Hazards in Delhi: A Geographical Inquiry

ANU KAPUR

Delhi's fourteen million residents live in a brewing crucible of hazards. The possibility of accidental death, murder and fire haunt people regularly. In the city 208 crimes, 33 road accidents and 25 fire calls occur each day. Sixty days in a year, Delhi is on red alert due to terrorist threat. This is not the terminus of hazards faced by the residents of the city. Scientists have made an addition to this spectre by confirming that the city falls in a vulnerable seismic zone and is prone to floods as well. Floundering buildings and dozens of colonies covered under the deluge of water are a testimony to the incidence of earthquakes and floods in the past. Though the city is reeling under a complex variety of hazardous perils, most consider these events as accidents, calamities, or simply misfortunes.

Hazards are a process. They can be variable, worse, and mild or less offensive, their condition may thus deteriorate, improve or acquire whole new features. Urban areas are the seed-beds of new and complex socio-environmental arenas fostering unprecedented permutations and combinations of old and new hazards. The city is not a static or homogeneous entity because its land use, population density, civic amenities and other features show a sharp change and contrast. These processes are also not random in space. Floods and other hazards take place at particular places, as they have specific locations. Fires erupt only where the setting provides an opportunity to blaze. Hazards thus, are not distributed evenly; they converge at certain places where they occur repeatedly. A policy for making the city safe can deftly be pegged only if the dynamics of precariousness and its spatial pattern are discerned. What are the regions of hazard and how could they be identified? This geographical analysis is not available for any city of India, let alone its capital: Delhi. A review of the literature confirmed the need for an inquiry. Lack of data, however, bogged enthusiasm. The absence of a pre-tested methodology and of authentic information balked the initial hope. The research therefore is tentative.

Scales of Urban Hazards

As small as a dot on the latitude and longitude map of India, Delhi's location between Latitude 28° 24' North to 28° 53' North, Longitude 76° 50' East to 77° 20' East inherits a geological structure that is trapped between faults and thrusts. Over a dozen land-related faults scar the immediate vicinity of Delhi. As a reminder of its geological remnants, the ancient Aravali range abuts the city from a south-southwest and north-northeast direction. Moreover, the city lies merely 200 kilometres from the Himalayas and cannot disentangle itself from the foundation of the earth's crust. As a sprawling circular shaped settlement, Delhi spans on the Yamuna. Flowing from north to south, the river bifurcates the urban area into two unequal halves and lashes a fury of floods on areas clinging to it. Above all, a chaotic mix of old and new constructions, high-rise buildings and pavement dwellings is what an outsider gets as a close up view of the city. In varied combinations and intensities are also evident the residential, commercial cum industrial land uses. A heady pace of unplanned growth, inadequate civic infrastructure reinforced by an inept administration is palpable throughout the city. These result in the occurrence of frequent fires, industrial mishaps, traffic deaths, a rising crime toll along with a host of other menaces. Delhi is riven with hazards.

Hazards dot this city at different places. The delineation of hazard regions should ideally be a combined score of such occurrences of all types in an area but inadequacy of data mar this expectation. Crime graphs suffer from gross under-representation because of unreported and suppressed cases while many cases of vehicular accidents never reach the official registers. This analysis is, therefore, confined to the occurrence of earthquakes, floods and fire. The selection of these three hazards was also influenced by the fact that whereas crime, accidents, epidemics are often accepted as emerging from the human-environment, earthquakes, floods and fire are often blamed on the whims of nature. How far this is true needs to be verified. The choice of these three hazards was governed not only by an availability of data, but also by the need to understand the spatio-temporal dimension of a spectrum of contrasting hazards—earthquakes are related to land, floods to water and fire to urban built structures. And attempt is made here to discern whether the geographical occurrences of hazards cluster in certain regions of the city. Whereas the temporal analysis of the three hazards have been dealt with separately, a methodology is spelled out to allow for the spatial analysis to combine these in delineating the hazard regions of the city. Some critics can argue that selecting only three out of a galaxy of hazards that assail a city is an inherent weakness. While this concern is valid, it should be used for improving the database rather than for abandoning the exercise.

Earthquake Hazard

Frequent earthquakes rudely rock Delhi. The first recorded earthquake took place on July 6, 1505 with its epicentre at Kabul. Since then earthquake shocks were successively felt in the city in 1720, 1803, 1819, 1905, 1937, 1945, 1949, 1958, 1960, 1966, 1975, 1980, 1994 and 1999. In the last 200 years, almost 25 earthquakes have had their epicentres in close proximity to Delhi. This shows an occurrence of one earthquake in every eight years. Historical sources confirm that earthquakes are not a recent phenomenon, and they have struck Delhi and its surroundings since ancient times. The great epic – the *Mahābhārata*—talks about earthquakes during the war at Kurukshetra around 3000 B.C. The susceptibility of the kingdoms of Kuru, Matsya, Salva, Yaudheya and Trigarta, which include and encircle the present Delhi region, to severe earthquakes is mentioned in the Sanskrit works, the *Bṛhat Saṁhitā* of Varāha Mihira in A.D. 5th-6th century and the *Adbhuta Sāgara* of Ballala Sena in the A.D. 10th-11th century (Iyengar, 2000: 572). The seminal *Seismotectonic Atlas of India and its Environs* (Narulla et al. 2000: 10) categorically states that earthquakes from the historic and pre-instrumental period lie in close proximity to the Yamuna river course between Delhi and Mathura.

The Bureau of Indian Standards also endorses this stamp of vulnerability. They have divided the country into five zones in an increasing order of seismic hazard from I to V. Delhi is placed in the Zone IV, which is referred to as the High Damage Risk Zone. On the Richter scale, most of the earthquakes here are of magnitude 5 and 6, a few of 6 and 7, and yet others, on some occasions, of 7 to 8 magnitude. Delhi's Zone IV corresponds to VIII on the Mercalli Scale, which is identified as one with the destructive intensity. When an earthquake of this intensity occurs, moving cars become uncontrollable, masonry fractures, poorly constructed buildings get damaged and walls of well built structures develop cracks. Delhi's geographical location is responsible for its seismically high ranking.

Table 1: Earthquakes in Proximity to Delhi

Year	*Month*	*Day*	*Latitude*	*Longitude*	*Intensity*
1720	07	15	28.7	77.2	X
1803	09	01	27.5	77.2	IX
1825	03	22	28.7	77.2	V
1830	07	17	28.7	77.2	V
1831	10	24	28.7	77.2	VII
1833	09	20	28.7	77.2	V
1842	01	02	28.7	77.2	IV
1842	07	04	28.7	77.2	VI
1842	09	27	28.7	77.2	IV
1842	11	06	28.7	77.2	IX
1930	06	25	25.5	77.5	5.6
1956	10	10	28.2	77.7	6.2
1960	08	27	28.2	77.4	6.0
1970	03	18	28.9	77.6	4.7
1973	06	26	27.0	75.2	4.0
1974	01	02	27.9	75.1	n.a.
1974	03	26	27.8	75.5	n.a.
1980	04	27	28.6	77.6	4.7
1981	05	11	28.3	76.5	n.a.
1986	11	02	26.5	77.3	n.a.
1988	09	20	28.8	76.9	n.a.
1990	01	01	27.8	75.3	n.a.
1990	08	27	28.9	76.5	4.0
1991	04	27	28.2	76.0	n.a.
1993	12	03	28.9	76.7	3.9

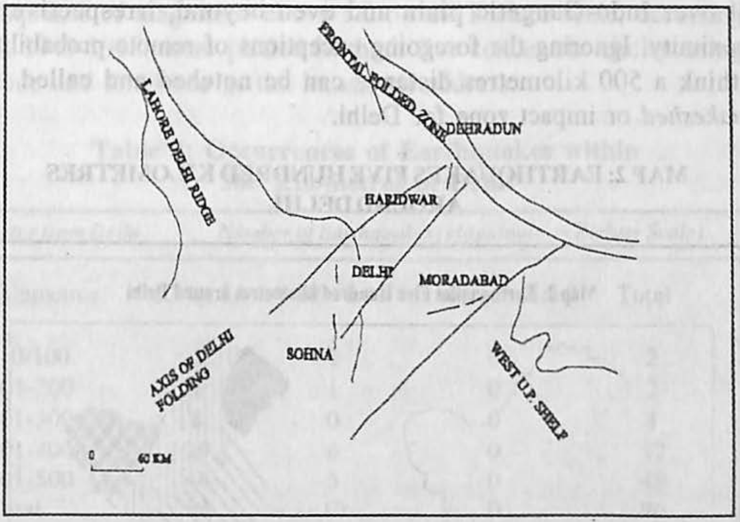
Source: *Seismotectonic Atlas of India and its Environs*, Geological Survey of India, 2000. (Data recalibrated)

Note: I to XII on Mercalli Scale, 1 to 8 on Richter Scale, N.A. data not available.

Note: The city of Delhi lies between Latitude 28° 24' North to 28° 53' North, Longitude 76° 50' East to 77° 20' East.

Twin tectonic features—one, its location along the Yamuna, which separates the Ganga basin from the Indus basin over a tectonic fold, and the other is its location near the Himalayas—place Delhi under a seismic hazard.

MAP 1: GEOLOGICAL FAULTS IN PROXIMITY TO DELHI



The city of Delhi is internally dissected by a number of faults, fractures, and shears which have an alignment from north-northeast and south-southwest to east-northeast and west-southwest. Important faults which cut the Delhi ridge occur at Rajinder Nagar, East Patel Nagar, Anand Parbat and the Inderpuri faults. Notable faults to the east of the ridge are the Kishangarh fault and a west-northwest and east-southeast treading fault between Qutab Minar, Mehrauli and the Lado Sarai faults. Not only those earthquakes that are located as close as Gurgaon and Mathura but ones with their epicentres in Shimla, Kangra, Kumaon and even in far neighbouring countries like Nepal, Pakistan and Afghanistan have an impact on the city. Both local and Himalayan sources are therefore discernible.

India has experienced 1467 earthquakes of magnitude above 5.0 in a span of 49 years from 1949 to 1998 (Indian Metrological Department, 1998). This is an average of 30 earthquakes per year. More than half of these earthquakes have their genesis in the Himalayas. The Himalayas are seismically the most active continent-continent collision zone, which account for approximately 15 per cent of the yearly global energy release (Acharya, Unpublished, Pg. 7). The question one can ask here is, how many of these have left their indelible marks on Delhi? Delhi's receptivity to earthquake pulses is difficult to delimit precisely. The focal depth and magnitude of the earthquake would also be an important factor, an 8-magnitude earthquake felt anywhere in the Himalayas would cause vibrations all over Indo-Gangetic plain and even beyond, irrespective of proximity. Ignoring the foregoing exceptions of remote probability, I think a 500 kilometres distance can be notched and called the *quakeshed* or impact zone for Delhi.

MAP 2: EARTHQUAKES FIVE HUNDRED KILOMETRES AROUND DELHI

Such a reckoning was eventually confirmed with seismic scientists of the Geological Survey of India. Thus, the bond between Delhi and the 500 kilometres *quakeshed* becomes even clearer.

Taking a cue from these, an attempt is made to assess the number of earthquakes that could possibly have been felt in the city during the last five decades. Concentric circles at 100 kilometre intervals were thus drawn, upto 500 kilometres with Delhi as the centre. All earthquakes of magnitude above 5.0 on the Richter scale, occurring from 1949-1998, were plotted in these five concentric circles using latitude and longitude as the locational address.

Table 2: Occurrences of Earthquakes within 500 Kilometres of Delhi

Distance from Delhi	*Number of Earthquakes (Magnitude on Richter Scale)*			
Kilometres	5.0 to 5.9	5.9- 6.9	More than 6.9	Total
0-100	1	1	0	2
101-200	1	1	0	2
201-300	8	0	0	1
301-400	29	6	0	42
401-500	44	5	0	49
Total	83	13	0	96

Source: Indian Meteorological Department Records of Earthquakes, 1949 –1998. (Data recalibrated)

Note: Earthquakes above 5.0 on Richter Scale have been considered.

Ninety-six earthquakes of magnitude above 5.0 have occurred in the 49 years within a 500 kilometre distance of Delhi. This averages to nearly two earthquakes a year or one in every six months. If only the impact of local earthquakes were considered, the frequency would have been one in eight years. Of this total, 10 per cent belonged to the above 5.9 category. While the first 300 kilometres from Delhi have been a relatively quiet zone with only five earthquakes, over 42 per cent of the total earthquakes have occurred within the 300 to 400 kilometres distance. The 400-500 kilometres took the single largest share of 51 per cent of the total earthquakes in a 100 kilometre stretch.

Most earthquakes thus disturbing Delhi originate either in the floor of the Ganga basin or in the roots of the Himalayas. The release of energy in the Himalayas finds an additional outlet in the tectonic surfaces around Delhi. The isoseismal maps of the Himalayan earthquakes seen *vis-à-vis* Delhi support this connection. The Uttarkashi earthquake of 1991 which took root

295 kilometres north of Delhi in the Uttaranchal, showed a petering earthquake with intensity from above XII near the epicentre to IV where the landform changed from Himalayas to the Ganga basin. This regular pattern of declining isoseismals showed an anomaly "around Delhi-Sonepat sector which recorded an intensity of V surrounded by areas with intensity IV". Another earthquake, rooted at Chamoli in the Himalayas, in early hours of March 29, 1999 also, according to a report of the Geological Survey of India (1999), "damaged well-constructed buildings in and around Delhi due to accentuation of intensity."

Tectonic features within and adjoining Delhi do respond to quakes in the Himalayas. The frame of local and Himalayan faults endows a frail safeguard to Delhi's structure, which frequently falls prey to the damage of earthquakes.

City Damage

Historical descriptions, reports and events glued together from news cuttings speak of more than just rumblings and sleep disturbances for the inhabitants of the city. Delhi has been victim of losses ranging from death to collapsed houses. An account of an earthquake on the July 15, 1720, as recorded by Quaff Khansays states,

> "At this time on Friday, when in most of the mosques of Darul Khilafat (capital i.e. Delhi) the recitation of Chute (pre - address) was in progress and people were getting ready for prayer, a horrible earthquake took place. People felt scared of the noise beneath the ground, shaking walls, cracking roofs of buildings."(Iyengar 2000: 574).

A translation of these descriptions into the Mercalli scale indicates damages comparable to those of the VIII and IX intensity (Narulla et al. 2000: 10). This however is not a solitary event. Qutab Minar, one of Delhi's prized archaeological monuments, once had seven storeys in all attaining a height of 92.3 metres. On the top of the fifth storey, there was a 3.6 metres high cupola. In 1803, this cupola crowning the Minar was thrown down and destroyed when an earthquake struck in Mathura, 145 kilometres to the southeast of Delhi. The Qutab Minar has thus been dwarfed to 72.5 metres. (Thapliyal 1987). Some people were injured in Delhi in the Khurja earthquake on October 10, 1956. In the epicentral tract of the 1960 earthquake located between Delhi Cantonment and Gurgaon in the south, two people died, 100 sustained injuries and 75 per cent of the buildings developed cracks that ranged from hairline to 13 mm wide ones. The seismic waves originating in 1991 from Uttarkashi jolted men, women and children out on to the streets as houses shook like cardboard boxes. A convulsing shock on July 28, 1994 generated isoseismals V on the MM scale encompassing areas around Red Fort, Jama Masjid, Pahar Ganj and Connaught Place. Nearly four years later, windowpanes quivered and cracks appeared in tall buildings of Delhi—again from a convulsing Uttarkashi on March 29, 1999. Crossed and encircled by numerous geological faults, lying in close proximity to an active tectonic plate, Delhi is vulnerable to ruinous scales of the earthquake.

Earthquake Expectancy

Forecasting is at a nascent stage in the case of earthquakes. Movements of the earth are but omens of possible earthquakes. Thrusts in the Himalayas are moving at varying speeds of 1 to 2 centimetres per year along the Nahan Riasi, it is 5.8 centimetres per year along the Himalayan thrust, and 0.9 centimetres per year along the Krol thrust near Kalsi (Valdiya 1976: 358) Even the advance of the Asian plate by 2 centimetres every year announces that the crust is still out-of-adjustment with its interior. It is estimated that quiescence in the Himalayas lasts for a period of 200 to 279 years after which a great earthquake reoccurs.

Experts predict that in the next 50 years the region is bound to be hit by a severe earthquake of magnitude 6.0 on the Richter scale. They also state that there is an 80 per cent probability of the occurrence of an earthquake of the magnitude 7.0 (Srivastava and Roy 1966: 420). A major seismic upheaval in the range of 8.0 or 9.0 magnitude is expected in northern India in the foreseeable future. The forecast is based on detailed analysis of past earthquakes and underground movement of the region backed up by satellite imageries. Delhi is no doubt sitting on a ticking bomb. With such a host of symptoms it would be propitious to ignore the prognosis of an intense earthquake knocking the city. What creates a hazardous situation is the thin armour it has against such an eventuality.

Houses in Delhi are fragile. The Census of Delhi 1991 claims that the city has 1.9 million houses of which 85 per cent are classified as *pucca* and 15 per cent as *kutcha* or semi *kutcha*. To state that only the two hundred thousand *kutcha* houses are the weak ones would be a gross underestimation. Several new flats built by the Delhi Development Authority in the Vikaspuri colony in west Delhi came crashing down after a heavy downpour. The Authority since its inception in 1957, has built an estimated 70,000 pucca houses, one would be suspicious of the construction of many of these.

The Delhi urban environment is continuously wearing out but the rate of replacement does not match the rate of urban obsolescence. The historic part of the walled city dates back to the 1650s, and it contains a dense concentration of old buildings. Most of these have lived their age and are thus fragile. Earthquake resistant design was developed in India as early as the 1930s, but the Bureau of Indian Standards developed its first code of seismic design only in 1962 (IS 1893-1962). This Bureau set detailed recommendations of earthquake resistant designs for all kinds of structures including houses. Within the patchwork of old and new, private and public, high rise and slums it would be not so far from the truth to say that not even a minuscule fraction of the constructions in Delhi adhere to the seismic hazard norms. Till now houses in Delhi have behaved like a camel that carries on for years, only to suddenly kneel down and die.

Flood Hazard

While the threat of earthquakes looms menacingly over Delhi, sweeping floods frequently drown much of its area. Delhi straddles along the Yamuna, one of the major tributaries feeding the mighty Ganga. The Yamuna itself is a river of no small magnitude. Originating from the 6387 metres high glacial field of Yamunotri in the Himalayas, it merges its identity into the Ganges only after completing an independent traverse of 1376 kilometres. The Yamuna flowing through Delhi is barely two per cent of its total length, yet this brief contact today is a curse in the form of recurrent floods. In the last 97 years, the river has risen to a danger level nearly 45 times, which means an occurrence of one flood every alternate year. Incidentally, this is similar to the frequency of earthquakes. Hidden by the law of averages is the fact that the occurrences of floods have been increasing distinctly. During the 1940s, the river did not reach a danger level even once in 10 years, floods became an alternative year phenomenon in the 1950s, and have been now taking place almost every year in the 1990s.

When the Yamuna oversteps the specified danger level by one metre and above, the floods acquire high intensity damage. In the last 97 years, the Yamuna flowed one metre above the danger level almost 15 times, and it thrice crossed the danger level by two metres. The all-time high floods occurred in the years 1978, 1988 and 1995. The catalogue of floods confirms that there has been a sharp multiplication in their occurrence as well as a rise in intensity, thus exposing the city to the hazard. This flood situation however seems to be a recent development.

Table 3: Occurrence of Floods in Delhi, 1900 – 1997

Decade	*No. of floods**[1]	*Average flood situation per year*	*River Flow 1 to 2 metres above danger level*	*More than 2 metres above the danger level*
1900-1910	3	0.3	0	0
1911-1920	1	0.1	0	0
1921-1930	1	0.1	1	0
1931-1940	2	0.2	0	0
1941-1950	4	0.4	1	0
1951-1960	5	0.5	2	0
1961-1970	8	0.8	3	0
1971-1980	8	0.8	5	1
1981-1990	7	0.7	1	1
1991-1997*[2]	6	1.0	2	1
Total 1900-1997		45	0.5	153

Source: Records of Central Water Commission & Irrigation and Flood Control Department, Delhi. (Data recalibrated)

Note: *[1] The Danger Level for a flood is identified as 204.83 metres.

*[2] Refers to occurrence of floods in six years, 1991-1997.

The Yamuna has been flowing in one channel ever since the British conquest of Delhi. But there are historical references to show that the river had been flowing in two-channels up to 1857. One, the channel that is still flowing through Delhi. The other channel flowed somewhere near Mehrauli, then known as Mihirpuri. The city remained safe from floods not only due to this extra channel but also because of its compact size and drain outlets as high as 6-7 metres. The latter allowed plenty of room for the river waters to rise, thus preventing it from flowing into the city. What actually happened to this second natural channel remains shrouded in mystery till today. Perhaps it was snipped, choked or filled. The neglect of the main channel started when the East India Railway Company built the

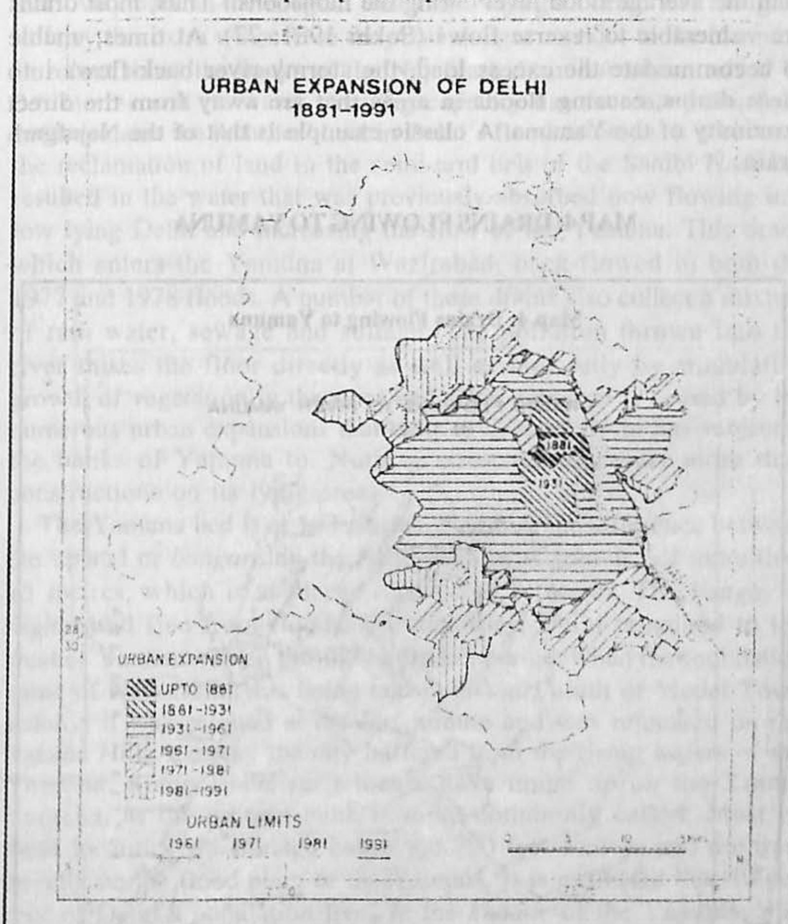
Yamuna bridge in 1876. Its conversion into a double lane in 1913 made it a busy thoroughfare, thus overtaking the important role that the river had played for the city. The city and the river have always had a relationship but in recent years the kinship with the Yamuna has been nonchalant. Impeding its movement, reducing its size, encroaching on its bed and degrading its catchment are all acts, which worsen the flood situation in Delhi.

The Yamuna experiences extreme seasonal stances and knows only two seasons, the dry and the wet. Seasonal aridity of the long dry months keeps the river lean for a long time. The Yamuna's shallow depth does not exceed 1.5 metres during the eight month long dry spell, and its width is a mere 0.2 kilometres. The monsoon arrives in early June and awakens this sloppy stream nourished with waters from July to September, so that it bloats 6 to 7 metres in depth and stretches to over a kilometre in width. The contrast of the dry and wet season is so vivid that it fosters the myth: rains flip Yamuna to flood. While it is true that 99 per cent of the total floods in Delhi occur during the monsoon months, the correlation between rainfall and runoff negates this relationship. The high intensity floods of 1976, 1977 and 1978 were chosen to prepare a statistical correlation or 'r' between rainfall and runoff. The results conclude 0.05, -0.24, and -0.42 for these three years respectively (Soun 1980-81: 72). The near stationary trend of rainfall in the last 50 years *vis-à-vis* the rise in the occurrence of floods also confirms that rain is not solely responsible for the occurrence of floods. Hence the Yamuna is much misunderstood.

Causes of Floods

Unlike earthquakes, which originate exclusively from natural processes, a plethora of human interactions with the river conspire to trigger floods. Behaving like a tin-cap, urban structures are impervious because they cannot absorb rain and thus direct it underground. The amount of runoff increases in relation to the paved area. Estimates in Delhi show that an increase in paved area by 10 per cent leads to an addition of 10,000 cusecs of water into the Yamuna (Sokhi 1981: 85). The runoff is unrestrained in Delhi owing to an extensive paved area. Delhi's urban area has expanded 43 to 710 sq. kms. from 1901-1991.

MAP 3: SPATIAL EXPANSION OF DELHI



Map 3: Spatial Expansion of Delhi

In this 16 time increase, 'paved' land use whether it is residential, commercial or transportation collectively forms an overwhelming 75 per cent of the total area. Drains coming from the urban terrain are thus overloaded. Adding to its burden are a number of big and small drains which make their way through the rural adjunct of Delhi. Traversing a length of 440 kilometres, 75 drains flow through various parts of Delhi and collect to form 17 major channels, which ultimately joins the river.

Puncturing the length of the Yamuna, these drains increase the load of river especially during the monsoons. The level of most of the drains and their outfall into the Yamuna is 4.46 metres lower than the average flood level during the monsoons. Thus, most drains are vulnerable to reverse flows (Sokhi 1981: 77). At times, unable to accommodate the excess load, the stormy river back-flows into these drains, causing floods in areas that are away from the direct proximity of the Yamuna. A classic example is that of the Najafgarh drain.

MAP 4: DRAINS FLOWING TO YAMUNA

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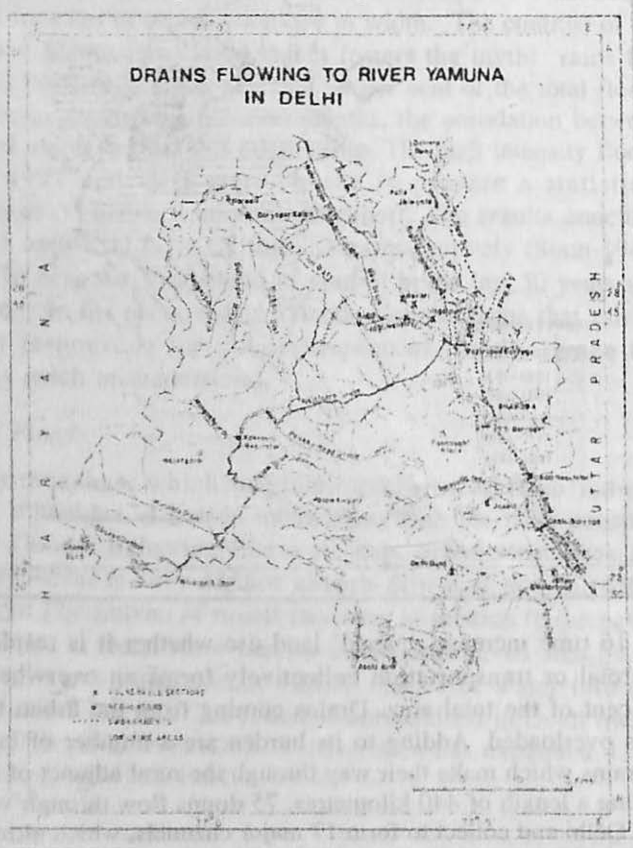


As water rushes from the western side of Delhi's Aravalis and the Sahibi Nadi in Rajasthan, it plugs a 45 square kilometre saucer shaped depression and forms a near permanent lake, the Najafgarh *Jheel.* Built way back in the Mughal times the Najafgarh drain was designed to ferry this extra water from the *jheel* along a corridor to the Yamuna. In recent times the banks of the Najafgarh drain have been raised by 0.6 metres and its water carrying capacity has increased fourfold, yet it remains the Achilles' heal in Delhi's flood situation. It is because the reclamation of land in the semi-arid belt of the Sahibi Nadi has resulted in the water that was previously absorbed now flowing into low lying Delhi and increasing the flow of the Yamuna. This drain, which enters the Yamuna at Wazirabad, back-flowed in both the 1977 and 1978 floods. A number of these drains also collect a mixture of rain water, sewage and sullage. The pollution thrown into the river raises the floor directly as well as indirectly by stimulating growth of vegetation in the river bed. This pollution is caused by the numerous urban expansions that the populace of Delhi has subjected the banks of Yamuna to. Nothing constricts the river more than constructions on its lying areas.

The Yamuna bed is at 183 metres, therefore the difference between the upland or *bangar* and the flood plain or *khadar* is not more than 15 metres, which is at places reduced to 8 metres. The *bangar* is higher and free from floods. For centuries, Delhi remained to the west of Yamuna. Even during the British period, when the foundation stone of New Delhi was being laid in *khadar,* north of Model Town colony, it was rescued at the last minute and was relocated on the Raisina Hills, keeping the city buffered from the rising waters of the Yamuna. Since 1947, settlements have come up on the Trans-Yamuna, as the eastern bank is more commonly called. Most of these localities are situated below the 700 feet contour and are thus directly on the flood plain of the Yamuna. It is estimated that 40 per cent of Delhi's population lives in the *khadar* of the Yamuna; this amounts to at least five million people being at risk to floods.

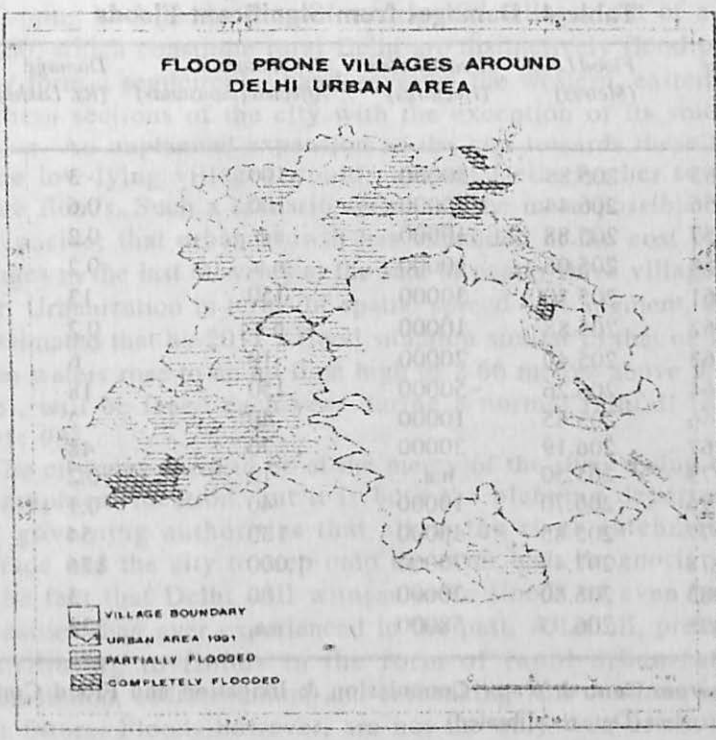
Floods in Delhi are not caused by these factors alone. Much like the tectonic thrusts, which shifted in the Himalayas, yet moved land in Delhi, the mountainous catchment of the Yamuna too plays a role in flooding the city. Fifty-eight per cent of Yamuna catchment lies in the Himalayan slopes, which were till the middle of the last century, covered with dense forests. Anchored in deep soil, trees like fir and deodar absorbed 25 to 30 per cent of the rain, which fell on to the slopes. Rapid deforestation at the rate of 2 per cent per annum, have denuded much of the Yamuna catchment as well as other Himalayan rivers. Bouncing off bare surfaces and assisted by steep gradients, the rain water now hurriedly rushes to join streams eroding the bare slopes on the way. The present rate of erosion in the Yamuna Basin is estimated to be 400 acre feet per year for every 100 square kilometres (Gupta 1979: 35). Such aggressive action cause soil and boulders to become loose, get detached, and at times get carried into the river. Ground and crushed with the passage of time, this eroded mixture gets converted into sediments that raise the bed of river and constrain its capacity of carrying water. Thus, on one hand, the high intensity of rainfall, coupled with reduced absorption increases the amount of water sedimentation while on the other hand, this decreases its capacity. These processes contribute to increase the incidence of floods.

Worsening an already bad situation are the technocratic solutions put forward for containing and training the river. Reinforced with cement, steel and mortar nearly 57 kilometres of the river in Delhi is embanked. The city authorities have also constructed three barrages at Okhla, Wazirabad, and the Income Tax Office bridge, 16 storm water pumping stations, 22 semi-permanent pumping stations, and a host of other means for desilting drains to control the hazard of flood.

It would be foolhardy to depend upon engineering solutions alone. They are not only costly and require constant maintenance but some of these measures are counterproductive. Take for instance, the embankments. Lining both sides of the river from Wazirabad to the Yamuna Barrage sector, these walls severely constrict the width of the channel to 500 metres. They ignore the vacillating character of the river, which in the case of Yamuna involves changing its course frequently. A comparison of Satellite Imageries of 1988 and 1995 by IRS-IA show that, 'The river bed near Burari, Shakarpur and Kundakalan villages has recently shifted its course and it is attacking the protection works' (Central Water Commission, 1999: 12). Indeed such swings in a span of barely 10 years mean that the river would strongly resist being embanked. Likewise, the Najafgarh drain was breached at 12 places during the 1978 flood.

MAP 5: FLOOD PRONE VILLAGES AROUND DELHI

Map 5: Flood Prone Villages Around Delhi



Perhaps it would be wiser to allow the river to have some room to expand and contract according to its natural processes, and the necessary engineering solutions should take better cognisance of nature's laws. In fact these structural defensive measures on the banks are under such adverse impingement of flow that vulnerable sections can be identified at several places like Burari, Jagatpur, Jasola and the Deoli Bund. Bursting at its seams, announcing its rage at being misunderstood, the river is forced to flood and in its wake damage the city.

Flood Damage: Floods cause widespread loss to a city. Some inkling of this harm can be gleaned from Table 4. Sixteen important floods displaced 2 million people, ruined 40 thousand hectares and caused damages worth Rs 600 million in and around Delhi. Floods played havoc in the city for no less than 45 times in the past 97 years, thus causing widespread damage, both in material and human terms.

Table 4: Damages from Significant Floods

Year	*Flood Level (Metres)*	*Area Affected (Hectares)*	*Population Affected (thousands)*	*Damage (Rs. Lakhs)*
1955	205.88	30000	100	3
1956	206.44	10000	100	0.6
1957	205.88	10000	n.a.	0.2
1958	205.06	10000	n.a.	0.2
1961	205.20	30000	150	13
1962	205.88	10000	n.a.	0.2
1963	205.40	20000	10	6
1964	206.26	50000	150	18
1966	205.85	10000	40	2
1967	206.19	30000	70	48
1973	205.50	n.a.	10	0.2
1976	206.70	10000	40	0.1
1977	205.85	40000	130	54
1978	207.49	70000	1,000	176
1983	205.80	20000	80	3
1995	206.93	58000	n.a.	323

Source: Central Water Commission & Irrigation and Flood Control Department.(Data recalibrated)

Where is the mention of the 1988 floods in the table? How can there be only 16 listings when the Yamuna flowed 1 m above danger level 15 times, 3 times over the 2 m danger level and 3 times all time high floods occurred during 1978. Houses remained submerged up to 0.61 to 0.91 centimetres under water and personal property and goods were damaged. Diseases such as malaria were rampant reaching epidemic proportions. Several cases of cholera, dysentery, conjunctivitis and gastro-enteritis were reported. All the four bridges over the Yamuna were closed, and suburban trains were stopped. The railway line between Sampla and Kharawar, a double section on the Rohtak-Delhi route, was adversely affected, and water eroded large chunks of the Najafgarh road. The flood led to severe shortage of milk and drinking water. As a consequence, the law and order situation also worsened. Private tempo and taxi drivers took undue advantage by charging exorbitant tariff. Tension among the villagers against the city dwellers assumed alarming proportions as villagers wielded spears and *lathis* to chase Delhi police pickets in a bid to breach the drains to lessen the flood pressure on their villages.

Coming back to the present, nearly 100 villages out of a total of 260, which constitute rural Delhi are distinctively flood prone. They form a semicircular band covering the western, eastern and northern sections of the city with the exception of its southern section. An unplanned expansion of the city towards these flood prone low-lying villages would catapult Delhi further towards future floods. Such a scenario seems all the more possible when we consider that urban growth has expanded at the cost of 167 villages in the last 60 years at the rate of nearly three villages per year. Urbanization in terms of spatial spread will augment, and it is estimated that by 2011 a flood situation similar to that of 1978, when waters rose to an all time high of 2.66 metres above danger level, will be faced each year during a normal rainfall (Sokhi 1981: 93)

The city may seem to be at the mercy of the river owing to its geographical location, but it is both the planning departments and governing authorities that allow the river catchment to degrade and the city to step onto the river bed. Prognosis point to the fact that Delhi will witness more floods of even higher intensities than ever experienced in the past. After all, processes contributing to floods in the form of rapid urbanization, deforestation, sedimentation, and embanking will continue in the near future. Floods however, are not the only woe of the city. While, during the monsoons, most of Delhi drenches and drowns, in summers, it simmers erupting into frequent cases of fire.

Fire hazard

Each day the fire stations in Delhi receive on an average, 25 calls requesting for a fire tender to douse a spreading blaze. A compilation of the city's twenty-three fire records confirm that these calls have increased from 7 per day in the 1970s to 13 in the 1980s and 25 during the 1990s. Once every fortnight such a request carries an urgent tone because then the demand is for 8 to 16 fire tenders, which means the fire is not a small one but of a major to serious intensity. Fires are a growing hazard in Delhi.

Table 5: Fires in Delhi, 1971-1999

Year	*Intensity*				*Total*
	Major	*Serious*	*Medium*	*Small*	
1971-72	0	3	13	2638	2654
1972-73	1	2	7	2779	2789
1973-74	0	6	15	2785	2806
1974-75	0	7	18	2529	2554
1975-76	n.a.	n.a.	n.a.	n.a.	n.a.
1976-77	0	5	9	2717	2731
1977-78	n.a.	n.a.	n.a.	n.a.	n.a.
1978-79	n.a.	n.a.	n.a.	n.a.	n.a.
1979-80	n.a.	n.a.	n.a.	n.a.	n.a.
1980-81	1	5	12	3218	3236
1981-82	0	3	11	3500	3514
1982-83	0	3	8	3791	3802
1983-84	2	4	11	4162	4179
1984-85	0	12	19	5236	5267
1985-86	1	2	11	4891	4905
1986-87	0	2	12	5011	5025
1987-88	0	9	17	5883	5909
1988-89	0	10	16	5884	5910
1989-90	0	7	16	6573	6596
1990-91	2	10	16	6908	6936
1991-92	0	11	17	7057	7085
1992-93	0	11	13	7201	7225
1993-94	0	5	24	8467	8496
1994-95	0	5	19	9431	9455
1995-96	1	6	16	11004	11027
1996-97	0	4	18	10644	10666
1997-98	0	6	15	9912	9933
1998-99	0	6	22	11310	11338

Source: Based on Number of fire calls to the Fire Department, Delhi.

Fires can be classified into four categories of intensity—major, serious, medium and small, based on the requirements of the fire extinguishing equipment. A major fire needs thrice the number of water and hose tenders, and thrice the number of water bousers, pumps and ambulances when compared to the medium fires. The serious ones are placed in between. Small fires in comparison are the least demanding to extinguish. The fire fighting equipment is then used as an indicator of the intensity.

Table 6: Intensity of Fire as Gauged from the Assistance Required for its Control

Fire Fighting Equipment	*Intensity of Fire*		
	Major	*Serious*	*Medium*
Water Tenders	16	12	8
Water Bousers	6	4	2
Pumps	6	4	2
Ambulance	6	4	2
Hose Tenders	2	1	1
Rescue Tenders	1	0	0

Source: Unpublished official circular of the Fire Department, Delhi. (Data recalibrated)

In terms of occurrence, the small intensity fires account for 99 per cent of the total fires experienced in the city. These are doused quickly and are not of severe consequence. The major, serious and medium intensity fires pose the real threat and have been therefore chosen as the basis of analysis in this research. In the last three decades the frequency of all these three high intensity fires has almost doubled in each case.

Table 7: Occurrence of High Intensity Fires, 1970 - 1998

Decade	*Average Annual Occurrence in the Decade*		
	Major	*Serious*	*Medium*
1970-1979	0.2	4.6	12.4
1980-1989	0.4	5.7	13.3
1990-1998	0.4	8.0	20.0

Source: Unpublished records of the Fire Department, Delhi, Years data: 1971-1975, 1976-1977, all years of 1980 and 1990-1998. (Data recalibrated)

Note1: Address of individual Fire cases were used to categorise them into land use.

Occurrence of fire shows that safety flaws are rampant in all kinds of urban uses whether it is residential, commercial, industrial or institutional. Considering the caveats in data, the annual average is a better yardstick to judge the type of land use that is more prone to fire. In Delhi, fires in residential areas have tripled in the last two decades. Industrial fires have also seen a rising trend while commercial areas attained a higher incidence rate from three per year in the 1970s to seven per year in

1990s. The category 'others', which includes prime properties like Delhi Telephone Exchanges, Supreme Court, Railway Stations, and Airports cannot be treated casually just because the share of this in the total high intensity fires is less. Such places are of public importance, and the incidences of fires in such premises have doubled thus furnishing evidence of the growing indifference towards safety in the city.

Table 8: Fire Incidences according to Land Use, 1970-1998

Land use	*Average Annual in the Decade*		
	1970-1979	*1980-1989*	*1990-1998*
Commercial	3.0	4.9	7.3
Industrial	0.6	3.1	3.3
Residential	0.4	4.7	12.7
Others	0.6	2.2	5.4
Total	4.6	14.9	28.7

Source: Unpublished records of the Fire Department, Delhi, No. of years data - 1971-1975, 1976-1977, all years of 1980 and 1990-1998. (Data recalibrated)

Note: 1. Includes only major, serious, medium fires.
2. Address of each fire was used to categorise them into these land uses.
3. Though fires cannot occur in decimals, data is kept like this to indicate the miniscule occurrence.

In residential areas medium fires have tripled from three per year in the 1980s to ten during the 1990s. Commercial areas like markets and high rise premises have also witnessed a doubling of the medium fires from 1980s to the 1990s. Sweeping through homes, shops, offices, and industries these flames inflict severe harm and the city has to pay a heavy price for it.

Table 9: Intensity of Fire by Land Use in Delhi, 1970-1990

Land use	*Average Annual in the Decade*								
	Major			*Serious*			*Medium*		
	1970s	*1980s*	*1990s*	*1970s*	*1980s*	*1990s*	*1970s*	*1980s*	*1990s*
Commercial	0.2	0.2	0.3	2.8	2.1	2.5	0.0	2.6	4.5
Industrial	0.0	0.3	0.0	0.6	1.0	0.6	0.0	1.8	2.7
Residential	0.0	0.1	0.0	0.4	1.5	2.5	0.0	3.1	10.2
Others	0.0	0.2	0.0	0.6	0.9	1.6	0.0	1.1	3.8
Total	0.2	0.8	0.3	4.4	5.5	7.2	0.0	8.6	21.2

Source: Unpublished records of the Fire Department, Delhi, No. of years data - 1971-1975, 1976-1977, all years of 1980 and 1990-1998. (Data recalibrated)

Fire toll: Fire imposes an enormous and dreadful waste on the society, measurable only in pain, suffering and death; a toll that is a wasteful destruction of property. Every alternate day one person in Delhi succumbs to his fire injuries.

Personal injury by fire is self inflicted or accidental. In 1985-86 and 1989-90, the number of such deaths soared to 316 and 309, respectively, while injuries were as high as 1760 (1988-89) and 1617 (1989-1990) per year. The ratio of death to injury was 1:5. Though these numbers can vacillate, not a year has passed by when the number is lower than eighty-six.

Table 10: Casualty from Fire in Delhi, 1971-1999

Year	*Dead*	*Injured*	*Year*	*Dead*	*Injured*
1971-72	121	613	1985-86	316	1493
1972-73	219	538	1986-87	255	1441
1973-74	197	680	1987-88	262	1422
1974-75	n.a.	n.a.	1988-89	287	1760
1975-76	n.a.	n.a.	1989-90	309	1617
1976-77	156	745	1990-91	97	632
1977-78	n.a.	n.a.	1991-92	105	490
1978-79	n.a.	n.a.	1992-93	119	505
1979-80	n.a.	n.a.	1993-94	112	487
1980-81	198	1003	1994-95	86	526
1981-82	266	1292*	1995-96	94	431
1982-83	280	1125	1996-97	139	512
1983-84	283	2113	1997-98	174	675
1984-85	251	1488	1998-99	150	225

Source: Unpublished records of the Fire Department, Delhi. (Data recalibrated)

A sample from Safdarjung Hospital, which houses Delhi's largest burn ward, negates the data of the Fire Department. It shows that not only are fire victims distinctly on the increase, but deaths are six to seven times higher to those recorded by the Fire Department. Doctors in the hospital confirm that even though many patients in the burn ward are victims of suicide, domestic accidents and quarrels, but the majority are triggered by what are called fire accidents.

Table 11: Patients Admitted to the Burn Ward of Safdarjung Hospital, Delhi, 1990-1999

Year	*Admission in burn Ward*	*Death within 48 hours*	*Death after 48 hours*
1990	1804	330	228
1991	2014	285	243
1992	1794	250	200
1993	1842	283	291
1994	1747	284	234
1995	1936	341	264
1996	1993	342	254
1997	3125	548	500
1998	3354	480	624
1999	4124	744	648

Source: Unpublished Medical Record Registers of the Safdarjung Hospital, Delhi. (Data recalibrated)

Note: Includes self-injury cases in the Hospital.

The tragedies are most glaring in some individual fire episodes. Uphaar is one of Delhi's prime cinema halls. On June 29, 1987, flames that started in its fifth floor led to the death of three individuals. Another glaring episode occurred at Siddhartha, one of Delhi's leading five star hotels. A major fire engulfed a number of its floors on January 23, 1996, killing 37 people and injuring equal numbers too. This is a high percentage because, on that night, the hotel had only 189 guests. On June 13,1997, 1075 viewers of the Hindi film 'Border' had no idea that 59 among them would soon be asphixed in smoke spurting from the cinema hall's 1000 Kilowatt oil filled transformer. Ansal Bhawan is a 48 metres high rise premise in Delhi's prime commercial-cum-business centre of Connaught Place. In a major flare that broke out in Sanjay Amar slum cluster on the banks of Yamuna on March 15, 1999, 28 people died and 40 were seriously injured. In the Lal Kuan calamity of June 1999, more than 40 persons were killed and over 100 severely hurt when a fire broke out in a godown of chemicals in this congested residential-cum-commercial area within the walled city area of Delhi. More lethal and far reaching in damage was the fire episode of Jwalaheri PVC market. PVC is an acronym, which stands for a toxic compound called Poly-vinyl-chloride. This is Asia's largest plastic recycling manufacturing area with over 2000 factories, which has already turned into an inferno seven times. Fire scalds and kills irrespective of whether the structure engulfed is a cinema hall, a high-rise building, a hotel, a slum, a godown or an industry.

A large amount of material wealth is bound up in the form of buildings and infrastructure in the cities. When hazards strike, losses are thus heavy. Over the years property losses have escalated from Rs 6 million per year in the 1960s to Rs 2.75 billion in the1990s. This is a forty time increase within a span of 40 years.

Table 12: Property Loss from Fire in Delhi, 1960-1990

Decade	*Average Annual in the Decade (Rs. million)*
1960 – 1969	6
1970 – 1979	138.0
1980 – 1989	555.9
1990 – 1998	2744.6

Source: Unpublished records of the Fire Department, Delhi. (Data recalibrated)

The value of goods have increased over the decades. The loss due to fires therefore has also increased manifold. The fire which gutted the Indian Airlines terminal at the Indira Gandhi International Airport of Delhi on October 29, 1996, ruined property worth Rs 155 million. This subsequently paralysed emergency telephone services, trunk dialling, and computerized reservation lines for many days.

The irredeemable loss of life and property causes destruction that cannot be measured in rupees. These include bereavement, business failure, destruction of vital official documents, personal treasures and the psychological trauma of living with a disfigured face or limbs. The capital of one of the largest democracies in the world, Delhi, is glaringly unable to safeguard its citizens from this most primitive element harnessed by man, fire. Why do fires occur in Delhi?

Cause of Fire

Fifty-four per cent of the fires occur in the dry months of April to June and 25 per cent of them in the cold dry months of November to February.

Table 13: Mean Monthly Maximum Temperatures in Delhi and High Intensity Fires

Month	*Average Temperature in Degree Centigrade*				*High Intensity Fires (Per cent to total high intensity fires)*
	1931-1960	1970-1979	1980-1989	1990-1999	
January	21.1	21.2	20.8	21.0	4.5
February	24.2	24.2	23.9	23.6	4.5
March	30.0	30.1	28.7	28.6	7.6
April	36.2	35.7	35.3	35.4	20.9
May	39.6	38.9	38.4	39.7	18.0
June	39.3	39.3	39.0	39.3	15.0
July	35.1	35.4	35.0	34.8	3.0
August	33.3	33.3	33.9	33.4	3.3
September	33.9	33.6	34.7	33.5	2.5
October	32.9	30.0	32.8	32.3	7.1
November	28.3	28.1	28.1	28.3	9.3
December	23.0	22.5	22.7	23.4	4.3

Source: Indian Meteorological Department, Delhi. (Data recalibrated)

The climate versus fire relationship for Delhi is established as the coefficient of correlation runs a + 0.6 between temperature and fire occurrence and it drops drastically to - 0.89 between relative humidity and fire and further down to - 0.35 between rainy days and fire. There is no doubt that Delhi's semi-arid climate is characterized by extreme dry conditions associated with hot summer. When the mercury in Delhi soars to more than 45° centigrade, three to four intense fires strike the city per month. July and August are almost free of fires due to the high humidity accompanying the prevailing monsoons. None the less, it is not Delhi's scorching summer temperatures, which make the city vulnerable to this hazard. In the last 70 years, the mean monthly temperatures have not changed yet the number of fires have escalated-proving clearly that temperatures alone do not cause the fires in the city. On scrutinizing the records kept by the Fire Department a variety of causes were found and their list included electric short circuit, naked flames, carelessness and lightning. According to their classification, 64 per cent of the fires were caused by electric short circuits and 16 per cent were acts of carelessness.

Table 14: Causes of Fire as Classified by the Fire Department

Causes	*Per cent to total fires*
Electric Short Circuit	64
Carelessness	16
Naked Flame	6
Others*	14
Total	100

Source: Refer Table 8

Note: *Others include causes like incendiary, lightening, children playing with fire.

While the Fire Department sets out its own classification of the causes of fires it tends to gloss over its own inadequate services. The following reasons may be responsible for this. At the time of independence, Delhi had 4 fire stations, and today it has 34. In 1951 Delhi had a population of 1.4 million and one fire station served 0.37 million people, today it has to serve 0.50 million. Another way to grasp the shortfall is to compare the growth of fires vis-à-vis the number of stations.

Table 15: Fire Stations versus Number of Fires, 1970-1990

Decade	*No. of Fire stations*	*No. of Fires* *
1970s	13	23
1980s	24	151
1990s	34	223

Note: *Only major, serious and medium fires have been considered

While high intensity fires have increased by six times the number of stations lag behind with only a three-fold growth. It is the manpower and fire fighting equipment, which are the strength of the stations. The fire service authorities state that it has a sanctioned strength of 1603 personnel but it needs 2138, indicating a straight shortage of 535 people. In addition to the feeble work force, the infrastructure is also inadequate. The fire department has a fleet of 103 fire tenders, 13 motor pumps, 12 trailer pumps, 8 high pressure pumps, 17 water bousers, and 33 ambulances (1998). If distributed equally among all the 34 fire stations then except for the fire tenders, all other vehicles get reduced to a fraction. This too is not whole reality. Nearly 40 per cent of the vehicles have outlived their life and are near a breakdown point. This reduces the functional figure to barely one fire tender per station. Let us not forget that in case of serious, medium, and major fires, 12, 8, and 16 tenders were the minimum number required, respectively. This means that while stations are few and far between, the fire fighting equipment is even more inadequate.

The desired response time by international standards is three minutes. But in Delhi, a fire tender often has to face chaos in the form of traffic snarls, narrow lanes, vendors, stalls, animals, and sometimes even angry mobs. A diary was maintained to check the time taken by a fire tender to reach and handle fires in four different land use areas. It took as much as 11 to 45 minutes for the first fire tender to reach the spot.

Arranging large quantity of water further adds to the delays. The number of fire stations, workers, vehicles, water tanks, traffic congestion and water supply, all conspire to hinder the efficiency of the city fire service. The revenue base of the civic department has also been eroding consistently, while its responsibilities for augmenting the existing services has been growing. But concluding that these inadequacies form the sole basis for the argument for a fire hazard to the city would be a myopic understanding of the ecology of fire breeding.

Table 16: Response Time to Fire in Delhi

Date	*Location*	*Time of fire*	*Arrival of first fire tender*	*Time taken*
09.06.1984	Jehangirpuri Slum	1610 hours	1655 hours	45 minutes
08.04.1989	Vandana Building	1800 hours	1811 hours	12 minutes
23.01.1996	Siddhartha Hotel	0212 hours	0224 hours	12 minutes
13.06.1997	Uphaar Cinema	1710 hours	1716 hours	6 minutes

Source: Compiled from News and Inquiry Reports.

Delhi has grown at a breathtaking speed of 0.20 million (per year) to accommodate 14 million people in 100 years. Accommodating and housing this annual surge of people is an awesome task, especially when one half of these can be traced to an exodus from rural areas. Delhi attracts a large number of migrants. Fleeing deteriorating ecological conditions and crushing poverty, most of these immigrants to Delhi seek shelter in hastily built huts or jhuggies. A closer look at this form of habitation is a key to understanding residential fires in Delhi.

A recent report states that Delhi has more than 1700 slum clusters and 1000 unauthorised colonies which house nearly five million people. The *Compendium of Environmental Statistics*, 1997 states that nearly 1080 such housing clusters containing nearly half a million jhuggies house 2.5 million people in different parts of Delhi. Each jhuggie, an anachronism of a habitat in which life is a cramp of all sorts, gives refuge to an overwhelming population of Delhi. Nearly 75,500 such jhuggies were destroyed by fires during the last 12 years, killing 150 and injuring another 370 people.

Table 17: Occurrence of Fire in Slums of Delhi, 1987-1998

Year	*No. of Jhuggies Gutted*	*People*		*Loss (Rs. millions)*
		Death	*Injury*	
1987	3999	5	22	4
1988	2766	5	14	2
1989	5856	15	49	5
1990	17286	13	39	8
1991	10202	44	44	6
1992	9634	15	5	5
1993	4557	8	37	5
1994	5639	8	19	7
1995	5277	20	32	6
1996	2891	9	45	5
1997	1985	8	28	8
1998	5820	10	38	8

Source: Dheri, S.K., 1999. (Data recalibrated)

It is difficult to count every jhuggie in the city, but records tell us that on an average each year nearly 6,000 of these poor men's abodes are gutted exposing at least 50,000 people to severe hardship.

Owing to their vulnerable ecology, slums are gutted in fire a number of times, yet most people show tenacity in rebuilding on that very debris. Jhuggies in the Jehangirpuri colony have been worn down by five fires within a span of ten years, one on the Yamuna embankment locality called *pushta* six times; and in Kirti Nagar the frequency has been seven times. On some days fires have struck at two different places in the city as on March 15, 2000, when Sanjay Amar jhuggies in west Delhi and the Rajiv Gandhi camp in east Delhi burnt simultaneously.

Politically, the slum dwellers are seen as vital vote banks. Economically, they provide cheap labour known as the informal sector. Despite their gains to the city, the inhabitants are locked into a ratchet effect of poverty and have the limited option of choice between rural starvation and low grade inflammable huts. While their homes are unsafe, their work environments are even worse. Many of these people find employment in the industries, which have mushroomed in the city.

The industrial landscape of Delhi is not dominated by large modern factories where production, storage, and marketing is streamlined and equipped with state of the art measures of fire safety precautions. A majority of the industries are small in scale. An index to their condition is the fact that of the 1,26,000 such units nearly 97,411 are located in the non-conforming zones. This means that 77 per cent of the industries violate this legal document and occupy garages, basements, backyard of shops and houses or small sheds in non industrial areas. Hundreds of these units manufacture plastic or rubber using highly inflammable raw materials. In most factories, electric wires hang carelessly while furnaces, smelters, and machines occupy crowded premises with no exhausts for ventilation. Manned by a low skilled and niggardly paid labour there is no concept of safety in these cubbyhole industries, resulting in quick fires.

The tragedy of industrial fires is further compounded by their situation within residential premises. Prime examples include the Wazirpur industrial area located near Shalimar Bagh and the Najafgarh industrial area situated between Patel Nagar and Moti Nagar. The entire Sarai Rohilla area houses hundreds of small scale industries manufacturing plastic, rubber and various other highly inflammable chemicals within residential areas. In Karol Bagh, the Regarpura colony has hundreds of goldsmiths working together by taking several connections from one or two gas cylinders in the residential buildings. Leakage in one pipe would lead to a major blast.

Commercial areas comprising markets, cinemas, and offices in high rise buildings have also become the frequent, niches of high intensity fires. If carefully observed many shops bear a close semblance to jhuggies. This may sound a bit far fetched, but here are the parallels: in Delhi, shops are of small size, most have only one entrance, or show-windows, and no ventilation outlets. All these factors are common to jhuggies. The exterior of jhuggies is made of wood shingles, cardboard, and polythene while the interior dÈcor of shops is also made of similar inflammable building materials. A jhuggie is stuffed with all things that the owner can afford; most shops are bursting with goods too. Shortage of space in jhuggies forces one to conduct domestic chores on the pavements, while racks and wares of shops stealthily encroach on to the pathway in a similar fashion. Almost five to six of a family cram inside a jhuggie and an average small shop of Delhi usually has the owner, his son, one salesperson, and a person doing odd jobs called a *mundu,* who crowd the shop with four to five people. The *chulla* or cooking hearth is of course, not there in the shop, but Delhi's chronic shortage of electricity makes a generator and its fuel cans essential gadgets in every shop. Shops huddled back to back on both sides of the narrow streets are also a similarity between a jhuggie cluster and a market. Congestion, high population density, and insufficient civic amenities are the other features common to both. The only difference is that markets thrive during the day and empty out at night. The shops house expensive, modern and new goods while ragged, obsolete, and second hands are outfits common to a jhuggie. Shop owners are the rich citizens of Delhi while jhuggies house the poor. But fires consider neither day and night nor rich and poor. If the aetiology is conducive, the hazard strikes both alike. Delhi has retail, wholesale, planned, and unplanned markets, but most typify the above said characteristics. Therefore, it is not surprising that fires attack one and all.

Sadar Bazaar is one of Delhi's leading wholesale market with an umbilical bond to the walled city dating back to A.D.1700. Its narrow winding lanes with neck-to-neck row of buildings, innumerable illegal encroachments, and the hustle bustle of thousands of traders have given the bazaar the feel of a beehive. On an average, a small fire erupts in the Bazaar on every alternate day. In the last 23 years, five serious fires erupted in its sub markets of Gandhi Market, Darvesh Bazar, Pan Mandi, Shiv Market, and Swadeshi Market. On April 16,1990, fire from a shop filled with hosiery goods smouldered and destroyed 700 shops. Even Connaught Place, a well laid out and open spaced retail market, becomes a victim of a small fire once every two days. A row of shops on Janpath Street was engulfed in a major fire in 1994 destroying five shops. These shops were huddled close to one another and stocked clothes and handicraft.

Markets are sprinkled across many areas of Delhi which have added attractions in the form of cinema halls as the foci of entertainment for the people. It is well known that Indians are enthusiastic cinema watchers. Every day nearly a quarter million people make a beeline into Delhi's 70 halls to seek recreation. Cinegoers have grown from 17 million per year in the 1960s to 90 million per year in the 1990s.

Table 18: Cinema Halls and Cinegoers in Delhi, 1960-1998

Year	*Cinema halls (No.)*	*Cinegoers (in millions)*
1961	36	17
1971	60	30
1981	72	66
1991	74	64
1998	64	90

Source: Delhi Statistical Handbook 1998, Statistics of the Government of National Capital Territory, Delhi. (Data recalibrated)

Yet the safety of cinema halls is dangerously fragile. Nearly 30 per cent of the cinema halls in Delhi are over 50 years old, and they are badly in need of refurbishing.

Table 19: Age of Cinema Halls in Delhi

Age of hall (years)	*No. of halls*	*Per cent to total halls*
More than 90	2	5
81-90	0	0
71-80	2	5
61-71	6	14
51-60	3	7
41-50	5	10
31-40	6	14
21-30	13	30
11-20	7	15
Total	44	100

Source: Based on Primary Sample Survey in 60 per cent of the cinema halls of Delhi.

If slums are symbols of poverty and markets that of utter chaos, fire in high-rise premises signify that even planned and nearly stacked structures do not escape from this hazard.These high rise premises project themselves as solutions to the population density, shortage of land, and soaring rent. In sharp contrast to the jhuggies, high-rise premises epitomise the input of professional architects, builders, multiple government inspections and clearance agencies, all of which exist to ensure the highest safety standards. What causes these constructions of the higher echelons in the city to suffer from this hazard?

Delhi has over 1200 high-rise premises. In a sample of 221 such areas, 70 were declared as unsafe by the Fire Department in 2001. If rules and laws are violated so blatantly these could turn into towering infernos, instead of fulfilling the promise of saving space and creating efficient work environs.

According to norms prescribed for fire protection, each high rise building has to follow 12 fire safety rules which include having provisions like a separate five metres wide approach road, water riser system, automatic sprinkler, fire detection system, fireman's switch board, alarm, public address system and hose reels. An estimated cost for the installation of all these would be around Rs 2 million, which apparently many seem to be unwilling to undertake. The apathy of the owners and users of the building towards safety, and at times the connivance of the administration towards enforcing safety rules pose problems in this regard.

Hazards in the city are evidently not accidents or acts of providence. Neither do rain nor high temperatures cause floods or fire. Even earthquakes do not cause damage—it is the faulty designs of structures and low quality building material, which spruces the figures of loss. Branding hazards as natural processes implies that we are abducting responsibility. On the contrary, these hazards are symptoms of larger conspiracies, which put society at grave risk. It reiterates what Beck said, "in the risk society the point of impact is not obviously tied to the point of origin" (Beck, 1992, Pg. 100).

In short Delhi contains all the ingredients for hazard occurrence—heightened risk, concentrated exposure, increased vulnerability, corrupt officials and lax governance. Such is the crucible, which fuels the soaring crime graph, road accidents, health epidemics and a string of other hazards breeding in this mega city. All these factors have propelled the city into the high-hazard category. The disadvantage of taking city level data is that the average conceals the discrepancies between different areas and makes the hazards seem isolated. These averages also make hazards seem random thus occurring anywhere in the city. The need for examining the spatial distribution of hazards in a city thus becomes imperative.

Geographers have traditionally divided cities on the basis of their age, type of land and the ways it has been put to use, population structure, building types and infrastructure. Today the occurrence of hazards in the city has an important spatial manifestation. After all the distribution of hazards, be it floods, fire or the imprint of an earthquake, cannot be overlooked, as it is an index of safety for the people. Hazard regions are thus an important spatial abstraction that geographers could create. Regional tags help to amalgamate vast areas and imagination is needed to define such regions.

Spatial study can reveal connections and patterns of hazards unseen at the level of the individual household, shop, industry, high-rise or slum. Hazard regions can also draw the attention of policy makers to these locales of a city. The maps also hold the mirror up to the society at large to see as to where the unsafe regions of the city are, that require urgent action. Such maps are thus useful in locating disaster assistance centres based on the number of facilities available, especially shelters like schools, hospitals, fire and police stations. Regional constructions demonstrated through maps have power when they become units for identity formations with an effect on local development policies. Therefore, the important questions are: what is the geographical distribution of hazards in the city? Where in a city do hazards concentrate? Do single or multiple hazard regions dominate?

Hazard Regions

A search for an appropriate unit for spatial analysis was met by the Planning Divisions identified in the Delhi Master Plan by the Town and Country Planning Organisation. These Planning Divisions were conceived as self-contained in employment, housing, recreation shopping and other essential services (Rana, 2000) They were assumed to be functional units reflecting their own patterns of development and land uses. For delimiting hazard regions, Zonal Development Units under the Planning Division have been selected because their boundary is governed by, 'the land use, where change in predominant function of land use would give a clue to the possible boundary for the next zone since this would indicate a major shift in the activities of the area.' Further the Zonal Development Units are not of fixed size 'those in populated areas are much smaller than those in less populated areas'. Each unit has some special features of its own and is named according to the most popular area included in it.

MAP 6: PLANNING DIVISIONS AND ZONAL DEVELOPMENT UNITS OF DELHI

Map 6: Planning Divisions and Zonal Development Units of Delhi

ZDU	NAME	ZDU	NAME	ZDU	NAME	ZDU	NAME
A1	Paharganj I	B7	Naraina	D14	Safdarjung Tomb	F11	Munirka
A2	Paharganj II	C1	Kashmere Gate	D15	Lodi Colony	F12	Basant Nagar
A3	Aram Bagh	C2	Qudsia Garden	D16	Dayal Singh College	F13	West of Cantonment
A4	Jhandewalan	C3	Civil Lines Main	D17	Nizamuddin	F14	Mahipalpur
A5	New Delhi Rly Station	C4	Subzi Mandi	D18	Jangpura	F15	Mehrauli
A6	Qadar Sarif	C5	Aryapura	D19	Kilokri	F16	Lado Sarai
A7	Motia Khan	C6	West Malkaganj	D20	Lajpat Nagar	F17	Madangir
A8	Jhandewalan	C7	East Malkaganj	D21	Sarojini Nagar	F18	Tughlaqabad
A9	Sadar Bazar	C8	Roshanara Garden	E1	Krishna Nagar	F19	Badarpur
A10	Bara Hindu Rao	C9	Shakti Nagar	E2	Shuman Chirag	G1	Najafgarh Road Industr
A11	Chamelian Road	C10	Roop Nagar - Kamla Naga	E3	Rohtas Nagar	G2	Ramesh Nagar Kirti Nagar
A12	Azad Market	C11	Northern Ridge	E4	Shahdara Residential	G3	Moti Nagar
A13	Kucha Pati Ram	C12	Old Secretariat	E5	Sakdarpur	G4	Mangol Sub-Station
A14	Sui Walan	C13	Delhi University	E6	Dilshad Garden	G5	North Cantonment
A15	Old Daryaganj	C14	Timarpur	E7	Jhilmil	G6	East Cantonment
A16	Lal Darwaza	C15	Kingsway Camp	E8	Khureji Khas	G7	Delhi Cantt Railway St
A17	Farash Khana	C16	Vijay Nagar	E9	Shahdara Commercial	G8	Rajouri Garden
A18	Naya Bans	C17	Rana Pratap Bagh	E10	East Karkar Duman	G9	Tatarpur
A19	Phatak Habas Khan	C18	Tripolia	E11	West Karkar Duman	G10	Madipur
A20	New Daryaganj	C19	Model Town	E12	Shakarpur Khas	G11	Parade Ground
A21	Jama Masjid	C20	Adarsh Nagar	E13	Shahdra Industrial	G12	West Cantonment
A22	Ballimaran-Charkhewala	D1	Connaught Place	E14	Gonda Village	G13	Jail Road
A23	Maliwaran-Garibakalan	D2	Mata Sundri Road	E15	Loni Road	G14	Tilak Nagar
A24	Katra Neel	D3	Curzon Road	E16	Kanchipura	G15	Palam Port
A25	Chandni Chowk	D4	Parliament Street	F1	Friends Colony	G16	Keshopur
A26	Red Fort	D5	Gole Market	F2	Greater Kailash	G17	Jwala Heri
A27	Raj Ghat	D6	Upper Ridge	F3	Siri	H1	Gulabi Bagh
A28	Old Delhi Rly Station	D7	Purana Quila	F4	Safdarjung Enclave	H2	Lawrence Road
B1	Kishan Ganj	D8	India Gate	F5	Rama Krishna Puram	H3	Wazir Pur
B2	Karol Bagh	D9	Central Secretariat	F6	Moti Bagh	H4	Shakur Basti
B3	Rajinder Nagar	D10	Buddha Jayanti Park	F7	Okhla Residential	H5	Pitam Pura
B4	Sarai Rohilla	D11	Khan Market	F8	Okhla Industrial Area	H6	Shalimar Bagh
B5	Ramjas Hill	D12	Akbar Road	F9	Kalkaji	H7	Badli
B6	Patel Nagar	D13	Chanakyapuri	F10	Malviya Nagar	H8	Mangol Pur Kalan

At present Delhi's urban area consists of 14 Planning Divisions but the delimitation of all the Zonal Development Units in it are unavailable. In 1971, the city was carved into 8 Planning Divisions, further subdivided into 136 Zonal Development Units. A map to this effect was available. Freezing the boundary of the city to the 1971 situation may seem an under representation of the area and population, but contained within the 1971 girdle is the main geographical, historical and commercial space of the city. People, goods and services maintain close ties with this area. The occurrence of hazards has been regionalised with reference to this spatial organisation of the city.

As a first step in regionalisation, three categories of zonal development units were identified, namely,

i. Areas that received any impact from earthquakes,
ii. Spaces which were affected by 1977-1978 floods, and
iii. Places that suffered high intensity fire during the last 23 years.

The reason for using a dissimilar range of data, all years for earthquakes, two years for flood and twenty-three years for fire is that evidence of the occurrence of earthquakes is scanty and only twenty-six addresses could be gathered. The 1977 and 1978 floods were of exceptionally high intensity spreading over a large expanse. Therefore, these two years can be considered as a representative sample for the area of occurrence of this hazard. Fires are erratic. To rule out this randomness it was important to study where they agglomerated. This necessitated collection of data over a long period of time. Fire records are available for twenty-three years and all of these were used. To make the data comparable major, high and medium fires were converted into uniform units by using the number of fire tenders sent to extinguish fires as the index of intensity.

Addresses of all the points of impact of earthquake, flood or fire were pinpointed in the Eicher City Map of Delhi, and these were then allocated into their corresponding 136 Zonal Development Units. A data set was thus created to identify the hazard areas of Delhi. Data has been confined to the occurrence of the hazard, as the purpose was delineation of hazard regions rather than vulnerable areas. The virtue of keeping the data set simple is that it locates all areas where the hazard has occurred, and it is a useful measure for certain policy decisions. Further, comparison across cities would require an index which is simple and for which data is available. The method makes use of the visualisation techniques embedded in Geographical Information System through the production of maps.

The following Geographical Information System queries were initiated. For:

A. Hazard regions of Delhi based on occurrence of hazard,

(i) Identify multiple hazard regions by selecting all Zonal Development Units where all the three hazards of earthquake, flood and fire have occurred.

(ii) Identify double hazard regions by selecting all Zonal Development Units where any two hazards have occurred.

(iii) Identify single hazard regions by selecting Zonal Development Units where any one hazard has occurred.

(iv) Identify regions where these three hazards in Zonal Development Units have not occurred.

B. Hazard regions of Delhi based on intensity of fire hazard,

(i) Identify dominant fire hazard regions by selecting all Zonal Development Units where more than 50 fire tenders have reached.

(ii) Identify high fire hazard regions by selecting all Zonal Development Units where 25-50 fire tenders have reached.

(iii) Identify low fire hazard regions by selecting all Zonal Development Units where less than 25 fire tenders have reached.

C. Fire hazard regions of Delhi based on land use which caught fire,

(i) Identify fire hazard regions where more than 25 fire tenders reached the slums.

(ii) Identify fire hazard regions where more than 25 fire tenders reached the commercial land use.

(iii) Identify fire hazard regions where more than 25 fire tenders reached the industrial land use.

D. Service Regions-Fire Hazard vs. Fire Stations,

(i) Identify regions with more than 50 fire tenders but no fire station.

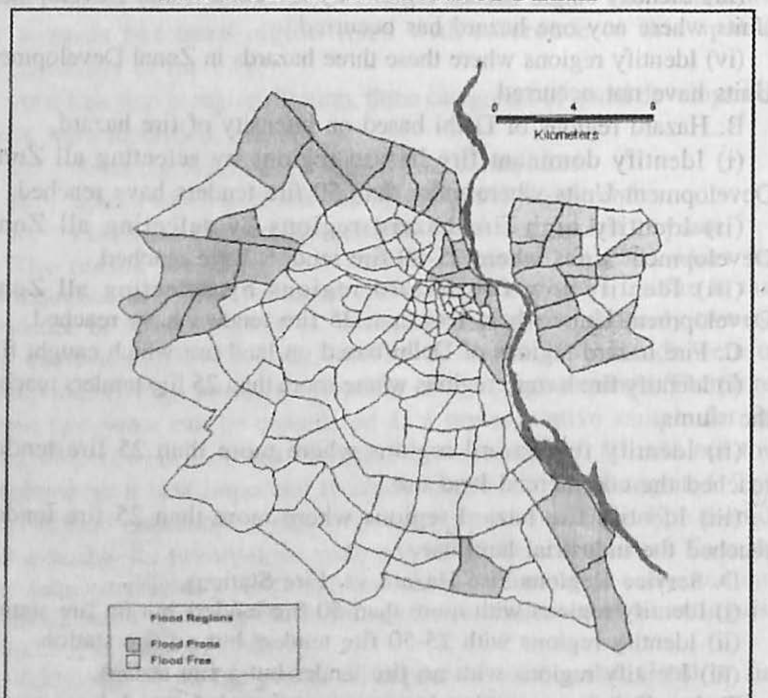
(ii) Identify regions with 25-50 fire tenders but no fire station.

(iii) Identify regions with no fire tender but a fire station.

Today, Delhi as a city has become a perilous habitat. A large part of the city has experienced the imprint of flood, fire or earthquake. If the occurrences of hazards are seen individually then 24 Zonal Development Units were witness to earthquake (17 per cent), floods have submerged 32 such units (23 per cent), and fire incidences have broken out in 80 of the total units (58 per cent). Spatially, fire occurrences are spread over a larger part of the city while floods and earthquakes have a comparatively restricted territory. Floods are only a hazard in the units along the banks of Yamuna and also through which the drainage lines such as Shahdara drain, Najafgarh drain and their supplementary offshoots traverse.

A high water level caused these drains to breach at several places, thus drowning a number of residential areas. Delhi is fast expanding into flood territory. Fifteen out of the 32 flood hazard units fall on the peripheries of Delhi and are recent entrants into the urban ambit of Delhi. Mistakes of urban construction in these areas in the past have invited floods into the city. The direction of expansion of the city needs to be drawn on the basis of vulnerability to hazards.

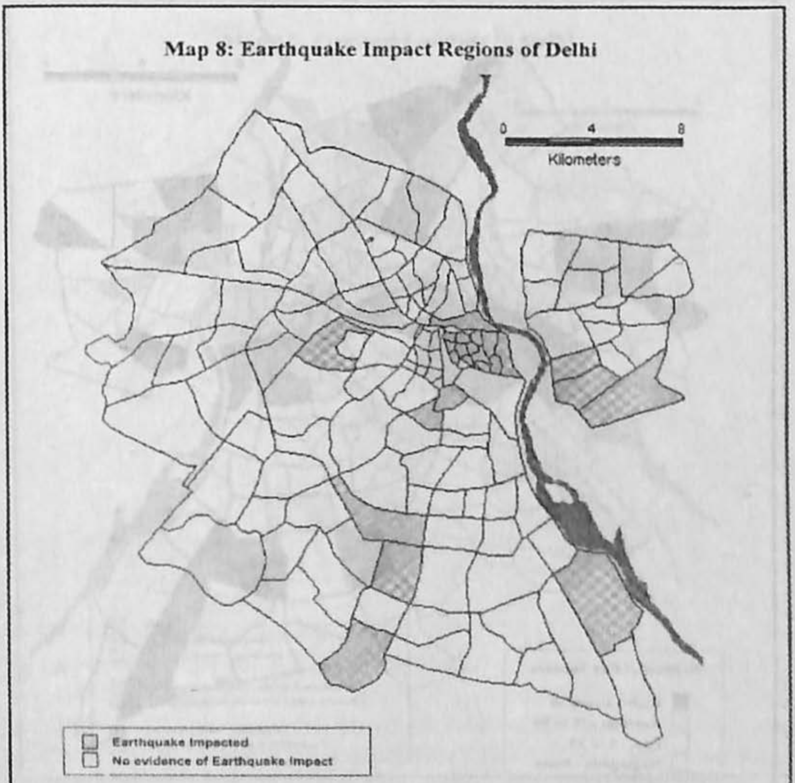
MAP 7: FLOOD REGIONS OF DELHI



While the experience of floods is vivid in the memories of most Delhi citizens, earthquake impacts are still isolated and lesser known in the city. Delhi does fall in the seismically vulnerable zone, yet evidence of visible impacts of damage to buildings could be gathered for only 26 locations, which cluster in 22 out of 136 Units.

These could be grouped into two types, by location; firstly in the flood plain, and secondly in the high rise areas. Representing the former is the damage to houses in Geeta Colony, Laxmi Nagar and, Daryaganj while the Surya Kiran building, Tarang Apartments and Qutab Minar that exemplify the vertical constructions, which dot the city. Records also point to the impact of an earthquake, which occurred way back in A.D. 1720 in the Zonal Development Unit of Chandni Chowk, Lal Darwaza and Farash Khana occupying an old floodplain in the core of Delhi. It is a well-established fact that the young and loose sediment deposits are more susceptible to earthquakes. Also buildings on the deep alluvial deposits are vulnerable to even long distance earthquake due to the resonance effect. Therefore, the depth of bedrock is of vital significance. In contrast to floods, the impress of earthquake occur in both the newer and the older units of Delhi. Overall Delhi's expansion on the flood plain and its eagerness to soar skywards without recourse to seismic sensitive building codes are harbingers to a more widespread distribution of earthquake damage in the future.

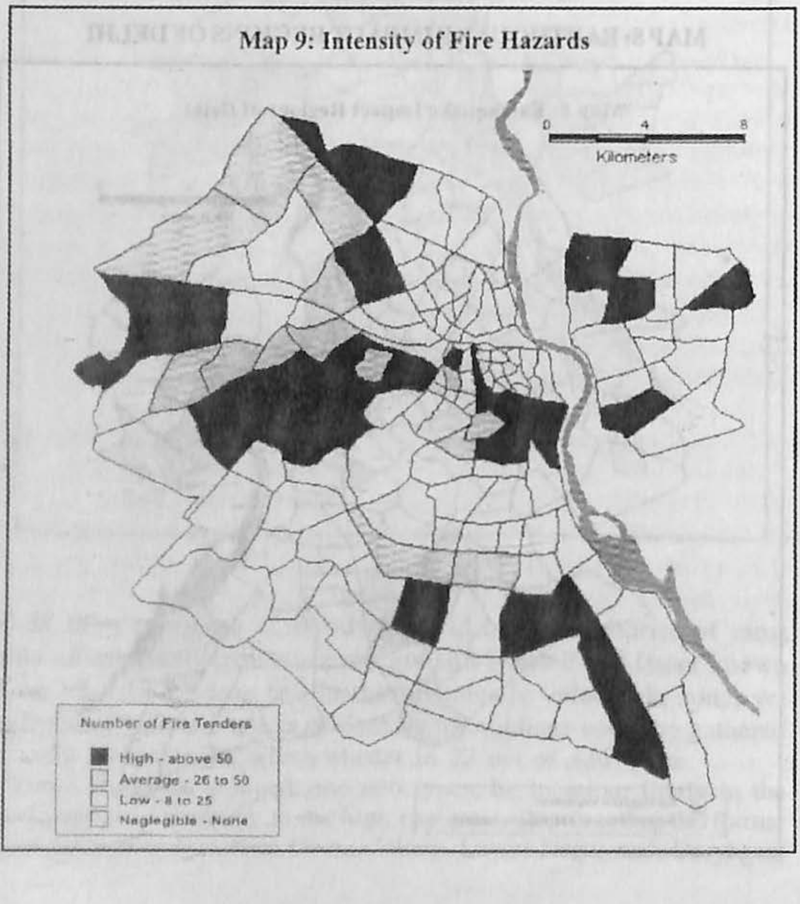
MAP 8: EARTHQUAKE IMPACT REGIONS OF DELHI



Fire when compared with earthquake and floods has a wide presence in the city. The geographical location of the fire regions includes a continuous belt in the north and north west, a prominent cluster in the centre, four isolated patches in the east and an inverted L zone in south Delhi.

Most of the fires in the north west and all the fires in the eastern part of Delhi have ignited in the slums. Commercial premises, such as markets and high rise buildings have drawn a large number of fire tenders in the central and southern parts of Delhi. The industrial areas of Naraina and Okhla enlarge the spatial extent of the north west and southern fire areas respectively.

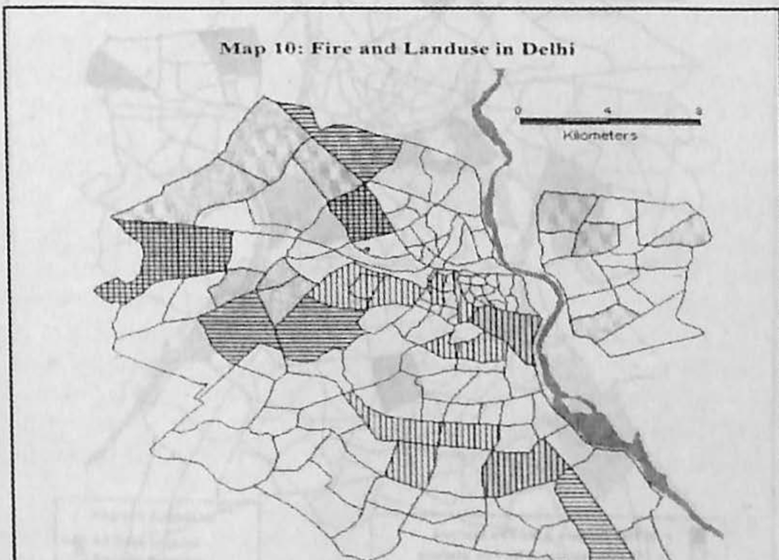
MAP 9: INTENSITY OF FIRE HAZARDS



In Delhi, fires occur both in the core and peripheral Zonal Development Units. Both these are zones of mounting urban pressures, though the manifestation of the stress has differed being jhuggies in the peripheries and high rise premises at the core. The critical units are those where all the land uses: jhuggies, commercial and industrial fires occur.

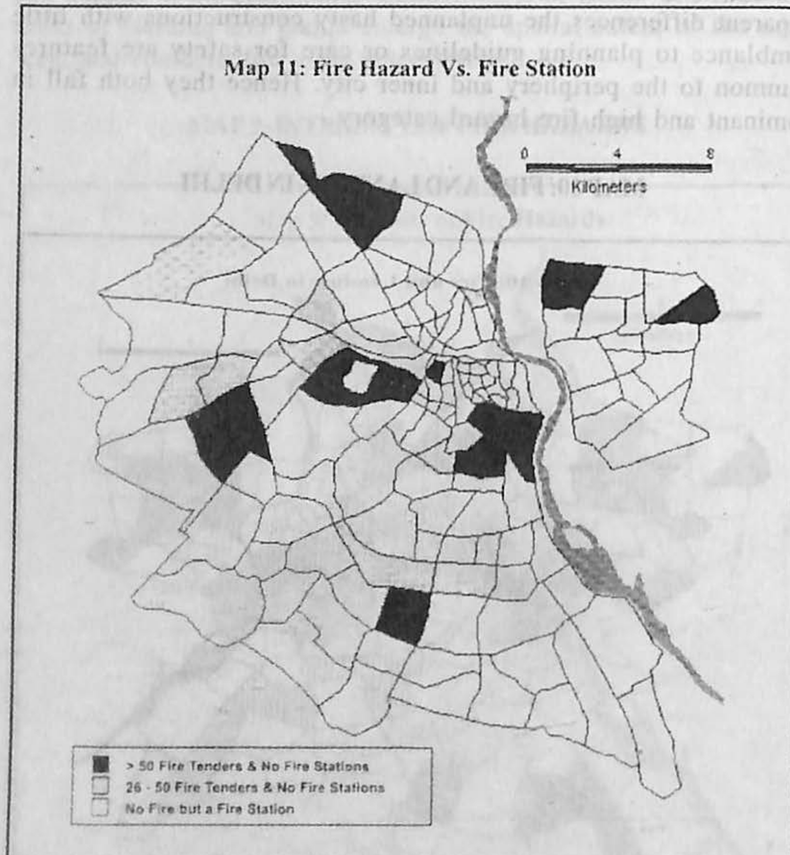
Land use too has undergone a change in both the peripheral and core units. In the former, the change has been from rural to urban and in the latter from residential to commercial. Despite these apparent differences the unplanned hasty constructions with little semblance to planning guidelines or care for safety are features common to the periphery and inner city. Hence they both fall in dominant and high fire hazard category.

MAP 10: FIRE AND LANDUSE IN DELHI



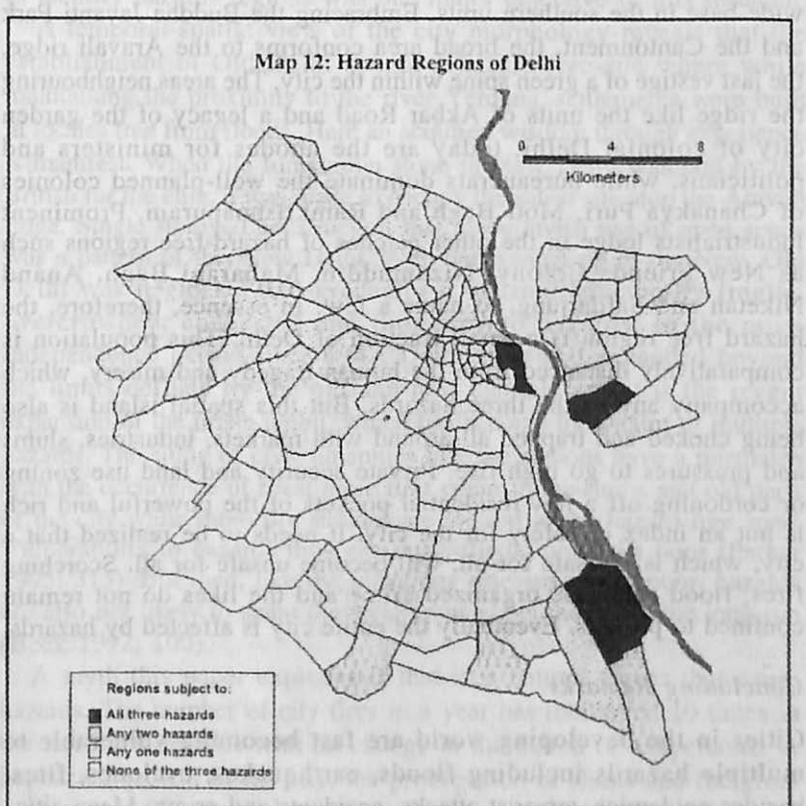
The criticality of fire hazard comes to light when fire occurrence is seen *vis-à-vis* location of fire station in the unit. There are a number of units distributed all over Delhi where over 25 fire tenders have reached but they lack a fire station. The occurrence of fires needs to be considered as a vital input while making a decision of locating fire stations in a city.

MAP 11: FIRE HAZARD VS. FIRE STATION



It is often assumed that the older parts of a city are victim to a greater number of hazards. Urbanization after all has occurred at different times in the Zonal Development Units. Some Zonal Development Units are old with urban settlement dating back to 1650s while others are as recent as the last decade. Superimposing the hazard region map on the time period, one of the Zonal Development Units disqualifies partially the statement: that the older the urban areas, the more are the hazards. While the older core of city has decayed and attracted hazards, the city of the 1930s is least prone to hazards when compared to the more recently urbanized Zonal Development Units of post 1970s on the northern and eastern peripheries. Comparing the geographical locations it is seen that the recent entrants into the urban ambit have accrued more hazards.

MAP 12: HAZARD REGIONS OF DELHI



Multiple hazard areas cover only four units, which are strung along the Yamuna, reminding that the land use along its alluvial bed is incompatible with the environmental vulnerability of the zone. Double hazard regions, either a combination of flood and fire, fire and earthquake, or flood and earthquake, occur in 36 units, they are scattered throughout the city. Ninety-six Units of the cityscape have been the victim of one or another hazard. A cardinal division shows that north, west and east Delhi are greater victims of the hazards while the southwest and south are relatively free of them. The latter areas happen to include relatively high-class residential and prestigious institutional areas and constitute 30 per cent of the Zonal Development Units. (Fig.12) Barring a few isolated locales, a continuous triangular shaped stretch of hazard free region occupies a prominent part of south and south-west Delhi.

With a narrow apex in Central Delhi, the region acquires a distinctly wide base in the southern units. Embracing the Buddha Jayanti Park and the Cantonment, the broad area conforms to the Aravali ridge, the last vestige of a green spine within the city. The areas neighbouring the ridge like the units of Akbar Road and a legacy of the garden city of colonial Delhi, today are the abodes for ministers and politicians, while bureaucrats dominate the well-planned colonies of Chanakya Puri, Moti Bagh and Ramkrishnapuram. Prominent industrialists lodge in the other patches of hazard-free regions such as New Friends Colony, Nizamuddin, Maharani Bagh, Anand Niketan and Safdarjung, to name a few. In essence, therefore, the hazard free region is a small fraction of Delhi. This population is comparatively distanced from the human tragedy and misery, which accompany any of the three hazards. But this spatial island is also being choked and trapped all around with markets, industries, slums and pressures to go high rise. Private security and land use zoning or cordoning off a few residential pockets of the powerful and rich is not an index of safety for the city. It needs to be realized that a city, which is not safe for all, will become unsafe for all. Scorching fires, flood refugees, organized crime and the likes do not remain confined to pockets. Eventually the entire city is affected by hazards.

Concluding Remarks

Cities in the developing world are fast becoming vulnerable to multiple hazards including floods, earthquakes, cyclones, fires, besides epidemics, terrorist attacks, accidents and crime. Mega cities in particular are crucibles of hazards (Mitchell 1999: 43). Yet no attempt has been made to identify hazard regions in cities and thereby design policies to mitigate the occurrence or to prevent recurrence of loss and suffering. A first step towards policy formulation for disaster management in cities is to identify places and spaces where hazards occur. The delineation of disaster regions within a city is of value in framing an integrated spatial policy. Collating data from diverse sources, and using the tool of GIS, this paper has identified the multiple hazard regions of Delhi. The boundaries of the hazard regions were determined by taking into account the extent of the urban sprawl on tectonically weak and flood prone areas, as displayed by satellite imageries. This procedure resembles the one followed by (Rosenfield 1994: 29) who favoured a landscape based geomorphological approach in such cases. Evolving a methodology to identify hazards regions was one major objective of this research.

A temporal-spatial view of the city morphology reveals that the establishment of Old Delhi sought a hazard free-site where while maintaining the proximity to the river Yamuna, settlements were built in locales free from floods. Here an acquired wisdom through experience is manifest. When the foundation stone of New Delhi was laid by the British for the elite, it was made to occupy the safest site atop the Aravali ridge. Single storeyed construction that made lavish use of open space was a pattern of this New Delhi. With the coming up of the New, Old Delhi was neglected and gradually it became structurally fragile, overcrowded, congested and thus prey to hazards. In the post-independence period since 1947, Delhi grew and expanded beyond the limits defined by the old and new capitals and it is the recent expansion of the urban ambit, which has become the victim of multiple hazards. The siting of civic amenities like fire stations have a mismatch with the occurrence of fires; more fires occur in the slums and old parts of the city while more fire stations are located in the hazard free zone. Vulnerability to hazards thus gets magnified among the poor (Parker 1995: 315). But then, like the infectious diseases of the poor, hazards are also not likely to spare the wealthy neighbourhoods in the long run (Beck 1992: 100).

A myth this paper explodes is that it is natural forces that cause hazards. The number of city fires in a year has multiplied 10 times in the last three decades with no change in the march of temperature. A haphazard growth of the city, the proliferation of slums and the gross inadequacy of fire control infrastructure emerge as the main explanatory variables. Briefly put, more of the hazards occur where the city population interfered with the natural processes, faulted in making locational decisions and failed to manage local habitats. Fragile infrastructure, in general, aggravates the situation (Horlick 1995: 332).

Hazard occurrence however cannot be exclusively explained away with reference to the age of city, its population density, or its land use. Embedded in the hazard map of a city is an invisible hand of political economy which influences the location of richer people in hazard free sites, leaving the hazard prone ones for the relatively poor. This is exemplified by the case study of Delhi. Only 39 Zonal Development Units out of 136 in all, covering one-fourth of the city area accommodating hardly 10 per cent of the population, are free from the hazard of earthquake, flood and fire. All such localities are elite in character and include the residences of politicians, bureaucrats, and industrialists, mainly the policy makers.

Forceful and direct measures, such as zoning, land use regulation, and condemnation of dwellings in particular hazardous environments are among the strategies recommended for meeting the situation (Palm 1981: 392). No less critical is the resolution of issues linked with relegation of the poor to hazard prone sites. Equally important is to grasp the peoples' perception pertaining to the vulnerability of different parts of the city to specific hazards and to assess their attitude and response to them. Are the residents of Delhi aware of hazards? What are their perceptions? How can they be motivated to mitigate the damage from hazards? These are relevant questions that need to be addressed through research.

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Note: The relevant data in the reports published by the Geological Survey of India, the Central Water Commission, the Government of National Capital Territory (Delhi), the INTACH , Justice Khanna Commission of Enquiry (on a fire incident at a hotel in Delhi) as well as the reports/news published in several well known national dailies have been consulted and sometimes used in writing this paper. The author places on record her gratitude to all these sources.

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