

**World Bank Institute & NIDM**  
**Natural Disaster Risk Management – Safe Cities**

**An Assessment of**  
**Earthquakes in Delhi with Short case study of 1999 Earthquake**

**An End-of-Course Project Submitted to World Bank Institute & NIDM In Partial Fulfillment of the Requirements for the Award of a Certificate in On-Line Course on Natural Disaster Risk Management – Safe Cities.**

**By**

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## 1.0 Background Information

### 1.1 Physical location and setting

- Latitude : 28.38 N
- Longitude : 77.12 E
- Area : 1483 sq. km. Out of which 783 km<sup>2</sup> is designated rural, and 700 km<sup>2</sup> as urban.
- Topography: Delhi lies almost entirely in the Gangetic plains. Two prominent features of the geography of Delhi are the Yamuna flood plain and the Delhi ridge. The low-lying Yamuna flood plains provide fertile alluvial soil suitable for agriculture but are prone to recurrent floods. Delhi Ridge (1043 ft) originates from the Aravalli Range in the south and encircles the west, northeast and northwest parts of the city. Delhi falls under seismic zone-IV, making it vulnerable to major earthquakes.
- Climate: Delhi is semi-arid with high variation between summer and winter temperatures. Summers are long, from early April to October, with the monsoon season in between. The average annual rainfall is approximately 714 mm (28.1 inches), most of which is during the monsoons in July and August. The average date of the advent of monsoon winds in Delhi is 29 June.

### 1.2 Demographic and socio-economic characteristics

- Population : 13850507
- Density : 9,294 persons per km<sup>2</sup>,
- Sex ratio : 821 women per 1000 men
- Literacy : 81.82%

By 2004, the estimated population had increased to 15,279,000. That year, the birth rate, death rate and infant mortality rate (per 1000 population) were 20.03, 5.59 and 13.08, respectively. Delhi has a per capita income of 53,976 INR which is around 2.5 times of the national average. Delhi's workforce constitutes 32.82% of the population showing an increase of 52.52% between 1991 and 2001. Delhi's unemployment rate decreased from 12.57% in 1999–2000 to 4.63% in 2003. Key service industries include information technology, telecommunications, hotels, banking, media and tourism.

### 1.3 Slums and slum population

As per Census of India slums can be defined as A compact area of at least 300 population or about 60-70 households of poorly built congested tenements, in unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities. As per Census 2001, 18.7% of total Population of Delhi lives in Slums i.e. 1,851,231 persons

### 1.4 Linkages

Public transport in Delhi is provided by buses, auto rickshaws, a rapid transit system, taxis and suburban railways. Buses are the most popular means of transport catering to about 60% of the total demand. Delhi is a major junction in the rail map of India and is the headquarters of the Northern Railway. The four main railway stations are Old Delhi, Nizamuddin Railway Station, Sarai Rohilla and New Delhi Railway Station. The city is well connected by Air with Indira Gandhi International Airport serving domestic and international connections.

### 1.5 General vulnerability to natural disasters

Delhi, a Megalopolis with over a fourteen million of population is extremely vulnerable to multiple disasters. The entire region of Delhi is in Seismic Zone IV that falls in the high risk to earthquakes. Yamuna floods during monsoon cause disaster for the people living in the low-lying areas. Delhi is unsystematically urbanized city, densely populated, having thousands of unplanned building structure, sizeable number of urban slums, unauthorized colonies and stuffed industrial clusters compound vulnerabilities in Delhi. In fact not only the natural disasters but the manmade disasters like fires, epidemics, bomb blasts, riots and terrorism etc. are also much more prevalent. Any of these hazards can cause unprecedented and colossal damage to Delhi. On the basis of Vulnerability Atlas of India (for Natural Hazards) and other available data, Delhi is Vulnerable to natural hazards namely Earthquakes, Floods, Wind Storms & Hail storms and Man-made Hazards like Fires, Industrial and Chemical Disasters, Nuclear disasters,

**Biological Disasters, Accidents & Epidemics.** (Source: Draft Delhi Disaster Management Policy & discussion forum)

### **1.6 Causes of Increasing Vulnerability of the city**

Vulnerability, as regards the urban environ, is related both to the structure form and function of the city and to the characteristics of the diverse human groups that occupy its space. Major causes and influencing factors for increased vulnerability are identified as follows:

- Inadequate physical infrastructure, environmental degradation and poor management, inappropriate territorial occupation and land use, and concentration of population in hazard prone areas leading to social and economic vulnerability.
- The above causes are directly influenced by pressures of chronic poverty, social and economic exclusion, rapid urbanization, inadequate planning, weak administrative control systems and economic transition on one hand and climate change and climate variability on the other.
- Lack of adoption of scientific and engineering advancements that provide the knowledge tools to fight the challenges of the natural hazards due to inadequate support and focus by appropriate government policies and administrative procedures.
- lack of risk awareness among the urban poor and Inadequate access to health care
- Inadequate City infrastructure:
  - The water supply in Delhi is managed by the Delhi Jal Board (DJB). Delhi faces severely acute water shortage. As of 2006, it supplied 650 MGD (million gallons per day) of water, while the water demand was estimated to be 963 MGD. The rest of the demand is met by tube wells and hand pumps.
  - Delhi daily produces 8000 tonnes of solid wastes. Delhi city is facing problems as out of 21 dumping site only 3 sites are functional, thus making the city vulnerable related health issues.
  - The daily domestic waste water production is 470 MGD and industrial waste water is 70 MGD. A large portion of the sewerage flows untreated into the river Yamuna. Also, the inefficient drainage and sewerages system is at its worst performance during rainy season due to which urban floods have become a regular feature for the city.
  - BSES supplies electricity in the city but the city is prone to erratic power failures.

The most vulnerable areas in Delhi city are its densely populated areas with large amounts of unsafe building stock, non-engineered structures, the sizeable number of unauthorized colonies and urban slums. An earthquake can cause unprecedented and colossal damage to Delhi. Further, on a day-to-day basis, Delhi is at risk to numerous hazards, such as bomb-blasts, other acts of terrorism, fires, industrial and chemical hazards, floods, building collapses, road accidents, water logging, etc.

## **2.0 City's Current Disaster Risk Management System**

**2.1 Do the city authorities have a set of policies, regulations and an organizational structure for managing disaster risk? Has the need for mitigation/ reduction of urban risk been recognized in the policies, regulations and structure?**

Yes, the Authorities have set of policies and an organizational structure for managing disasters. The Draft Delhi disaster Management policy has been prepared and also district disaster Management Plans are under preparation for nine districts of Delhi. Also, the disaster Management Act is applicable in the city. Government of Delhi has recently initiated a Disaster Risk Management Program considering it as one of the most significant indicator towards social and economic development. The vital output of the program is to prepare multi-hazard risk management and recovery plans at community, panchayat and district level. The need for mitigation/ reduction of urban risk has been recognized in the policies, regulations and structure but Delhi governments transport policy does not recognize the same.

**2.2 In the local government, with what department(s) does this responsibility reside? Do departments of urban planning, transport, water and sewage services, construction, energy and infrastructure, deal with disaster risk? Is there a City Disaster Management Plan and if so, does it address disaster risk? If there is no City Disaster management Plan, does risk management find mention in any of the Development/ Master Plans?**

Disaster Management in Delhi City

In the Local Government departments like DJB, PWD, MCD, DDA, NDMC, NCRPB, BSES, NDPL, Transport Departments, Delhi Police, Horticulture Department, Health Departments, **Delhi Fire Services, Delhi Civil Defense, NGOs & Volunteer based organizations etc.** have the responsibilities towards disaster management. Yes, departments of urban planning, transport, water and sewage services, construction, energy and infrastructure, deal with disaster risk.

The **Government of Delhi has established a nodal agency, namely Delhi Disaster Management Authority**, to facilitate, coordinate and monitor disaster management activities and promote good disaster management and mitigation practices in the city/ State (Delhi has a status of State). Responsibility for declaration of Disaster at any level in the city/state rests with the state Government and the same can be made on the recommendation of the Divisional Commissioner or a Deputy Commissioner. Initiation and execution of emergency relief measures and relief in times of disasters rests with the state revenue department in conjunction with other relevant government departments. **Working Groups** for implementation of the DRM Program - (i) Prevention and Mitigation (ii) Preparedness and Response, have been approved by Government and have been notified. The District Disaster Committees under the chairmanship of deputy commissioners are being formed, which are responsible to build capacities of communities and prepare community based disaster management plans. Construction of **Emergency Operation Centres (EOC)** has been completed in districts North East, North West, East, Central and South with necessary communication and IT infrastructure. State or Delhi Government has identified Fire Safety Management Academy, Rohini as state level nodal institute for conducting Training of Trainers program in search & rescue, for police and fire personnel. Besides this the local Authorities like NDMC, DDA and MCD have to **constitute Hazard Safety Cells within their departments** and Office of the Divisional Commissioner has requested various line departments to nominate experienced engineers to constitute a hazard safety cell within the department.

As per the draft Disaster Management policy, the role of **local government is to carry out the reconstruction and rehabilitation activities in accordance with the policies and guidelines specified by DDMA** and report various parameters related to progress and outcome of various projects undertaken by them. They are also **responsible for Amendment in Urban Development Legislations / Regulations / Bye-laws for incorporating "multi-hazard safety" provisions.** **MCD has put up a draft of the new building byelaws**, in which amendments as per the recommendations made by the National Expert Committee have been incorporated.

#### **Approved Structure of the DDMA**

An Apex Committee headed by the Lt. Governor of Delhi will govern the Disaster Management Authority. The Divisional Commissioner of Delhi as the head of the nodal department for disaster management in Delhi will be the Convenor of the DDMA Secretariat.

The Apex Committee consists of members namely Lieutenant Governor of Delhi - Chairman , Chief Minister of Delhi - Member , Ministers, Government of Delhi - Members , Chief Secretary, Delhi – Member, Principal Secretary (Revenue), Divisional Commissioner, Delhi - Convenor/Secretary/Co-ordinator, Principal Secretary (Finance) – Member, Principal Secretary (Home) – Member, Principal Secretary (Health) – Member, Principal Secretary (UD) – Member, Principal Secretary (Power) – Member, Any Secretary to be co-opted from time to time – Member, CEO, Delhi Jal Board – Member, Commissioner, MCD – Member, Secretary (Transport) – Member, Joint Secretary (Disaster Management)MHA, GoI – Member, Joint Secretary (UT) MHA, GoI – Member, Commissioner of Police – Member, Chairman NDMC – Member, Chief Fire Officer – Member, General Officer Commanding, Northern Command, Director General, Civil Defence and Home Guards. The Authority may associate/co-opt as members of the Apex Committee, any other Officers from Government of Delhi, Central Government or other agencies. Deputy Commissioner (North District) and the Additional District Magistrate (HQ) in the office of the Divisional Commissioner will be the DDMA Secretariat.

**Delhi city does not have a Disaster Management Plan** but as the common wealth games are approaching the Government has concretized a disaster management plan for common wealth games to meet any eventualities like fire, stampede, earthquake, terror attacks, building collapse or any other possible disaster that might happen during the Games. However, the **Disaster Risk Management (DRM) Program has been started in all the districts of Delhi including West District, which has been determined to be more vulnerable** to industrial and domestic fires, earthquakes and chemical explosions. There are three levels on which Disaster risk Management Program is being implementing i.e. community, district and state level. The intended output of the program is to prepare multi-hazard risk management and recovery plans at community, Panchayat and district. Besides this Draft Delhi Disaster

Management Policy (Draft DDMP) has been prepared and shared with all departments for comments. Also, DDA is looking into the existing provisions and preparing text incorporating Multi Hazard Safety provisions in the Master Plan for Delhi -2021. Thus, the risk management finds its mention in Draft DDMP and will some find mention in MPD – 2021.

### Preparedness and response plans at various levels

- Regarding Chemical Disasters, the Government of NCT of Delhi has been regularly following up with the Local Crisis Groups and the District Crisis Groups. Offsite Emergency Plan for chemical disasters is also being finalized.
- The Deputy Commissioners have been requested to identify school buildings/ Safe places in their respective districts which may be used for the purpose of rescue and relief operations during sudden crisis in the area.

### 2.3 Do the local authorities have a process for understanding risk parameters and the options for their mitigation? Do they have partnerships with academia, research institutions, local groups, central government?

Yes, the local bodies do have a process for understanding risk parameters and the options for their mitigation through trainings and capacity building. The local Authorities have partnerships with with academia, research institutions, local groups, central government. The DDMA has formed partnerships with various voluntary organizations and Industrial bodies like Civil Defence and Home Guards, Bharat Scouts and Guides , National Cadet Corps, National Service Scheme , Nehru Yuva Kendra Sangathan , Indian Red Cross Society , St John Ambulance Brigade, PHD Chamber of Commerce and Industry and Confederation of Indian Industry. Also, the partnerships are being made with Indian Institute of Architects, Institutions of Engineers, Indian Medical Association and Various National and International NGOs

### 2.4 Do the city authorities have a process for communicating with residents regarding natural disaster risk for making use of community groups? Do they provide training to employees?

The local Authorities communicate with residents regarding natural disaster risks through Print media, campaigns, etc. In this regard Information, Education and Communication Material have been developed and distributed to all districts, schools, communities, markets, RWAs, offices etc. Disaster Preparedness Months have been celebrated in districts New Delhi, North East, North West, North and South. Yes, the local Government provide training to the employees. Delhi Government has identified Fire Safety Management Academy, Rohini as state level nodal institute for conducting Training of Trainers program in search & rescue, for police and fire personnel. The Office of the Divisional Commissioner has imparted training to engineers, architects and masons from various Government, Public Sector and private departments.

## 3.0 Brief Description and Analysis of the Selected Disaster Event

### Earthquake in Delhi – a capital Problem

Seismicity around Delhi appears to be associated with geological structure known as the Delhi-Hardwar Ridge, the Aravalli - Delhi fold, the Sdohna fault, the Mathura fault and the Moradabad fault. As per the Indian seismic zone map, Delhi and its surroundings are placed in, seismic zone IV Considering many other day-to-day problems of a mega city like Delhi (traffic, environmental pollution, water and power shortage, etc.), the issue of seismic risk for Delhi has not drawn the attention that it deserves.

In the past, five earthquakes of Richer Magnitude 5.5 to 6.7 are known to have occurred in the UT of Delhi or close to it since 1720 AD. The most recent 29 March 1999 Chamoli earthquake (M6.5) was felt all over Delhi which occurred 280 km from Delhi. There have been reports of cracks in a few tall buildings

Recent earthquakes in Delhi (location and magnitude)			
Date	Latitude oN	Longitude oE	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 06, 1993	28.64	77.14	2.5
Dec 03, 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

located on alluvial deposits in the trans-Yamuna area. Though the chosen case study does not show serious damages or losses and may not even sound significant but the Chamoli earthquake effects in Delhi indicate that there is real possibility of a large earthquake in the Himalaya causing considerable damage to Delhi.

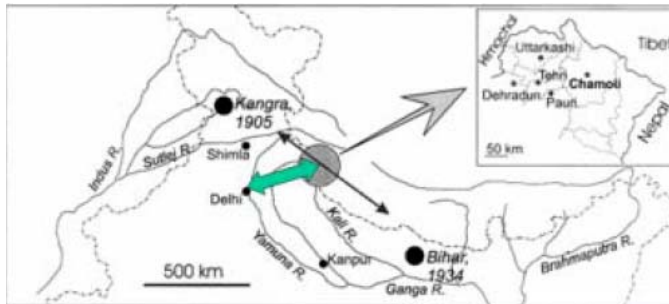


Illustration on left - Map showing location of Chamoli & Delhi and Illustration on right - Tarang Apartments in Patparganj, which developed major cracks during Chamoli earthquake

Every time we look at the aftermath of Latur or Bhuj-like earthquakes, the **Capital's high-sounding disaster management committee rings rather hollow**. Despite the paraphernalia assorted in the name of a disaster management committee, the Delhi government is often caught off guard when calamities of serious intensity strike the city. **Fighting fire and floods are the only two functions for which the disaster management committee has prepared it. The committee does not have any concrete plan for coping with a crisis like earthquake, which the city is prone to. However, The Government of Delhi has undertaken Earthquake Safety Initiative project** under which the 5 lifeline buildings namely Delhi Secretariat (Players building), Police Headquarters, Ludlow Castle School, Guru Tegh Bahadur (GTB) Hospital and Divisional Commissioners office complex have been identified for retrofitting.

## 4.0 Observations and Recommendations

### 4.1 Observations:

- 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 to be addressed is that 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.
- **Considering areas affected during past earthquakes of M - 6.5, it can be expected that such an earthquake occurring in Delhi could adversely affect the whole of it with damaging intensities and more than 50% of the Delhi Metropolitan Area** - in terms of probable damage scenario, earthquake would be the worst natural disaster for Delhi.
- As such, management measures in earthquake-related disasters mainly cover actions to minimize structural damage, and preparedness for rescue and relief. Delhi, which lies in Seismic Zone IV, is currently experiencing mild seismicity. **An earthquake of magnitude 7.0 on the Richter scale, that was once considered hypothetical, is today a very real possibility. Keeping in view the forecast of a major earthquake resistant design consideration, it has become imperative to size up the earthquake scenario of the city and increase awareness of earthquake resistant techniques.**
- The areas of major concern are that the city's settlement pattern has never been viewed in relation to location and geological characteristics. Pockets with high rise buildings or ill-designed high-risk areas exist without specific consideration of earthquake resistance. Similarly, unplanned settlements with sub standard structures are also prone to heavy damage even in moderate shaking. The Central Business District namely Connaught Place, numerous District Centres and sprouting high rise group housing schemes are high risk areas due to the vertical as well as plan configurations. The walled city area, the trans-Yamuna area, and scattered pockets of unplanned settlements also figure as high risk zones due to their substandard structures and high densities. So far as housing is concerned, vulnerability analysis has never been carried out and preliminary estimate of damages is not available for strengthening of structures under normal improvement development schemes. As per Vulnerability Atlas of India (1997), for shaking intensity VIII, 6.5% houses in Delhi have high damage risk, and 85.5% houses have moderate damage risk.

- Till date there is no legal framework to require that all constructions in Delhi must implement seismic code provisions. The result is that most buildings in Delhi may not meet codal requirements on seismic resistance. Moreover, even if from now on we somehow ensure that all new construction will be earthquake resistant, there still will remain a very large inventory of old buildings that will be deficient for seismic safety. We need to develop a rational seismic retrofitting policy, first for the government- owned buildings and later for the private constructions. Also, we should notice that Delhi has about 24 lakh building which would require retrofitting.
- It is understood that certain activities cannot cover 100% of the city and building retrofitting is one of them, for example we cannot retrofit all the buildings in old Delhi but it is required to be ready with the contingency plans and emergency calls in event of disaster.
- Delhi is currently passing through a major infrastructure development phase with a large number of bridges, flyovers and the metro project under construction. After a severe earthquake, the transport infrastructure is earthquake resistant and the old one is seismically retrofitted. Indian seismic code (IS:1893-1984) is not applicable for major projects which require special studies on seismic design criteria. Moreover, the Indian seismic codal provisions on bridges as these exist today are obsolete and inadequate (e.g Jain and Murty, 1998).
- Earthquake disaster in Delhi has the potential to go well beyond the statistics of deaths and injuries. Such a disaster in the country's capital, which also happens to be a major commercial and industrial centre, will have huge economic and political implications which will affect the entire country and not just the population of Delhi. This adds an extra dimension to the earthquakes problem for Delhi.

#### 4.2 Recommendations

- A valid question at this stage will be: should one be concerned about an earthquake which has a very low probability of occurrence, when Delhi faces so many day-to-day problems of environment, noise, traffic, water and power shortage, etc? Considering the potential for a mega disaster, we cannot afford ignore the earthquake problem.
- As a first step towards earthquake disaster mitigation the problem must first be recognized and quantified. Herein lies the first challenge: to discuss and debate the problem of this kind on a rational basis and yet not cause panic. Once the problem is identified and an action plan agreed upon, the need will arise for a political and administrative will to implement the action plan. It is emphasized that the problem requires huge efforts and is well beyond a few individuals or a few organizations. Numerous scientific and engineering activities will have to be initiated simultaneously before we can even quantify the size of the problem by way of seismic risk scenarios.
- We must focus our attention to the institutionally and manpower development at all levels. Extensive studies are needed for seismic hazard evaluation for different parts of Delhi and vulnerability assessment for different kinds of constructions; using these, seismic risk evaluation for Delhi must be carried out.
- Manuals need to be developed outlining methodologies for new constructions and retrofitting of old ones. A strong legal and enforcement framework with appropriate incentives and punitive measures is required together with awareness programs for general public. All these components must be taken up simultaneously; ignoring one aspect for the other could be counterproductive.
- There is an urgent need for healthy debates on seismic risk aspects of Delhi and for reasonable assessment of the problem. Studies are needed on seismic hazard evaluation for different types of construction. Using these, seismic risk scenarios must be developed and implementation strategies chalked out for new and old constructions.
- The efforts required are truly multidisciplinary and should include components on technical training, institutional development, development of technical manuals, legal and enforcement aspects, and public awareness programs.
- Most importantly, we need the political will to handle this problem and the biggest challenge perhaps lies in drawing the attention of political leadership to this problem when the city faces many other urgent problems.
- The Authorities must follow the Landuse pattern as given in the development plan or Master Plans.
- Landuse change of sensitive/ vulnerable areas like Delhi ridge, river banks etc. must not be allowed by law.
- Legal framework and building byelaws should be enforced strictly to mandate that all constructions in Delhi must implement seismic code provisions.
- Concentration of population on marginal lands within the city must be made available with precautionary tools for sustaining earthquake damages.
- Existing Unauthorized colonies in the city must be undertaken for redevelopment on compulsory basis or must be improved through land pooling techniques. Thus, upgrading them to a level where certain earthquake

resisting techniques can be introduced or if not then at least relief can reach the areas in event of disaster. This may vary from case to case and area to area.

- **Public-Private partnerships** wherever done for urban development must ensure the component of disaster mitigation must be addressed. This may be related to natural as well as man-made disasters.
- **If I were to write the Disaster Risk Management Master Plan** the foremost inclusion will be ban on Landuse conversion and stringent actions against violation of development codes and building byelaws. Besides this, introduction of disaster management course in schools be mandatory. This should be extended to adult education institutions also.

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Beside the mentioned references, the discussion forum and the course material was the basis of understanding approach towards safe cities and the mechanism to undertake the same.