

Pyro-geographic Management of Flammable Kolkata City, at Risk(2006– 2023)

ABSTRACT

The present search has focussed on fostering current incidents, analysing challenges the Kolkata fire victims face, and enhancing preparedness for such hazards in the last decade. This paper guides the firefighter to better manage the fire system (F.S.M.) in Greater Kolkata. The 202 fire events from the previous two decades have been analysed in Kolkata.

The methodologies involved are collecting secondary data for 2006-2024 from print and electronic media, making time series, and applying statistical methods using EXCEL and S.P.S.S. packages. The demographic study, including hazard, vulnerability, risk, and criticality assessment (H.V.R.C.A.), is a part of the investigation. G.I.S./Rs with Erdas software is used to picture figures after data acquisition, georeferencing, image processing, and ~~digitalisation~~ digitalization.

The risk zones are the north and south of Kolkata, including central Kolkata. Discussions focus on enhancing building houses with West Bengal municipal rules and firefighting laws of National Disaster Management Agencies, including updating and well maintaining the equipment and fire tender skills. Suggestions for updating the fire services in Kolkata city are the focus of the arena to satisfy Sustainable Development Goals-2030, such as S.D.G. 9, S.D.G. 11, and S.D.G. 12 indirectly.

Key Words: Fire, wildland-urban Interface, H.V.R.C.A., Municipal, Disaster, Kolkata

Introduction:

Pyne coined the phylogeography in the mid-1990s, which is the science of ~~Fire~~ fire, in the past, present, and future fires, that combines geography and fire ecology and also considers the physical environment, human cultures, and societies, [Pynes et al., 1997^{\[1\]}](#), [Krawchuk et al., 2009^{\[2\]}](#), [Pyne et al., 2009^{\[3\]}](#), [Mishra et al. 2021^{\[4\]}](#), [Rooset al., 2023^{\[5\]}](#). The Fire was with the Earth since its inception, $4.54 \pm .005$ billion years ago (B.Y.A.), from the Sun (Hindu cosmology 4.32 BYA with Brahma and Kalpa). The genetic ancestors of humans, Homo erectus, are thought to have discovered wildfire and tamed around two million years ago. Evidence/proxies from phylogeography revealed that our ancestors, the Homo erectus, tamed ~~Fire~~ fire ≈ 200 mya for heat, light, hunting, cooking, making tools, and driving away wild animals, [Bowman et al., 2009^{\[6\]}](#), [Zhong et al., 2013^{\[7\]}](#), [Gowlett J.A.J. 2016^{\[8\]}](#), [Rooset al., 2023^{\[5\]}](#). As Homo erectus controlled and used Fire long before modern humans grew, it was tough to regulate the ~~Fire~~ fire used by the Homosapiens; no definite record of history is available ([Nicholas et al., 2023](#)).

Fire on the globe, **famous as wildland-urban** Interface (WUI), dates back to when hominids tamed natural Fire two Mya. The Fire is either natural or anthropogenic. The history of natural Fire proxied on Earth from the late Silurian Period, around 420 million

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years ago (mya) Kobazir et al., 2014^[9] Copernicus. 2023^[10], Editor Nat. plants 2024^[11]. People around the globe have experienced apocalyptic consequences of the ferocity of fire hazards in the past (Gonzalez et al. 2024^[12], Hoslanski D 2024^[13]).

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The present challenges of Fire in India are apocalyptic. The recurrent incidents pose significant threats to both life and property. Natural, climatic, or anthropogenic causes of fire. India is fire-prone due to lightning, extreme heat, short electrical circuits, and slums in urban areas (Mishra S.P. 2023^[14]). In the 2017 Risk Survey, India ranked third, whereas it was fifth in 2015 (<https://ficci.in/public/storage/SEDocument/20416/India-Risk-Survey-2017-Report.pdf>).

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Kolkata is a city for the millionaires and paupers. However, after 1947 (India's partition), the influx of massive refugees and migration from neighbouring states for livelihood contributed to the growth of many slums and refugee colonies along with the city's agglomeration. More people stay in compact shanty houses, which invites fire hazards. The city is susceptible to fire due to illegal hoarding/careless handling of combustible materials.

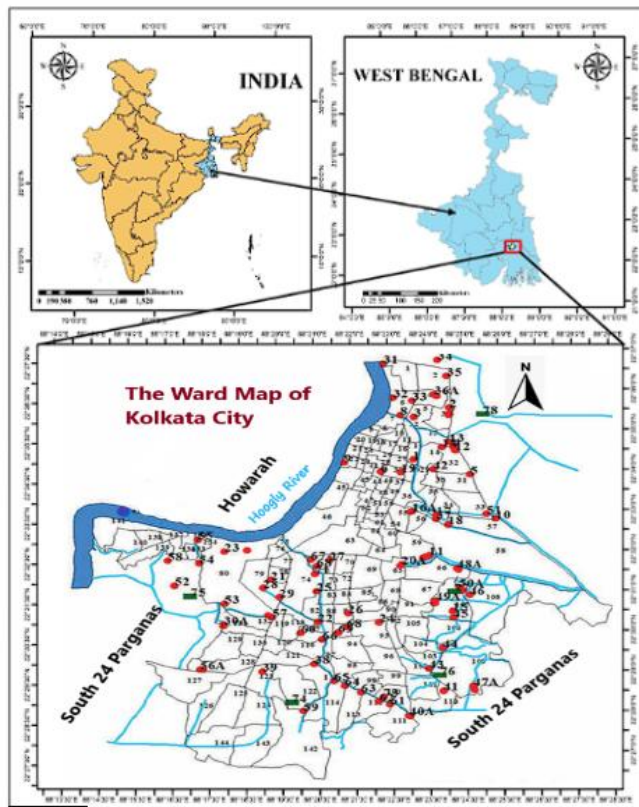


Fig 1: The index map showing wards of the Kolkata city

The people in the city lack fire safety precautions, and there are more people in less space (slum dwellers) and old structures. Inadequate fire fighting stations and high-traffic roads. The

application of geomatics can be effective management of fire hazards(Ghosh et al., 2021^[15]) (Fig 1~~7~~₂).

The number of blazes is because the underprivileged city infrastructure is close to the central business district (CBD), with immediate access to the vulnerable among heavy traffic; there is a lack of communication, improper management, and ignorance of fire handling (Dhar, 2013)^[16], Ghosh, 2018^[17].

Study area:

The greater Kolkata (22° 28 N to 22° 58 N lat and 88° 10 to E 88° 27 E, Long)houses in the eastern part of West Bengal, India, along both banks of the Hooghly River. Most of the area belongs to the reclaimed wetlands of the bird-footed delta of the Ganga River. The projected population of the greater Kolkata is 15.57 million, accommodated in 188 km². In 2012, The Kolkata Metropolitan Development Authority (K.M.D.A.) projected that 3.82 million people registered slum dwellers in 25,000 sq. meters and 3,500 unregistered slums in Kolkata. The slums are localised/localized in boroughs 7 and 8, in the core city, including Kiddirpur, Tollygung Lake Gardens, Kalikapur area, Kasba Canal side, Anandapur area, Ballygauge, and Bosepukur, etc.

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Review of literature

Fire is the exothermic reaction that burns materials based on the quantity of available Oxygen, fuel, and heat, and phylogeography is the science of Fire (Gowlett, 2016^[8]; Roos et al., 2014^[5]; Mc.Granahan et al., 2024^[18]). The modern flammable landscapes threaten urban dwellers' homes, lives, and livelihoods and are known as the wildland-urban interface (WUI).

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Urban fires involve buildings or structures in urban areas that propagate to nearby mansions and settlements. The causes of wild urban fires in cities and Cosmopolis are anthropogenic, technical triggers (e.g., overloading or sparks), and natural (lightning or frictional). At times, volcanic eruptions include lava flows, pyroclastic density currents, tephra, and ground shaking (Baxter et al., 2005^[19]; ISO, 2020^[20]). The cataclysm caused by city fires invites massive fatalities to urban poor (95% of deaths globally (about 180,000 to 300,000 people/year) and excluding injury to 10 million D.A.L.Y. (Disability-Adjusted Life Years lost/ year). Generally, low- and middle-income households are the worst sufferers (Mock et al., 2008^[21]; WHO, 2018^[22]). The utmost risk goes to the vulnerable, handicapped, disabled and careless youths (UN DRR, 2015^[23]; Rush et al., 2020^[24]). Resilience describes risk factors such as acceptance, results, reduction, and early recovery of risks due to fire hazards (Banerjee A., 2022^[25]).

Cities that suffered cases of Repeated Fire Outbreaks were Amsterdam (1421 and 1452), Copenhagen (1728 and 1795); Moscow (4 times between 1547-1812), New York City (1776 and 1835), New Orleans (1788 and 1794), London (more than six times during 1130-1666, 1794, 1861 and 1940). WUI impact posed a more significant threat with agglomeration in habitation and people living in cities. Satellite imagery studies have inferred that WUI blazes have decreased worldwide by 10% and burned areas by ≈22%. However, fires in WUI have

surged $\approx 23\%$ areawisefrom 2005 to 2020, per the U.S. National Science Foundation National Center for Atmospheric Research (NSF NCAR). [\(Wang Lo 2011^{\[26\]},\(Mishra SP, 2021^{\[28\]}, Tang W., 2024^{\[27\]}, <https://www.sciencedaily.com/releases/2024/04/240416214219.htm>\).](https://www.sciencedaily.com/releases/2024/04/240416214219.htm)

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India leads the Countriesin fire-related deaths, followed by China(about two times), which ranked second in population as per WHO 2019 based on C.I.T.F. data. Cell phone fires are a serious safety hazard that can cause significant damage to property and even loss of life. According to the National Fire Protection Association, approximately 24% of cell phone fires cause burnsby improper charging or incompatible chargers.As per the National Science Foundation National Center for Atmospheric Research (NSF NCAR), fires worldwide have declined, but WUI areas increased by about 23% from 2005 to 2020 (Hosanski 2024^[14]).

Aim of Study

The objectives of the present investigation are:

- a. To conduct Hazard Vulnerability Risk and Capacity Assessment (H.V.R.C.A.) studies about Fire in Greater Kolkata.
- b. To assess whether the slums, marketplaces, industrial areas and Hospitals are major epicentres for a fire break.
- c. Optimize and preplan the shortest and substitute routes for prompt service.

Comment [A11]: It was not clear from the article how the vulnerability risk assessment was conducted. What methods were used. What was the basis used to define low or high level of vulnerability and what data was used.It is interesting to detail in the methodology which methods and data were used for this assessment.

Methods and methodologies:

The Kolkata cosmopolis has identified 490 pockets of Fire in Greater Kolkata, refilled by about 750 deep tube wells in the city along with shallow wells and water bodies. It is time to locate the strategic points and optimiseoptimize the routes so fire tenders can provide prompt service and save lives and properties (Census of India, 2011^[29];Roy et al., 2022^[30]) Fig 2(a).

Comment [A12]: It is interesting to detail in the methodology which methods and data were used for this assessment.

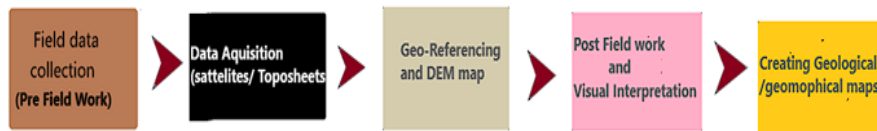


Fig 2(a):Methodology for preparation of maps for G.I.S. study of the Greater Kolkata area

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The various grades of Fire are representedbelow

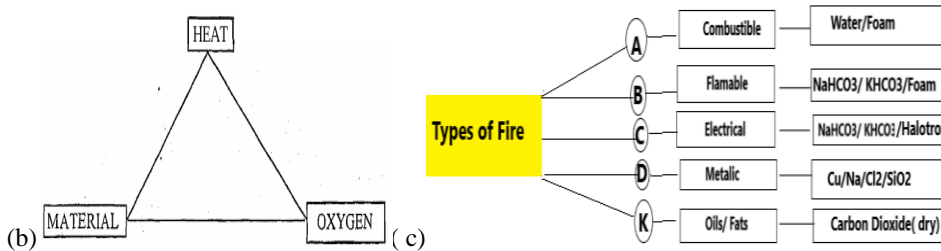


Fig 2: (b) The various grades of Fire and(c) types of Fire with their extinguishing elements

The above classification is reorientated as per Indian standards (IS 15683: 2018) is Class A: combustibles (ordinary); Class B: Flammable (liquids); Class C: Flammable (gases); Class D: Combustible (metals) and Class F: Fires from Cooking Oil and fats). After the COVID-19 pandemic, Fire is compartmentalised as A,B,C,D, and K, as given in Fig 2(b and c).

The Fire in Wildland Urban Interface (WUI) is classified as Type A (combustibles like trash, paper, cloth, plastic, etc.), Type B (flammables like liquids and gases like propane, oil, and gasoline, etc., Type C(defective electric gadgets), Type D (involving with metal, like aluminium (Al), magnesium (Mg), beryllium (Be) and sodium (Na), and Type K (Vegetables and animal fats), (Voelkert, 2009; Ghosh S., 2021).

The methodologies adopted in the present study are gathering urban blaze data from extensive primary field surveys or collected data from newspapers, electronic media, and local people. The area of study and route chart for early fire services, the geographical information system (G.I.S.), and remote sensing (R.S.) to identify the locations using E.R.D.A.S. software (Fig 2). Correlating fields of the data and preparing a time series is the task. Finally, inferences are drawn to conclude. All diagrams were constructed using statistical tools such as EXCEL and S.P.S.S.

The present methods analyse the collected data, including the source, types, concentration, frequency, and places susceptible to WUI blazes. The damages caused, and the lives lost have been accounted for to ameliorate the fire miseries. The results shall show innovative methods to develop various approaches to address the fire mishaps by chalking out a disaster management plan for the agglomerating Kolkata city.

Global WUI History:

The major wildfire urban Interface up to the 19th century in urban growth globally Table 1.

Table I: The global Wildfire Urban Interface (WUI) blazes before the Industrial Revolution

Date/ year	WUI /Country	Losses	Date/ year	WUI /Country	Losses
July, 18 th , 064AD	Ancient Rome	Nero set Fire to the slums; four out of the fourteen districts saved	Great Chicago Fire of 8-11 th Oct. 1871	"Great Rebuilding" built a new urban centre	destroyed 2,100 acres of the city, 3000 deaths
Cairo 1321; 1852	Egypt: great Fire	Result of violence between Muslims and Christians	The Great Boston Fire 10 th Nov. 1872	Most losing fires in American history	20 died, > 700 firefighters,
Cairo January 26, 1952	Black Saturday	Riots and looting (750 buildings) against the Britishers of Egypt	The great Hinckley, on September 1, 1894.	Hinckley, Minnesota	418 deaths, 350000 acres burnt; Skunk Lake, gravel pit
London Bridge fire, 1131, July 1212; & Sept. 2, 1666.	Great Fire of London./	Southwark: 3000 died. A spark from his oven fell onto a pile of fuel.	San Francisco, Apr 18-21, 1906 E.Q.; & stove burst fire;	California; EQ 8.3 Richter scale	Destroyed about 28,000 buildings and killed over 3,000 people
Whitehall fire January 4 1698 (Michelangelo's Cupid burnt)	Cardinal Wolsey of 1530	Catching Fire in linen sheet White Hall Palace.	Tokyo E.Q., Tsunami (7.9 R), and Fire Sept. 1 1923;	Tokyo-Yokohama earthquake	142800 deaths due to Fire and E.Q., Tsunami(60)
2 nd great fire Lisbon (1755) on	An E.Q. following	E.Q. fires, later impact, killed an	The 2nd Great London Fire	London City air strike high	1300 dead and injured 1600; 2000

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Portuguese city All Saints' Day	tidal wave, looting and pestilence.	estimated 10–30,000 people's death.	(Dec. 29, 1940 to May 11, 1941.(WW II)	explosive/incendiary bombs	homeless; Buckingham Palace
On October 16, 1834, Fire blazed the Palace of Westminster,	British parliament, the House of Lords	Set Fire to the panelling in the Lord's Chamber.	Firebombing of Tokyo on the night of March 9–10, 1945,	World War II; Nagasaki City; Operation Meetinghouse	killed an estimated 80K-100K one million homeless
Great Fire of Hamburg began on May 5-8, 1842	Hamburg has 2500 bridges and a red-light district	Burnt Eduard Cohen's cigar unit, art museums, and 19th-century work.	Major Paris fire,(August 26, 2005),	Notre-Dame Cathedral Paris, France	17 dead, West African immigrants, 14 children
Peshigo Fire of 1871, October 8	Michigan	1500-2500 dead; many cities burnt	Black Saturday, Feb. 7, 2009	Melbourne, Australia	173 dead, and 400K Ha bush burnt

EQ: Earthquake; R. Richer scale; WW: World War

Source: von Hees 2017^[31]; Korkmaz 2023^[32]

The fire hazard becomes cataclysmic due to the lack of even fire safety regulations, safety violations, inadequate/outdated gadget resources,

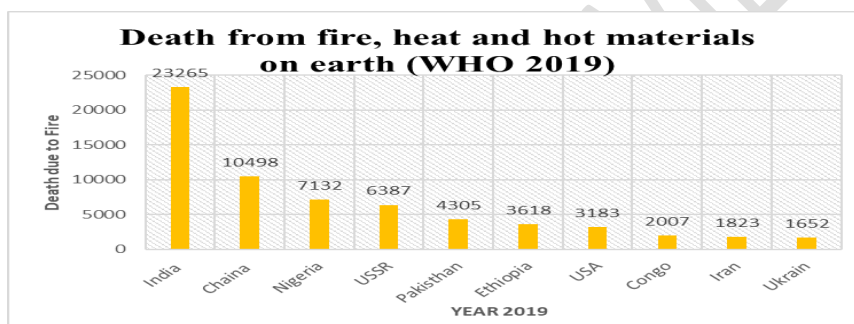


Fig 3(a): Top ten countries' deaths due to Fire as per WHO 2019 (C.I.T.F. data -2022)

India ranked top in fire hazard deaths in 2019: deficient infrastructure, less public awareness, and lack of practices. India is suffering from the highest number of fire blazes, followed by China.

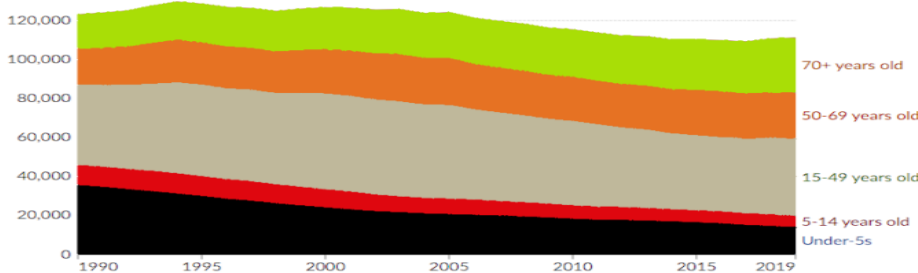


Fig3(b) Global annual human deaths from various age groups caused by Fire (1990 to 2019). Source: I.H.M.E., Global Burden of Disease (2019) –OurWorldInData.org/causes-of-death

Global fatalities in fire accidents are high in the middle-aged group (16 to 49yrs) due to ignorance and callous activities (Fig 3(a) and Fig 3(b)).

Major WUI blazes India:

The fire hazard data has become available on various websites. The secondary data sources for analysing fire threats are NIDM-2020 (National Institute of Disaster Management), paper clippings, research papers from Ghosh Sandip's thesis, and the Kolkata Institute of Disaster Management (K.I.D.M.A.). The fire data about Hospitals, residencies, markets, and Industrial areas are focussed. Past fire occurrences in India are in Table 2.

Table 2: Some critical fire incidents in India with fatalities/losses in India (1995 to April 2024)

Place of Fire	Year	Impact	Cause	Source
Nigamananda conf. (Madhuban, near Baripada, in Orissa)	Mar 15, 1997	178 devotees dead, 165 hospitalised	Makeshift straw huts for men	https://m.rediff.com/news/feb/24fire.html , India Today; Mar 15, 1997
Dabwali fire accident	December 23 1995	442 deaths/150 burns	Short circuit/stampede	The Tribune February 21, 2018
Uphar Cinema fire, New Delhi	June 13 1997	59 deaths/ 100 traumatised	Short circuit/smoke choked	Times of India, June 13, 2023
Baripada religious gathering, Orissa	February 24 1997	206 dead (thatched camp)	Electric spark	India Today; April 25, 2013
Shree-Jee Shoe Factory Agra	May 24 2002	42 +1 people died	Violated safety occupational	Times of India; May 25, 2002, 00:41
Srirangam Marriage Hall	January 23, 2004	57 dead burnt	Thatched house burnt	https://www.mapsofindia.com/my-india/india/major-fire-disasters-india-still-remembers
AMRI Hospital Dhakuria Cal, WB.	December 9 2011.	About 73 deaths	Electncally short-circuited	Times of India; TNN/December 9, 2011,
Sivakasi Factory fire, Sivakashi TN.	September 5 2012,	54 dead/>injured	Falling safety; fireworks on Fire	Decan Herald; September 5, 2012.
Surya Sen St. fire, Kolkata	February 27 2013	20 dead/12 injured	Short Ckt. blazed (56 gas cylinders)	The Economic Times; February 28, 2013,
Puttingal Devi Temple Fire, Kerala	April 10 2016,	111 dead/ 400 injured	high decibel cracker burst	India Today; April 10, 2016, 18:44 IST
SUM Hosp, PVT BBSR, Odisha	October 17 2016 (AN)	23 dead, 120 injured	Short Ckt 1st floor spread to I.C.U.	The New Indian Express, Published: October 17 2016
Karolbag Fire, New Delhi	February 12 2019; 8:54AM	17 dead	Hotel Fire, Arpit Palace; laxity	The Indian Express: February 12, 2019
Sarhana Taxashila Coaching Centre, Fire Surat	May 24 2019	22 dead/ 35 injured, burning	Short ckt A/C; 4th Floor, H R bldg.	Kids falling off a burning building: May 26, 2019
Swarna Palace Hotel (C.C.H.), Vijayawada	August 9, 2020 (Morn)	10 deaths; 22 injured	Electrical short-circuit in air conditioner	The Wikipedia
Uday Sivananda Hospital, Rajkot	November 27 2020	05 deaths	short ckt electrical equipment	Mint, November 30 2020
Civil General Hospital, Bhandara	January 9, 2021; (Night)	Ten dead Neonatal care unit)	Short Ckt in I.C.U.	Business Today; January 9, 2021, 9:51 AM
Bharuch Gujarat; Patel Welfare Hos.	May 1 2021 Midnight	19 died (I.C.U.)	I.C.U. Fire	Reuters; 1-5-2021
ESIC; Kamgar Hos., Mumbai,	December 20 2018 (AN)	Nine dead, 175 injured	Short Ckt from A.C., firefighters	The T.O.I., Published on January 9, 2020 17:06 I.S.T.

UdaySrvananda Hospital, Rajkot	November 27, 2020	13 deaths	Short ckt; I.C.U.	News 18: March 4, 2021
Swarna Palace Hotel Vijayawada	August 9, 2020 (Mng)	10 deaths; 20 injured	COVID-19 ICU Short Ckt	B.B.C. News, 9 Aug. 2020 (from the dis-infected spray)
Sunrise Hospital, Mumbai, C.C.H.	March 26 2021	11 persons dead;	fire swept from a mall	Alok Deshpande, 2021 08:05 IST
Tank leak near Nashik Hosp.	April 21, 2021	22 dead Oxygen	Gas tanker leaked (on-road)	The Economic Times News; Updated: April 22, 2021,
Vijay Vallabh Hosp. Virar Gujarat	April 29, 2021(dawn)	14 deaths, 27 shifted, Short ckt	Short Ckt (I.C.U.)	The Economic Times; August 28 2021, 0922 AM IST PTI
Jama Nagar, SE Delhi; Punjabi Bag	April 14, 2022	13 injured hotel-cum-bar,	Cylinder exploded	The Hindustan Times; April 14, 2022, 06:23 PM
Om Sons Paint & Chemicals blast	February 19, 2024	11 dead/ many injured	Illegal paint factory	www.industrialunion.org/india-factory-fire-kills-eleven-

Abb: AN: Afternoon; Ckt: Circuit; Elec. Electrical; ICU, Intensive care Unit; Private; Hos: Hospital; Morning; HR Bldg: High rise Building; NICU neonatal intensive care unit; GF: Ground Floor; WB: West Bengal;

Kolkata's climate: The city belongs to the Savanna Tropical hot and humid climate (Aw), a tropical S.W. monsoon region.

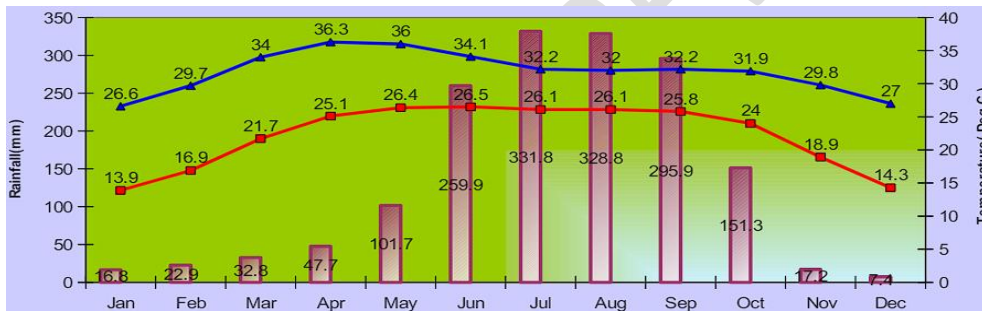


Fig 4: The Average max/min temperature ($^{\circ}$ C) and the monthly rainfall (mm) of Kolkata city (Source: M.O.E.S., IMD, G.O.I.) https://www.bose.res.in/linked-objects/nr/statistics_kolkata_eather.pdf

The maximum and minimum temperatures observed in the past were 40.2° C and 10° C, with a prevalence of four seasons (Summer, Rainy, Autumn, and winter). The average rainfall in Kolkata city is 1600–1836.5 (mm).

Causes of fire incidents in Kolkata:

The major types of urban Fire found in Kolkata are as follows:

Industrial Fire: An industrial fire is an inferno, often accompanying explosions. Ex- Tangra Christopher Road (garments factory), Kolkata, April 24, 2020.

Markets and Mall fires: Fires in large markets, malls, shopping complexes, religious premises, business units, Offices, buildings, and commercial centres originate mainly from electrical short circuits. Example: New Market (S.S. Hogg's Markets).

Hospital area fires: The most common cause of electrical fires in hospitals is faulty wiring or equipment. Faulty wiring might result from incorrect installation or damaged wires. For

example, a fire broke out in the state-run SambhunathPandit Hospital library in Kolkata in 2019.

Residential Fires: The large proportion of residential buildings (mainly slums) is the largest of all buildings, and with the development of urbanization, residential building fires are at high momentum. Example: Lake Town V.I.P. Town 4th floor, February 17, 2023.

Institutional Fires: Fire in institutions, etc. Examples are (a) Nova Nalanda School (Lake Garden, 09/003/2022), (b) Don Bosco School, Park Circus, (3). C.M.D Girls High School, Bow Bazar, 2016

Other fire accidents are wooden or polymer sheetstructures,building/fire code violations, inappropriate flammablematerial handling,nonavailability of working fire extinguishers, firework industries/ shops, illegal exposed electric short circuits from faulty connections, fittings and fixtures.,

Agglomeration in Kolkata:

The populous Kolkata city is now undergoing vast horizontal and vertical expansion. The surface, water, and underground areas overexploited to accommodate the rising population. The Kolkata Municipal Corporation is expanding towards the south and east. At Present, Kolkata Municipal Corporation (K.M.C.) has 144 wards, which will increase due to statutory urban building and fire norms. South, Central and North Kolkata are thickly populated and have growing population densities. The K.M.C. has agglomeration areas in Greater Kolkata, Fig 5 (a and b).

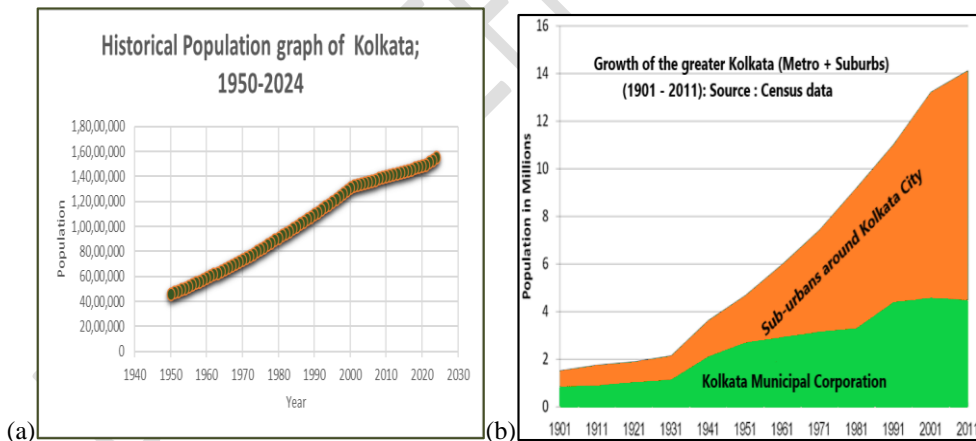


Fig 5(a): The decadal population (1950 to 2024), Fig 5(b) Growth of Kolkata city 1901-2011

Population History of Kolkata City

In 1901, it was Asia's second most popular city, with a population of 0.847 million living in an area of 83.15 km². From 1951 to 1981, the population grew faster, from 2.68 million to 3.29 million, and the area of Calcutta increased from 83.15 km² to 104 Km². In 1984, the Calcutta City Corporation was established. Later there was decennial growth of population upto 1991. In 2001, Calcutta was renamed Kolkata, and the city expanded to an area of 200.71

Km2 with a population of 4.496mi, but there was a decrease in its demography with the present population. 15.57mi, shown in Fig 5 (a and b).

Significant fire incidence in Kolkata city

Previous fire records reveal that Ward numbers 32, 34 and 62 are highly prone to fire occurrences. The heavy loads of Oxygen, air conditioners, and medical equipment have increased hospital fire cases during the pandemic Covid 19. , as shown in Table 3.

Table 3. Some major fire incidents in the greater Kolkata, India, with fatalities and losses

Place of Fire	Year	Impact	Cause	Source
33© Topasia Fire,Kolkata	November 22, 2006	10-12 dead 18 injured	Illegal Leather factory	Wikipedia
Tangra	Mar 19, 2008	20 firefighters to douse	Five persons were hospitalized.	Times of India March 19, 2008
Tangra	May 27, 2008	Fire (Leather) Industry	Two dead, and two suffered	Purkait et al., 2016
BasantiColony fire; Science City Auditorium	January 12, 2010 (Noon)	Fire Blazes near Ultadanga	Gas Cylinder burst	The Hindu, January 13, 2010
E.M. bypass blaze	March 5, 2010	From slums at E.M. Bypass	Short circuit	March 12, 2022; India Today
AMRIHosp. Dhakuria,WB	December 9, 2011,	About 73 deaths	Elect. short-cikt	Times of India; TNN/Dec. 9, 2011,
A.M.R.I. Hos. Cal. W.B. (PVT)	December 9 2011 (Night)	92 dead, & property loss	Flammable Materials Basement	Econo.&Politica Wkly 52 (34), August 26 2017
TiljalaTopsia Fire, 2014	January 23, 2014 (Evening)	One died; brother injured	Slum area, Tiljala; one died, and one injured	TOI; April 14; 2014
Park Circus; Rly stnfire.	December 26 2014 (night)	300 shanties gutted	Burst of gas cylinder	Purkait et al., 2016
Dundun park; harichandPalli slums	December 26 2015 (Evening)	One dead, 80 shanties gutted	Slum area; gas cylinder burst	Hindustan Times; December 28, 2015
Brace Bridge, Rly stn.Taratata Road	, January 13, 2016; AN	Train services disrupted	Short circuit; five injured	Purkait et al., 2016 ³³
Govt Med. College &Hosp.Cal WB	September 14 2018 (Morn)	250 patients shifted	A.C. Short circuit: Pharmacy ground floor	India Today, September 14, 2018, 11:20 I.S.T.
School of Trop. Med. Cal. W.B.	12th Nov 2018,,Mng.	Seven patients shifted	A.C. Short Circuit	The Hindu. nOctober 3, 2018.
Calcutta, GMC&Hos College(WB)	31st Dec 2018,(00AM)	patients shifted	Short-ckt. In a refrigerator in the Haematology dept.	SujitNath, News 18, December 31, 2018, 13:21 I.S.T.
Park Circu Areas; Rifle Range Road	May 29, 2019	No casualties	Plywood shop	News Nation; May 29, 2019
Tangra, 3 Maher Ali Lane	March 12, 2022	Godown, stocks burnt	The reason is not known,	7:47 PM · March 12, 2022
Topasia, Jorasanka; Nila-MadhasenLane	December 30, 2022	Old materials burnt	Fire in a warehouse	TOI; 30.12.2024
Falguni housing complex(SaltLake)	April 23, 2023	Cylinder Blast	Slum, 50 burned,(father-son died)	India Today; April 23, 2023
Saraf House (Top Floor) Raj Bhavan	May 10, 2023, 11 AM	Multi Storied Bldg Canteen of a bank	One injured, 12 fire tenders	May 11, 2023, The Indian Express

Taljala Lane; Medical College New Town;	November 14 2023 (6-incidences)	slum area of Nivedita Pally.	Many houses gutted after a blaze.Nalini Seth Rd.	India Today, April 13, 2023
Ultadanga area, Kolkata	October 22, 2023	From the forensics team.	Injuring three people	ABP News, October 22, 2023
Nonapukur area	December 17, 2023	3 rd Floor of a building	Five rescued by ladder	Dec. 17, 2023, India Today.
Ananda pur E.M. bypass	Feb 26, 2024 (1030AM)	One dead, 2000 homeless	Multiple Cylinder blasted, burning 50 houses (Kata gas)	The Times of India, Feb. 26,2024
Dashdorna,Garment factory fire, Chinar park	May 4, 2024, 10:18 AM	4 th floor cause not known	No injuries, No deaths, Four fire tenders	Lokamat Times, May 04, 2024

Abb: AN: Afternoon; Ckt: Circuit; Elec. Electrical; I.C.U., Intensive care Unit; Private; Hos: Hospital; Morning; H.R.Bldg: High rise Building; NICU: Neo-natal intensive care unit; G.F.: Ground Floor; W.B.: West Bengal;Rly stn, Railway station.AN; After Noon

Source: Collected from some News daily.

Comment [A15]: formatting

Sector-wise,Fire blazes in Kolkata.

Considering Fire a mishap, Kolkata compartmentalised into four sectors: the northern sector, the central sector, the eastern sector, and the southern sector. The Hoogly River dividesKolkata from Howrah District.

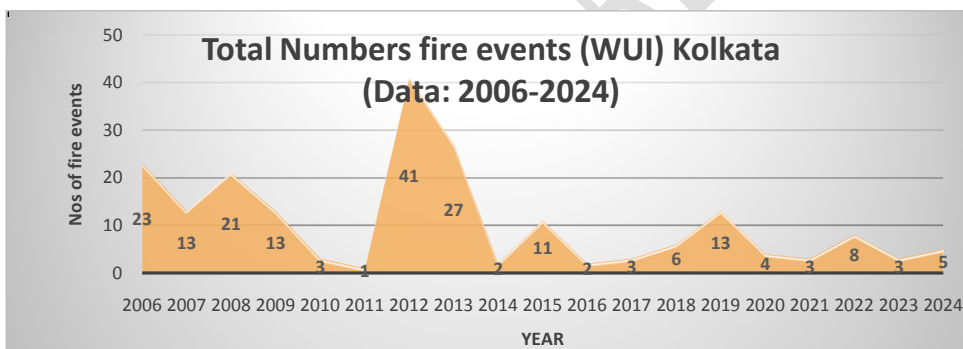


Fig6(a): Total Number of major WUI fires in Kolkata (2006 to April 2024)

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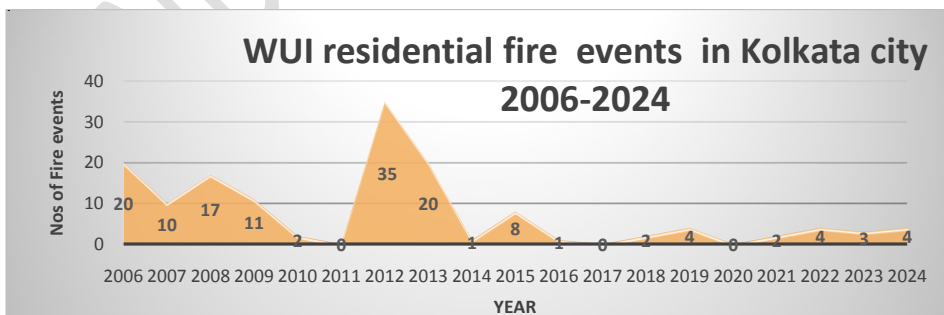


Fig6(b): Total Number of WUI Residential fire mishaps in Kolkata (2006 to April 2024)

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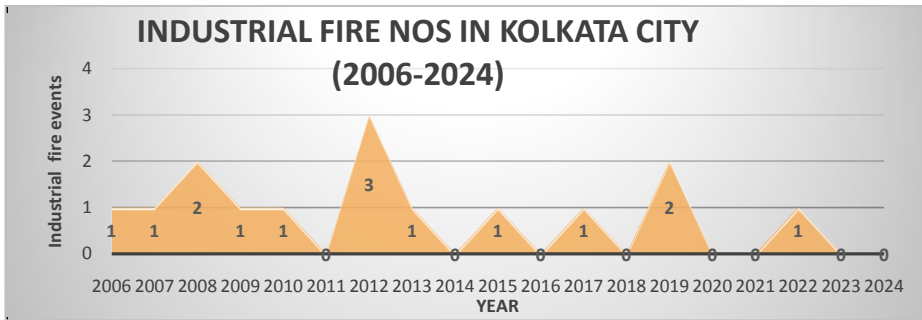


Fig6(c): Total Number of major WUI (Industrial) fire mishaps in Kolkata (2006 to April 2024)

Comment [A18]: formatting



Fig6(d): Total Number of major WUI market fires in Kolkata (2006 to April 2024)

Comment [A19]: formatting



Fig6(e): Total Number of major WUI (Hospital) fire cases in Kolkata City(2006 to April 2024)

Comment [A20]: formatting

Two hundred two cases are under analysis, considering all significant fire events in Kolkata city from 2006 to 2024 (April). WUI's residential, Marketplace, Industrial, and Hospital types of fires are 71.3%, 17.8%, 7.4%, and 3.5%, respectively. The slum economy and lifestyle contribute to fire hazards among WUI. The records show that South Kolkata, including central Kolkata, is at high risk of fire blazes(Fig 6 a-e).

Fire in market complexes of Kolkata:

Kolkata is in the news regarding fire mishaps in different wards. Table 4 shows ward-wise fire events from print and electronic media from 2013 to 2024.

Table 4: Fire incidences (ward-wise) at various markets of Kolkata City from 2013-2024

Year	Date	Market Name	Ward	Year	Date	Market Name	Ward
------	------	-------------	------	------	------	-------------	------

			No			No	
2013	05.01.2013	Burrabazar	41		14.04.2019	Golf Green Area	93
	07.02.2013	Surya Sen	57		29.05.2019	Park Street	65
2014	12.03.2014	Shalimar Point	45		08.06.2019	JaganathGhat	45
2015	26.04.2015	New Market	87		16.06.2019	Bow Bazar	47
	18.05.2015	New Market	45		13.07.2019	Burra bazar	45
	30.07.2015	New Market	63A		21.11.2019	Park Street	63
	02.02.2015	College Street	39	2020	05.02.2020	Rabindra Nagar	37
2016	21.03.2016	BallygaungePhari	68		16.02.2020	Raja Bazar	38
	21.10.2016	Kadamtala Market	23		20.05.2020	New Market	46
	04.12.2016	South City	93		04.08.2020	Baraipur-Puratan Bazar	17
2017	28.02.2017	Bagree Market	42	2021	05.10.2021	Burra Bazar	42
	25.04.2017	Fancy Market	79	2022	09.06.2022	Shalimar Point, Howrah	45
	20.07.2017	Burrabazar	63		30.12.2022	Jyoti Nagar Mridha	22
2018	22.01.2018	Gorabazar	23	2023	11.08.2023	Kolkata's Eden Gardens	45
	17.04.2018	BallygaungePhari	68		24.09.2023	Central Avenue	48
	11.05.2018	Bowbazar	44		01.10.2023	Kolkata's Elliot Road	61
	23.05..2018	Bowbazar	36		22.10.2023	Ultadanga area	32
	12.06.2018	New Market	46		15.12.2023	Waterloo Street	39
	13.06.2018	Park Street	63		10.05.2023	Raj Bhavan in central Kolkata	45
	16.09.2018	Bagree Market	42	2024	04.05.2024	Garment Factory, New Town area	27
	03.10.2018	Bowbazar	79		29.04.2024	Nakhoda Masjid, Burrabazar area	42
	05.11.2018	Park Street	63		08.04.2024	Dhapa area	58
2019	05.01.2019	Burrabazar	42		16.04.2024	BNR Hospital, Garden Reach area	80
	20.01.2019	Gorabazar	86		13.04.2024	Mela Bagan, Dum Dum	23

Source: From past literature and electronic and print media.

The major fire mishaps in health care units during COVID-19 were of concern throughout India; Kolkata had some hospital fires during 2019-2023.

Table 5: Some major fire incidents in Kolkata with fatalities and losses amalgamated

Place of Fire	Year	Impact	Cause	Source
A.M.R.I. Hos. Dhakuria, Cal.	Dec. 9, 2011, 2:30am	≈73 dead, prop. loss	Electricity short-ckt	73 killed, several injured; Economic & Political weekly 52 (34), Aug 26 2017
Calcutta Govt. Med. Col. & Hos. Kolkata	September 14 2018 (Morn)	No injury; 250 patient shifted	Short circuit A.C.; ground floor	India Today (Published on September 14 2018, 11:20 I.S.T. Major fire at Calcutta Medical College.
C.R. National Cancer Inst. Kolkata	November 20 2018 (After Noon)	Nil Casualty	A.C. Short Ckt, patients shifted to safe	Fire breaks out in cancer hospital in Kolkata; The Hindustan Times, Published on November 20, 2018
Calcutta Govt. Medical College & Hospital, Kolkata	December 31 2018 (Midnight)	Nil Casualty, patients shifted to safe wards	A short circuit (refrigerator) haematology department of Fire at NICU	SujitNath, Fire Grips Kolkata's Calcutta Medical College and Hospital; Second incident in 3 months; News 18, Published on December 31, 2018, 13:21 I.S.T.

Comment [A21]: formatting

Comment [A22]: Source?

Slums, the epicentre of fire break

About 3.82 million people live in 3500 shanty registered/unregistered slums (including major slums) among ≈15.57 million Greater Kolkata metropolitan area residents. For two generations, people have lived in 40% of K.M.A.'s slums. The officially authorized slums are squatter settlements along canals, large drains, garbage dumping grounds, railway tracks and roadways. The official slums are old slums, Thika tenant slums, and Bustee and Udbastu Colonies (Refugee).

Comment [A23]: Source?

A few major poor and compact slums are the focusing places as the epicentre of fire hazards. The Fire in slums in Kolkata has been rampant in Hastings, Falguni Housing Complex, Canal West Gas Godown, Falguni Lane, Number 12 Water Tank, Mecchua, Lalmandir, and Bhangamath (K.M.D.A., 2012^[35]; Islam 2019^[36], Puhan et al., 2022^[37]), and Shanties by the side of few Rly stations. In 2023, two slums fired out of five significant fire breaks in Greater Kolkata. Slums are the core area of fire hazards.

Fire event zoning of greater Kolkata

Kolkata has 16 boroughs consisting of 144 wards. Purkait et al., 2016^[33] reported that Kolkata City has four zones (Table 6).

Table 6: The ward numbers in various zones and intensity of fire frequency in Kolkata.

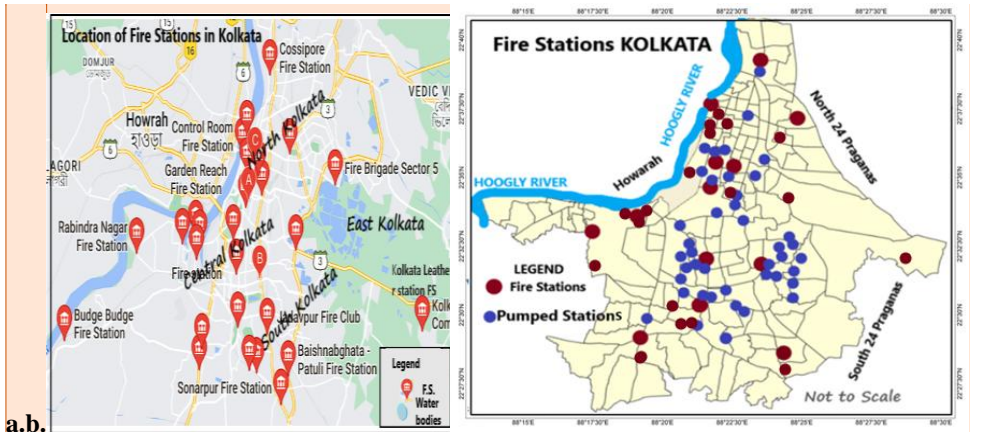
Comment [A24]: Source?

Zone Number	Ward number	Number of fire reports	Prone to fire blazes
Zone I	1,4,5,8, 12, 14, 17, 23, 24, 28, 30, 36, 41, 47,48, 51, 52, 68, 72 to 77, 79, 83 to 87, 89, 91, 93 to 99, 101, 103, 104, 109 to 124, 126, 127, 129, 130, 132, 134, 135, 139 to 144	73 wards	Least
Zone 2	2,3,7, 9 to 11, 13, 15, 16, 18 to 21, 25 to 27, 29, 31, 33, 35, 37 to 40, 42 to 46, 50, 53 to 59, 61, 63, 64, 66, 67, 69, 71, 73, 78, 80 to 82, 88, , 90, 92,100, 102, 105 to 108, 125, 128, 131, 136 to138	65 wards	Less
Zone 3	34, 60, 65	3wards	High
Zoe 4	6, 22, 32, 62	4wards	Very High

Comment [A25]: How these ratings were obtained

Dousing network for fire blazes, Kolkata

Kolkata, on modernisation/modernization of its Fire and emergency services, has modern control rooms at the state H.Q. and the divisional H.Q. All facilities like modern communication systems, data recording, information analysis, identifying location by and G.P.S. in Fire Tenders to douse the Fire immediately. The fire stations, water bodies and pumping stations are in Fig 7(a) and Fig 7(b), and the sectoral map of the fire-hazard frequency is in Fig 7(c).



a.b.

Fig 7(a) The water bodies and fire stations Fig 7(b): The pumping units in Greater Kolkata

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Comment [A27]: It is important to detail in the methodology how the maps were obtained, and what data were used.

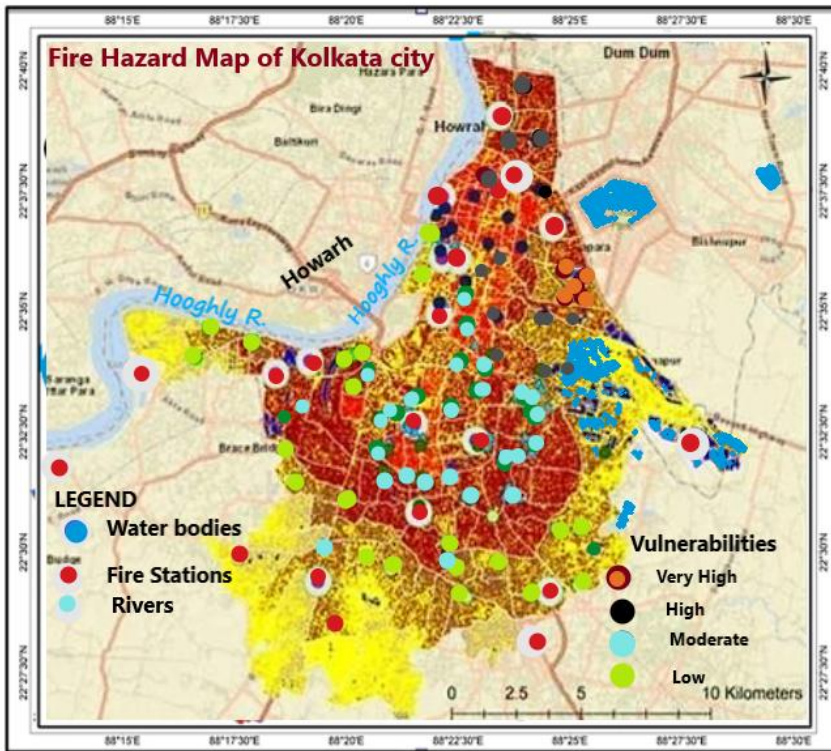


Fig7(c): The fire zone map of the greater Kolkata (source modified: Ghosh et al. 2019)

Causes of fire disasters in WUI:

Urban areas experience WUI from homes, markets, old equipment and dumping yards. Fire may start from fuel supply leaks, electric sparks from faulty electric lines, flammable material dealings (legal or illegal), accidents and collisions, machinery, human commission of error and arson, and extreme weather, such as lightning and extreme heat-like situations in

Kolkata. The Disaster Management Act of 2005 mandates the development of safety and risk management plans in all districts. Every district developed a disaster management plan. The difference in geographical characteristics and climate conditions changes the impact of the type of hazard in every district.

Kolkata is housed in the southern, multi-hazard-prone region of West Bengal. It is at a significant risk of loss of lives and frequent damage, mainly because of public misunderstanding. Although domestic fires occur frequently, the losses are minimal. Both home and commercial fires are small fires that take on a large shape when they become vigorous and uncontrollable. However, it might be difficult or impossible when there are not enough spaces or alternate escape routes in the building.

Discussions:

The following precautionary measures need redressal in agglomerated Kolkata City: (i) standardising the fire stations throughout the city and upgrading old fire stations as per norms (Haque et al., 2013). A worldwide campaign has become pertinent on the following issues:

Management in Firefighting Operations and Urban Safety Improvement Source modified: (<https://www.tifc.ir/en/>)

(A) Safety in fire management (Pre fire events)

- a. Urban occupational studies: Slums, market areas, health care units, commercial facilities, etc.)
- b. Safety during transportation: Airports, railways, and bus stand on roads (parks, carriageways, shoulders, installations, and equipment).
- c. Safety of old, dilapidated buildings: Old monuments and heritage buildings need protection from Fire.
- d. Safety in slums: The risk of fire hazards is frequent. Kolkata is required to be a zero-sum city.
- e. Safety of highrise buildings: Necessary state legal action plan formulation and strict adherence are essential per the National Building Code of Practice.
- f. Optimize the shortest route for prompt services, vehicles, and fire fighting equipment access.
- g. Maintain the physical and mental fitness of the fire tenders.
- h. Dissemination of fire occurrences at the earliest is urgent keeping all electronic equipment in order.

(B) Promotion and Strategies to Engage Citizens

- a. Promote innovative methodologies to indigenous safety culture through orientation training.
- b. On humanitarian approaches, plan evacuation procedures for the vulnerable.
- c. Constitute a fire committee in each fire-prone area. Champions must be well-trained and have hands-on experience with safety gadgets.
- d. Start firefighting subjects should be introduced in each study curriculum, from primary to university, and in citizen training courses.
- e. Rewards for efficient firefighters and punishment for defaulters (legal) are also part of citizens' engagement.

(C) Upgrading fire safety skills:

Comment [A28]: This chapter should discuss the results of the study, the maps rather than a set of recommendations.

Comment [A29]: review this form of citation

- a. Reporting and recording is the need. Old statistics warrant analysis for the risk assessment, Earthquake fires, vulnerability, exposure, and hazard of any fire incidence and rating of the disaster risk area to be calculated regularly with formulae and grading or zoning is to be done for the fire department, Ghosh et al., 2019^[37].

$$\text{Fire Risk} = \frac{\text{Hazard} + \text{Vulnerability} + \text{Exposure}}{\text{Capacity}}$$

- b. Models development on risk assessment are the priorities
- c. Since congested markets and slums are the most vulnerable corners for fire hazards. The vertical growth of markets and the zero-slum concept may be planned for city agglomeration.
- d. Scientifically investigating fire type, cause, and vastness, the extinguishing methodologies to be adopted should be appropriate and effective. Smoke challenges, the dousing activity should be managed expeditiously to reduce suffocation deaths,
- e. Properly selected fire-proof building materials should be used to maintain sustainable development Goals such as S.D.G. 9, S.D.G. 11, and S.D.G. 12 (not directly). S.D.G. 11 focuses on the flammability of the built environment and vulnerability to wildfires, such as slums and WUI. Similarly, S.D.G.s 12 and 9. On the horizon, S.D.G. 15 deals with life on land and terrestrial ecosystems and the performance of construction materials.

(D) Safety Governance of Physical and Fire Hazards

1. Data-driven models on the urban governance domain in favour of safety and physical hazards are to be prepared by the government based on regulatory, judiciary and professional institutions that need to be instituted for better fire management.

(E) Smart Technologies for Firefighting

1. The application of the Internet of Things (I.O.T.) and the use of cloud technology in fire management in Cosmopolis, such as smart firefighting in smart and green cities through innovative methods.
2. Prompt and judicious operational management based on advanced processing-based surveillance systems, optimising travel time, using early and appropriate methodology, and applying innovative gadgets and robotic methodologies should be used in identifying, rescuing, and dousing the Fire.
3. Proper building design using A.U.T.O.C.A.D., S.T.A.D.P.R.O., and BIM models operated according to the National Building Code, KMC Building Code 2007, and 2024 can reduce fire hazards.
4. Modern buildings, machinery and manufacturing intelligent firefighting robots can also help in ameliorating fire impacts.
5. Artificial intelligence (AI) must be used to analyse, predict and investigate the causes.
6. The role of knowledge-based companies in increasing the effectiveness and improving educational processes
7. Implementing and integrating Building Information Modeling (BIM) in fire safety engineering.

(F) Government Action warranted

For Kolkata, some advances are needed for the state's fire service system, such as enhancing the system to 100 gallons/ minute, with a pumping capacity for every 10,000 people. The minimum pipe diameter in industrial/commercial areas should be $\geq 15\text{cm}$ and can supply 1000 gallons/min. A fire tax must be levied for the supply of water and fire services. All fire tenders should have the same Fire Service Uniform and shoulder Badges of all tenders.

As per the W.B. Municipal (Building) Rules of 2007 (Section 12(6) (B), all multi-storied buildings (Height $\geq 14.5\text{m}$), the buildings must attend to easy access, building services, circulation, parking space, safety, ingress or egress, and occupants/users' health as per the National Building Code (N.B.C.) of India and in the West Bengal (Sub-rule 1) and Fire Services Act, 1950; Act XVIII of 1950. Construct buildings as per K.M.C.(Building) Rules 2024. Fast aid boxes, fire lifts /exits and basements must be displayed to avoid the risk of a panic situation.

(G) Citizens Action Plan

To avoid the start of WUI from bushfires, the buildings/old structures must be away from vegetation. Green tree/grass growth should be encouraged to have low flammability in those areas. To avoid or reduce fire mishaps, large trees must be planted. Houses must be constructed using fire-resistant building materials, have multiple stairs, and be equipped with fire alarms. Risk factors and countermeasures include regular checking of fire alarms, strict adherence to fire safety laws, and upkeep of safety equipment, vehicles, and roads with a minimum of 20m turning radius as per N.B.C. and town planning building codes.

Role of Fire Champions:

The community should have all fire alert systems for early dissemination of Fire. The community commanders and fire champions trained in every ward to help fire victims immediately. These fire champions should have hands-on practices to attend to the fire victims, raise public awareness, and disseminate fire alerts for early attainment.

The K.M.C. Rules (Building) 2024:

The West Bengal Municipal (Building) Rules, 2024 (The Kolkata Gazette, www.wbdma.gov.in), must be followed to supersede the rule formulated in 2007 and modified in 2009, stipulating high-rise buildings' height. Table 4 provides the stipulations:

1. The height of the multi-storied building (m) depends on The height allowed when the frontal clear margin is 2.5m beyond the setback (Entry road width). When the width is $\leq 9\text{m}$, the allowable maximum height is 11m; up to 9-12m, the height allowed is 15m; up to 12-18m, the permitted height is 24m; and above 18m, the maximum allowable height is 45m (<https://www.magicbricks.com/blog/kmc-building-rules/131339.html>).
2. The parking areas are to be installed either in the basement or on the ground floor
3. Each residential house must have one kitchen (area 4 sqm) and one bathroom 1.5sqm.
4. The building is constructed with open space, using waterproof materials for better usability and to prevent Fire from propagating.

Recommendation for Remedial Measures:

The study reveals a lack of inspection and calculation of high-risk fire hazard zones, which can be addressed. The address can substantially diminish its risk and vulnerability, ensuring the safety and well-being of residents are necessary. The improvement and recommendations of H.V.R.C.A. for buildings and multi-storied buildings in Kolkata are (a) deployment of fire alarms, (ii) both video and audio systems, (iii) I.O.T. apps for early dissemination, (iv) smoke detector installations, (v) display of fire exits (vi) regular inspection of electrical wiring, mobile batteries, fire extinguishers, electrical/ electronics equipment sets (vii) regular mock drills in fire stations and community, (viii) training to local fire champions and fire tenders,

Comment [A30]: review this form of citation

Comment [A31]: review this form of citation

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(ix) public awareness, (x) preparation of database, (x) engagement of Fire Roberts under integrated fire framework and many others.

Conclusion

Fire has emerged as a crucial issue in modern city planning. Agglomerating cities frequently suffer from fire blazes, and there is a considerable risk of fire vulnerabilities in various livelihood sectors, such as Housing for accommodation, slums for people with low incomes, and commercial and industrial sectors. Fire blazes occur due to carelessness or ignorance and can sometimes become apocalyptic if not addressed immediately, as can violations of building and fire safety bylaws as part of the architect's domain.

Safety culture planning, governance, promotion, strategic management, and incorporation of safety engineering in high-rise buildings or institutions should be practised as innovative firefighting establishments in modern Kolkata. The state's alertness to providing fire stations with adequate capacity and resources is the priority, along with efficient, willing, and devoted fire tenders.

It is high time to have an integrated fire safety comprehensive plan, documentation and regular analysis of fire mishaps in various settings to prevent deaths in WUI, industries, marketplace commercial buildings, slums and health care units for the Kolkata city

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Comment [A33]: This conclusion is generic. It does not reflect the results obtained in the study.

Comment [A34]: Some authors cited are not referenced

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