CHAPTER-III

HAZARD AND RISK ASSESSMENT

Introduction

A disaster is an event triggered by natural or man-made causes that lead to sudden distribution of normalcy of life within society, causing widespread damage to life and property. Distribution can be caused due to occurrence of frequent hazards like earthquakes, fires, cyclones, terrorism, biological wars and chemical explosions. When hazards connect with risk and vulnerabilities leads to the destruction. Level of risk (high/medium/low) depends upon the various hazards for which any specific area is prone to and/or also on the various physical, social-economic and institutional parameters. The chapter has been covered into two parts. First part is covering hazard assessment and second part is covering risk on vulnerability assessment on the basis of hazard assessment.

Hazard Assessment

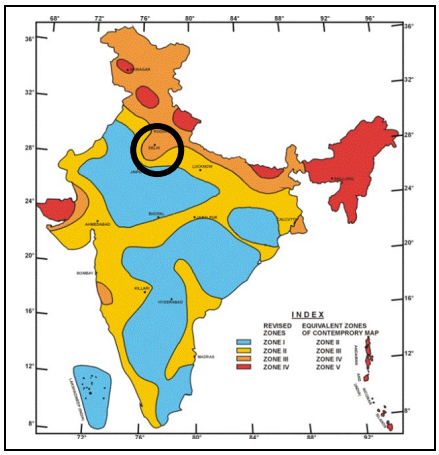
"Hazard is an event or occurrence that has the potential for causing injury to life or damage to property or the environment. The magnitude of the phenomenon, the probability of its occurrence and the extent and severity of the impact can vary. In many cases, these effects can be anticipated and estimated." (Terry Jeggle and Rob Stephenson, Concepts of Hazard and Vulnerability Analysis)

In order to focus limited resources on to those areas of the state at risk, it is necessary to understand the pattern of hazard activity precisely and put a quantitative probability to the likelihood of occurrence of hazards. Information is available through newspaper clippings and records maintained with the various government departments of the hazard prone areas in the State with respect to various hazards has been documented for assessing the types of hazards probably occur in Delhi.

Earthquake Hazard:

*An **earthquake** is a sudden shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface and followed by a series of vibrations. Earthquakes can cause buildings and bridges to collapse, telephone and power lines to fall, and result in fires, explosions and landslides.*

Seismicity in Delhi



The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. The region with intensity less than V is designated as Zone 0. Thus, the designation of area as seismic Zone V indicates activity. Delhi is located in zone IV which has fairly high seismicity **where the general occurrence of earthquakes is of 5-6 magnitude, a few of magnitude 6-7 and occasionally of 7-8 magnitude. Delhi thus lies among the high-risk areas.**

Seismicity in North India, including the Himalayas, is due to collision of the Indian plate with Eurasian plate. It is seen that the Delhi region has a long seismic history being affected by earthquakes of local origin as well as these on Himalayan origin. Based on the tectonic map of the region prepared by Srivastav and Roy, this region is characterized by several dominant features such as the ***Delhi - Hardwar ridge***, the ***Aravalli - Delhi fold***, the ***Sohna fault, the Mathura fault and the Moradabad fault***.
The distribution of the epi-centres appears to have a NE-SW trend correlated with the direction of major tectonic features of the region. It coincides with the extension of the Aravali Mountain belt beneath the alluvial plains of the Ganga basin to the northeast of Delhi towards the Himalayan mountain (Jain,1996). **According to these authors it is not possible to associate the seismicity of Delhi with any particular tectonic unit.**

In *engineering terminology* this generally referred to as the depth of bedrock below ground level. It is quite well known that tall buildings founded on deep alluvial deposits can be vulnerable to even long-distance earthquakes due to resonance effects. Detailed and accurate information on the depth of bedrock in the Delhi region is not available. *Geological Survey of India(GSI) reports mention that the bedrock depth is 60 m in the Patel Road area, 15 m in Connaught Place Central Park, 40-50 m near Rajghat and 150 m and beyond in the Yamuna river bed. Similarly, the depth is reported to be 80-100 m in the Aurobindo marg-Hauz Khas area*

Soil conditions affecting Delhi Seismicity

Liquefaction Zonation Map

Coupled with the settlement pattern, the geological characteristics, such as depth of alluvial soil, play a crucial role in determining the magnitude of risk.

Impact of earthquake in Delhi may compound the expected colossal damage due to liquefaction[1], physical location and hydrogeology (combination of geology and ground water) details. There is severe threat of liquefaction along the river *Yamuna* areas covering northeast, east and some part of North West district. A moderate to high threats across the belt running from central district, West district and South-West district is also expected. Delhi lies in the Indo-Gangetic Geosyncline, a down wrap of Himalayan foreland of variable depth that is converted into flat plain by rigorous sedimentation. Gangetic Geosyncline has shown considerable amounts of flexure and dislocation at the northern end, which is bounded by the Himalayan Frontal Thrust on the north. The floor of the Gangetic trough (without all the sediments) shows corrugated inequalities and buried ridges (shelf faults). The **Naraina-Patel Road section and the Yamuna River** - bed section, extending till **NOIDA and Faridabad, are more vulnerable to damage even by a moderate earthquake because they are on alluvial soil upto 200 m deep**. These regions face a very grave problem of soil liquefaction during an earthquake. Moreover, **earthquakes are amplified by alluvial soils**. The Ridge is comparatively safe as it has a rocky base.

[1] During ground shaking sometimes cracks are developed or filled and the traveling seismic waves transfer materials (also groundwater largely in case of soft alluvium) resulting in loosening of foundations that causes complete collapse of structure

Past Trends of Earthquakes in Delhi

Delhi has been a witness to earthquakes in past. As Poer Iyengar (2000) damaging earthquakes have occurred around Delhi since ancient times. He points out that the great epic, Mahabharata mentions about earthquakes during the war at Kurukshetra (Circa 3000 BC). More recently, damage to Delhi in the 1720 earthquakes (intensity IX in Delhi) is well discussed by Kafi Khan (Iyengar, 2000). Tandon (1953) mentions of damage to the Qutab Minar during the 2803 earthquake near Mathura. Srivastava and Roy (1982) discuss several more earthquakes in Delhi region. These include: (a) earthquake of year 893 or 894 (Intensity XI XII) which took place not far from Delhi in which many persons died; (b) earthquake of 22 March 1825 near Delhi Intensity VII; earthquake of 17 July 1830 near Delhi (Intensity VIII); and (d) earthquake of 24 October 1831 near Delhi (Intensity VI)

Table: Recent Earthquakes in Delhi :

Date	Latitude °N	Longitude °E	Magnitude
June 6, 1992	28.65	76.69	2.8
Feb 16, 1993	28.63	76.35	2.6
Mar 27, 1993	28.63	77.20	3.6
Aug 6, 1993	28.64	77.14	2.5
Dec 3, 1993	28.60	77.40	3.5
July 28, 1994	28.51	77.25	2.8
Oct 15, 1994	28.59	79.92	2.8
Nov 16, 1994	28.50	76.95	2.9
March 18, 2004	28.62	77.25	2.7
March 28, 2004	28.60	77.10	1.6
April 4, 2004	28.60	77.20	1.5
April 5, 2004	28.70	77.30	1.9
April 21, 2004	28.60	77.30	1.5
June 06, 2004	28.60	77.00	2.0
October 08, 2004			5.6

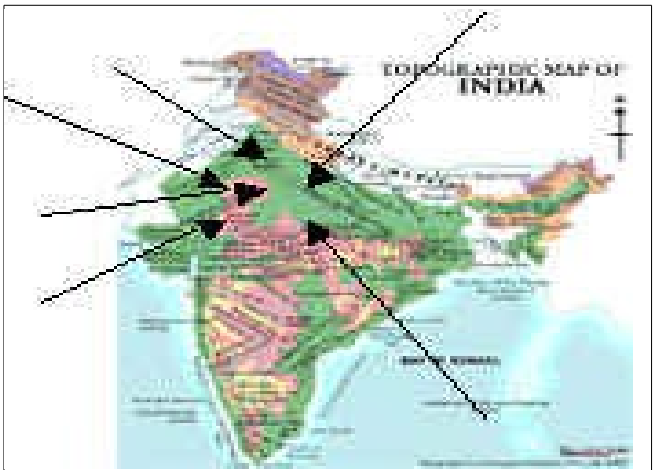
Source: www.amateursesmiccentre.com

Delhi has also sustained earthquake damage in more recent times. For instance, Srivastava and Somayajuluy (1966) mention of (a) Khurja earthquake (M6.7) of 10 October 1956 in which 23 persons were killed in Bulandshahr and some injured in Delhi; (b) M6.0 earthquake of 27 August 1960 near Delhi wherein about 50 persons in Delhi were injured; and (c) an earthquake near Moradabad on 15 August 1966 that killed 14 persons in Delhi. Iyengar (2000) also mentions about damage to one of the minarets of Delhi's Jama Masjid during the M4.0 earthquakes on 28 July 1994. Most

recently, the 1999 Chamoli earthquake (M6.5) took place about 280 km from Delhi. Such a moderate earthquake does not normally cause damage at such large distance. And yet, several buildings in Delhi sustained non-structural damage possibility due to peculiar geological and geotechnical features if this area. Only recently in the Month of march to May 2004 minor tremors ranging from 1.6 to 3 on Richter scale have rocked the capital, reminding once again Delhi's susceptibility to earthquakes.

Future Analysis of Earthquake Disaster

- Recent plate movements show a classical stress formation and a major possible earthquake within three months in Delhi. Ranging from 1.6 to 3 on Richter scale, a series of minor tremors have rocked the capital, reminding once again Delhi's susceptibility to earthquakes.



---> Recent plate movements and cracks on the earth surface

- Six minor earthquakes in ten days some times is the precursor to a large one. The current local seismic behavior is very similar to the one in Gujarat few years back. The net effect can way more devastating that even a nuclear bomb in Delhi.
- The Chinese center for earth studies has a station in Tibet. The Tibetan monitoring systems is providing a similar reading in the Southeast of Tibet. The satellite mappings are also pointing towards some unusual seismic activities in the Delhi area. The epicenters for the small earthquakes are clustered around a series of local fault lines in Delhi.
- Normally before the major shock comes, there is a dull period of no activity for a few days or even weeks. The major shake normally comes in suddenly and normally is of six or higher in Richter scale.
- There is something called cycle of earth quakes. We looked into India's major cycles. Delhi is due for a big one since 1997. However, seven years in geographic

scale is very minuscule. It can come anytime during next seventy years. If the small tremors subside and nothing happens for the next six months, probably nothing will happen for at least three years. However, when all evidenced are put together, it does not look very good.

A great disaster may occur if three conditions are met: (a) An earthquake of sufficiently large magnitude, (b) Occurrence of the earthquake close enough to a population centre, and (c) The population centre having buildings which are not earthquake resistant. The question we must address is: is there a possibility of these conditions being met for Delhi at some time in the future? In view of huge population and the economic-cum-political significance of Delhi, occurrence of such conditions can cause not just a great disaster; but a mega disaster.

Flood Hazard

Floods in Delhi are not natures wrong doing, it is invariably the irresponsibility of the authorities and those who are to tally insensitive of human life blinded by the economics of haves and haves not. This is very clear from the recurring phenomenon of floods in the mighty river Yamuna and flash floods caused by rains due to choked drains of Delhi.

River Yamuna and Floods

Keeping in view the topography, Yamuna catchments upto Delhi is divided in two parts - (1) The upper catchments from source in Himalayas to Kalanaur in Haryana - which comprises parts of Himachal Pradesh and hills of West Uttar Pradesh and (2) the lower catchment from Kalanaur to old Delhi rail bridge which consists of West Uttar Pradesh and Haryana.

River Yamuna enters Delhi from the northeast near Palla at an altitude of 210.3 meters and after traverse of about 40 km. it leaves Delhi at an altitude of 198.12 m near Jaitpur in the South. The width of the riverbed varied from 1.5 to 2.0 km. In its flow from Wazirabad barrage, a network of seventeen drains joins the river on the West bank during its traverse in the northern parts of the city. Najafgarh and Alipur drains, due to heavy discharge from Sahibi river, inundate a number of villages in Nazafargarh block causing heavy damage to life and property. There was,

however, little effect of it in Yamuna river flow. Only one drain joins on the East bank near the old rail bridge.

Flood zoning

The flood situation is projected in the flood atlas map prepared by central water commission.

As per the map of the flood prone areas of Delhi has been classified into thirteen zones based on the flooding risk in relation to incremental rise in the water level of the Yamuna (DDA, 1993). These cover a range from 199m to 212 m level of water in the Yamuna. This zoning map covers part of North Delhi on the West bank of the Yamuna and almost the entire Trans Yamuna Area on the East bank. Besides this, the Delhi Flood Control Order also the NCTD into four Flood Sectors, namely Sectors, namely, Shahadra, Wazirabad - Babrapur, Alipur and Nangloi - Najafgarh sectors.

Although the unprotected flood prone area is only 1.7% or 25km only towards the south east and about 5% or 74 sq km in the north eastern parts which is protected by earthern embankments every year water level ruses in Yamuna above danger level and large population has to be evacuated to the top of the bunds and Delhi highways.

As already stated, main reasons for this rise of water level is not natural but release of excess water from Tajewala headworks upstream to the two canals one on left and other on the right bank of the river. Rise in water levels also cause back flows in the connecting drains and have effect on the city drain network causing overflow cause of many monsoon related diseases.

Local Flooding

A significant phenomenon which has been increasing during recent years is that of local flooding. Urban areas are characterized by a high area under impervious surfaces (Roads, pavements, houses etc). High rates of development along with the resultant loss of soft landscape has led to high surface water sun-off rates. This results in flash floods in the low lying areas even after moderate precipitation. Another factor adding to this effect is that of river because the river is already flowing at a

higher level within its embankments. Thus, the water gets logged in the city areas and it takes several days to mechanically pump it out and bring the situation under control. Similarly, during the past few years, flooding due to the city's 18 major drains has also become a common phenomenon. Already under the pressure of the city's effluent discharge, these drains experience reverse flow from the Yamuna, which is in spate, and as a result they tip their banks, flooding the neighbouring colonies.

Past Trends of Floods

The flow of Yamuna within Delhi is by and large influenced by discharge from Tajewala Headwork 240 kms upstream. In the event of heavy rain in the catchment area excess water is released from Tajewala. Depending upon the river flow level down stream, it takes about 48 hours for Yamuna level in Delhi to rise. The rise in water level also causes backflow effect on the city's drains. The city also experiences floods due to its network of 18 major drains having catchment areas extending beyond the city's limits.

S.No.	Date	Gauge (mm)
1.	28.5.63	205.40
2.	28.9.64	205.64
3.	15.8.66	205.85
4.	19.7.67	206.19
5.	9.8.67	205.27
6.	16.8.69	204.89
7.	10.8.71	206.28
8.	18.7.72	205.00
9.	29.7.73	205.50
10.	7.8.74	205.15
11.	12.9.75	206.00
12.	12.8.76	206.70
13.	7.8.77	205.85
14.	6.9.78	207.49
15.	16,7,80	205.55
16.	5.8.81	204.90
17.	13.8.83	205.80
18.	12.10.85	205.20
19.	27.9.88	206.92
20.	20.8.89	205.67
21.	5.8.90	205.02
22.	19.8.92	205.40
23.	24.7.93	205.06
24.	26.8.94	205.36
25.	8.9.95	206.93

Source : Irrigation and Floods Control Deptt.

Major Floods in Delhi

1977: Najafgarh drain experienced heavy floods due to discharge from the Sahibi River. The drain breached at six places between Dhansa and Karkraula, marooning a number of villages in Najafgarh block. Six human lives were lost due to house collapse. 14 persons died in a boat mishap. Crop damage was estimated at Rs 10 million.

1978: (September) River Yamuna experienced a devastating flood. Widespread breaches occurred in rural embankments, submerging 43 sq km of agricultural land under 2 meters of water, causing total loss of the kharif crop. In addition to this, colonies of north Delhi, namely, Model town, Mukherjee Nagar, Nirankari Colony etc. suffered heavy flood inundation, causing extensive damage to property. The total damage to crops, houses and public utilities was estimated at Rs 176.1 million.

1988: (September) River Yamuna experienced floods of very high magnitude, flooding many villages and localities like Mukherjee Nagar, Geeta Colony, Shastry Park, Yamuna Bazzar and Red Fort area, affecting approximately 8,000 families.

1995: (September) The Yamuna experienced high magnitude floods following heavy runs in the upper catchmen area and resultant release of water from Tajewala water works. Slow release of water from Okhla barrage due to lack of coordination between cross state agencies further accentuated the problem. Fortunately, the flood did not coincide with heavy rains in Delhi, and could be contained within the embankments. Nonetheless, it badly affected the villages and unplanned settlements situated within the river-bed, rendering approximately 15,000 families homeless. These persons had to be evacuated and temporarily housed on roadsides for about two months, before they went back to living in the river-bed (Source : Sharma, 1996).

Flood vulnerability

The city has been experiencing floods of various magnitudes in the past due to floods in the Yamuna and the Najafgarh Drain system. The Yamuna crossed its danger level (fixed at 204.83m) twenty five times during the last 33 years (table 3.1).

Since 1900, Delhi has experienced six major floods in the years 1924, 1947, 1976, 1978, 1988 and 1995 when peak level of Yamuna river was one meter or more above danger level of 204.49m at old rail bridge (2.66m above the danger level) occurred on sixth September 1978. The second record peak of 206.92m was on twenty seventh September 1988.

In the recent part, the city experienced high magnitude floods in 1977, 1978, 1988 and 1995, causing misery and loss of life and property to the residents of the city. A profile of these four floods (table 1) indicated the extent of damage caused by these calamities.

In Delhi Environment Status Report: WWF for Nature-India (1995), it has been pointed out that since 1978, the flood threat to Delhi has increased. In 1980, a discharge of 2.75 lakh causes at Tajewala resulted in flood level of 212.15 meters at the bund near Palla cillage in Delhi.

Flood Management

The Irrigation and Flood Control Department of Delhi is the sole incharge of execution, repair and maintenance of flood control works on River Yamuna and Najafgarh drain system. Till date both banks of the River Yamuna has been embanked through its run in Delhi right from Palla in the North to Jaitpur in the South. On the right bank. Delhi is protected by Rural Marginal Embankment (RME) from Palla to Supplementary drain, Jagatput Bund from Jagatpur to upstream of Wazirabad Barrange, Yamuna Bazaar Wall upstream of Old Railway Bridge and Rural Marginal Embankment Madanpur Khadar from Okhla to Jaipur. On the left side, Delhi is protected by Left Forward (LF) Bund from Delhi - U.P. Border upto Wazirabad, Shahdra Marginal (SM) Bund from Wazirabad to Old Delhi railway Bridge and L.M Bund from Old Railway Bridge to NOIDA.

Analysis shows that while RME Palla meets the requirement from with-standing a 25 year frequency flood, Jagatpur Bund, Yamuna Bazaar wall, Mughal Bund, L.F Bund, S.M Bund and L.M Bund all fail to meet this standard and would overtop in such a flood. In the eventuality of a 100 year frequency flood, all these embankments would fail to meet the requirement (Sharma 1996.)

Settlement Pattern in Flood Plain

A close analysis of the flood zoning pattern reveals that the high risk zones are the areas that have earlier been identified as unplanned or poorly planned areas having high population densities and sub standard housing structures. These include areas of North Delhi, and Trans Yamuna Area. Some of the colonies that have come up in these areas are at levels 3 to 4 meters below the 1978 flood level.

The community exposed to the highest risk from floods comprises the families living in the villages and unauthorized colonies within the river-bed. There are over 15,000 such families, having over 75,000 persons. Situated on the wrong side of the embankments, these people live on the edge of the floods, and are the first ones to find their homes washed away.

Direct effect of floods in the river Yamuna and the city's network of drains. These affect the population living in the Yamuna River-bed and on the banks of the river and drains.

Local flash floods and water logging increased surface run-off due to high ratio of hard surfaces leading to flash floods. This in turn badly affects the low lying areas, particularly the unplanned colonies which get water logged.

Risk of break in embankments

Protection from the river by embankments lead to a false sense of safety and development starts taking place in the shadow of these embankments. In the event of failure of these protective works, as has been seen in the form of breaches during past floods, the effect is devastating because the pressure of the entire embanked stretch is released at one point, and it takes the people by surprise.

FIRE HAZARD

Fire hazards, for the purpose of this study, include fires due to chemicals, LPG, explosives as well as short circuit of electrical systems. However, while assessing the resource needs of the state fire services, it must be considered that these services are also used in rescue operations during building collapses. Additionally, the fire

department's services are also required in rescue and relief operations in fires caused by accidents involving hazardous inflammable substances.

Past Trends of Fire Hazards in Delhi

- According to Delhi Fire Service statistics, **Delhi** had **more than 75,000 fire incidents** during the **last five years** (1995-96 to 1999-2000), resulting in more than 1825 deaths, injuries to more than 7,600 persons and loss of property valuing more than Rupees 176 crores. These incidents included two major, twenty-five serious and ninety-nine medium fires. Echoes of Uphaar tragedy have still not died down nor have the families of victims forgotten the Lal Kuan fire. Delhi has witnessed an **increasing trend in fires in *jhuggies*** (up by 49% from 5277 *jhuggis* in 1995 to 7840 in 1999, residential areas (up by 21% to 2701 in 1999 from 2240 in 1995), and other fires (up by 33% from 6640 in 1995 to 8858 in 1999). Persons vulnerable to such fires constitute a majority of the populace of Delhi.
- The numbers of calls have only marginally increased, numbers of deaths have increased potentially. The **basic reason** is that deaths are not as much due to burning but more because of **inhalation of toxic fumes**, which get concentrated in **high density less open space area**. It is the **lack of circulation/ventilation** within tenements. In **industrial areas** there is **disrespect for the safety measures** required and hence large number of deaths or injury due to fires occur.
- Numbers of fire incidents in *jhuggie* cluster and high-rise buildings has reduced while fire incidents in industrial and residential areas have increased. One of the reason for such increase is, that **industrial areas have started hosting non-confirming industries and residential areas have become haven for illegal storage's and dangerous commercial activities in pursuit of mixed permitting land and occupancy in these areas**.
- Also, **disrespect to circulation space** and **open space** and **increase in congestion** in these areas have **caused poor accessibility to the place of tragic incidence**, which takes only records to increase.

Details of total fire calls and loss in Delhi

No	Year	No. of calls	Approx loss (lakhs)	Property saved(lakhs)	Injured	Deaths	Medium	Serious	Major
1	94-95	13334	4620	7144	1397	318	19	5	0
2	95-96	15519	5787	6493	1504	389	16	6	1
3	96-97	14866	4989	8190	1704	398	18	4	0
4	97-98	14254	2439	10389	1967	399	15	6	0
5	98-99	15455	2170	5547	1495	375	22	6	0

Source: Delhi Fire Services

Occupancy wise breakup

Year	JJ Cluster (No. of slums)	High Rise	Industrial	Residential	Others
1989	168 (5856)	158	422	1571	3924
1990	180 (17286)	138	489	1760	4357
1991	150 (10201)	150	475	1604	4880
1992	168 (9634)	128	516	1785	5853
1993	163 (4557)	173	458	1882	4950
1994	150 (5639)	113	602	2139	5809
1995	173 (5277)	72	655	2240	6640
1996	130 (2891)	75	767	2606	7734
1997	115 (1985)	87	653	2681	7646
1998	108 (5820)	87	590	2462	7081

Division wise percentage of calls in Delhi

Zone	1993-94	1994-95	1995-96	1996-97	1997-98	Average
EAST	20.27%	20.63%	23.40%	23.56%	22.76%	22.12%
WEST	11.07%	14.21%	14.27%	15.83%	15.84%	14.38%
NORTH-WEST	22.07%	37.05%	19.67%	19.04%	18.28%	23.22%
CENTRAL	25.34%	24.20%	22.72%	23.33%	23.07%	23.73%
SOUTH	20.52%	20.80%	19.85%	21.27%	20.87%	20.67

- If the number of incidents of fires is carefully studied **area wise** in Delhi **maximum percent of calls of fire incidents** have been received in **Shahdra (east division)**, **Janakpuri (west division)**, **Moti Nagar (northwest)**, **Connaught Circus (central)** , **Roopnagar and Nehru Place in South Delhi**. The **reason is congestion and illegal storage of recycling material and chemicals.**

Total Number of Calls and Concentration of Call in Delhi

NAME OF STATION	1993-94	1994-95	1995-96	1996-97	1997-98
EAST DIVISION					
GEETA COLONY	525	494	691	610	645
LAXMI NAGAR	402	498	717	672	591
DARYA GANJ	573	543	755	692	598
TOTAL	2468	2751	3632	3456	3245
WEST DIVISION					
JANAKPURI	82	625	867	859	837
NAJAFGARH	208	252	273	229	257
KIRTI NAGAR	446	316	309	279	269
SHANKAR ROAD	214	200	246	328	244
PRASAD NAGAR	303	310	354	405	285
NARAINA	176	192	166	221	166
TOTAL	1429	1895	215	2321	2258
NORTH WEST					
MOTI NAGAR	749	570	608	601	512
KESAV PURAM	527	508	591	568	568
BADLI	167	191	229	191	173
ROHINI	324	464	481	488	540
BAWANA	120	108	138	119	101
NARELA	177	185	213	211	148
WAZIR PUR	327	349	46	338	310
JANAKPURI	296	307	377	277	307
TOTAL	2688	4940	3053	2793	2606
CENTRAL					
CONNAUGHT CIRCUS	830	787	899	879	934
RAKAB GANJ	267	252	282	253	311
RASTRAPATI BHAWAN	16	20	6	11	8
TELEWARA	190	236	227	207	182
J.R.ROAD	423	428	508	512	444
ROOP NAGAR	832	915	1021	997	924
S.P.MUKHRJEE MARG	528	589	583	563	485
TOTAL	3086	3227	3526	3422	3288
SOUTH					
OKHLA	200	239	264	232	209
NEHRU PLACE	705	782	974	984	916
MATHURA ROAD	417	486	552	568	551
B.CAMA PLACE	376	414	417	405	391
CHANAKYA PURI	318	378	360	405	348
SAFDERJANG	484	474	519	526	560
TOTAL	2500	2773	3086	3120	2975

Causes of Fires

- About 70%of fires are estimated to arise from electrical causes, mainly **short-circuiting** and another about 17% due to **carelessness.** Electric short circuiting results mainly from **illegal loose connections**, **substandard wiring** and **over-loading of the system**. Illegal tapping of electricity from overhead lines through use of loose hooks has been a common sight in Delhi.

Major Causes of Fire

	1993-94	1994-95	1995-96	1996-97	1997-98
Electricity short circuit	5848	6473	70.40%	7433	7268
Carelessness	1701	1728	18.37%	1896	1466
Miscellaneous	308	504	0.75%	356	387
Spark M/Heat	156	258	1.73	203	160
Fire Works	139	146	1.68%	198	59
Unknown	138	184	1.49%	181	166
Naked Flame	105	133	4.59%	351	288
Intentional	75	986	0.90%	121	109
Incendiarism	45	16	-	22	16
Spontaneous	13	1	-	0	0
Radiation	10	4	-	1	0
Lighting	6	0	0	1	0
Children Playing with fire	6	2	0.00%	1	0

Source: Delhi Fire Service, 2001

- During Gandhi Market, Sadar bazar, fire (1990) enquiry, it was found that an electric pole had even being enclosed within the unauthorised construction with overhead wires running only about 4/5 feet above the roof of the illegal construction. Yet, no Municipal Corporation of Delhi or Delhi Electric Supply Undertaking official had even taken notice of these blatant violations of all norms and rules.
- Fire was also caused due to wood shavings lying on the roof catching fire from the sparks from the overhead electric line. Due to loose connection of wires of the irregular tapping and over loading, distribution losses are also known to be one of the highest.

- Yet, the **authorities are unable to check such illegal tapping**, supposedly due to resistance from local residents and politicians. The recommendations of various Committees to replace overhead lines with underground cables too have not been implemented, particularly in the fire prone older areas.

EPIDEMICS HAZARD

In all the districts of Delhi, preventive, primitive and curative health is being looked after by the health department. There are also Dispensaries, referral hospitals and community hospitals supplementing the task.

With the view of detecting epidemics at the earliest, an epidemiological cell has been established under the Directorate of Health Services.

The following epidemics are monitored in Delhi:

- Cholera
- Gastroenteritis
- Acute Diarrohea / Dysentery
- Infective Hepatitis
- Encephalitis
- Poliomyelitis
- Typhoid

In addition to the above, the following outbreaks are also monitored :

- Food poisoning
- Viral Fever
- Meningitis
- Dengue Fever

Epidemic Management

The monitoring is in the form of daily, weekly health condition report and monthly report. Each outbreak is supposed to be thoroughly investigated by the officials and the report regarding the action taken to contain the outbreak, the actiology and the measures to prevent similar occurrences has to be submitted.

The state has a system to forecast epidemic. However, it seems that health facilities at Municipal level get activated quickly on perception of threat. Actions were taken to survey the risk prone areas and also to control mosquito breeding in various places. Similarly, actions had been also taken for vector control during the threat of plague in 1994. The response mechanism to epidemics gears up only after there is a

perception of threat which mitigates the risk of the hazard to a certain extent. Essentially, however, the diagnostic facilities need to be strengthened.

ROAD ACCIDENTS

Road accidents, for the purpose of the Disaster Management Action Plan include all forms of motor vehicle accidents involving two / three/ four wheeler passenger vehicles, vehicles carrying goods including hazardous substances. These accidents may lead to injuries and fatalities to pedestrians, bystanders and/or passengers.

Vulnerable locations

Unlike in the case of hazards, such as floods or road accidents, definition of specific vulnerable spots is not possible. However, a broad definition of the type of locations where there is a potential of fire hazard can be identified. Some of these areas are :

- Storage areas of flammable / explosive material in the vicinity of populated areas.
- Hotels and restaurants in crowded areas using improper practices of storage of cooking fuel such as LPG, kerosene etc.
- Multistoreyed buildings, especially in cities, with inadequate fire safety measures.
- Narrow lanes, congested, overcrowded buildings, old buildings with poor internal wiring.

INDUSTRIAL HAZARDS

Industrial accidents may occur as a result of natural phenomena, such as earthquakes, forest fires etc., however, most accidents occur as a result of human activity leading to accidental or deliberate harm. Although there are a number of different definitions of these accidents, the most practical appears to be as follows : any incident connected with an uncontrolled development (such as leak, fire and / or explosion) of an industrial activity involving a serious immediate or delayed hazard to man and / or the environment. This is summarized in table XVIII below.

Definition of Industrial Accidents

Type of accident	Examples
Natural	Earthquakes, forest fires
Man made : Accident or error	Uncontrolled release of hazardous substances fire/explosion. Mechanical failure : operational deficiency, design, construction, installation deficiency. During transportation : collision / overturn.
Deliberate	Misuse of or failure to control hazardous material. Arson / malicious act. War.

(Source : Natural Risk and Civil Protection, Ed. by T. Horlick-Jones, A. Amendola, Casale, R, E&FN Spon, London, 1995)

Industrial hazards are most likely due to accidents occurring during chemical processing, manufacturing, storage, transport and from the disposal of toxic waste as described in the table below:

Chemical Process	Examples of potentially hazardous circumstances
Manufacturing, processing	In the workplace, industrial plant, manufacturing site, higher education facility and research labs.
Storage	In warehouses, chemical stores, silos, storage tanks.
Transport	On the public highway, railway, waterway, shipping and air freight. Freight handling areas of transport systems, such as harbour, airport or station.
Waste	Disposal of potentially toxic waste by dumping or incineration, knowledge of toxic waste and landfill sites.

Nature and Occurrence

Industrial hazards, like natural disasters, can be understood in terms of their occurrence in time and place, how they affect social units and how these units take responsive actions to mitigate disaster consequences. The off-site impacts of industrial accidents and other hazards such as fire or natural disasters, often lead to loss of human life, property, financial damage and considerable environmental pollution. The severity of these disasters occurring in a developing country like India is increased due to high levels of poverty, illiteracy, inadequate housing structures, under-resourced health services, lack of expertise in training and planning for risks and hazards, necessary support structures and finance from relevant organizations

for the rehabilitation of victims. Both preventing and mitigating effects of crisis depend upon the improvements made in the above areas.

List of Hazardous installations

	Major Hazardous Units	Nature of Hazardous substance used
1	Indian Oil Corp. Indane Bottling Plant, Shakur Basti	Motor Spirit and other petroleum Products
2	Indian Oil Corp. Ltd. Marketing Division	Motor Spirit and other petroleum Products
3	Hindustan Petroleum Corp. Ltd., Shakur Basti	Motor Spirit and other petroleum Products
4	Bharat Petroleum Corp Ltd, Shakur Basti	Motor Spirit and other petroleum Products
5	Delhi Jal Board, Water treatment Plant, Nangloi	Chlorine

Source: Offsite emergency plan, GoNCTD

TERRORIST ATTACKS AND BOMB BLASTS

- Delhi being National Capital is also under the threat of any form of conventional and contemporary warfare.
- History perceives that generally terrorist attacks takes place in important government building, air ports, cantonment areas, historical monuments, populous places and important public gathering etc. Many events of bomb-blasts and terrorist attacks gives an insight towards the importance of this issue.
- Being capital city NBC threats are one of the major potential hazard in the state

OTHER HAZARDS

Delhi is also prone to some other natural hazards like Tornados and hailstorms which are not commonly noticed. Tornados and hailstorms are other two events which occur less frequently but have caused physical and human damage.

RISK AND VULNERABILITY ASSESSMENT FOR THE STATE OF DELHI

Risk and Vulnerability

Risk Analysis

Risk has defined by the United Nations as a measure of the expected losses due to a hazard event of a particular magnitude occurring in a given area over a specific time period. The level of risk depends upon the nature of the hazard, the vulnerability of the elements which it affects and the economic value of those elements. As communities grow larger, more established and more complex, experience has shown that the level of risk which they face increases.

Risk Analysis means the identification of undesired events that lead to the materialization of a hazard, the analysis of the mechanisms by which these undesired events could occur and, usually, the estimation of the extent, magnitude, and likelihood of any harmful effects.

Vulnerability Analysis

The vulnerability of a particular element of society is defined as the degree of loss which is would suffer as a result of a specific hazard event. The nature of vulnerability and its assessment vary according to whether the element involved represents people and social structures, physical structures, or economic assets and activities. The vulnerability of an area is determined by the capacity of its social, physical and economic structures to withstand and respond to hazard events. Certain groups of people, types of physical assets and economic activities can be particularly vulnerable or susceptible to damage. The concept of vulnerability implies a measure of risk combined with the level of social and economic ability to cope with the resulting event in order to resist major disruption or loss. Vulnerability is thus the liability of a community to suffer stress, or the consequence of the failure of any protective devices and may be defined as the degree to which a system or part of a system, may react adversely to the occurrence of a hazardous event.

In this part, on the basis of nature of hazards, socio-economic parameters and institutional arrangements (discussed previous chapters) and community preparedness Strength, Weakness, Opportunity Threats (SWOT) risk and vulnerability assessment has been conducted.

Risk and vulnerability Analysis based on Hazards

Delhi is vulnerable to various disasters. Below table explains (on the basis of hazard analysis) district-wise degree of risk and vulnerability involved in Delhi.

Risk and Vulnerability levels on the basis of Hazards in Delhi

S.No	Hazard	Districts of maximum risk (in terms of damage and losses-)	Vulnerability
1	Earthquakes	North East, East, Central , North, North West and West Southwest and New Delhi	More than High Moderate to High
2	Floods	North-east, east, North, North west	Moderate to High
3	Wind storms	All districts	Low
4	Epidemics (water borne diseases)	All districts	Medium
5	Road Accidents	All districts	High
6	Fires	All districts	Medium
7	Industrial and Chemical Accidents	All districts	High

(More details are present in the district disaster management plans)

For risk and vulnerability assessment, physical, socio-economic, housing, community and institutional preparedness related parameters had been identified. To assess their importance, checklists were prepared under each parameter and information was gathered from various primary and secondary sources. Based on the information collected under the checklists, few indicators were formulated and status of strength, weakness, opportunity and threat has been assigned which was further utilized for risk and vulnerability analysis. Below given table explains the risk and vulnerability assessment based on the certain parameters.

SWOT Analysis for Risk and Vulnerability Assessment in Delhi

Parameters	Indicators	Strength	Weakness	Opportunities	Threats
Physical	Soil				
	Terrain/Physical features				
	Geology				
	Water depth				

Socio-Economic	Population Density				
	Literacy rate				
	Slums/JJ clusters etc				
	Industrial density				
	Type of Employment				
Housing	Residential Conditions				
	Occupancy Rate				
	Quality of Design				
	Quality of Construction				
	Quality of Materials				
Community Preparedness	Public awareness about local disasters				
	Local level Disaster management planning				
	Vulnerability and resource mapping done				
	Local people trained in Disaster management				
	Local People active in disaster management initiatives				
	Identification of Disasters by local authorities				
Institutional Capacities	Disaster Management Plan				
	Communication				
	Transportation				
	Response planning				
	Fire fighting capabilities				
	Medical Facilities				
	Search & rescue Capabilities				

The SWOT analysis (Table 2) clearly shows a fragile condition of Delhi. Some of the inferences are mentioned below:

1. Soft alluvial soil around river Yamuna pose risk of high damages during earthquakes and floods. A high population, high residential and industrial density, scattered slums and JJ clusters, living in poor housing conditions along with poor preparedness and administrative response aggravates the risk and may lead to colossal losses to lives and property during emergencies.

2. On the other hand, Delhi being a capital city is also full of strengths, which may become opportunity in case of any disaster and a systematic approach may

also help to overcome from above-mentioned weaknesses. For example, more than 90% of area in Delhi is urbanized and enjoying a good communication and transportation facilities therefore response time of any disaster can be reduced with the help of systematic institutional approach and proper decision-making. Similarly, around 80% population of Delhi is literate with highest per capita income in Nation. Therefore an approach towards community preparedness for disaster management may help in reducing risk at the local level.

Reasons of Growing Risks in Delhi:

Haphazard Growth in Delhi: In Delhi there has been a substantial increase in population and industrialization, since Independence. Well over 1,50,000 small scale industrial units in identified industrial units in identified industrial pockets (in addition to industries running illegally), over 1200 J.J. Clusters providing shelter to nearly one third of the population and over 3.5 million automotive vehicles have choked infrastructural services. The fast increased has not been planned for. Master Plan for Delhi had been created as an instrument to control the use of land in urban area and protect the welfare of people. The concept of zoning has not yielded desirable results over and above allowing for mixed use and occupancy, authorized as well as unauthorized. Banquet halls in residential areas, cottage industries in congested areas, trade of hazardous chemicals from the highly congested residential/commercial areas, hazardous and non hazardous industries in close vicinity are few to mention which have further **deteriorated environmental services**.

Failing of Zoning and mixed use planning is a vital part of urban design. However, it can fail through abuse, misuse, and resistance to changes in urban pattern essential for the general welfare of the population. This has certainly added to the fire risk already inherited by a particular occupancy. As a result losses due to fire are increasing to both the life and property. This is developing a dangerous trend. Man-made disasters are likely in these areas.

CONCLUDING REMARKS

Delhi is exposed to various risks due to soil, which is liable to liquefaction, very high population density, sub-standard habitat, disproportionate occupancy rate, poor design and construction qualities and lack of community preparedness and adequate response. Therefore it is desirable to incorporate these risks elements into the development plan. Following broad set of recommendations has been suggested below which may help in integration of risk assessment in regional development:

1. There is a need for an institutional setup at various level of administration to ensure the management of disasters during emergencies. The responsibilities and reporting system of the various departments such as Police, Fire, Transport, Communication, NGOs, Public Work Department, Municipal Corporation and Revenue department etc should be clearly demarcated within a well-defined structure so that response time may be reduced at the time of disasters.

2. Mainstreaming Disaster Management into development planning may be ensured by regulating land-use zonation according to the exposure of risks, Updation and enforcement of building byelaws as per the disaster resistance codes and retrofitting of life line buildings and other important buildings. Such practice may help in reducing risk by improving the condition of existing buildings and new constructions.

3. There is a need of awaking generating public by fostering community based disaster management planning initiative in schools, hospitals, residential areas and villages etc. in the disaster management initiatives at grass root level so that community preparedness may be ensured

4. Geographic Information System and databases, focusing on the development of techniques and decision support tools using GIS to integrate, manipulate and display a wide range of risk-related information should be developed. Such system may also include the techniques to assess the vulnerabilities of buildings, infrastructure and people to the impact of hazard that may be helpful for the local authorities in taking decisions during emergency situation.

5. Availability for quantified database at various administrative levels for various aspects is very limited, which was also faced while conducting the present study. A detailed database on disaster risk aspects should be developed so specialized studies and assessments can be facilitated at all levels of planning. It may help in exploring and expanding means of indicators and parameters which will result more relevant picture in front of us.

In all we can conclude that risk management is needed which may embraces all administrative and operational programs that are designed to reduce the risk of emergencies involving acutely hazardous materials. Such programs include, but are not limited to, ensuring the design safety of new and existing equipment, standard operating procedures, preventive maintenance, operator training, accident investigation procedures, risk assessment for unit operations, emergency planning, and internal and external procedures to ensure that these programs are being executed as planned.