Reducing Sesimic Hazard - A Case Study of Meerut City

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***Abstract*- The rapid and often unplanned expansion of cities is exposing more people and economic assets to the risk of disasters. Disasters can slow down financial development, affect human suffering. Without considerable action, the degree and impact of social damage associated with disasters will get horrific. The Present study is confined on economic capital city of Uttar Pradesh i.e Meerut city. It is very nearer to capital of India so that the massive developments are going on in and around Meerut. It has also attracted thousands of people from other cities of Utter Pradesh and other states, which have caused increase in the density of the city. The present approach to find the disaster risk on field data collection by community based.**

Keywords—Disater risk, community, disaster plan, population density

I. INTRODUCTION

Earthquake is one of the most destructive natural hazards of geological origin. Moreover, earthquakes may occur at any time without any warning and can destroy buildings, infrastructure and above all lead to human loss or injury. It is difficult to predict with the current state of scientific knowledge when an earthquake will occur although we know the probable region and expected magnitude based upon seismic zonation maps. Cities, the engines of economic growth and where population resides in higher concentration are also vulnerable to hazards such as earthquake. This is particularly true for cities in developing countries. The vulnerability of cities is due to a number of factors such as rapid growth and inadequate planning, inappropriate construction practices and high population densities, dependency on infrastructure and services, concentration of political, industrial, financial or other resources etc [1].

The Bhuj earthquake of January 26, 2001 in India resulted in the reported loss of about 13,805 people (GSDMA 2002); approximately more than 30,000 lives were lost in the Bam earthquake in 2003. Most of the researches focus on earthquake phenomenon rather than its impact. The impact of natural disasters such as earthquake – which account for one of the highest losses amongst all types of disasters in terms of the numbers of population affected, properties & infrastructure affected as well as economy. Population vulnerability needs to be studied carefully in the urban areas of developing countries which usually do not have disaster preparedness plans in place and where high concentration of population resides often in building that are vulnerable to natural hazards such as earthquake. In every earthquake, vulnerability is heavily concentrated in the area where the buildings are poor quality [2].

II. PROBLEM DEFINITION

The Meerut city lies in the seismic zone IV. The surrounding and nearby districts such as Saharanpur, Muzaffarnagar, Bijnor, Moradabad also fall in this zone. The population pressure on the city is ever growing. The population of Meerut was 11, 67,399 in 2001.The population of Meerut are 1,309,023 in 2011 [2]. The total area of the Meerut city is 178 Km^2. The average population density of Meerut was 6500 persons/Km^2 in 2011 there is change in 8166 persons/ Km^2. The older/inner Meerut has more density as compare to the outer. Some of the inner wards having population density are more than 20000 persons/ Km^2.

The threat of a potential natural disaster such as an earthquake looms over the city. As city is not free from any major earthquake hazard, an assessment of the elements at risk (population and Building) is required in order to determine population vulnerability. This entails the need for study of detail population activity patterns as well as collection of detailed individual characteristic information

Efforts for reduction of vulnerability of elements at risk are needed on a priority basis. One such effort is that of government of India and United Nations development programme's Disaster Risk Management Programme (DRM) from 2002-2007. Under the DRM programme was the urban earthquake vulnerability programme (UEVRP) that deals specifically with urban areas (38 cities in India). Meerut is one of the selected cities under the UEVRP. The thrust of the DRM Programme and UEVRP is that it is community based. The UEVRP programme was underway in Meerut and since it was community based, the present study includes an overview of the same.

In Meerut city the problem of urbanization is continuously increasing, further unplanned urbanization and landuse distribution has aggravated problems related to drinking water, continuous construction of houses without following building norms safe as per suggested by National Disaster Management Institute etc. Majority of the houses in and around the Meerut city are not as per the building norms for earthquake therefore people living in these areas are in endanger. The bad quality of the construction materials and the unplanned construction work that is still going on are increasing the risk of heavy losses and deaths during earthquakes like disaster. There are two approaches toward efforts to reduce vulnerably- one is the technocratic approach wherein the Government/ research institutions/multilateral agency/NGO undertake risk assessment without the involvement/participation of the communities.

III. RESEARCH METHODOLOGY

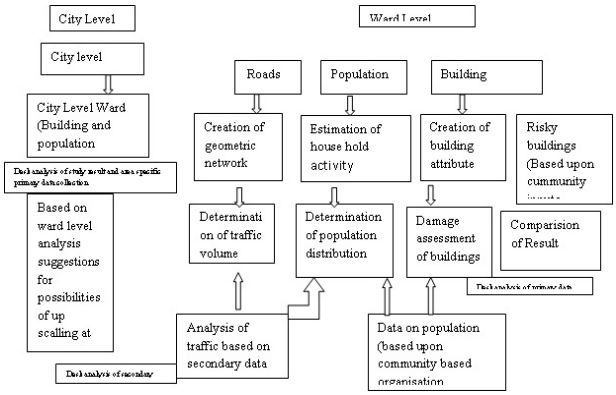


Figure 1: Research Methodology

A. Study area

The study area Meerut is a metropolitan city. It is an ancient city located 56 km (35 mi) north-east of New Delhi. It is the 16th largest metropolitan area in India and the 17th largest city in India. It ranked 292 in 2006 in the list of largest cities and urban areas in the world.

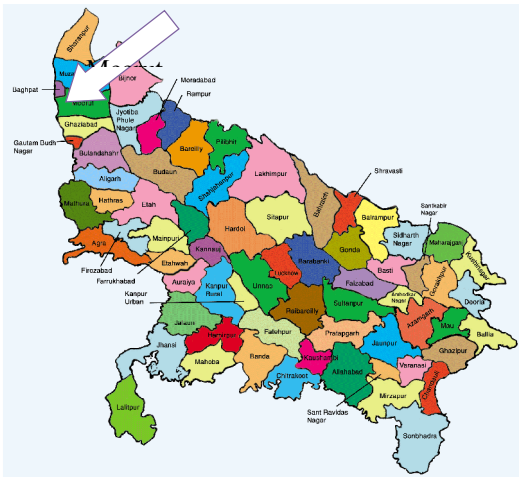


Figure 2: Location Map of Meerut

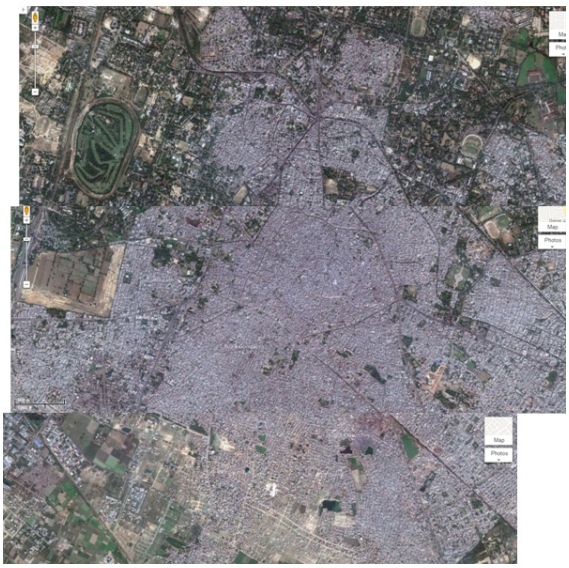


Fig 3 Sattelite image of meerut city (source: google map)

Meerut is the 63rd fastest growing urban area in the world. It is also the fastest developing city of Uttar Pradesh after Noida and Ghaziabad. It is spread in about 172 square km. It is the 14th fastest developing city of India. The total metropolitan area is third in Uttar Pradesh after Lucknow and Kanpur. Meerut lies between plains of rivers Ganga and Yamuna. This plain is the part of Indogangetic plain/ Ganga plain, which is a fore-deep, a down warp of the Himalayan foreland, of variable depth, converted into flat plains by long-vigorous sedimentation. The Ganga Plain has considerable amounts of flexure and dislocation at the northern end and is bounded on the north by the Himalayan Frontal Thrust. The floor of the Gangetic trough is not an even plain, but shows corrugated inequalities and buried ridges (shelf faults). The study area is surrounded by Delhi-Haridwar Ridge (DHR), trending NNE-SSW along New Delhi to the Gharwal region. The Delhi-Muzaffarnagar Ridge (DMR), which trends east to west, running from New Delhi to Kathgodam.

B. Population Profile

The population pressure on the city is ever growing. The population of Meerut was 11, 67,399 in 2001[1]. The population of Meerut is 1,309,023 [2]. The total area of the Meerut city is 178 Km^2 [2]. The population density of the city is increased as per the data shown above (Table-1). These are increase the unplanned and undefined growth of the city. The population density of Meerut Municipal Corporation was 7,532.4 persons/sq.km and Meerut cantonment board was 2,604.2 persons/sq.km [1] an average density about 6558.2 persons/sq.km in 2001 and 7374.77 persons/sq.km in 2011 there is change in 816.6 persons/sq.Km. The older/inner Meerut has more density as compare to the outer. Some of the inner wards having 200000 persons/sq. Km

Sr. No	Year	Population	
		Numbers	Lakh
1	1901	1,21,180	1.21
2	1911	1,19,435	1.19
3	1921	1,25,506	1.25
4	1931	1,41,025	1.41
5	1941	1,79,155	1.79
6	1951	2,39,440	2.39
7	1961	2,94,853	2.95
8	1971	3,71,760	3.72
9	1981	5,36,615	5.37
10	1991	8,49,799	8.50
11	2001	11,61,716	11.62
12	2011	14.24908	14.25
Census decade			Growth rate
1951-61			23.14
1961-71			26.08
1991-2001			37.8
Between 1971-2001 the increase in population : more than 58%			

C. Geology and soil type

The area is almost devoid of any significant relief features and is composed of unconsolidated alluvial deposits. The land surface lies at an elevation of 220 m from mean sea level. The city is a part of Indo-Gangetic plains, which is mainly composed of pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Lithologically, sediments consist of clay, silt and fine to coarse sand. The deposits of sandy horizons of varying thickness are containing the groundwater [3].

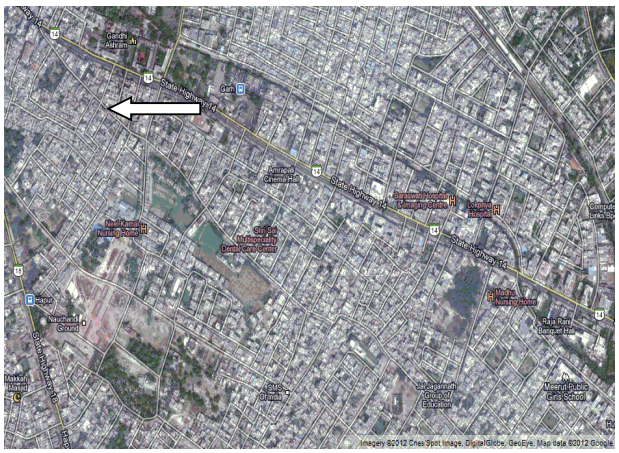
D. Gross Density of Meerut

Table 2: Gross density (Source: Census report 1991, 2001)

Area Name	1991			2001		
	Area (Km^2)	popul ation	Density (per/Km^2)	Area (Km^2)	popul ation	Density (per/Km^2)
Meerut MC	141.9	753778	5300	146.4	1068772	7400
Meerut Cantt.	35.7	96021	2700	35.7	92944	2600
Total Meerut City	177.6	849799	4800	182.1	1161716	6500

IV. PILOT CASE STUDY

To find the vulnerability analysis of area the following details to be collected at micro level. A sample area is chosen to collect all the aspects of the area.



A. Location

Dr.Zakir Hussain Colony (Zakir Colony) shares its boundary with other slums in three sides and a posh colony on its 4th side i.e. Shastri Nagar colony. The major slums that share its boundary with Zakir colony are Dhawai Nagar, Fateullapur and Ali Ahmed Nagar.Zakir Colony itself is a big slum comprising of small poverty pockets within it. Its area starts from Madina Masjid till Chamda Peth.It comprises of Kamela Colony, Iqubal Nagar,Zohra Bagh,Humayun Nagar, Rasool Nagar, Jamuna Nagar and Katchchi Zakir Colony. The colony is divided into different blocks starting from A to F. The Zakir Colony in all covers 3 wards i.e. 76, 77, 66. Zakir Hussain colony and its adjoining areas are shown in figure 4.

B. Population

Total no. of houses in the Zakir Colony is near about 8,600 with an average family size of 7.At an approx. the population will come to more than 60,200.

C. Occupation

Majority of the people in the slum are daily wage earner and few are engaged in business as they have set up cottage industries for the manufacture of sports good such as bats, wickets, etc. Basic occupation categories are:

- Khairati Machine
- Rickshaw puller
- Weavers
- Daily Wagers
- Well off

D. Religion and Social Structure

The almost total populations of are followers of Islam. Joint family system is prevalent in the area. Male member is the head of the family. Old pardah system is still prevalent.

Illiteracy is the major problem in the area as there are no Govt. schools in the close vicinity. As evident from health records that this area comes under HRA (High Risk Area) due to lack of proper education about the services provided.

E. Housing Condition

In the periphery of the slum, the houses and roads are in better condition but as moving inwards from the main road the condition is vulnerable. The roads are narrow with complex vein nation of gallies is visible in the entire slum. Open drainage system and water logging in the roads is common scene of the slum. In terms of structure most of the houses are pucca and two storied.5-6 people accommodate in a single room and the rooms have no ventilation facility.

Table 3 Brief detail of Zakir colony

Items	**Details**
Total population	60,000 (approx)
Total number of blocks	6
Total number of Houses	8600
Average family size	7
Total number of Private primary schools	20
Total number of religious institutions (Madrsa)	6
Total number of charitable clinic	2
Total number of private nursing homes	1

F. Road Inventory and Surveys

The knowledge gained from repeated visits to the ward, the still and movie photographs taken, the landuses observed and the impressions about business/quietness of the roads/lanes/alleys and along with the actual demarcation of the road network and blockages in this network formed the basis of the road, traffic and pedestrian volume survey.

G. Building Surveys

Buildings house or have people residing or working in them, the number of people during each time of the day and night within each building vary based upon nature of use of the

building and; the set indoor and outdoor routines of the people residing or working in them. The aim of the building survey was to map them as accurately as possible and collect details on physical characteristics and the number of families/shops housed within each of the buildings. For building assessment, the questionnaire was used. The survey was mainly done by survey teams formed in pairs of surveyors (with Civil Engineering background) and after an initial training imparted by the researcher (both on desk as well as in the field) on how to assess the individual buildings; the survey of buildings was carried out. Survey work of individual buildings was also based on individual blocks. It is to be noted that this part of the work took up considerable amount of the field work time

H. Collection of Other Information

Apart from the above activity pattern survey and also during the same; simultaneous information about the various holidays that are observed in the city was also noted down.

I. Community Based Organisation

Information on Ward level Community Based Organisation active in the study area has been given in the following section.

J. Civil Defence

The Civil Defence is a semi government organisation operating under the umbrella of the Ministry of Home Affairs, Government of India. The organisation operates under the District administration Campus in Meerut. Information on the Civil Defence organisation was obtained through many rounds of discussions with the organisation's Sector Wardens and Post Wardens (present as well as ex). The Civil Defence Organisation operates right up to the community level. The basic purpose of formation of this organisation was preparedness of the local community against any enemy attack.

Figure 5 Map of Study area: Prepared by Civil defence with help of local community

Meerut is a major military head quarter and a sensitive base for the enemy to strike by air (that may lead to fire and thus a requirement for rescue operations and first aid would arise) and hence this city (17 cities and towns in the state of Uttar Pradesh and in all, 171 cities and towns through the country) have the Civil Defence Organisation operating in them under the umbrella of the Ministry of Home Affairs situated in New Delhi. Presently the organisation provides thirteen different services which include providing training – to various organisations, factories, government offices, private offices, schools and colleges - on how to undertake preparedness measures in case an air attack takes place. In Meerut, every ward has representatives of the organisation from within the community. Each ward has been divided into sectors. Each sector has two functioning representatives of the ward known as 'Sector Wardens'. Besides, there is also a Reserve Warden. Thus, in all, the ward has 10 Sector Wardens and 5 Reserve Wardens. The Post Warden is overall incharge of all the sectors and Wardens. In fact, the entire city has been divided into Sixty sub-units named as Posts. Each post may be a part of one or more ward. Approximately a population of 10,000 people are covered in one post (i.e. one Sector Warden is appointed per 1000 population). Thus, in the case of Zakir Colony, the six sectors not only cover this ward, but in fact, also cover a part of the adjoining ward. The Sector and Post Wardens work on voluntary basis and are provided training in Warden Services from time to time by the District administration Campus at Meerut. It is to be noted that the Sector Wardens are professional or known person of the area. At the city level, for a population of 100,000; there are 10 Post Wardens, 3 Reserve Post Wardens and 3 Deputy Post Wardens. After receiving training from the Civil defence Training Centre, the Sector wardens in-turn, impart the training to selected representatives from the population. For example they select 10 people per 1000 population and provide fire fight training programme to them. Thus, for every 100 persons, there is trained fire fighter. Here the assumption is that the fire may be caused by a gas leakage or some kind of bomb. Also, for every 750 persons, the Assistant Deputy Controller provides other training programmes – thus four persons from the community in ever sector receive the training. Besides the 24 people mentioned per sector having attended such training programmes, as reserve manpower, 6 persons (i.e.25% of trainees) are also trained for similar training programmes.

Fig 6: Sensitization programme

Fig 7: Mass Awareness

In terms of information that the Sector Wardens maintain (and submit to the Home Guards office) these include an updated enumeration of each household per sector, list of officials of the Civil Defence organisation, main places in the sector, important people living within the sectors and also important facilities (such as police station), name of members in the Warden Service. The above data is an important source of information for many purposes (such as vulnerability analysis). Since the community based organisation representatives belong intrinsically from within the community, their local knowledge base is extremely strong and relevant. It appears to be an important and potential source of database as well as a community based mechanism for disaster risk management. However, this leads to the requirement of policy level interventions right at the Central Government level.

K. Community Based Workshop

A Community Based workshop with population of sector A (based upon Civil Defence's classification of the ward) was carried out in order to have the community mapping their risk and resources – as perceived by them in their surroundings. A questionnaire was prepared to have a discussion about the level of awareness amongst the community. The study area analogue map was shown to the community members for this exercise. The Ward residents (particularly those residing /working in Sector A) were contacted directly as well as through the Community Based Organisation Representatives (i.e. Civil Defense Sector Wardens). Finally the communities views on disaster awareness and reduction were obtained along with a risks and resources (refer table 4) map prepared by them according to their perception.

TABLE 4 LIST OF RISKS AND RESOURCES FOR COMMUNITY BASED MAPPING

Risk	Resource
Weak Building	Open ground
Densely Populated area	Schools
Income wise poor people	Clinic/Hospital
Low lying area	Public building
Petrol Pump (due to risk of fire	Police station
Industrial Location	Collection/commission
Sensitive areas (due to communal unrest)	NGOs

Source: Based upon UNDP- UEVRP's risk and resource mapping method

V. CONCLUSION AND RECOMMENDATIONS

The information from the CBO at Zakir Colony appears to be an important and potential source of database. The functions that the CBO carried out is strongly related to not only civil defence purposes but the role of the CBO can be expanded towards preparedness for disaster risk and management. However, for work to follow on these suggested lines, implies the requirement of policy level interventions right at the Central Government level. The Civil Defence organisation needs to formally be roped in along with other stakeholders such as the DMMC, the two ULBs (MDDA and DMC), NGOs, other CBOs, and professionals and interested individuals (representing the larger Civil Society) and; the UNDP-GoI's UEVRP. A combined effort from all these stakeholders – the most important being the community will ensure the successful preparation and implementation of the DMP.

There is a need to provide a format for data collection and data sharing across the disciplines that can be involved in casualty estimation. Such a data format should be flexible enough to handle the currently available data, re-evaluate previously collected data and accept new data as they become available.

The Civil Defence Organisation data collection mechanism at sector level is a highly efficient and updated one and useful for a variety of purposes especially basic steps towards disaster mitigation and management such as vulnerability assessment.

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