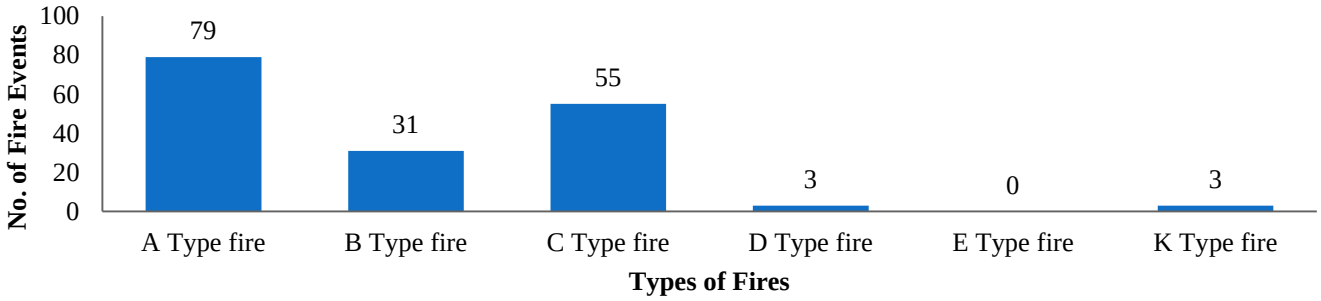

Fig.6: Different types of fires in KMC market and shopping complex areas

V. FIRE MANAGEMENT

A. Preparedness and quick response

Planning is one of the most efficient tools to deal with disasters. The quick response indicates the two steps methods to include the identification of the vulnerable area and the response to it. A disaster preparedness plan should be clear, realistic, flexible, and easy to use and it must be covered every stage of disaster management cycle (Joshi and Joshi, 2005). Identification of vulnerable area and section of appropriate measures should be the first steps of disaster preparedness.

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Identification of the fire victim place can be done through GPS and DGPS. The response to fire disaster demands a quick rescue operation as soon as possible. And time is a very important factor to control the fire impact. So the duration of the gap between a fire event and its rescue operation is very crucial. Moreover, the response to fire disaster is a systematic damage assessment process, to restore the utilities.

B. Preparation of the Route Map

An attempted has been taken to find out the shortest route between the fire victim wards and its nearest fire stations. Beside this, during the office time a number of alternative routes have been proposed to reach the fire-affected wards to avoid road congestion. There are four wards, which have been identified for their highest fire occurrence or frequencies (fr) i.e. ward no 32 (fr 18), 34 (fr 10), 62 (fr 10), 60 (fr 6) and other minor fire prone wards e.g. 27 (fr 3), 64, 65, 66 and 26 (fr 2).The most vulnerable wards are 32, 34 and 62.

Flow chart from fire station to ward no.32 and 34: The nearest fire station of these two wards is Maniktala Fire station (Ward no. 31/1).These two wards are situated within the 2km buffer zone of this fire station. The shortest route direction between Maniktala fire station and ward no. 32 is given below (Fig. 7 a).

Maniktala Fire Station → CIT Road (w: 15m) → ward no. 32

In the case of traffic jam of shortest route, the alternative route between Maniktala fire station and ward no. 32 is (Fig. 7 a)

Maniktala Fire Station → Maulana Abul Kalam Azad Road → EM Bypass → Maniktala main Road → CIT Road ward no. 32→

The shortest route direction between Maniktala fire station and ward no. 34 is (Fig. 7 .b).

Maniktala Fire Station → CIT Road → Hem Chandra Naskar Road → wards no. 34

The alternative route/ routes between Maniktala fire station and ward no. 34 is (Fig. 7 .b)

a. Maniktala Fire Station → CIT Road →Narkeldangha Road → Kavi Sukanta Sarani →Dr Suresh Chandra Bannerjee Road ward no. 34.→

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b. Maniktala Fire Station Hemchandra naskar Road Dr Suresh Chandra Bannerjee Road ward no. 34.

Fig. 7 (a) Fig.7. (b)

Source: Prepared by the authors.

Fig. 7 (a, b): Shortest and alternative routes for fire rescue operation to ward no. 32 and 34.

Flow chart from nearest fire station to ward no. 60 and 62

Another fire vulnerability area is belonged to the ward no 60 and 62. The nearest fire station of this fire prone area is the head quarter of fire office of KMC, which is situated in ward no. 52(1). The shortest route between the fire station and ward no. 60 (1 & 2) is as follows (Fig. 8):

Head Quarter (52/1) → Mirza Galib Street (Width 14m) → Park Street (width 15m) → Ward no. 60 /1 (total 2.3Km).

But in this journey there are five crossings throughout the road, i.e. Park St. + Mirza Galib St., Martin Luther King Sarani + Wellessly St. + Park St., London St. + Park St., Park St. + AJC Bose St. and Mrigendralal Mitter Road + Park St. So, it is very difficult to reach the fire victim place during the office time avoiding the road congestion of these crossings. Therefore, the proposed substitute alternative route is as follows (Fig.8):

Head quarter → Alimuddin St. → AJC Bose Road → Park St. → Ward 60(1)

The shortest route between the fire station and ward no 60 (2) is given below (Fig.8):

Head quarter → Mirza Galib St. → Alimuddin St. → AJC Bose Road → Baniapukur St. → Giris Chandra Bose St. Hore Krishna Koner Road Ward 60(2) (Total 2.29Km).

The alternative road is (Fig.8):

Head quarter → Mirza Galib St. → Ripon St. → AJC Bose Road → Baniapukur St. → Ward 60 (2) (Fig. 8)

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The shortest route direction between the fire station and ward no 60 (2) is (Fig.8):

Head quarter → Mirza Galib St. → Marquis St. → Ward 62(1)

Head quarter → Mirza Galib St. → Marquis St. → Alimuddin St. → Ward 62(2)

The alternative road is, (Fig.8):

Head quarter → S. N. Bannerjee Road → Rafi Ahamed Kidoi Road → Ward 62(1)

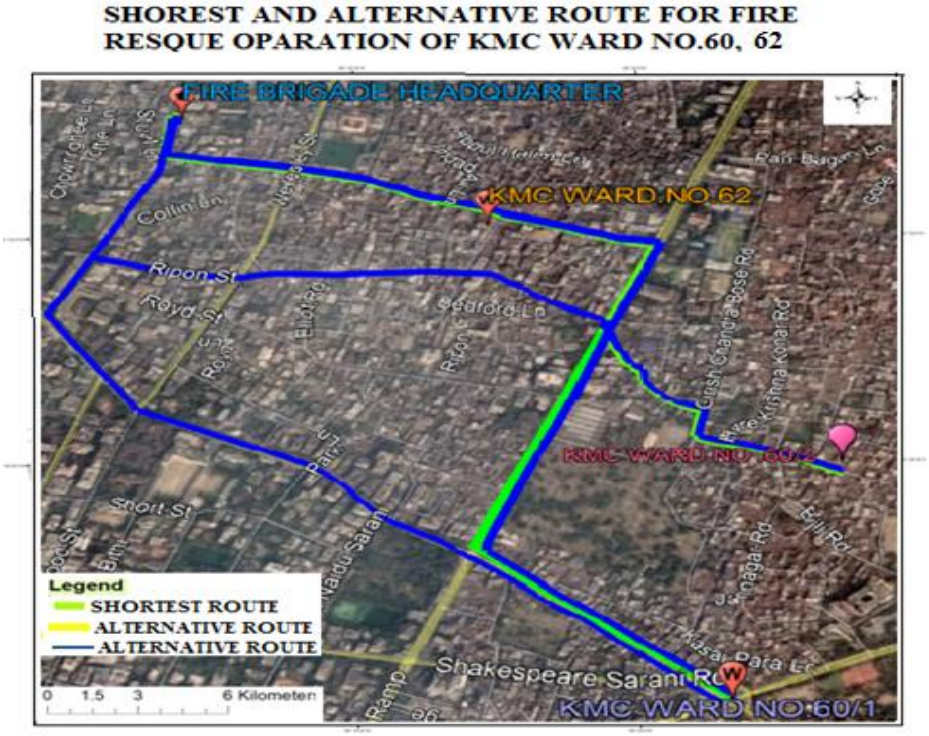

Fig.8: The shortest and alternative routes for fire rescue operation to ward no. 60 and 62. Source: Prepared by the authors.

C. Selection of the appropriate fire engines

The selection of fire engine for the fire event is an important task. The layout of road is an important factor for the quick rescue operation. If the selected fire engine is too big for the selected road it can be easily operative. The appropriate fire engine to be selected according to the road width is presented below (Table III).

Table 3: Selection of fire engine for the KMC area

Ward no.	Name of the road	Width of the road in m	Fire fighting vehicles and accessories to be selected
32	CIT road	**27.32**	Mini Bus, Mounted Pump, Mid Size Water Tender, Mini Water Tender, Water Browser. Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, R.J. Van, T.T.L & Boronto, Emergency Tender, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
	Maniktala Main road	**19.63**	Mini Bus Mounted Pump, Mid Size Water Tender, Mini Water Tender, Water Browser, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, T.T.L & Boronto, Emergency Tender, Regular/CD Jeep Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
	Maulana Aul Kalam Azad road	**14.36**	Mini Bus, Mounted Pump, Mid Size Water Tender, Mini Water Tender, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, R.J. Van, T.T.L & Boronto, Emergency Tender, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
	EM Bypass	**30.36**	Mini Bus, Mid Size Water Tender, Mini Water Tender, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, FCT, JMP, R.J.

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			Van, T.T.L & Boronto, Emergency Tender, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
34	CIT road	**16.25**	Mini Water Tender, Water Browser, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, T.T.L & Boronto, Emergency Tender, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
	Hemchandra Naskar road	**15.78**	Mini Bus, Mounted Pump, Mid Size Water Tender, Mini Water Tender, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, R.J. Van, Emergency Tender, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1, HRU,HP2,FCC1
	Kavi sukanta Sarani	**6.3**	Mini Water Tender, Bullet & Two Wheeler, Utility Vehicles, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
	Dr Suresh Chandra Bannerjee	**12.01**	Mini Bus, Mounted Pump, Mid Size Water Tender, Mini Water Tender, Water Browser, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
60	Mirza Galib St.	**14.03**	Mini Bus, Mounted Pump, Mid Size Water Tender, Mini Water Tender, Water Browser, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, R.J. Van, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
	Park St.	**10.39**	Mini Water Tender ,Mini Bus, Mounted Pump, Mid Size Water Tender, Water Browser, Water Carrier, B JMP Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
	Baneapukur St.	**4.97**	Mini Water Tender, Bullet & Two Wheeler, Utility Vehicles, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
	Giris Chandra Bose St.	**5.77**	Mini Water Tender, Bullet & Two Wheeler, Utility Vehicles, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
	Hara Krishna Kunar St.	**4.85**	Mini Water Tender, Bullet & Two Wheeler, Utility Vehicles, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
	Alimuddin St.	**7.05**	Mini Water Tender, Bullet & Two Wheeler, Utility Vehicles, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
	AJC Bose road	**22.04**	Mini Bus, Mounted Pump, Mid Size Water Tender, Water Browser, Water Carrier, Bullet R.J. Van & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, T.T.L & Boronto, Emergency Tender, Regular/CD Jeep, Towing vehicles Ambulance, Staff Car, HRU,HP2,FCC1
62	Mirza Galib St.	**14.03**	Mini Bus, Water Browser, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, R.J. Van, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles, HRU,HP2,FCC1
	Alimuddin St.	**7.05**	Mini Water Tender, Bullet & Two Wheeler, Utility Vehicles, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
	Park St.	**10.39**	Mini Water Tender, Water Browser, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, Regular/CD Jeep, Ambulance, Staff Car, Towing vehicles
	Marquas St.	**8.3**	Mini Water Tender, Water Browser, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, Regular/CD Jeep Towing vehicles
	SN Bannerjee road	**12.01**	Mini Bus, Mounted Pump, Mid Size Water Tender, Mini Water Tender, Water Browser, Water Carrier, Bullet & Two Wheeler, Utility Vehicles, MPFT, FCT, JMP, R.J. Van, Regular/CD Jeep, Towing vehicles, HRU,HP2,FCC1
	Rafik Ahamed Kidoi road	**6.73**	Mini Water Tender, Bullet & Two Wheeler, Utility Vehicles, Towing vehicles

Source: Compiled and prepared by the authors

D. The sources of water

Fire history of the KMC area reveals that most of the fires are A type (fr 79 or 45%), C (fr 55 or 31%) and B (fr 31 or 17%). So, water was the main extinguisher of those fires. Therefore, the location map of water point or water sources is very important as the firemen can locate the nearest water body (Fig. 9) during the fire at any ward.

E. Selection of the appropriate fire extinguishing materials

Selection and application of the fire extinguishing materials are the sole subject matter of the officials of fire service. Selection of these tools would depend on the information about the character of the fire (i.e. A, B, C, D and K). The techniques of the use of fire extinguishing tools depend on the character and extent of the fire. Above all the spot decisions play a vital role for the selection of the fire extinguishing tools (i.e. width and reach of water tender, water carriers, hose pipes, etc.).

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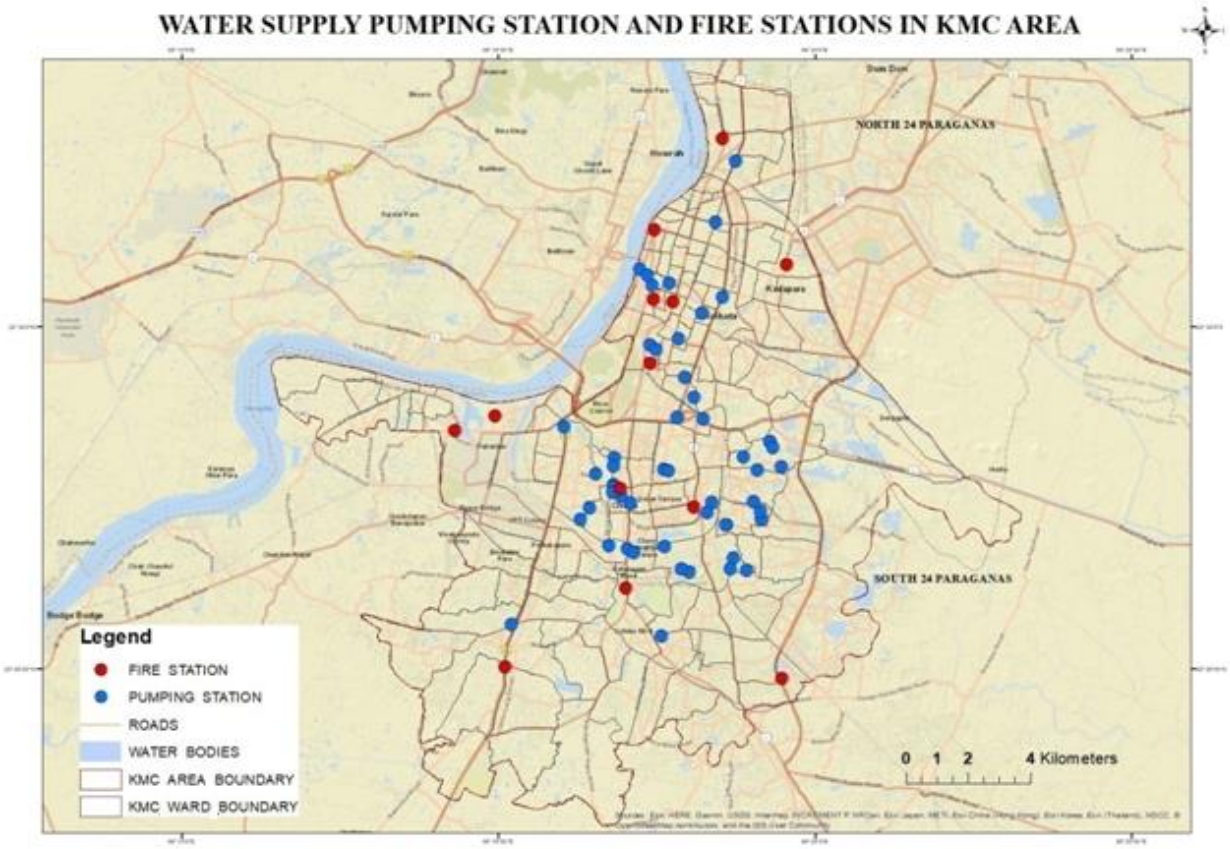

Fig.9. Location of the major water body

Source: Prepared by the authors

VI. FINDINGS AND SUGGESTIONS

The main findings of the present study are as follows:

1. Fire prone areas (F.F: 1-4/y to 10-13/y) are concentrated in the central, north, east and western part of KMC whereas fire stations are mostly located in these regions.

Justifications:

a. Concentration of market areas (having weak or inactive fire preventing system)
b. Location of CBD
c. Narrow and congested transport system.
d. Lack of protective electric system in market area.
e. Human ignorance about fire management systems.
f. Presence of slum areas etc.
g. Old, unplanned city layout.

2. Lass fire porn areas (F.F:0/y)is concentrated in south and western part of kmc area and a few fire stations are located in this area.

Justifications:

a. This area is comparatively new therefore planed region.
b. most of the buildings, complex, institutions follow the fire-safty noems.
c. roads are wide and comparatively less congested.

The present article proposed the following sugessitions for the fire management of KMC area,

1. Awareness generation, Training and Capacity building of people at all levels (from administration to grass root level)

a. Awareness program
b. Preparedness and Response
c. Training and Capacity Building
d. Techno Legal Regime

***2.* Strengthening and improvement of existing infrastructure**

a. water supply b. Roads and Transportation *c. H*ealth Services

3. Ensuring Stricter Enforcement of Relevant Rules & Regulations

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a. Shifting of storages and hazardous units from residential areas

b. Communication and Public Information Systems

c. Implementation of KMC Building Rules

d. Control of Spread of Slums and Informal Squatter Settlements

4. An effective Information Dissemination System:

5. Standard Operating Procedure of KMC

6. The field level operational functions of KMC Control Room and its Departments.

VII. CONCLUSIONS

This study indicates that the ordinary fire events (A and B type fire) are more frequent than the special category one (C or D type fire). Along with the fire classification we have also pointed out the water sources through relevant map. Then the important task is to indicate the shortest route from the nearest fire station to the fire-affected place, and if there is traffic jam during the fire, we have also indicated the alternative routes. Besides, we have suggested the suitable fire engines according to the width of the suggested roads to overcome the unnecessary delay. Finally, it is the time for the selection of the suitable fire extinguisher for the very fire.

The present research has tried to critically investigate the nature of fire hazard in Kolkata Municipal Corporation (KMC) area including its geographical and seasonal distribution, frequencies and magnitude, its risk factors, identification of problems and their control. This article will provide the guide lines for future activities towards fire management other megacity as well as Kolkata Municipal Corporation.

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