Assessment of fire hazard in Pakistan

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Abstract

Purpose – There is an acute shortage of infrastructure to deal with fire hazard in big cities in Pakistan. Consequently, fire hazard poses a serious threat to economic and social activites in these cities. Unfortunately, the scale of this threat is not fully recognised in Pakistan despite the fact that recent fire incidences in different cities of Pakistan have resulted in considerable economic and life losses. The purpose of this paper is to present the results of a survey which was conducted in one of the largest cities of Pakistan to determine the nature and level of this threat. A critical evaluation of available resources with the Fire Brigade Department (FBD) to deal with the fire hazard in the city confirmed a lack of infrastructure facilities and adequate training. A conceptual framework model for fire risk management is proposed to reduce the level of this threat.

Design/methodology/approach – This study is based on a survey of fire exposed buildings in Karachi (one of the largest cities of Pakistan) and the analysis of available resources and infrastructure of FBD. A total of 13 sites were visited and interviews were conducted. Fire stations in the city were visited and an inventory of available resources was prepared. The data of fire incidents and human and economic losses were collected and analysed. Based on the findings, a conceptual framework model was suggested for fire risk management in the city.

Findings – The survey of the fire exposed structures indicated that negligence, violation of building codes, unawareness of safety measures, carelessness, and lack of training were the major causes of fire incidents. An acute shortage of facilities and infrastructure for fire fighting was noted. The recording mechanism of data related to fire incidents was found to be inadquate.

Research limitations/implications – The paper is a small but original contribution to identify a potential hazard which is faced by the businesses and community in the city. This is the first attempt (to the best of authors' knowledge) to mitigate the effects of fire hazard.

Practical implications – The suggested model can be employed by the authorities as a guideline to mitigate fire hazard in the country.

Originality/value – The paper provides valuable information on the fire incidents and human and economic losses in Pakistan. The suggested model can become helpful in reducing fire hazard in Pakistan.

Keywords Pakistan, Fire, Risk assessment, Fire hazard, Vulnerability, Damage, Life loss, Capacity

Paper type Research paper

Introduction

The urbanisation of big cities has increased many folds in the under-developing countries owing to a rapid population influx. The development process, which is triggered by this rapid population growth, prompts various types of construction in order to cater for the needs of this population. Commercial, industrial and residential buildings typically constitute a significant proportion of the overall construction. Historically, these are very vulnerable to several possible hazards like earthquakes, floods, high winds, fire, etc. However, fire is considered one of the biggest threats to both the building occupants and its contents (Salleh and Ahmad, 2009).

The causes of fire in urban areas include accidental fire, antisocial activities, criminal acts, industrial accidents and, at present, terrorism. Building fire incidents

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result in significant life and economic losses. In the UK, nearly 800 people are killed in fire incidents annually whereas direct material damage reaches to £1,200 million each year (Ramachandran, 1999). High-fatal fire incidents are normally associated with high poverty rates, poor housing, undereducated populations and sole parenting (Fire Research Report, 2000). Apart from the famous London fire of 1666 and fire in San Francisco after the 1906 earthquake, there is a marked increase in the number of structures involving fire exposure within the last couple of decades in major cities of the world. For instance, there are more than 40,000 accidental house fires in England every year resulting in about 285 deaths and 9,000 injuries (Communities and Local Government, 2006). Similarly in the USA, 83 per cent of fire deaths are resulted from residential structure fires which accounted for 64 per cent of direct economical losses (Federal Emergency Management Agency (FEMA), 2008). More than 75,000 fire incidents were reported in Delhi during 1995-2000 which resulted in 1,825 deaths and 7,600 injuries (Environmental Information System (ENVIS), 2003). In Malaysia, 70,276 fire incidents were recorded during 2005-2007 which claimed 221 lives and injured 268 people (Salleh and Ahmad, 2009). Unfortunately, reliable statistics of fire hazard are not available in Pakistan. Consequently, fire hazard in Pakistan is poorly characterized.

Many cities in the developing countries face a disparity between available space and large population (Bilham, 2009). The city of Karachi presents a typical example of this disparity and its consequences. This city is a fast growing metropolis and one of the major urban centres of Pakistan. It is an industrial city which, with time, has become a hub of Pakistan's commerce and industry. The growth rate is around 6 per cent (Japan International Cooperation Agency (JICA), 2008), which is twice the national growth (Shamsi and Ahmed, 1996). Such an intense growth rate has boosted the development process of the city. Consequently, construction has become the biggest and most flourishing business (Kazmi, 1996).

Karachi has an approximate population of 14 million. The city has been divided into 18 municipal towns and five cantonment areas (Figure 1). The area of each town (Master Plan Group of Offices (MPGO) – CDGK, 2007) and expected population in 2010 (JICA, 2008) is given in Table I. Although Karachi has now become a mega city but it has been developed without a master plan. Since the pace of development in the city was derived mainly by the pressing needs of people very little, if any, planning was done for fire prevention in the building infrastructure.

Construction activities in Karachi are monitored and controlled by Karachi Building Control Authority (KBCA). Although KBCA regulations provide provisions for fire safety for different building types these are generally not followed. Bilham *et al.* (2007) noted that building code was never enforced effectively in Pakistan. Moreover, uncontrolled and unmonitored construction is also common in Karachi owing to partly corrupt behaviour of KBCA officials. In Karachi, corruption has effectively replaced governance (Bilham, 2009). As a result, sufficient provisions to control fire spread are either overlooked in the design or are not implemented during construction.

Although fatal fire incidents do not occur randomly they occur more frequently (Fire Research Report, 2000). A number of incidents of building fires have been recently reported in Karachi. As a result, fire has become but one of a spectrum of risks which endangers the businesses and population in the city. This is further aggravated by the lack of facilities and capacity of Fire Brigade Department (FBD) to deal with the fire incidents effectively. This paper presents the details of a study that was conducted to assess the extent of fire hazard in Karachi. Data of fire incidents in the city have been

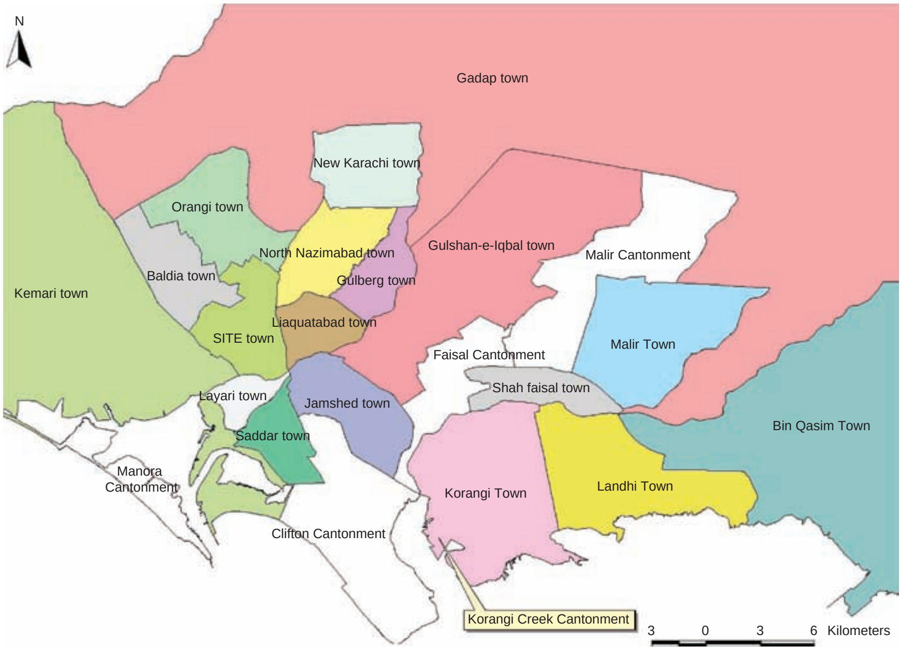


Figure 1.
Details of municipal towns in Karachi

Table I.
Statistics of towns in Karachi and fire stations

Sl. No.	Town	Area (km^2)	Population (10^3)	No. of fire stations
1.	Kemari	429.8	951	2
2.	Orangi	23.5	1,189	1
3.	Baldia	29.2	752	1
4.	Layari	8.0	936	1
5.	SITE	25.4	761	1
6.	New Karachi	20.5	1,096	1
7.	North Nazimabad	16.7	815	–
8.	Liaqatabad	10.9	999	1
9.	Jamshed	23.4	1,236	1
10.	Saddar	24.1	987	3
11.	Gulberg	13.8	745	1
12.	Gadap	1439.9	1,163	–
13.	Gulshan-e-Iqbal	53.7	1,340	3
14.	Korangi	41.5	1,103	1
15.	Shah Faisal	11.7	538	1
16.	Malir	17.8	688	1
17.	Landhi	39.1	1,234	1
18.	Bin Qasim	558.3	940	1
Total		2,787.4	17,473	21

collected and causes of fire spread are identified. The level of service and capacity of FBD has been assessed and discussed in relation to the available resources. However, determination of causes of fire outbreak is beyond the scope of this work. In the end, a conceptual framework for dealing with fire hazard is also presented and its aspects are discussed.

Methodology

A survey of the fire-exposed buildings and sites, in different parts of Karachi, has been conducted for this study in order to identify the causes of fire spread and associated damages. A total of 13 sites were visited and interviews were conducted to gather information on fire-related damages at these sites. Fire incidents at the visited sites took place over the span of two years during 2007-2008 and represent recent data. Meetings and interviews with the officials of FBD were arranged and statistics of fire incidents and resulting human and economic losses in the city were collected. These provided a broader picture of fire hazard in the city. A critical facilities analysis of the fire fighting resources available with FBD was carried out and an inventory was prepared to assess the capacity of FBD to deal with fire hazard in Karachi. Although the presented data are collected only in Karachi the situation may not be different in other cities of Pakistan.

Results and discussion

Analysis of FBD capacity

FBD works under the management of City District Government of Karachi. Fire stations for each town in the city are provided in Table I. It is noted in Table I that two of the towns in the city, i.e. north Nazimabad and Gadap did not have any fire station. Fire fighting operations in these towns are carried out by the fire stations, respectively, in New Karachi and Gulshan-e-Iqbal towns. This put enormous burden on the resources of fire stations in the later two towns.

Figure 2 illustrates distribution of fire incidents dealt by the fire stations in different towns (Table I) in 2008 and 2009. It is noted in Figure 2 and Table I that the distribution of fire stations in these towns is not according to the level of risk. For example, the Gulberg town received a significantly large number of fire incident calls compared to the Kemari town. However, the former town is provided with only one fire station compared to the later town where two fire stations are situated.

All the fire stations in Table I were visited and the data of available resources were collected and analyzed. It was found that, of 21 fire stations, 20 were provided with only one fire tender. Only the station in the town named Gulberg had two fire tenders. Further, fire tenders for at least five fire stations in four towns were found to be out of order at the time of this survey. These fire stations were located in Baldia, Kemari, Gulshan-e-Iqbal and Bin Qasim. Therefore the fire stations in these towns were without any fire tender. It was also noted during the survey that 12 fire stations in different towns in the city did not have reservoirs to store water for an emergency situation.

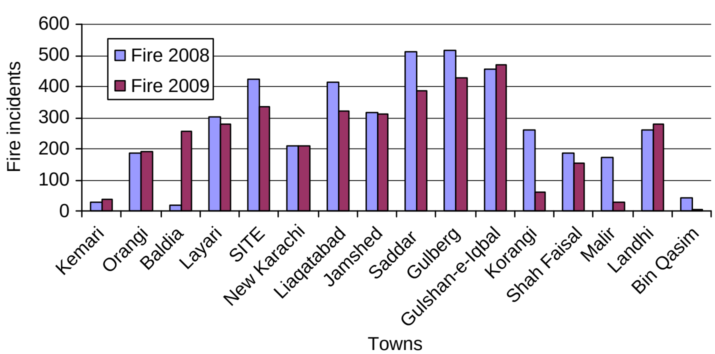


Figure 2.
Distribution of fire incidents in different towns in 2008 and 2009

A complete inventory of essential equipments required for communication, fire fighting, rescue and personal protective equipments (PPE) was prepared for all the fire stations in the city. Table II presents a cumulative summary of only a few of these equipments. An acute shortage of even very simple, yet necessary, fire fighting equipments is noted in Table II. For example, not every fire station had a fireman axe and only ten axes were available for 21 fire stations in the city. Similarly, only 12 chemical suits were available with FBD for a mega city like Karachi despite the fact that these are essential PPE. Wireless communication system was also found to be inadequate (in terms of range of signals) and was not working properly either. This unavailability of necessary fire fighting equipments can seriously hamper the ability of FBD to control spread of fire and to save precious lives and property.

The technical capacity of FBD was also found to be inadequate to meet the challenges of present time particularly in the context of terrorist activities. The department officials have no training to conduct fire forensic in order to differentiate between accidental fire and arson fire. No database of fire-related properties of locally available ignitable liquids exists which can help in determining the causes of fire initiation. Consequently, no investigations are carried out in the aftermath of a fire. Similarly, no policy or guidelines exist regarding the estimation of economical losses related to fire incidents and the information provided by the owner(s) of the affected premises is relied upon. The owners usually prepare this estimate for insurance claims which, at time, is inflated in order to maximise their claims. Loss of life because of fire only is not separately recorded from other causes, such as explosions, and total casualties are entered in the data. There is no coordination of FBD with other emergency services such as police, hospitals, etc., at the site of a fire incidence.

Survey of fire-exposed buildings

A summary of fire-exposed buildings in terms of human casualties, injuries and economic losses is given in Table III. It is noted in Table III that the PNSC building was subjected to fire twice in a span of six months. It is further noted in Table III that life losses in most of the buildings were small. This is owing to the commercial nature of business of these buildings. Since the fire incidents mostly took place during off-working hours when these facilities were not fully operational and their occupancy levels were low, the life loss was avoided during these events. The data of financial losses were not available at the time of this survey for some of the buildings, as can be

Sl. No.	Equipments	Quantity (Nos)
1.	Breathing apparatus sets	30
2.	Refilling units	02
3.	Chemical suits	12
4.	Turnout suits	100
5.	Fireman helmet	100
6.	Gas mask	135
7.	Fireman axe	10
8.	Fire escape ladder	10
9.	Jumping sheets	04
10.	CO_2 trolley	01
11.	CO_2 extinguisher	07

Table II. Inventory of equipments at Fire Brigade Department

Table III. Statistics of fire exposed buildings

Sl. No.	Building/facility	Location	Date	Nature of facility	Fatalities	Injuries	Financial losses (USD)[b,c]
1.	Union export	SITE	15 January 2007	Industrial	9[a]	35[a]	1.88 mn
2.	PNSC building	M T Khan Road	18 February 2007 19 August 2007	Public	1	4	Not available
3.	Iqbal centre	M A Jinnah Road	31 May 2007	Commercial	–	–	Not available
4.	Hashmi electronics market	Saddar	8 January 2008	Commercial	–	–	0.13 mn
5.	Burger paints Pakistan	SITE	23 January 2008	Industrial	2	1	6.25 mn
6.	International textile	Korangi	7 February 2008	Industrial	–	–	Not available
7.	Novatex Ltd.	Landhi	7 February 2008	Industrial	–	–	Not available
8.	Universal rags	KEPZ[d]	8 February 2008	Industrial	–	–	0.44 mn
9.	Qadafi timber market	Korangi	6 February 2008	Commercial	–	–	0.08 mn
10.	Dawlance industries	Landhi	16 March 2008	Industrial	–	–	Not available
11.	Board of revenue	Saddar	20 March 2008	Public	–	–	Not available
12.	Essatex industries	SITE	04 October 2007	Industrial	–	–	Not available
13.	Radio Pakistan	M A Jinnah Road	28 October 2007	Public	–	–	Not available
Total					12	40	8.78 mn

Notes: [a]Deaths and injuries took place during fire fighting and include those of fire fighters also. [b]1 USD = Pak Rs. 80. [c]Losses were estimated by the facility owner. [d]KEPZ, Karachi Export Processing Zone seen in Table III. For the rest, the information was collected from the owners. It is noted in Table III that the reported damages are worth US$8.78 million for the assessed fire-damaged facilities. These can be considered as significant losses for a developing country like Pakistan. These are in addition to indirect losses such as income and employment losses, owing to the closure of the facility, and environmental pollution, etc. Negligence, poor design and construction (e.g. faulty electrical wiring and connections, poor building design, violation of building codes, etc.) and lack of awareness and training were found to be the major causes of fire outbreaks and spread in these buildings. Figure 3 shows the fire damaged Union Export building.

Factors such as careless handling of burning or combustible materials, smoking close to hazardous areas of flammable storage (paints, chemicals, textiles, plastics, etc.), lack of planning for the prevention of spread of fire, ill-planned storage facilities, etc., indicated negligent behaviour and unawareness of safety measures. Adequate fire fighting equipments and training were found to be missing as these were never considered important and/or necessary and an attitude of "it cannot happen here" prevailed. No sprinkler system was found in any of the fire-exposed buildings, which was a clear evidence of violation of building regulations and bye laws. In some instances cosmetic fire fighting arrangements were put on display (possibly to satisfy an agency or authority) by installing fire extinguishers, which were not maintained and merely served as decoration pieces on the walls. No attention was paid on the improvement of poor state of existing electrical wiring and installations. Finished products, such as shoes packed in cardboard boxes, clothes, etc., were stacked in the passage ways (Figure 4), which blocked the entrance of fire fighters inside the building. This hindered the work of firemen, delayed a control over the spread of fire and, consequently, caused further damages.

Fire incidents statistics

Figure 5 illustrates the fire incident data each year in Karachi since 1960. A total of 81,975 fire incidents were recorded during 1960-2009. These included data of residential, commercial and industrial fires. The results in Figure 5 are significant in several respects. First, it is clear that the numbers of building fires are on the increase

Figure 3.
Fire-damaged building of M/s Union Export

Figure 4.
Bales of cloth stacked in the passageways

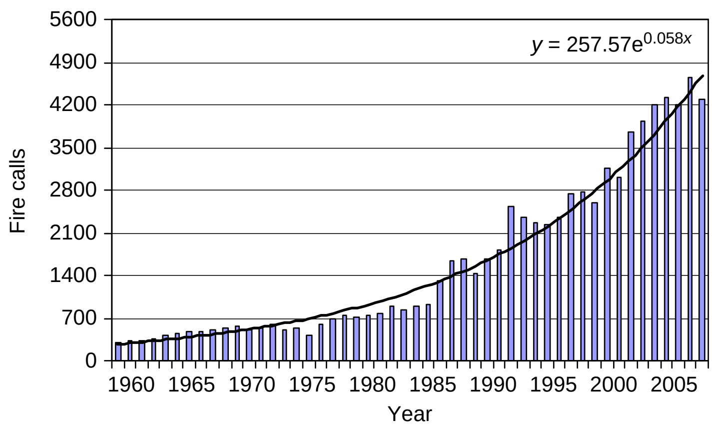


Figure 5.
Data of fire incidents for the period 1960-2009

since 1960. Of these 81,975 fire incidents, a large number (63,375) took place over the last 20 years (1989-2009). This is the same period when the development process of the city started taking a pace. A simple regression analysis confirms that the rise in these fire incidents (FI) can be represented exponentially (Equation (1)). Further, the fire incident data in Figure 5 indicate a trend, which shows that these incidents stay within a particular range for a decade and then they change significantly. For example, the fire incidents remained in the range of 2,200-3,000 for the period of 1993-2002. Thereafter, they increased well beyond 3,500 reaching above 4,600 in 2008. This trend may indicate a steady growth of economic activities in the city over a decade:

$$\mathrm{FI} = 257.57e^{0.058Y} \tag{1}$$

where Y is the number of years.

The number of human casualties each year is plotted in Figure 6. A total of 974 lives were lost in fire incidents during 1960-2009. The data for 1974 and 1975 is not available with FBD! A tremendous rise in the fire-related deaths was noted in 1977 and 1987. However, it is not possible to establish the causes of this rise as there is no information available with FBD. If the data for these two years are excluded from the rest of the data then the average deaths come out to be 15 which indicates that more than one person dies each month in the city as a result of building fire.

Figure 7 illustrates the direct financial losses in million USD for the period of 1990-1999. The record of losses after 2000 is not available with FBD! Similarly, since no mechanism of estimating losses exists with FBD, the presented data in Figure 7 is based on the estimates from the owners and may be subjected to some variations. The aforementioned period was included to keep the effects of inflation on the presented data to a minimum. Although quantitatively the amounts may not be reliable it is clear in Figure 7 that the losses have increased many folds since 1996. Since Karachi is the biggest industrial city of Pakistan, which generates the largest revenue for the country it is clear that these losses badly hamper the overall economic growth of the country.

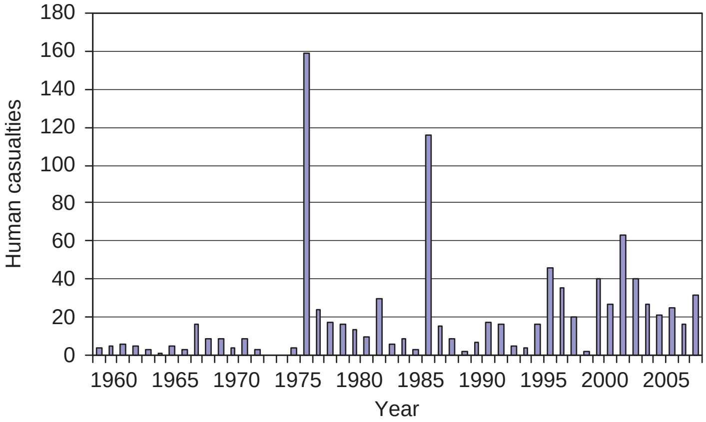
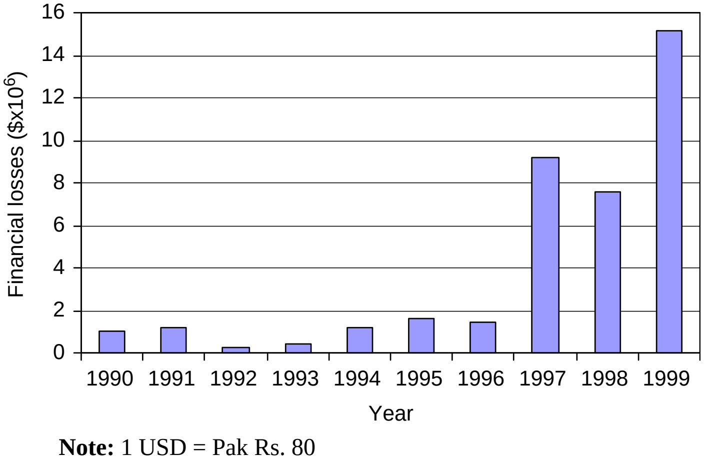


Figure 6. Human casualties from fire incidents during 1960-2009



Note: 1 USD = Pak Rs. 80

Figure 7. Financial losses from fire incidents during 1990-1999

Fire risk management framework

It is evident in the previous discussion (Table III, and Figures 5-7) that fire incidents, and economic and life losses associated with them are continuously increasing. The burden of these losses is often shifted to the poor people of the society. These people are considered the most vulnerable group of the society as they suffer more from hazards than the rich people (Blaikie *et al.*, 1994; Yohe and Tol, 2001). These people become victims either directly by loosing life and/or property or indirectly by loosing employment owing to a closure of fire-affected business.

It was mentioned earlier that the development process of the city is carried out without any planning and the existing construction lacks fire prevention measures. Consequently, huge stock of buildings remains vulnerable to fire risk. This deficient construction puts extra burden on FBD. At the same time, a lack of resources and infrastructure facilities with FBD to provide effective services was identified on the basis of the interviews and data analysis. Keeping the above-mentioned factors in view, the development of a comprehensive fire risk management model for the city is crucial to reduce the level of this particular threat. The concept of risk management has grown up recently within insurance and industrial organisations (Crockford, 1980) and the need for an effective fire safety management can hardly be overemphasised which is considered essential for public safety (Howarth and Kara-Zaitri, 1999). Based on the findings of this study, a proposed conceptual fire risk management model is illustrated in Figure 8. This is a global model which is based on the contemporary emergency management principles of prevention, preparedness, response and recovery (Emergency Management Australia (EMA), 2004). The model has two major components, which are aimed at reducing fire risk of not only new construction in future but also the fire risk associated with the existing built environment. The former task is dealt with the block that branches off the main tree to the right and is entitled "Building Fire Safe Environment". The initial four steps of the tree that immediately follow the main task of Fire Risk Management are aimed at the assessment of fire risk of existing vulnerable elements which is a vital component in any risk management model. Each of the sub-tasks in both components of the model may need separate process flow diagrams at a micro-level. The reader is suggested to study other risk management models also such as those suggested by EMA (2004), Australian and New Zealand Standards (2004), New South Wales Government (1993) and Australian Capital Territory Insurance Authority (ACTIA) (2004). Various stages of the proposed model are briefly described as under.

Fire hazard maps

The first step in the global fire risk management framework is the preparation of hazard maps. In preparing these maps factors such as accessibility of fire fighting staff, fire fighting scenario, building types, lifeline facilities, etc., can be considered as these can affect the level of a hazard. These maps can provide information of possible damages due to a particular fire scenario to people, buildings, lifeline and essential services within the community. Existing fire incident data can be helpful in creating these maps at least qualitatively, if not quantitatively.

Fire vulnerability analysis

Vulnerability is defined as the degree of susceptibility of a person, group, community or an area towards defined hazards (Schmidt-Thomé, 2005). The ability to measure vulnerability is of utmost importance for reducing disaster risk (Birkmann, 2006).

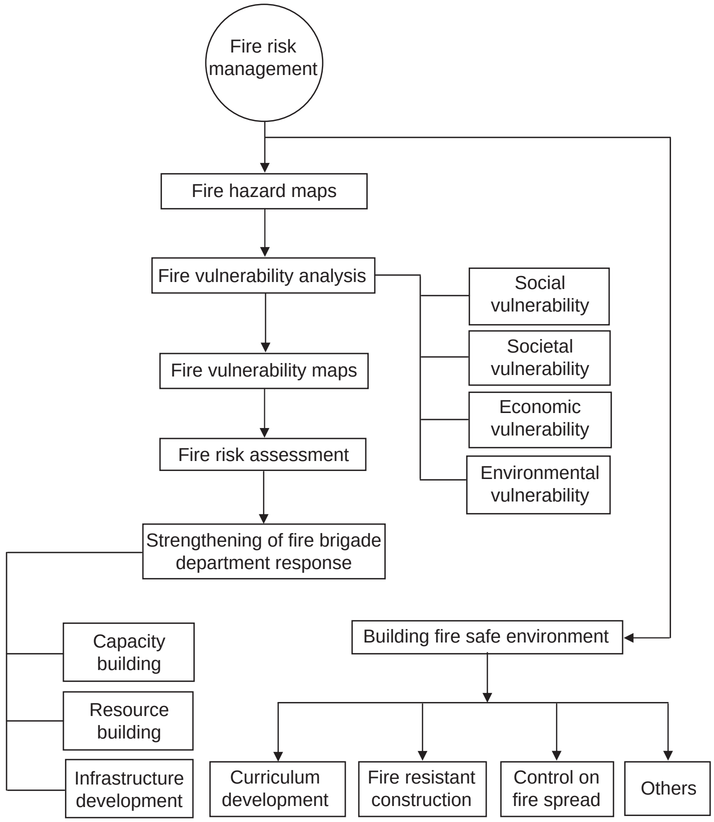


Figure 8.
Conceptual framework for fire risk management

Different factors can increase the susceptibility of a community to the impact of hazards. These include social (education and religious centres, offices, health centres, recreation facilities, etc.), societal (population density, age, gender, etc.), economic and environmental factors. All these factors have an impact on the vulnerability and need to be considered in a comprehensive vulnerability analysis. This is owing to the fact that these factors create a set of conditions and processes that describes vulnerability (Kumpulainen, 2006). These factors have also been suggested in the Hyogo Framework for Action 2005-2015 (United Nations (UN), 2005).

Fire vulnerability maps
The fire risk vulnerability analysis can help in drawing vulnerability maps. The city can be divided into areas having different potential for fire hazard. These maps can become helpful in prioritising the areas for providing fire safety measures.

Fire risk assessment
Risk is defined as a product of hazard potential and vulnerability (Equation (2)) (Schmidt-Thomé, 2005). The fire hazard and vulnerability maps can be employed to produce an aggregated risk map. This enables the assessment of risk associated to communities, business, economy and environment due to a possible fire incidence.

Various fire hazard scenarios can be considered within representative samples of community and their consequences can be assessed either qualitatively or quantitatively. This can provide a holistic picture of the level of risk and fire protection measures required to minimise the losses related to fire hazard:

$$\text{Risk} = \text{Hazard potential} \times \text{vulnerability} \tag{2}$$

Strengthening of FBD response

It is quite obvious that the role of FBD is vital for effective control of fire hazard. This role has not been realised so far in Pakistan. If people are not able to evacuate a fire-exposed building in time, the risk to their lives increases if the fire department cannot respond quickly (Yung, 2008). The occupants' rescue is dependent both on the time taken to extinguish the fire and resources required for this purpose. Although the results of fire risk assessment can become helpful in providing a clear picture of what is needed to enable FBD to meet the present day challenges three possible areas were identified earlier in the discussion which required immediate attention for the strengthening of FBD response. These include capacity building, resource building and infrastructure development. While some efforts have been made by the National Disaster Management Authority towards providing more resources to FBD at the time of this write-up no progress has so far been made to improve upon the other two areas. Specialized studies are required in order to determine the specific needs in the aforementioned areas. Advanced trainings and courses can increase the capacity of fire fighters and officials. These courses may become helpful for fire fighters to understand the fire characteristics. At the same time training can help fire fighters to learn the effective use of equipments and techniques to control fire. On the other hand, the FBD officials may benefit from the trainings by becoming able to better understand staff and resource requirements. Similarly, proper infrastructure is required both to respond quickly to fire incidents and to maintain a proper record of these incidences and resulting losses in the city. The provision of adequate number of fire stations and their distribution in different towns is necessary to improve the response time. These must be carried out scientifically based on the level of risk, which is dependent on the population density, travel time and routes, crew size, water resources, etc. Similarly, an efficient communication system is also vital in order to reduce notification time of a fire incident. The notification and response times are the key elements in the overall response of the fire department.

Building fire safe environment

As mentioned earlier, this part of the model deals with the new construction activities. In order to build a fire safe built environment, the code for fire safety design needs to be developed in Pakistan and the existing building regulations need to be modified in the light of this code. The code should emphasise upon two areas. These include fire resistant construction and control on fire spread. Note that some work on this particular aspect of the model is underway and the first author is the convenor of a committee, which is working on the fire code development. It is also important that a mechanism is developed to ensure proper implementation of the code in the building construction. There is also a need of introducing fire safety as a subject in the professional education institutions. Therefore, a course should be developed at post-graduate level. Other efforts towards fire safety include regular drills at the business and community levels, maintenance and inspection of fire control equipments, identification of evacuation routes in buildings and awareness and training within the community.

Conclusions

Fire hazard is inadequately characterized in Pakistan owing to a lack of reliable statistics related to fire incidents and losses. Mushroom growth of poorly designed and/or constructed structures has increased their vulnerability to damages from fire. This paper presents the results of a study, which was conducted to assess fire hazard in Karachi which is one of the largest cities of Pakistan. The survey of fire-damaged structures indicated that major causes of fire spread included negligence, poor design and construction, violation of building codes, lack of awareness and training. The data of fire incidents in the city showed that these incidents were increasing exponentially and were causing significant human and property losses. This study identified that the FBD is not adequately equipped to carry out an effective job of fire fighting. A conceptual framework model for fire risk management is also presented and discussed.

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