EARTHQUAKE DISASTER PREPAREDNESS FOR EMERGENCY MANAGEMENT IN HIMALAYAN REGION

A THESIS

Submitted in partial fulfilment of the requirements for the award of the degree

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DOCTOR OF PHILOSOPHY

in

ARCHITECTURE AND PLANNING

By

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **EARTHQUAKE DISASTER PREPAREDNESS FOR EMERGENCY MANAGEMENT IN HIMALAYAN REGION** in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy and submitted in the Department of Architecture and Planning of the Indian Institute of Technology Roorkee, Roorkee is an authentic record of my own work carried out during a period of July 2003 to July 2007 under the supervision of Prof. R. Shankar, Department of Architecture and Planning, Indian Institute of Technology Roorkee, Roorkee.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other Institute.

(ILA GUPTA NEE ILA ANNA JOSHI)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Date: 30th July 2007

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Supervisor

The Ph.D Viva-Voce Examination of **Ms. Ila Gupta Nee Ila Anna Joshi**, Research Scholar, has been held on ....

Signature of Supervisor

Signature of External Examiner

ABSTRACT

India is prone to almost all kinds of natural and man-made disasters especially to earthquakes. In the last 16 years India has witnessed six major earthquakes, three of which occurred in Himalayan ranges. The sudden impact of earthquakes and the realization of disaster reduction possibilities emphasize the need of research in the preparedness aspects of earthquakes.

The review of literature in the field of earthquake preparedness identified research gap in terms inadequacy in guidelines for community involvement; lack of standardized methodology and risk indicator for formulating preparedness plans for rural settlements; neglect of highly vulnerable Himalayan settlements; and marginal involvement of architects and planners in earthquake disaster management. Hence the research work is carried out with the aim of formulating a practical and holistic earthquake disaster preparedness plan, for a micro region of Himalayas. The research methodology formulated on the basis of literature review, mainly consists of activity analysis, vulnerability analysis, resource potential analysis, generating a hypothetical earthquake scenario within the region, estimation of likely losses in terms of building damage and human casualties and development of appropriate risk indicator for settlements. All these facilitate formulation of preparedness plans and action plans. Narendranagar block of Tehri-Garhwal district in Himalayan state of Uttarakhand is selected for detailed investigations and proposals. This selected sub region has a total population of 103032 living in 214 villages and 17 market towns. All relevant data about Narendranagar block was collected through secondary surveys, a brief pilot survey and a detailed primary survey of representative samples of 15 villages. The construction typology prevailing in the Narendranagar block is found to be vulnerable and influenced by the accessibility of the villages. All the constructions existing in Narendranagar block are categorized as per descriptions provided in the MSK scale and their respective numbers are estimated. The vulnerability of settlements due to other factors like landslides, inaccessibility, river proximity, high altitudes and various social factors is analyzed. An inventory of potential of existing resources in terms of infrastructure facilities, institutional setup, manpower availability and material supplies in the sub region is made.

A hypothetical earthquake scenario within the region is developed with epicenter near Tapowan at $30^0 08'10"$ N and $78^0 20'30"$E and magnitude 7.5 determined from the major tectonic elements and microzonation studies. The effect of this earthquake on residential buildings estimated that almost 5.14% buildings of Narendranagar block would experience collapse while other 19.8% buildings would experience high damage, rendering almost 26% total population homeless. The human casualties in these buildings are estimated to be 990 (0.96%) persons would be dead or unsavable. The locations of most probable landslides and the settlements rendered inaccessible due to landslides are identified. The assessment of available resources for handling earthquake of this magnitude is estimated for their shortcomings and further needs are computed. A Seismic Risk Indicator (SRI) developed, identifies 12 villages of Narendranagar block which are at very high risk.

The plan formulated, gives measures for vulnerability reduction, detailed preparedness plan with focus on strengthening community capacities proposed for 5 most critical activities viz. damage assessment, search and rescue, relief distribution, medical assistance and temporary sheltering for emergency management. A model settlement level preparedness plan worked out for 3 selected settlements, consists of details such as material requirements, location of critical facilities, key persons and training aspects. The proposed guidelines for effective implementation of plans, the evolved planning norms and general recommendations for vulnerability reduction are generally applicable throughout India. The scope identified for further research would achieve the objectives in a comprehensive way.

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Finally, I thank the almighty *God* for all the positive things in my life.

Ila Gupta

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ABBREVIATIONS AND ACRONYMS

APHC	Additional Primary Health Centre
BHW	Basic Health Worker
BIS	Bureau of Indian Standards
BMTPC	Building Material Technology Promotion Council
CBO	Community Based Organization
CHC	Community Health Center
CVA	Capacities and Vulnerabilities Analysis
DMMC	Disaster Management and Mitigation Centre
DPI	Damage Probability Index
DPM	Damage Probability Matrix
DRM	Disaster Risk Management
EDRI	Earthquake Disaster Risk Index
EM-DAT	Emergency Disaster Database
EP	Exceedence Probability
G1	Very Low Damage
G2	Low Damage
G3	Moderate Damage
G4	High Damage
G5	Very High Damage
GIS	Geographic Information System
GoI	Government of India
GSI	Geographical Survey of India
H	High
HA	Hazard Analysis
HF	High Frequency
HPC	High Power Committee
ICT	Information and Communication Technology
ICU	Intensive Care Unit
IHR	Indian Himalayan Region
IMD	Indian Meteorological Centre

Inj 1	Dead or Unsavable
Inj 2	Life Threatening Cases Needing Immediate Medical Attention
Inj 3	Injuries Requiring Hospital Treatment
Inj 4	Light Injuries Not Necessitating Hospitalization
ISET	Indian Society of Earthquake Technology
L	Low
M	Moderate
MBF	Main Boundary Fault
MCT	Main Central Thrust
MM	Modified Mercalli Scale of Intensity
MSK	Medvedev-Sponheaer-Karnik Scale of Intensity
NDM	National Disaster Management
NGO	Non-Government Organization
OR	Operating Room
PAR	Pressure and Release Model
PGA	Peak Ground Acceleration
PHC	Primary Health Center
PRA	Probabilistic Risk Analysis
PRI	Panchayat Raj Institute
PSI	Parameterless Scale of Intensity
PT&T	Postal Telephone and Telegraph
PWD	Public Works Department (Government of Uttarakhand)
RCC	Reinforced Cement Concrete
SAR	Search and Rescue
SL	Sustainable Livelihood
SLA	Sustainable Livelihood Approach
SRI	Seismic Risk Indicator
SSB	Single Sideband
VH	Very High
VHF	Very High Frequency
VL	Very Low

CHAPTER 1

REVIEW OF LITERATURE AND PROBLEM IDENTIFICATION

1.1 INTRODUCTION

Disasters have always been affecting the living world and would continue to do so. Natural disasters like floods, cyclones, earthquakes, volcanic eruptions, tsunamis, wildfires, landslides and droughts are constantly occurring in different parts of the world and their effect on living environment is on increase (UNISDR, 2005; EM-DAT, 2007). The most affected are developing countries and weaker sections of the society where over 90 percent of natural disaster fatalities occur (United Nations, 2004; Sapir *et. al.,* 2004; Mistry *et. al.,* 2001). Apart from these, man made disasters like major accidents, social violence, and terrorist activities are also increasing at an alarming rate. Rubin (1998) cautions about the increasing complexity of the new threats and risks we face on account of technological advances and the need for more sophistication in response and recovery.

India is prone to almost all kinds of natural and man-made disasters due to its sub - continent size and a wide range of climatic and topographic conditions (BMTPC, 1997; NCDM, 2001a). It is well known that the year 2005 has been one of the worst years of natural disasters for India. The tsunami in Indian Ocean of December 26, 2004 proved to be a massive disaster followed by the devastating earthquake that struck India and Pakistan in October 2005. Apart from these, in July / August 2005, Mumbai received the highest recorded rainfall in 95 years, witnessing the collapse of almost all essential services. Similar unprecedented rainfall was also recorded in the southern parts of India in Andhra Pradesh, Karnataka and Tamil Nadu, rendering metropolises like Bangalore and Chennai inundated. All these events have highlighted the shortcomings of our present disaster management system. If disasters can affect the major cities of India in such severe manner, one can imagine the vulnerability of the less developed Indian rural settlements.

These days, along with other disasters, earthquakes are drawing our attention because of the enormous amounts of losses they are causing (EM-DAT, 2007). In India the disaster response has been so far directed primarily to relief action, but it is now realized that the consequences of increasing number of disasters are becoming very serious and hence greater emphasis needs to be given to planning and prevention.

In the past 16 years India has witnessed six major earthquakes, out of which three occurred in highly vulnerable Himalayan ranges. The latest India Pakistan earthquake on October 8, 2005 has once again emphasized the importance of earthquake vulnerability assessment and preparedness measures for loss reduction and emergency management (Sinvhal *et. al.*, 2005; EERI, 2005). This study deals with the mitigation aspects of earthquake disaster management (Arya, 2006), pertaining to the specific tasks of preparedness planning for vulnerability reduction (preventive measures) and emergency management through suitable analytical studies, in a selected micro region in the Himalayas.

1.2 NATURAL DISASTERS

A disaster is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community / society to cope using its own resources (UNDRO, 1984).

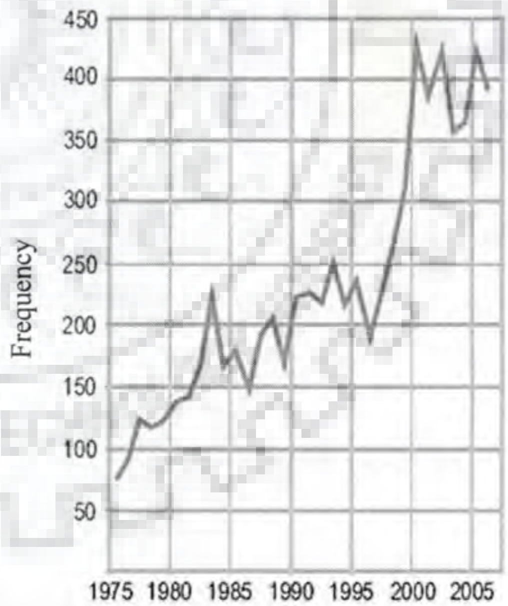


Figure 1.1: Time trend of natural disasters, 1975 – 2006

Source: EM-DAT (2007)

Over the years mankind is becoming increasingly alarmed by disasters, which have tended to be more destructive as they affect ever-larger concentrations of populations (Smith, 2001; UN-ISDR, 2007). UNISDR (2007) gives the alarmingly increasing time trend of natural disasters for a period from 1975 to 2006, as shown in Figure 1.1.The frequency of disasters, particularly in the last decade, has increased at such an alarming rate that vulnerable populations do not always have the opportunity to recover from one disaster before the next one strikes (IFRC, 2007).

1.2.1 Disasters: Global View

The statistics related to disasters occurring worldwide show that the hydro- meteorological disasters including floods, windstorms, droughts, extreme temperatures, slides and wild fires are the cause of maximum economic damage (Table 1.1). They are followed by geological disasters including earthquakes, tsunamis and volcanoes. The share of biological disasters like epidemics and insect infestations is the least.

Table 1.1: Total amount of reported economic damages by continent and disaster origin (US$ billion) 1991 – 2005

	Hydrometeorological	Geological	Biological
Africa	3.93	6.14	*0.01*
Americas	400.82	29.98	*0.13*
Asia	357.70	219.74	*0.00*
Europe	142.83	16.17	*0.00*
Oceania	*14.51*	*0.87*	*0.14*

Source: UNISDR (2005)

Table 1.1 suggests that the maximum economic damage is caused due to hydro-meteorological disasters in Americas followed by hydro-meteorological disasters in Asia and Geological disasters in Asia. Figure 1.2 shows year wise level of annual (reported) economic damages from natural disasters for the period of 1975 to 2006. Figure 1.2 also shows selected disasters with largest economic impact which are earthquakes in Italy and Kobe (Japan), flood in China and windstorms in USA.

A look at the top ten natural disasters by number of deaths in 2006 suggest that the worst disaster of the year was earthquake in Indonesia, followed by typhoon in Philippines, landslides in Philippines, heat wave in Netherlands and others (Table 1.2).

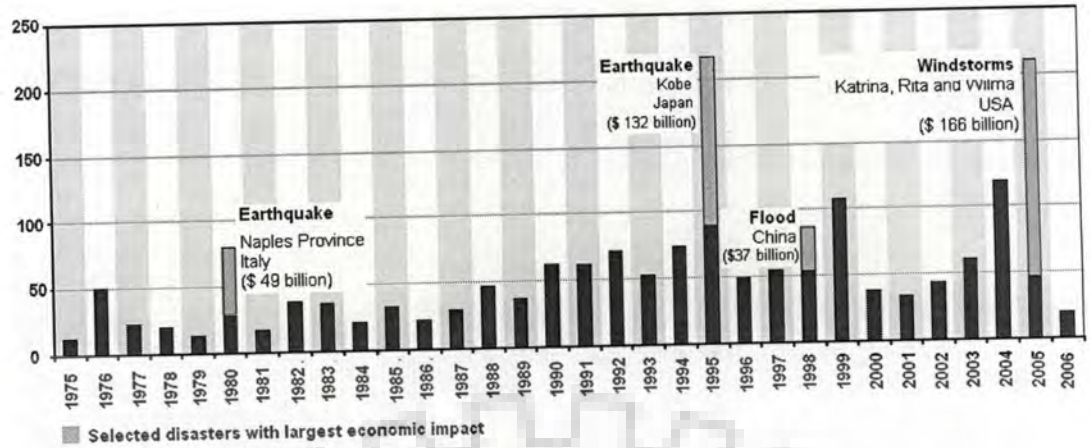


Figure 1.2: Annual reported economic damages from natural disasters: 1975 – 2006

Source: EM-DAT (2007)

Table 1.2: Top ten natural disasters by number of deaths - 2006

Type of Disaster	Month	Country	Number of Deaths
Earthquake	May	Indonesia	5778
Typhoon Durian	December	Philippines	1399
Landslide	February	Philippines	1112
Heat wave	July	Netherlands	1000
Heat wave	July	Belgium	940
Typhoon Bilis	July	China, P Rep	820
Tsunami	July	Indonesia	802
Cold Wave	January	Ukraine	801
Flash Flood	August	Ethiopia	498
Typhoon Samoai	August	China, P Rep	373

Source: EM-DAT (2007)

The human impact of different natural disasters is given by EM-DAT (2007) (Figure 1.3). The figure shows that maximum numbers of persons are affected due to droughts followed by floods, windstorms and others. Whereas, maximum number of persons killed are due to wave / surge (including tsunami) which are followed by earthquakes and others. This high number of killed persons is due to the unexpected nature of occurrence of wave/ surge / tsunami and earthquakes. EM-DAT has given percentage of people killed by natural disasters by continent (Figure 1.4).

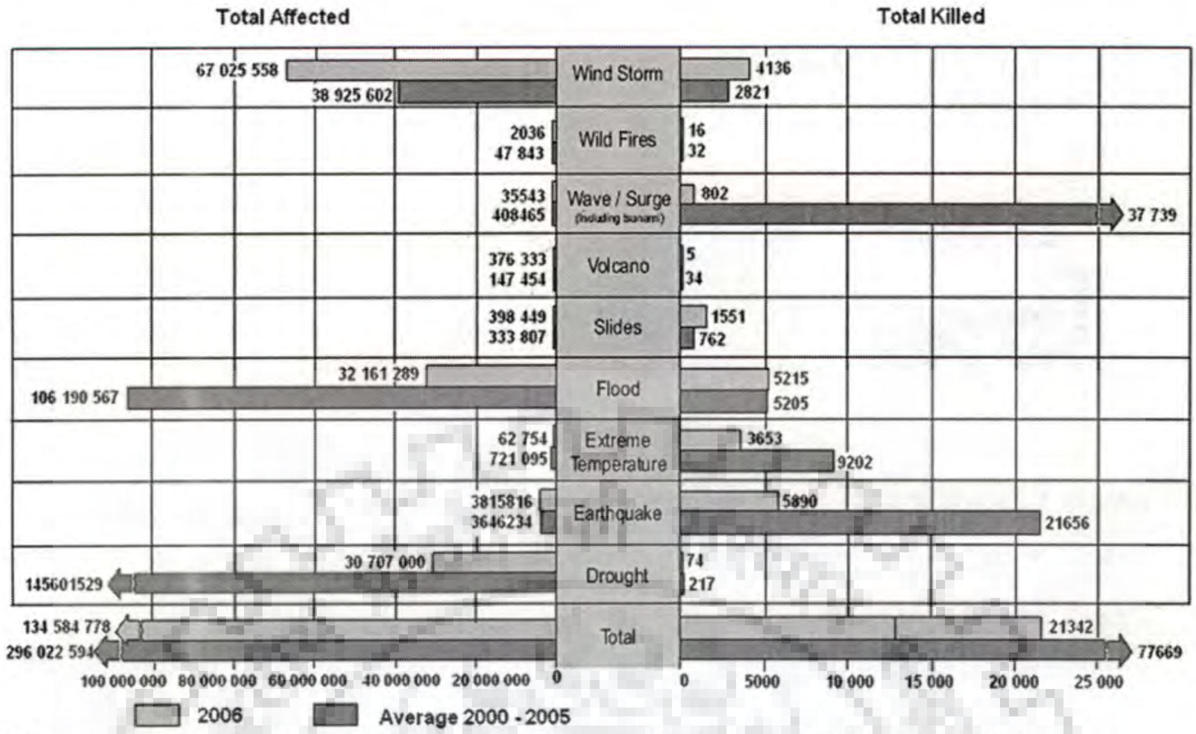


Figure 1.3: Human impact by disaster types 2006, Source: EM-DAT (2007)

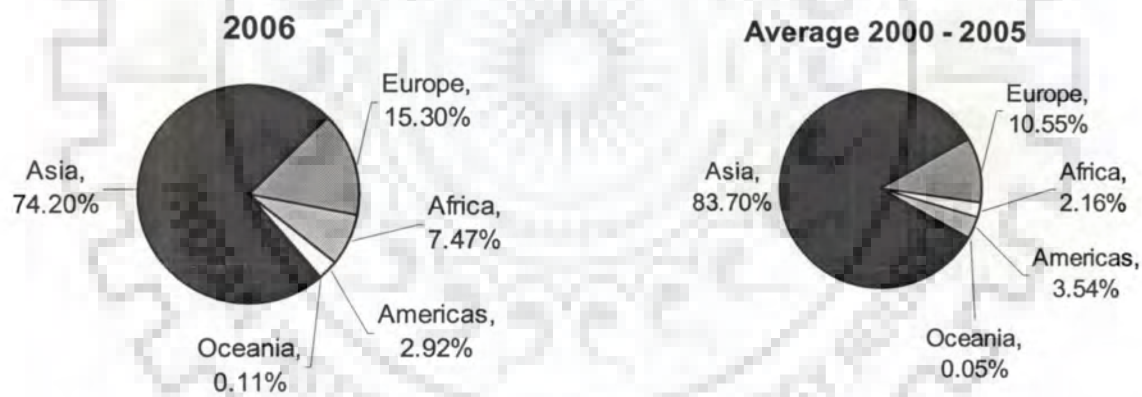


Figure 1.4: Percentage of people killed by natural disasters by continent

Source: EM-DAT (2007)

Omachi and Huu (2003) have given compilation of both human and material losses due to natural disasters within Asia for a period from 1900 – 1987. (Figure 1.5; 1.6), which show that within Asia earthquakes account for almost 50% human and material losses; and the rest is accounted mostly by floods and wind damage.

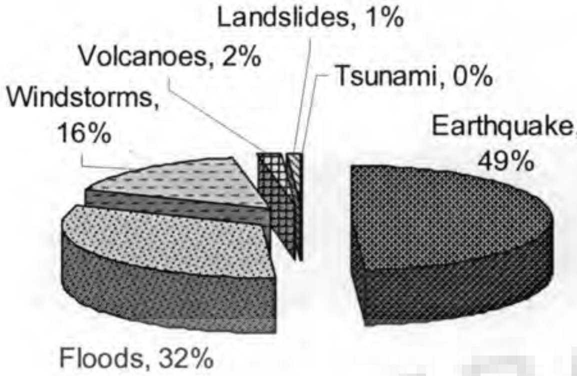


Figure 1.5: Material losses by type of hazard within Asia 1900 – 1987
Source: Omachi and Huu (2003)

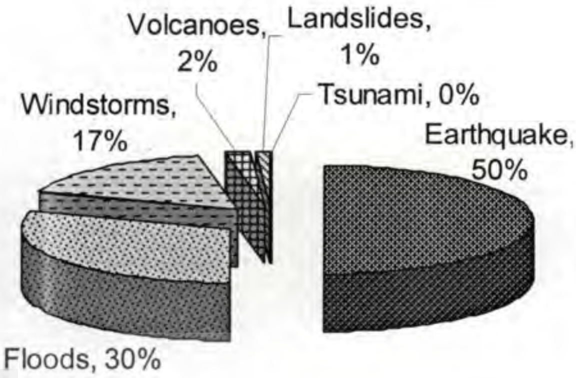


Figure 1.6: Human losses by type of hazard within Asia 1900 – 1987
Source: Omachi and Huu (2003)

1.2.2 Natural Disasters in India

The unique geo-climatic conditions of India make this region particularly vulnerable to all kinds of natural disasters. India stands fourth in the list of countries most hit by natural disasters in the year 2006, following the countries China, United States and Indonesia & Philippines. (Table 1.3)

Various thematic maps made available by EM-DAT (2007) showing disaster statistics for the years 1974 – 2003, highlights India, which is most frequently in the worst affected category (Figure 1.7). The vulnerability of India to various natural disasters given by BMTPC (2001) is:

- About 50 to 60% of total area of the country is vulnerable to seismic activities of varying intensities.
- 16 % of the country's total area is drought prone and approximately 50 million people are annually affected by drought.
- India has a long coastline of 8041 kms., which is exposed to the tropical cyclones arising in the Bay of Bengal and Arabian Sea.
- Also in India river floods are the most frequent and often most devastating.

Table 1.3: Countries most hit by natural disasters – 2006

Country	Disasters
China, P Rep	35
United States	26
Indonesia, Philippines	20
India	17
Afghanistan	13
Vietnam	10
Australia, Burundi, Pakistan	8
Ethiopia, Mexico, Romania	7
Germany	6
Bangladesh, Canada, Japan, Kenya, Russia, Malaysia, Papua New Guinea, Somalia	5

Source: EM-DAT (2007)

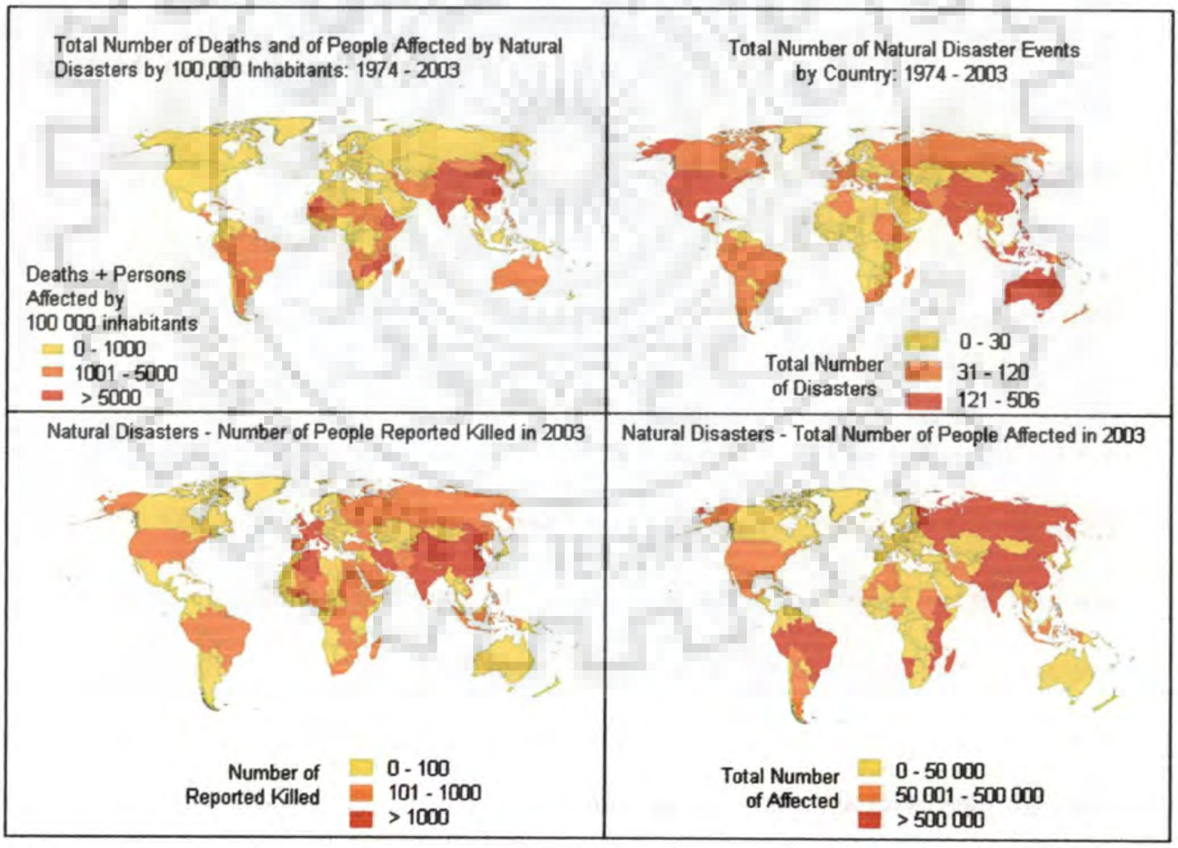


Figure 1.7: Thematic maps showing disaster statistics of all countries 1974 – 2003,

Source: EM-DAT (2007)

1.3 EARTHQUAKES

Earthquake is a term used to describe both sudden slip on a fault, and the resulting ground shaking and radiated seismic energy caused by the slip, or by volcanic or magmatic activity, or other sudden stress changes in the earth (USGS, 2007a). The occurrence of earthquake is best explained by the Plate-tectonics, which is a theory supported by a wide range of evidence that considers the earth's crust and upper mantle to be composed of several large thin, relatively rigid plates (Figure 1.8). These plates move relative to one another and cause accumulation of stresses inside the earth which result in the occurrence of earthquakes (Bolt, 2000; USGS 2007 b).

Figure 1.8: Major tectonic plates of the world
Source: USGS (2007 c)

Earthquakes are the least predictable of all natural disasters. Partly due to this, earthquakes top the scale of immediate mortality and structural destruction.

1.3.1 Earthquakes: Global View

Over the last 30 years, a total of 660 earthquakes were reported in EM-DAT (2007) resulting in the death of 559,608 people and affecting more than 82 million people. The average number of people affected by an earthquake for every person killed was 147 (EM-DAT, 2007). Figure 1.9 shows the earthquake events across the globe for a period from 1990 to 2000 (USGS, 2007). As per Wisner (2000) 'Earthquakes happen, but disaster follows because of human action and inaction'. Mortality rates due to earthquakes vary from country to country, primarily due to differences in building styles and the density of settlements.

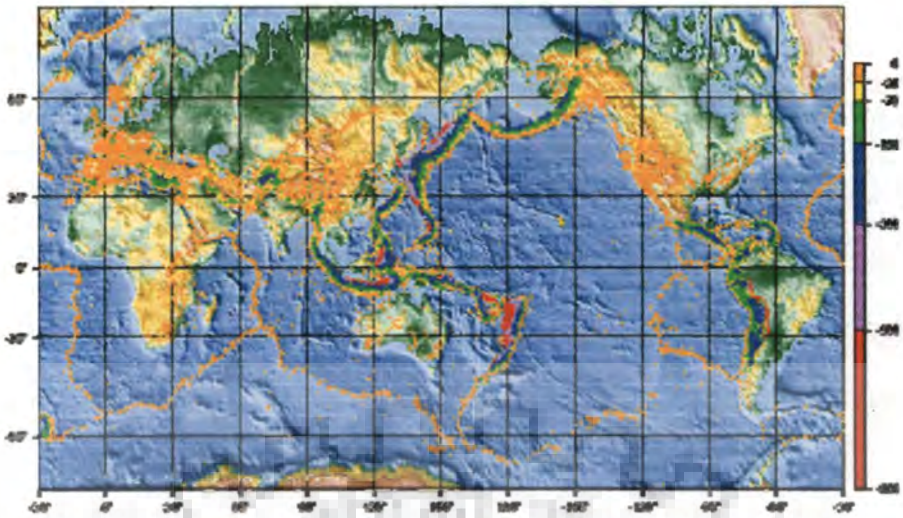


Figure 1.9: World seismicity 1990 – 2000, Source: USGS (2007)

A look at top ten countries affected by earthquakes shows that China occupies the first three positions in the list of people killed due to earthquakes, whereas, India occupies first two positions in the list of people affected due to earthquakes (Table 1.4 ; Table 1.5).

Table 1.4: Top ten countries affected by Earthquake on the basis of number of people killed 1901 - 2007

Country	Date	Killed
China P Rep	27-Jul-1976	242,000
China P Rep	22-May-1927	200,000
China P Rep	16-Dec-1920	180,000
Japan	1-Sep-1923	143,000
Soviet Union	5-Oct-1948	110,000
Italy	28-Dec-1908	75,000
Pakistan	8-Oct-2005	73,338
China P Rep	26-Dec-1932	70,000
Peru	31-May-1970	66,794
Pakistan	31-May-1935	60,000

Source: EM-DAT (2007)

Table 1.5: Top ten countries affected by earthquake on the basis of number of people affected 1901 - 2007

Country	Date	Total Affected
India	21-Aug-1988	20,003,766
India	26-Jan-2001	6,321,812
Pakistan	8-Oct-2005	5,128,000
China P Rep	3-Feb-1996	5,077,795
Guatemala	4-Feb-1976	4,993,000
Peru	31-May-1970	3,216,240
Indonesia	27-May-2006	3,177,923
China P Rep	1-Nov-1999	3,020,004
Japan	8-Aug-1983	2,550,028
Chile	8-Jul-1971	2,348,973

Source: EM-DAT (2007)

According to Coburn and Spence (2002), over the last century, about 75% of fatalities attributed to earthquakes have been caused by the collapse of masonry buildings (Figure 1.10). These buildings are primarily weak masonry buildings (adobe, rubble stone or rammed earth) or unreinforced fired brick or concrete block masonry that can collapse even at low intensity of ground shaking and will collapse very rapidly at high intensities. The authors opine that much of the increased populations in developing countries will continue to be housed in this type of structure for the foreseeable future.

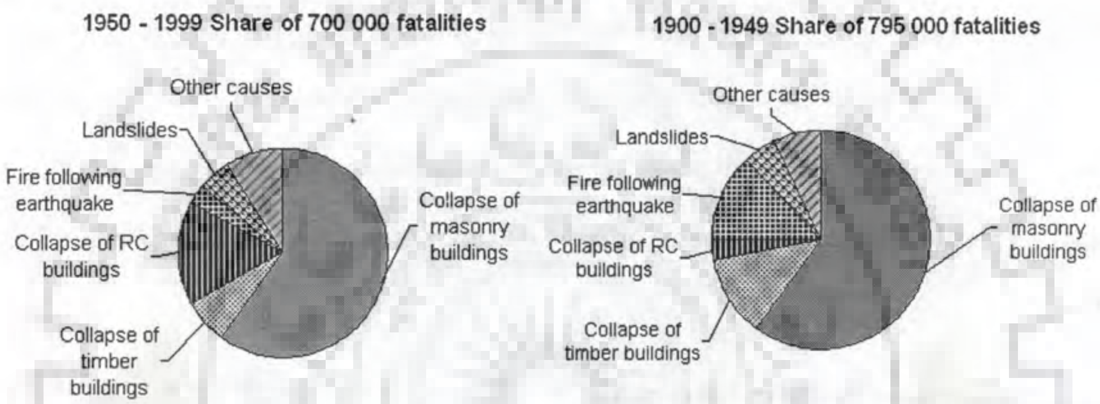


Figure 1.10: Earthquake related fatalities by cause type,

Source: Coburn and Spence (2002)

The earthquake related statistics sorted by continents for a period from 1901 to 2007 given by EM-DAT (2007) suggest that Asia is far too ahead as compared with other continents where earthquake related losses are concerned (Table 1.6).

Table 1.6: Earthquake damage continent wise, 1901 to 2007

	No. of Events	Killed	Injured	Homeless	Affected	Total Affected	Damage US(000's)
Africa	69	21,021	59,463	894,874	701,023	1,655,360	11,073,899
ave. per event		305	862	12,969	10,160	23,991	160,491
Americas	237	214,789	446,117	3,515,418	20,851,139	24,812,674	46,517,406
ave. per event		906	1,882	14,833	87,980	104,695	196,276
Asia	545	1,470,363	1,204,401	14,004,938	62,658,197	77,867,536	202,063,974
ave. per event		2,698	2,210	25,697	114,969	142,876	370,760
Europe	145	275,610	43,930	1,279,917	4,035,123	5,358,970	58,894,376
ave. per event		1,901	303	8,827	27,828	36,958	406,168
Oceania	38	439	767	19,820	67,574	88,161	2,509,419
ave. per event		12	20	522	1,778	2,320	66,037

Source: EM-DAT (2007)

1.3.2 Earthquakes in India

The issue of seismic hazard was addressed in India in 1956 when a 3 zone seismic zoning map of India was produced (Tandon, 1956). This map was based on a broad concept of earthquake distribution and geotectonics. Since then, many versions of the seismic zoning map of India have been brought out by Bureau of Indian Standards which is the official agency for publishing seismic zoning maps. The latest one showing five zones is given as Figure 1.11.

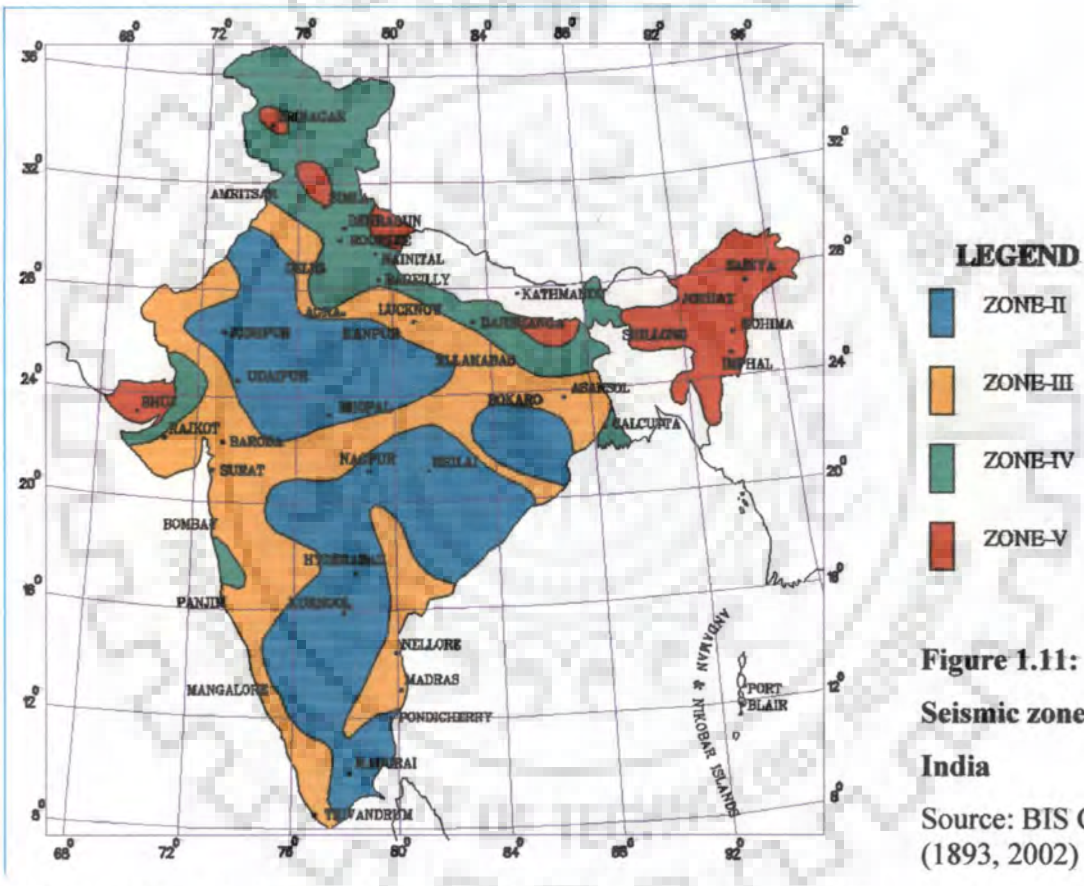


Figure 1.11: Seismic zones of India

Source: BIS Code (1893, 2002)

(Note: Zone I and II of previous version were merged and named as zone II)

India has witnessed some of the most devastating earthquakes during the past century. In the past 16 years India has witnessed six major earthquakes including the Kashmir earthquake of October 08, 2005 the epicenter of which was located in Pakistan (Table 1.7).

Table 1.7: Chronological Occurrence of significant earthquakes in India

DATE	EPICENTRE		LOCATION	MAGNITUDE
	Lat (Deg N)	Long (Deg E)		
1819 Jun 16	23.6	68.6	Kutch,Gujarat	8.0
1869 Jan 10	25	93	Near Cachar, Assam	7.5
1885 May 30	34.1	74.6	Sopor, J&K	7.0
1897 Jun 12	26	91	Shillongplateau	8.7
1905 Apr 04	32.3	76.3	Kangra, H.P	8.0
1918 Jul 08	24.5	91.0	Srimangal, Assam	7.6
1930 Jul 02	25.8	90.2	Dhubri, Assam	7.1
1934jan 15	26.6	86.8	Bihar-Nepalborder	8.3
1941 Jun 26	12.4	92.5	Andaman Islands	8.1
1943 Oct 23	26.8	94.0	Assam	7.2
1950 Aug 15	28.5	96.7	Arunachal Pradesh-	8.5
1956 Jul 21	23.3	70.0	Anjar, Gujarat	7.0
1967 Dec 10	17.37	73.75	Koyna, Maharashtra	6.5
1975 Jan 19	32.38	78.49	Kinnaur, HP	6.2
1988 Aug 06	25.13	95.15	Manipur-Myanmar Border	6.6
1988 Aug 21	26.72	86.63	Bihar-Nepal Border	6.4
1991 Oct 20	30.75	78.86	Uttarkashi, Up Hills	6.6
1993 Sep 30	18.07	76.62	Latur-Osmanabad, Maharashtra	6.3
1997 May 22	23.08	80.06	Jabalpur, MP	6.0
1999 Mar 29	30.41	79.42	Chamoli Dist, UP	6.8
2001 Jan 26	23.40	70.28	Bhuj , Gujarat	6.9

Source: IMD (2007)

The most vulnerable areas according to the present seismic zone map of India are located in Himalayan and Sub-Himalayan regions, Kutchh and the Andaman and Nicobar Islands. Depending on varying degrees of seismicity, the entire country can be divided into the following seismic regions (Figure 1.12) as given by NCDM (2007):

'1. Kashmir and Western Himalayas: covers the states of Jammu and Kashmir, Himachal Pradesh and sub-mountainous areas of Punjab.

2. Central Himalayas –includes the mountain and sub-mountain regions of Uttar Pradesh and the sub-mountainous parts of Punjab.

3. Northeast India: includes the whole of Indian Territory to the east of North Bengal.
4. Indo-Gangetic Basin and Rajasthan – This region comprises of Rajasthan, plains of Punjab, Haryana, Uttar Pradesh and West Bengal.
5. Cambay and Rann of Kutchh.
6. Peninsular India including the Islands of Lakshwadeep.
7. The Andaman and Nicobar Islands.'

Figure 1.12: Seismic regions of India (after: NCDM, 2007)

The distribution of earthquakes of magnitudes equal to or more than 5.0 in these regions and their average return periods are given in Table 1.8, which shows that the entire Himalayan ranges are very highly vulnerable to earthquakes as compared to rest of the country.

Table 1.8: Distribution of magnitudes and their average return periods in India

S. No.	Seismic Region	No. of earthquakes of magnitude				*Return Period*
		5.0 – 5.9	6.0 – 6.9	7.0 – 7.9	8.0 +	
1	Kashmir and Western Himalayas	25	7	2	1	*2.5-3 yrs.*
2	Central Himalayas	68	28	4	1	*1 yrs.*
3	Northeast India	200	128	15	4	*<4 months*
4	Indo-Gangetic Basin and Rajasthan	14	6	-	-	*5 yrs.*
5	Cambay and Rann of Kutchh	4	4	1	1	*20 yrs.*
6	Peninsular India	31	10	-	-	*2.5-3 yrs.*
7	*Andaman and Nicobar*	*80*	*68*	*1*	*1*	*<8 months*

Source: NCDM (2001)

According to a research carried out by Khattri *et. al.* (1984) the Peak Ground Acceleration (PGA) value for the Himalayan region was 0.7g. for 10% probability of exceeding in 50 years. Bhatia *et.al.* (1999) calculated the seismic hazard for the Indian region using probabilistic computational approach , the PGA calculated for the Northwest Himalayan region for the 500 years return period varies from 0.35g to 0.4g.

1.3.3 Earthquakes in Himalayas

Himalayan ranges extending from Hindukush in North-West to Burmah in South-East for a length of around 2400 km. make a natural mountain barrier of 250 to 300 km in width and 500 to 8000 meter in height in the northern part of Indian subcontinent. Geographically these are spread between 21^{0}57'37.5" N latitude and 72^{0}40'97.25"E longitude, covering an area about 5.3 lakh km^2. Himalayas contributes about 16.2% of India's total geographical area and most of the area is covered by snow clad peaks, glaciers of Higher Himalaya, dense forest cover of mid Himalaya. These ranges are characterized by two syntexial bands near Nanga Parbat in West and Wamcha Bairwa in East is one of the youngest and the highest mountain ranges of the world (Nandy and Rao, 2001; Satyendra, 2003). The reason for high earthquake vulnerability of Himalayas lies in the evolution of Himalayas as a result of collision of Indian plate with Eurasion plate (Figure 1.13). The Himalayas continue to rise more than 1 cm a year and hence the tremendous stresses which build up within the Earth's crust, are relieved periodically by earthquakes along the numerous faults (USGS, 2007 b). Considering the vulnerability of Himalayas to earthquakes, these days a lot of research is being conducted in the field of strong motion (Shrikhande *et. al.* 2002; Saini *et. al.* 2002; Nath, 2002).

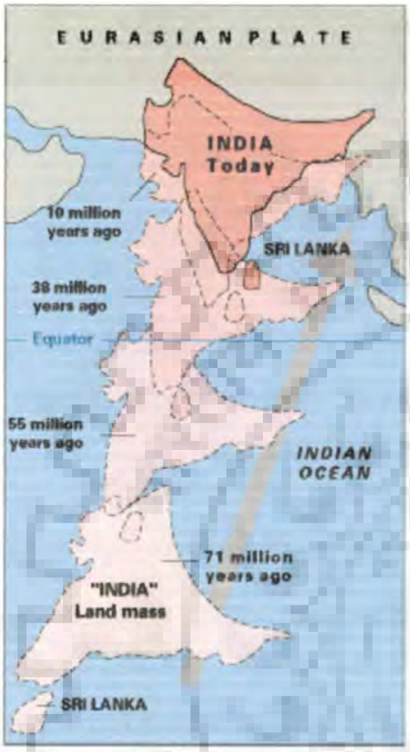


Figure 1.13: The 6,000-km-plus journey of the India landmass (Indian Plate) before its collision with Asia (Eurasian Plate)
Source: USGS (2007 b)

Human Settlements of the Himalayas

The Indian Himalayan Region (IHR) comprises of a population of 39628311 spread in 10 states and hill regions of 2 states of Indian Republic (Census of India, 2001) (Table 1.9).

This human population in IHR is thin and dispersed as compared to the national figures due to physiographic conditions and poor infrastructure development (Nandy and Rao, 2001).

It can be seen that the total population as well as the percentage contribution to the total IHR population is highest in the state of Jammu and Kashmir followed by Uttarakhand.

Table 1.9: The population of Himalayan states

STATE	Population	Percentage to the total IHR population (2001)
Jammu & Kashmir	10069917	25.41 (0.98)
Himachal Pradesh	6077248	15.34 (0.59)
Uttaranchal	8479562	21.40 (0.83)
Sikkim	540493	1.36 (0.05)
West Bengal Hills	1605900	4.05 (0.16)
Assam Hills	998509	2.52 (0.10)
Arunachal Pradesh	1091117	2.75 (0.11)
Nagaland	1988636	5.02 (0.19)
Manipur	2388634	6.03 (0.23)
Mizoram	891058	2.25 (0.09)
Tripura	3191168	8.05 (0.31)
Meghalaya	2306069	5.82 (0.22)

(Note: Values in parenthesis are % contribution of the respective state to the total country's population.) Source: Nandy and Rao, (2001)

Vulnerability of Himalayan People

Murshed (2006) brings out the vulnerability of mountain communities particularly in the Himalayan region, importantly because of the following factors:

'1. The Himalayan communities are vulnerable due to physical isolation, the scattered settlement patterns, and the harsh climatic conditions.
2. The development of infrastructure for health, education, safe drinking water and sanitation is often overlooked due to the high construction costs and the physical distances and the nature of terrain involved.
3. The physical inaccessibility is further multiplied due to fragile mountain ecosystem, susceptible to soil erosion, landslides and loss of bio-diversity which exposes the residents to multiple hazards.

4. The difficult availability of land area often compels for building any house or roads on vulnerable locations.
5. The remotely located communities totally lack access to earthquake resistant building technologies and construction materials.
6. Because of the poor communication technology, the communities remain cut-off from the rest of the world.'

Murshed (2006) also states that the historical record of major disaster occurrence in Himalayas demands the need of appropriate actions for ensuring adequate response system in order to reduce the loss of life and property in case another major disaster strikes here.

1.3.4 Landslide Hazard

India has about 25% of its geographical area under mountainous terrain. The southern, central and western mountains namely the Western Ghats, Satpura and Vindhyan ranges and Aravalis are geologically very old and are stable formations as compared to the Himalayas and the Shiwalik ranges in the North. (Valdiya, 1975). The Himalaya is a geologically and ecologically fragile mountain ecosystem where, landslides have been a major and widely spread natural disaster that often strike life and property and occupy a position of major concern (NCDM 2001a; Valdiya 2002). An estimate of landslide generated loss in the Himalayan ranges as quoted in Naithani (1999) says:

> 'It has been estimated that, on an average, the damage caused by landslides in the Himalayan ranges costs more than US$ one billion besides causing more than 200 deaths every year.'

Kanungo *et. al.* (2006) has defined landslide risk as:

> 'Landslide risk can be defined as the potential for adverse consequences or loss to human population and the things that humans value due to landslide occurrence.'

Kanungo *et. al.* (2006) have combined neural and fuzzy approach for development and implementation of landslide susceptibility zonation mapping and have proposed a fuzzy concept for risk assessment. The results of the landslide zonation studies are discussed with the habitation in the selected area.

The factors causing landslides can be broadly classified as geological, hyrological, seismic and land use and importantly are erosion, saturation, deforestation and excavation of hill slopes. Hence in Himalayas, people are both culprits and victims in the dismaying incidence of environmental depredation and degradation (Sastry *et. al.* 1981; Valdiya 2002). According to Ghosh *et. al.* (2006)

> 'The problem of landslides is very severe in Uttarakhand due to the adverse geologic and topographic condition supplemented by heavy rainfall.'

Krishnaswamy and Jain (1975) have listed effects of landslides under four major groups viz. those affecting highways and communication routes, urban and rural settlements, location and maintenance of river valley projects and environment.

The methodology adopted by NRSA (2001) for the demarcation of landslide hazard zones in the most critical areas of Uttarakhand and Himachal Pradesh states, involved integration of remote sensing based inputs from space and conventional data. A number of thematic maps like rock types, geological structure, landforms, land use / cover, slope, soil and drainage were generated using satellite data and integrated with non – spatial data in GIS environment. Further the landslide hazard zonation was arrived at employing a specially developed knowledge based decision – support module. The landslide hazard zonation maps show different categories of landslide hazard from severe to low. Separate maps with suggestive management plans for different hazard zones are also provided.

One more landslide hazard zonation study carried out by Mehrotra *et. al.* (1992) for a Himalayan region, gives a map showing different zones of instability within a region bounded by latitudes 30^0 and 30^030'N and longitudes 78^0E and 78^030'E. However, as per Bhandari (2002) the landslide hazard is strongly dependent on the degree, extent and rate of human intervention, and those are the hardest things to comprehend, judge and evaluate, hence the maps admittedly cannot be free from the ensuing limitations.

1.4 DISASTER MANAGEMENT

Disasters have serious adverse impact on physical, socio-cultural and economic conditions. It often becomes difficult to meet the development lag created due to the disasters. It is now being increasingly realized that the disastrous impact of natural hazards can be reduced to a large extent by undertaking various mitigation programmes and better management practices (Arya, 1997; NCDM, 2001; Satyendra, 2003).

1.4.1 Significant Global Initiatives for Disaster Management

In view of ever mounting disaster related statistics, there is now international acknowledgement that efforts to reduce disaster risks must be systematically integrated into policies, plans and programmes for sustainable development and poverty reduction, and supported through bilateral, regional and international cooperation, including partnerships (ISDR, 2005). A list of few important international agencies active in the field of disaster management along with the major roles played by them is given in ***Annexure I***. Some important global initiatives of recent years are discussed briefly below.

International Decade for Natural Disaster Reduction (IDNDR) programme, launched by the United Nations, is one of the most significant attempts to mitigate the effects of disasters in recent times. IDNDR effectively shifted the focus from rescue and relief to preparedness and mitigation (United Nations, 2004). The decade 1990-2000 was declared as the International Decade for Natural Disaster Reduction (IDNDR) with the aim to save human lives and reduce the impact of natural disasters. (NCDM, 2001).

Yokohama Strategy was evolved as a plan of action for disaster reduction during major conference of the IDNDR programme held in Yokohama in May 1994. The Yokohama Strategy gave guidelines for Natural Disaster Prevention, Preparedness and Mitigation, shifting the focus and emphasis from disaster management to disaster prevention and preparedness (United Nations, 2004; ISDR, 2005).

International Strategy for Disaster Reduction (ISDR) was founded by the UN General Assembly in 2000 as the successor to IDNDR, to continue to promote work and commitment in disaster reduction (UNISDR, 2004). The ISDR aims at building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters. (United Nations, 2004)

Kobe Conference and Hyogo Framework was held from 18 to 22 January 2005 in Kobe, Hyogo, Japan, and adopted the Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters with an expected outcome of '*the substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries.'* (ISDR, 2007).

World Conference on Disaster Reduction Mumbai with focus on Role of Corporate Sector was held as a follow up event of the UN World Conference on Disaster Reduction (UN WCDR) during November 2005 and again in November 2006. The conference focused on the roles and responsibilities of the corporate sector as well as the partnership of corporate sector with the other stakeholders to ensure sustainable disaster management (Sinha *et. al.*, 2006).

1.5 DISASTER MANAGEMENT IN INDIA

The existing disaster management set up of India, considering the vulnerability of India to various disasters is given as ***Annexure II***. An important initiative was taken in India for disaster management in July 1994, was appointment of an expert group by the Ministry of Urban Development, Government of India, to examine the disasters related issues and evolve recommendations for improving preparedness and prevention with respect to natural disasters caused by earthquakes, floods and cyclones (BMTPC, 2001; Arya, 2006).

The outputs of the work carried out by the expert group are given in Table 1.10.

Table 1.10: Output of the work done by the expert group for natural disasters, India.

Part-I	Techno Legal Measures	Techno-Legal aspects of earthquake / windstorm / flood hazards and land use zoning. Disaster damage scenarios, cost-benefit analysis. Recommendations and Action Plan
Part-II	The Vulnerability Atlas of India	State-wise hazard maps and district-wise risk tables
Part-III	Technical Guidelines	Land-use zoning and design guidelines for improving hazard resistant construction of buildings and housing.

Source: BMTPC (2001)

Committee of experts have proposed amendments in Town and Country Planning Legislations, regulations for land use zoning, additional provisions in development control regulations for safety and additional provisions in building regulations / byelaws for structural safety in natural hazard zones of India.

A High Power Committee (HPC) was appointed by Government of India soon after the super cyclone in Orissa in 1999 with the objective strengthening of organizational structure of disaster management and reorienting existing organizational and administrative structures. The HPC made important recommendations for assigning the work of disaster management to the Ministry of Home affairs and other Ministries concerning specific disasters to those Ministries (Government of India, 2002).

The Central Government has enacted the Disaster management Act, 2005 and has established a National Disaster Management Authority (NDMA) to act as an apex body for disaster reduction and management and National Institute of Disaster Management (NIDM) for training, research and human resource development. (Arya, 2006).

Government of India has undertaken a disaster risk management programme in collaboration with United nations Development Programme (UNDP) with major components of development of disaster risk management and response plans at village / ward, gram panchayat, block / urban local body levels, mainstreaming of disaster management in training, capacity building and education curricula at all levels, integration of disaster management plans with development plans of local self governments and preparation of State and District Disaster Management Plans (MHA, 2007; UNDP 2007).

States with high disaster vulnerability like Gujarat and Orissa have initiated large scale community based disaster preparedness programs, Uttarankhand has a separate department and appointed a Minister for Disaster management, Madhya Pradesh has formulated Disaster Management Policy. Similarly other States are advised to formulate the policy, act and constitute Disaster Management Authority for undertaking the Disaster Mitigation Activities. (Arya, 2006)

1.5.1 Earthquake Monitoring and Mapping in India

Earthquake Monitoring and Mapping in India are mainly carried out by Indian Meteorological Department, Geological Survey of India and Bureau of Indian Standards Committee (IMD, 2007). The India Meteorological Department maintains the national seismological network (Jain and Nigam, 2000). It is the organization responsible for monitoring of earthquakes in India, and preparing their catalogues. The organization also prepares the epicentral maps of the earthquakes (IMD, 2007). The Geological Survey of India Studies the sismotectonics of the country, carries out surveys of damages and preparation of Iso-seismal maps (GSI, 2007). The Department of Earthquake Engineering at IIT – Roorkee as well as IIT Kanpur and IIT Mumbai have also started carrying out damage surveys. Many other institutions and organisations operate local microseismic and strong motion networks.

Establishment of seismic observatories

A project on 'Establishment of a network of 22 Broad band seismic observatories and 40 strong motion accelerograph stations in Gujarat to study seismicity of the state was conceptualized by Government of Gujarat to carry out the task of up-gradation of the existing observatories and establishment of new observatories (Ashara *et. al.*, 2006). Department of Earthquake Engineering, Indian Institute of Technology Roorkee, Roorkee, India is involved in a project entitled 'National Strong Instrumentation Netwrok' under which it is proposed to install 300 acceleragraphs in Himalayan Belt (Indian) (Figure 1.14) (Mittal *et. al.* 2006).

It is planned to control functioning of all accelerographs from Roorkee (Base Station). For this accelerographs installed in about 180 district headquarters will be connected through VSAT of National Informatics Center (NIC), which will transmit the data to NIC headquarters at Delhi. Remaining 120 accelerographs will be installed in other towns (sub-divisions, Tehsils etc.) and these will be connected through Modem (landline or mobile) (Figure 1.15) (Mittal *et. al.,* 2006).

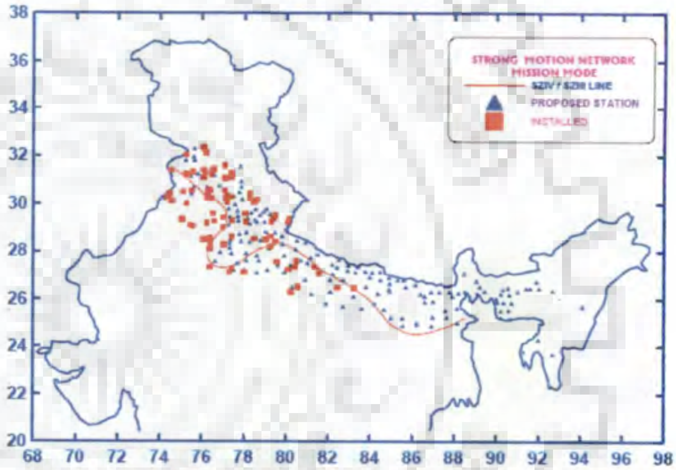


Figure 1.14: Locations of installed and proposed stations, Source: Mittal *et. al.* (2006)

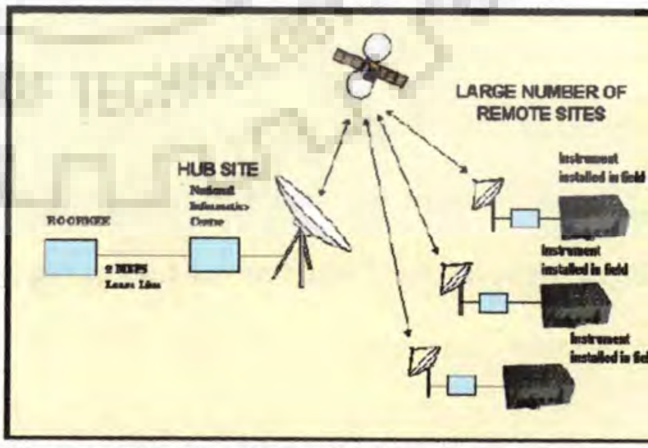


Figure 1.15: A schematic diagram of data flow using NICNET, Source: Mittal *et. al.* (2006)

1.6 MODELS FOR DISASTER MANAGEMENT

Models are representations of real situations and can be presented in various types viz. iconic models, analog models, mathematical models, deterministic models, probabilistic models and conceptual models (Anderson *et. al.* 2003). Satyendra (2003) states:

> 'Modeling as a technique has been found to be very effective in resolving issues which are of multi pronged origin and options and when more than one agency is involved in mitigating the same. Modeling techniques help in improving the performance of the implementing agencies be it government agencies, public sector organizations or NGOs.'

After studying the extensive research which is being conducted at global level, this section provides a review of some remarkable approaches and models in the field of disaster management.

1. Capacities and Vulnerabilities Analysis (CVA)

The framework of Capacities and Vulnerabilities given by Anderson and Woodrow as referred by Twigg *et. al.* (2001) is a matrix meant for analyzing people's vulnerabilities and capacities in three broad, interrelated areas: physical/material, social/organizational and motivational/attitudinal (Figure 1.16). CVA is an easy to use, realistic and indicative tool which has wide applications in the field of disaster mitigation.

	Vulnerabilities	**Capacities**
Physical / Material What productive resources, skills and hazards exist?		
Social / Organizational What the relations and organization among people?		
Motivational / Attitudinal How does the community view its ability to create change?		

Figure 1.16 : CVA matrix, Source: Twigg *et. al.* (2001)

2 Pressure and Release Model

An important model designed for peoples vulnerability and their livelihood conditions is 'Disaster Pressure and Release (PAR) Model' given by Blakie *et. al.* (1994). This model has combined human factor to the study of disasters and illustrates how human actions and structures impact disasters. The 'Access model' was developed along with the PAR model. According to this model the key to understanding the way people cope with hazards is the livelihood strategies that people choose. Both these models recognize that the most vulnerable live with constant hazards such as inadequate shelter, dangerous locations, lack of access to food and regular income and poor health – which can become disasters Figure 1.17 and Figure 1.18 represents PAR model and Access model respectively.

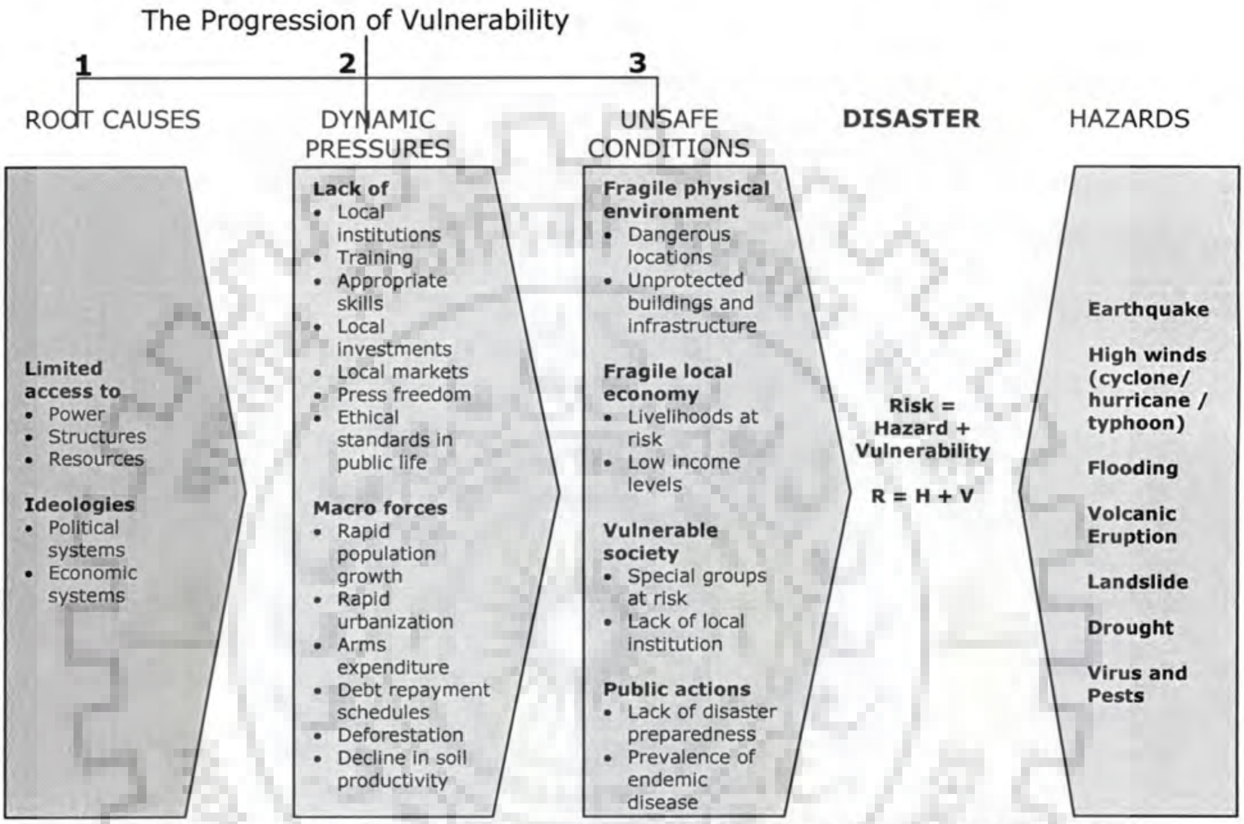


Figure 1.17: Pressure and release model, Source: Blakie *et. al.* (1994)

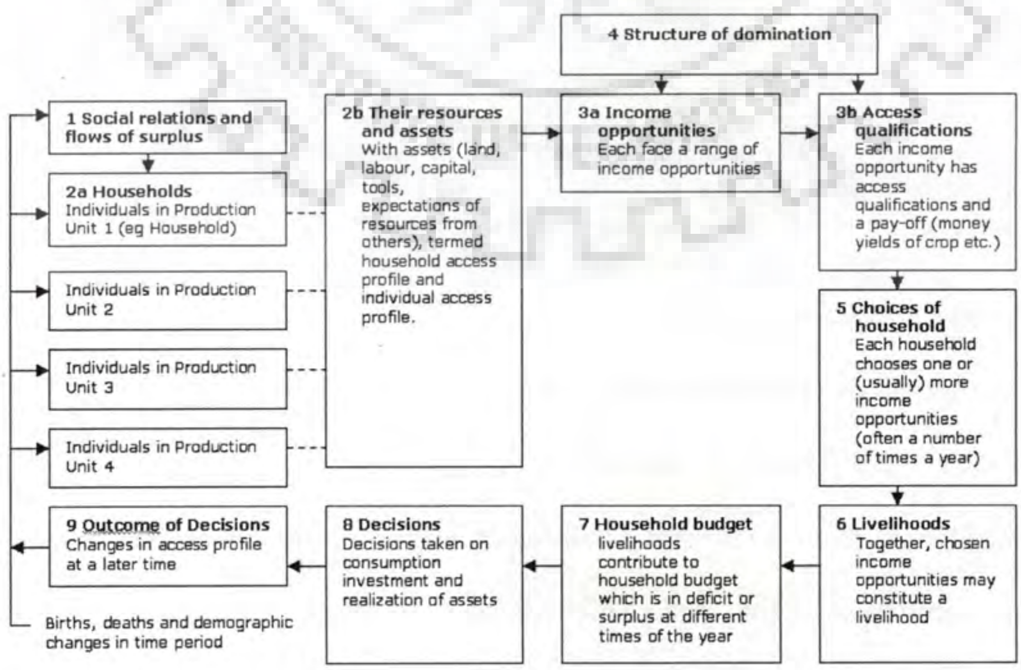


Figure 1.18: Access to resources to maintain livelihoods, Source: Blakie *et. al.* (1994)

The strength of PAR / Access models as given by Palakudiyil and Todd (2003) is

> 'They take a wide ranging view of vulnerability, providing a framework for defining the way people live and earn their living, as well as their vulnerability to disaster.'

3 Sustainable Livelihood Approach (SLA)

Sustainable Livelihood Approach (SLA) is given by Department for International Development (DFID, 2001) which states that

> 'A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.'

The SL framework is built around five inter – related factors that determine livelihoods: the *vulnerability context* in which people live their lives; the *livelihood assets* they possess; the *transforming structures and processes* which influence positively and negatively the livelihood strategies available to people; and the *livelihood outcomes* resulting from their interaction. (Figure 1.19)

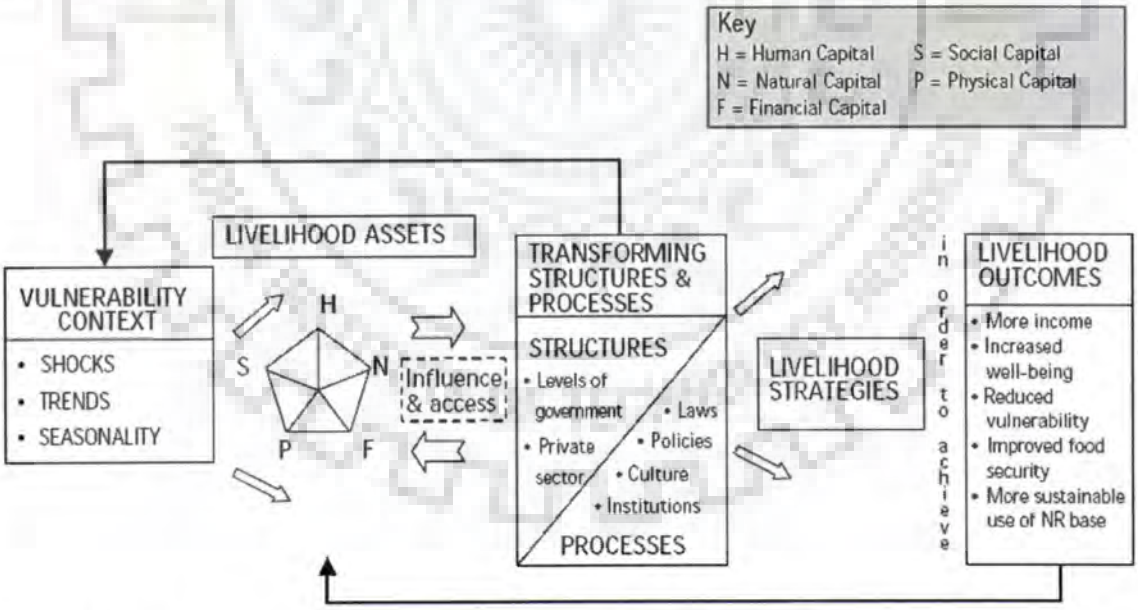


Figure 1.19: Sustainable livelihood framework for disaster management
Source: DFID (2001)

SLA encompasses a more holistic approach which focuses primarily on vulnerable people's livelihoods. It analyses the multiple factors that affect them and gives appropriate importance to the interrelationship between the various factors that affect people's livelihoods. (Palakudiyil and Todd, 2003).

4 Framework Model for disaster management

United Nations (2004) gives a framework model for disaster risk reduction in sustainable development context as shown in Figure 1.20.

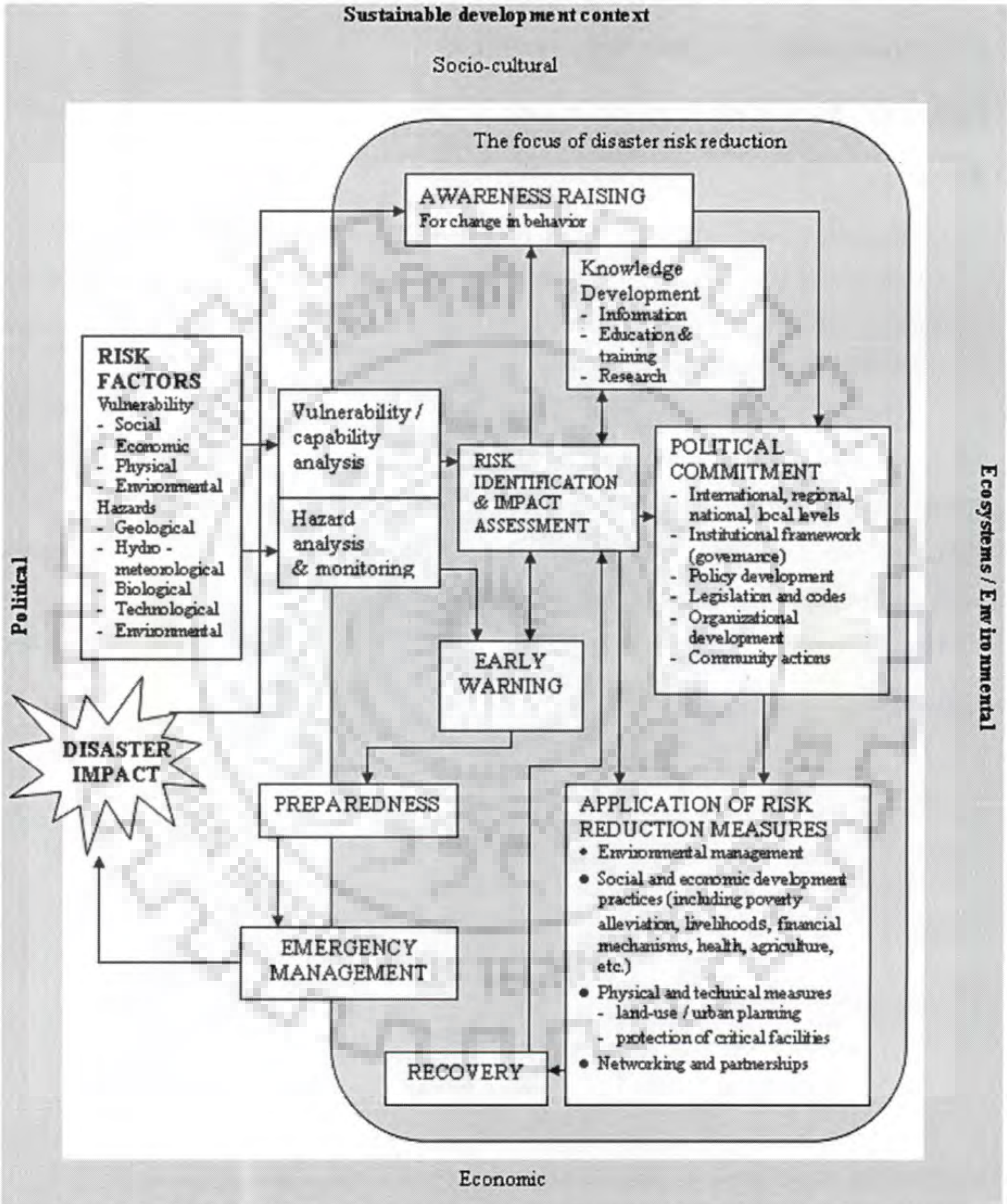


Figure 1.20: Model for disaster risk reduction in sustainable development context

Source: United Nations (2004)

This model though general in format, not only categorizes the risk reduction measures, but also identifies the interlinkage and importance of risk identification and impact assessment through analysis of vulnerability and resource capability.

5 SusTLE Model

Mukherjee (2005) has given a SusTLE model which aims at rural and urban settlements of developing countries to break the cycle between damage, reconstruction and other losses from hazards; and to bring a sustainable impact into the settlement through disaster mitigation. The author states that

> 'The prerequisite of the SusTLE model is the formulation of appropriate multi – stakeholders' decision making body – the neighbourhood management council. This would have representation from community, local government and consultant groups.'

The characteristics of the Sus TLE model as listed by the author are:

- Application of the model to any community (especially those who are vulnerable to periodic disaster) does not require waiting until the disaster occurs i.e. this is a proactive one.
- The model is neither a transformatory nor reformatory model for the existing trend. This advocates a new attitude.
- Key of success or failure of the model depends on the community's attitude and participation in the disaster mitigation process.
- Mitigation would open up an avenue for interaction among the community and local economically and environmentally if leadership is appropriate.

The SusTLE model encompasses very practical aspects in view of effective implementation of disaster mitigation measures in developing countries.

6 Vroom Yetton Model (2005)

Hellstrom (2005) gives a decision model (Vroom Yetton model) supporting employee involvement in industry vulnerability reduction. The author states:

> 'An industrial system degree of vulnerability is in large respect dependent on social factors working before, during and after an incident. The reduction of vulnerability must likewise include participation by employees, ***before*** in terms of providing risk information and engaging in risk prevention, ***during*** in terms of engaging in event mitigation and responsive and competent counter – action, and ***after*** in terms of fast recovery, learning and communication..

The dimensions of vulnerability provided by the authors as shown in Figure 1.21 can serve as an important model for vulnerability analysis, with suitable alterations.

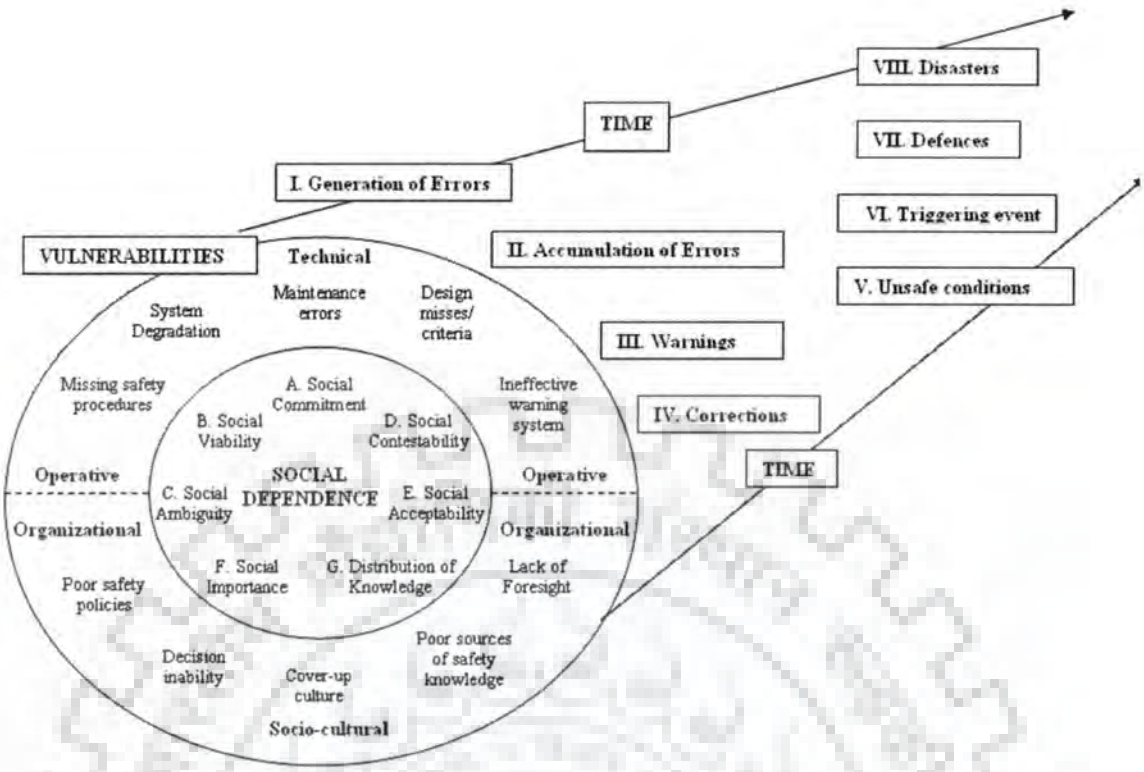


Figure 1.21: Dimensions of vulnerability, Source: Hellstrom (2005)

7 'Cat' Model

Grossi *et. al.* (2006) gives modeling of earthquake risk in China, on the basis of the 1976 great Tangshan earthquake. A fully probabilistic catastrophe loss or 'Cat' model is developed in which tens of thousands of potential earthquakes on various seismic sources are sampled and an annual rate of occurrence is attributed to each one. The authors state:

> 'Output from the Cat model can be used to determine the probability that many separate locations could be affected within the same earthquake event. It can also determine the technical price for risk, whether for a single property or a whole portfolio of properties across multiple locations. Cat models perform at their optimum when details on a building and its location characteristics are available.'

The model incorporates the exposure, property damage, casualties and economic losses as a result of earthquake. The authors have advised insurance companies aiming at increasing their presence in the residential sector in China to use Cat models to develop a fair and attractive pricing strategy on the basis of Cat model.

8 Earthquake Disaster Risk Index (EDRI)

One important step in the field of disaster risk assessment and management is development of Multidisciplinary Earthquake Risk Index (EDRI) (Davidson, 1996). The author has developed EDRI which facilitates direct comparison of the relative overall earthquake risk of cities worldwide with contributions of various factors in the form of an composite index. The author describes the EDRI as given below

> 'The EDRI is developed using the following six-step procedure:
>
> 1. Create a conceptual framework of all the factors that contribute to earthquake disaster risk – geological, engineering, economic, social, political and cultural factors;
> 2. Identify simple, measurable, scalar indicators to represent each of the factors in the framework (e.g. population, per capita Gross Domestic Product, percentage of urbanized area that is soft soil);
> 3. Combine the indicators mathematically into the composite EDRI;
> 4. Gather data and evaluate the EDRI for each of the world's major cities;
> 5. Perform a sensitivity analysis to determine the robustness of the results;
> 6. Interpret the numerical findings to access their reasonableness and implications and present the results in a variety of easily understandable graphical forms. A ten city sample analysis was conducted to explore the challenges associated with this process, and to illustrate its feasibility and the usefulness of the results.'

The factors considered in development of EDRI ensures that disaster situation created by an earthquake is a function of physical impact of earthquake, response of the affected city to earthquake and also the relevance of the impact to the city and to world affairs. The easy comprehension of the resultant index would increase the utility of EDRI for public, governments, insurance companies and other potential users. Hence, Gupta *et. al* (1996) has commented that 'the EDRI moves one step further from existing practice'.

9 GeoHazards International (GHI) Earthquake Lethality Estimation Method

The GeoHazards International has developed the GHI Earthquake Lethality Estimation Method to estimate lethality potential of earthquakes in communities which would reduce earthquake risk particularly for in developing countries (GHI and UNCRD, 2001). The report states that:

The GHI method has the following characteristics:

- Estimates a community's potential earthquake casualties;
- Uses readily available, published information, augmented with data from local experts;
- Evaluates and quantitatively compares the effectiveness of mitigation options;
- Facilitates local understanding of earthquake hazard, vulnerability, lethality and risk management programs; and
- Allows for an easily interpreted, quantitative comparison of the relative risk of several communities.

The GHI method does *not* include the following:

- "State-of-the-art" or high resolution estimates of community earthquake risk;
- Dependence on information collected from a large number of randomly selected data samples for its reliability and usefulness; and
- Poll of randomly selected local people to determine their opinion of their community's risk.

The GHI method was used in Global Earthquake Safety Initiative (GESI) carried out by GeoHazards International along with United Nations Center for Regional Development. The EDRI method served as the starting point of GESI project. The GESI project obtained very interesting results by evaluating the implications of potential earthquakes in important cities of the world. The GHI method appears to have tremendous potential to improve earthquake risk management predominantly in the developing countries (GHI and UNCRD, 2001).

10 RADIUS

Risk Assessment Tool for Diagnosis of Urban areas against Seismic disasters (RADIUS) tool was developed for IDNDR (International Decade for Natural Disaster Reduction) by OYO Corporation, Japan and RMSI to enable a city administrator to do quick assessment of earthquake risk to a city. The goal of this tool is to aid users in understanding the seismic hazard and vulnerability of their cities and to guide them in starting preparedness programs against future earthquakes (GIS Development, 2007).

11 HAZUS

HAZUS (Hazards U. S.) is a Geographic Information System (GIS) based earthquake loss estimation tool, developed by the Federal Emergency Management Agency (FEMA) in cooperation with the national Institute of Building Sciences (NIBS). The HAZUS tool provides an approach to quantifying future losses that is national in scope, uniform in application, and comprehensive in its coverage of the built environment. (FEMA, 2001)

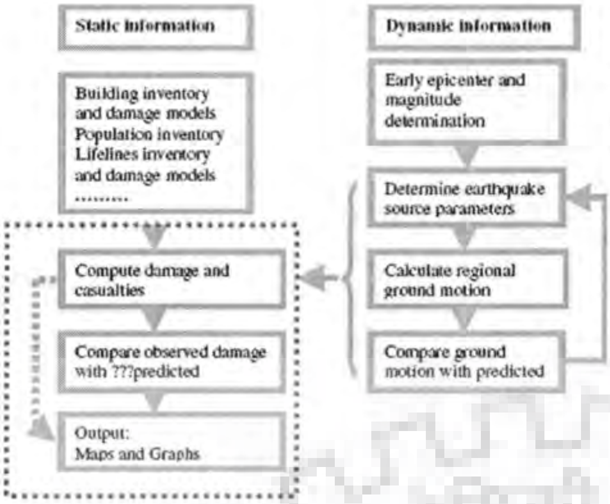
1.6.12 RISK.iitb

Recently, a GIS based earthquake risk assessment system (RISK.iitb) suitable for India has been developed at Indian Institute of Technology Bombay. Aditya and Sinha (2006) state:

> 'It is felt that RISK.iitb provides a significant contribution to the field and helps to bridge the varying requirements of scientists, policy makers, executing bodies and public in terms of understanding earthquake risk and its consequences.'

1.6.11 SELENA

SELENA (**SE**ismic **L**oss **E**stimatio**N** using a logic tree **A**pproach) (Molina and Lindholm, 2006) is extension in the Hazus methodology to a logic tree computation. It gives the user full flexibility with respect to input and presentation of results in a MATLAB environment (Lindholm *et. al.* 2006). A rapid earthquake damage processing scheme is outlined in Figure 1.22. The components in the dotted box indicate the core of the damage computations. These engineering computations depend on input information that is both static and dynamic. Once the first ground motion maps are generated, these are handed over to the SELENA process where two approaches may be followed in parallel as shown in Figure 1.23. Delineation of the damage computation along two branches depends on input form. (a) using a library of precomputed scenarios if the source is well defined. (b) using near-real-time computation of shake maps in other situations.



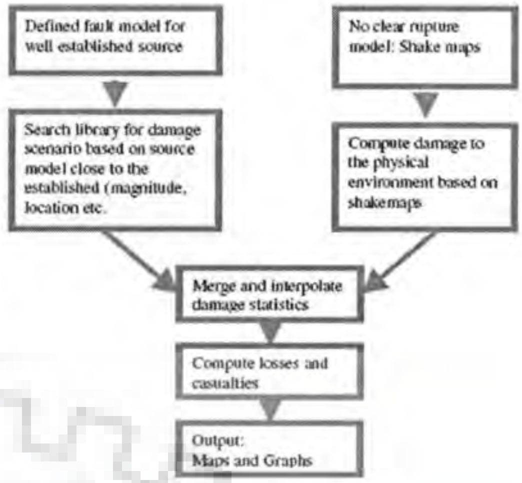


Figure 1.22: Simplified processing scheme for a rapid damage information system.
Source: Lindholm *et. al.* (2006)

Figure 1.23: Delineation of the damage computation along two branches depending on input form.
Source: Lindholm *et. al.* (2006)

SELENA has generated very promising results and authors suggest that the software can be used in a near real time model to evaluate damages inflicted by an earthquake; however more testing with different scenarios need to be conducted.

1.6.12 Other Research

The probabilistic seismic hazard analysis (PSHA) is being carried out for various Himalayan regions, which could be used for seismic microzonation of the area and for earthquake engineering (Malik *et. al.,* 2006).

A lot of uncertainties are usually present in spatial data which may have an impact on the quality of outputs. Prasad and Arora (2006) have given methods and measures to model uncertainties in spatial data.

In India the recorded strong ground motion data is totally absent or scanty. Hence it becomes imperative to use physical model to represent the ground motion generation and propagation. Hanumantharao and Ramana (2006) have generated synthetic bedrock acceleration in the Delhi region from local sources using specific barrier model.

Aditya and Sinha (2006) have demonstrated the influence of fault – plane orientation on earthquake scenario development. Loss is estimated for each model building type in terms of number of injuries and fatalities depending on the damage state of the building using procedure described by Sinha and Adarsh (1999).

Kumar *et. al.* (2006) have adopted a methodology to estimate source parameters namely, seismic moment, stress drop and source radii from digital data of 81 local earthquakes in the western part of Arunachal Himalayas. While Sarkar and Anil (2006) have given a case study of Rudbar earthquake of June 20, 1990 for illustrating method for objectively estimating earthquake source parameters from band limited data. Cole (2004) has stated the basis for performance and protection as

> 'Disruptions (due to events ranging from potholes to earthquakes) are a constant and unavoidable aspect of development and that all institutions and production activities are structured and adapt overtime so as to balance performance and protection.'

The protection regimes for different systems and magnitudes of disruption are suggested. The optimum levels of protection are determined algebraically using input-output (IO) tables and social accounting matrices (SAMs). A multi sectoral simulation model is used to describe the impacts of disruptions and protection on economic systems. The result of the model shows the important effects of size and frequency of events on costs of protection (Cole, 2004).

Bungum (2006) has described an algorithem which derives seismicity from the rate of seismic slips. Bhatt (2006) on the basis of studies conducted about physics and fault pattern of Kachchh region have proved the presence of 2 more active faults and presence of concentrated stresses in eastern mainland part of Gujarat and Saurashtra Block.

Saraf *et. a.l* (2006) are working on the earthquake rupture process through satellite detected pre earthquake transient thermal anomalies. Moe and Pathranarakul (2006) have provided a framework for effective natural disaster management from a public project management perspective, including both proactive and reactive strategies.

1.7 EARTHQUAKE DISASTER MANAGEMENT

According to Arya (2006)

> 'Earthquake disaster management involves all actions required to ensure that the state and community have capability to deal with all types of hazards at all phases of the earthquake occurrence by coordinating wide ranging actions utilizing all necessary resources available from numerous agencies'.

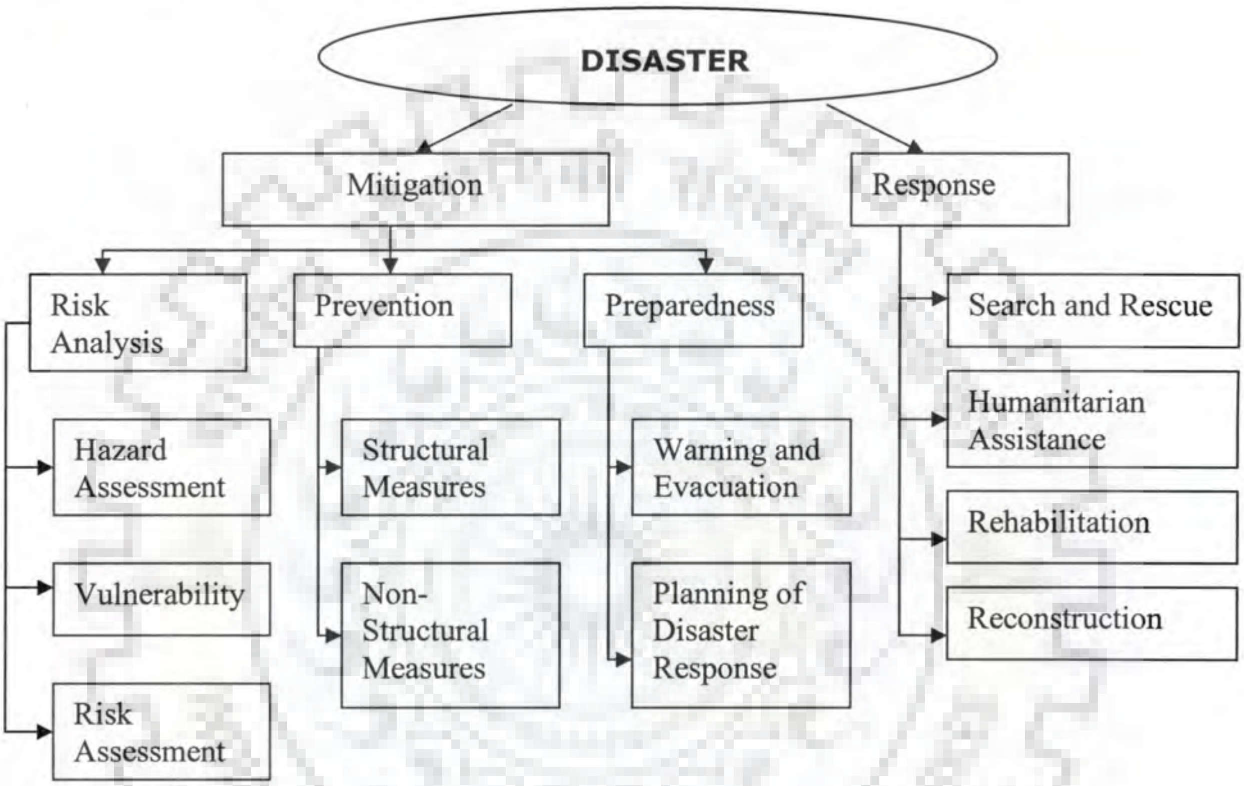


Figure 1.24: Disaster management Structure

Source: Arya (2006)

The disaster management structure given by Arya (2006) shows that mitigation and response are the two important components of earthquake disaster management structure in the pre-disaster phase and post disaster phase respectively (Figure 1.24). Mitigation forms a very important part of overall earthquake disaster management structure including risk analysis, preventive and preparedness measures. Response in turn, consists of various short term and long term actions.

According to Shaw (2006), the key issue of earthquake disaster management is how to reduce the vulnerabilities and how to enhance capacities of different levels to cope with the future event.

One critical problem in the field of earthquake disaster management is collection and management of earthquake data. EERI (2003) suggests a very important action plan for improving data collection, supporting data access and improving data access and use. Such an action plan needs to be implemented at national level in India for supporting research related to earthquake disaster management.

Sinha and Bose (2002) have stated that earthquake disaster mitigation programme is a multi-dimensional and multi-disciplinary exercise in which individuals and segregated attempts can never be successful to satisfaction.

Bose *et. al.* (2002a) identifies all the stakeholders for earthquake disaster mitigation based on the presence of knowledge and information and the capacity to take charge for initiating and advancing disaster mitigation efforts as: policy planners, elected public representatives, professional groups, academicians & researchers, emergency managers, development groups, property owners and dealers, local staff officials of various departments, local elected officials of various departments, environment groups and NGOs., insurance departments, media and the general public.

As per Dowrick (2003)

> 'Earthquake risk reduction is a complex affair involving many people of many vocations, much information, many opinions and many decisions and actions.'

The relationships between the contributing sets of information and people are illustrated schematically in Figure 1.25. As can be seen, this scientific process identifies the inclusion of architects and planners involvement in many aspects of earthquake risk reduction.

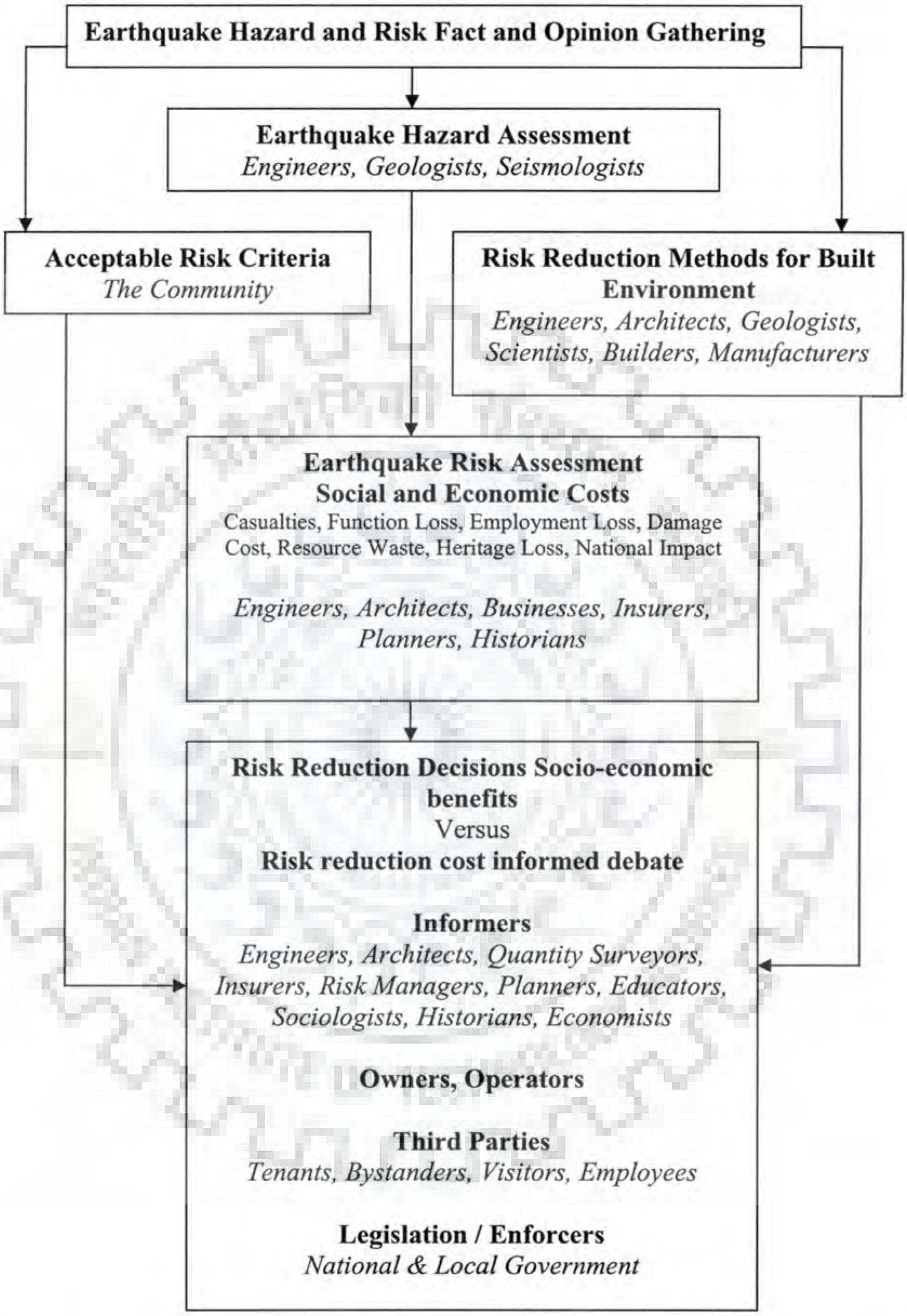


Figure 1.25: Information flow and those involved in the earthquake risk reduction process, Source: Dowrick, (2003)

1.7.1 Phases of Earthquake Disaster

Understanding of earthquake disaster scenario in terms of various phases is vital for preparedness planning. Arya (1997) has divided the earthquake disaster scenario into five phases viz. pre-disaster phase, emergency phase, temporary shelter phase; reconstruction of settlements and economic and social rehabilitation. The concept of disaster management cycle has been explained by many sources (Arya, 1997; NCDM, 2001; WHO, 2002; Shankar and Gupta, 2005). A typical disaster management cycle, particularly for earthquake hazards including 5 phases of earthquake are shown in Figure 1.26.

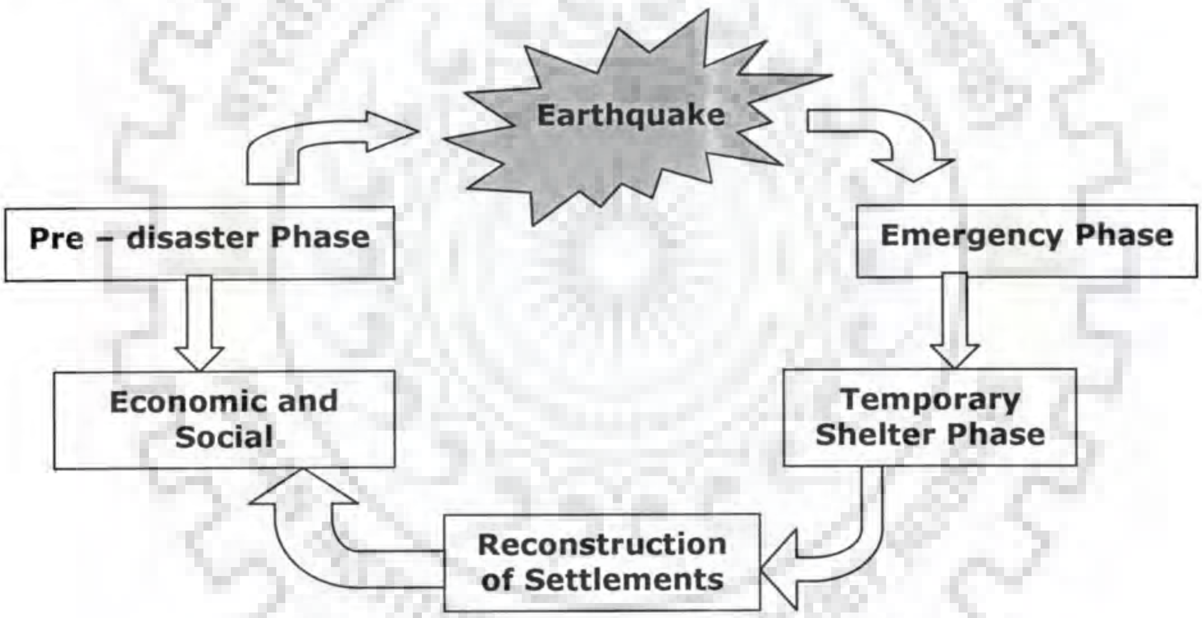


Figure 1.26: Earthquake disaster cycle

These five phases of earthquake disaster as given by Arya (1997) are explained below

1. **Pre-disaster phase:** This is the time of peace, the phase before the occurrence of disaster. Economic, social and developmental activities take place at their own pace. There may or may not be fore shock activity before the earthquake.
2. **Emergency phase:** This phase starts immediately when an earthquake strikes and continues for the next 7-8 days. During this phase buildings collapse, lives are lost, property is destroyed, communication, community services, transportation etc are disturbed and reduced, power is gone, hospitals become non operational. Victims need to be rescued and provided with food, drinking water, temporary shelters, sanitation etc.

3. **Temporary shelter phase:** In a large magnitude disaster, the permanent reconstruction can get started only 3 to 6 months after the earthquake occurrence and may take two to three years or even more to complete the task. Requirements like privacy in living, water supply, cooking platform, sanitary installations and drainage have to be ensured, along with schooling of children and dispensary facilities. Temporary ration shops vegetables and fruits, flourmills, etc. will be the further needs of the community.
4. **Reconstruction of settlements:** A minimum time of 3 to 6 months is needed to plan the strategies for reconstruction. Shaw (2006) states that, reconstruction process can be considered as a tool to reduce vulnerability.
5. **Economic and Social Rehabilitation:** This phase goes in parallel with reconstruction. Varied sociological problems are created in large disasters. The bread-earner of the family may die. Single parents, uncared old people, orphans, widows, psychologically disturbed people, etc., are left to be taken care of by the society unless their relations are in a position and willing to look after them.

   Bose *et.al.* (2002c) opine that 'reconstruction work and rehabilitation of earthquake victims should follow in right earnest to ameliorate their condition with respect to even the mental and physical trauma of victims'.

WHO (2002) represents disaster scenario in terms of temporary interruption of development as shown in Figure 1.27.

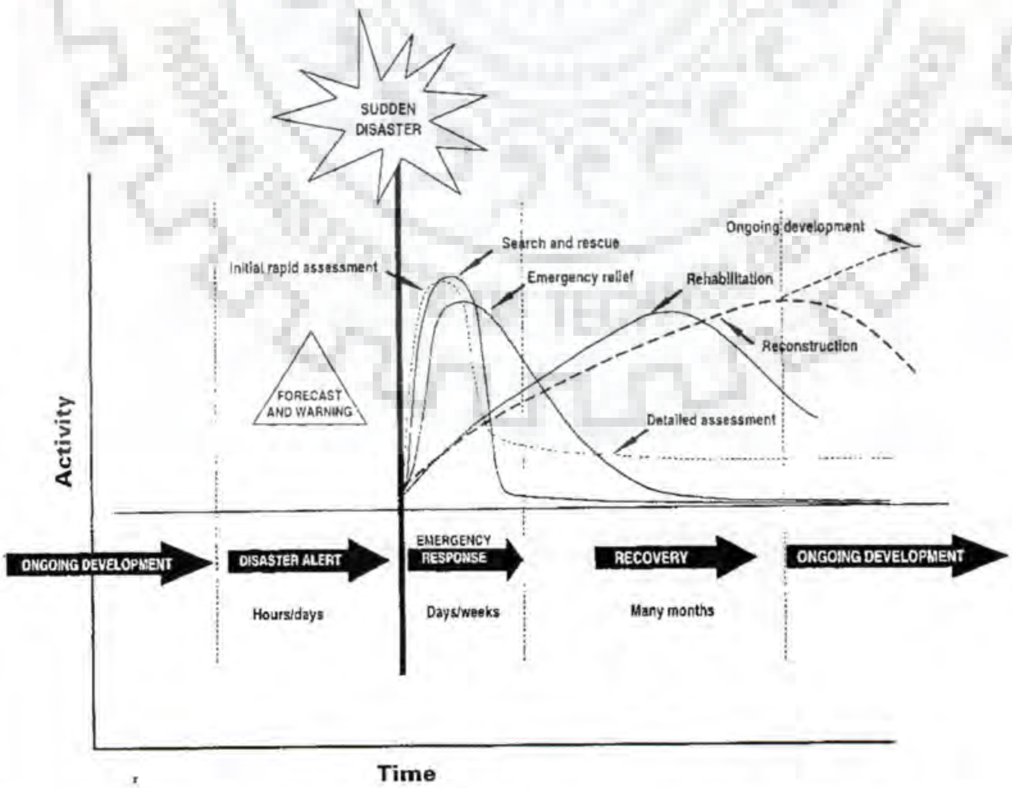


Figure 1.27: Earthquake disaster scenario, Source: WHO, (2002)

1.7.2 Emergency Phase and Need for Preparedness Plan

As given by UNDRO (1984) preparedness activities are measures, which enable governments, organizations, communities and individuals to act efficiently and effectively in earthquake situations. They consist of both long term and short term measures taken by all stakeholders to reduce the impact of the hazard which otherwise would cause a disaster. Arya (1997) opines that preparedness for earthquake disaster is to be in readiness to cope with and manage the situation immediately after the disaster strikes, involving rescue, relief and rehabilitation of the affected people; and so to minimize additional loss of lives and further damage to properties and loss of belongings of the affected people due to secondary effects and the aftershocks. UNDRO (1984) states:

> 'Preparedness is not limited only to the short – term measures which are taken during a warning period before the impact of a disaster event: it must be supported by legislation and be concerned with operational planning; education and training of the population at large, and the technical training of those who will be required to help in a relief operation; stockpiling of supplies; and emergency funding arrangements. The more effectively these tasks are carried out in advance, the more readily will it be possible to take also the action necessary during the emergency phase itself and in the later phase of relief, rehabilitation and reconstruction.'

All phases of earthquake disaster scenario after the event of earthquake have specific actions to be carried out, within certain time limits. When all these requirements are analyzed against the time factor it has been seen that emergency phase is the most crucial one. There are many more tasks to be performed in this phase with minimum time available. There is no time to think, to plan out the mitigation activities and to arrange the resources like manpower and material (Shankar and Gupta, 2005). This underlines the need and importance of being prepared to tackle the aftermath of earthquake in an efficient manner. In the context of Himalayan earthquakes, the important challenges in the emergency phase as given by Murshed (2006) are accessing the affected people, harsh Himalayan weather in winters, lack of good documentation and problems of governance. Hence extensive research is required for disaster reduction and preparedness in Himalayas.

1.8 EARTHQUAKE RISK MODELING

It is essential to know the amount of earthquake risk to take measures for reducing the same and hence a lot of research is being conducted in this field (Smith, 2001; Narula, 2002). It is important to quantify various socio-economic consequences of earthquakes. According to Dowrick (2003):

> 'We need to be able to quantify one or more of the nine socio-economic consequences of earthquakes viz. number of Casualties; trauma and bereavement; loss of employment; loss of employees and skills; loss of heritage; material damage cost; business interruption; consumption of material and energy (sustaining resources) and macro-economic impacts (negative and positive)'

Coburn and Spence (2002) have suggested that important aspects of earthquake risk modeling are loss estimation, vulnerability assessment, human casualty estimation and the applications of loss estimation.

Dowrick (2003) opines that to fully account for seismic hazard, it is important to consider the earthquake induced hazards like liquefaction and landslides also on account of significant destructions that are caused on account of them.

Smith (2001) provides theoretical framework of risk assessment and a detailed account of loss sharing, hazard and vulnerability reduction strategies for disasters. Author stresses that different types of hazards have different impacts on different countries and the issues and problems faced are also different. Hence micro level risk assessment is important.

1.8.1 Vulnerability Analysis

Definition of vulnerability as given by Blakie *et. al.* (1994) states: 'Vulnerability is a degree to which a population, individual, organization is unable to anticipate, cope with, resist and recover from the impacts of disasters.' Weichselgartner (2001) has given a collection of 24 definitions of vulnerability collected from different sources.

The concept of vulnerability in terms of risk, susceptibility, resistance and resilience given in McEntire (2005) is given in Figure 1.28.

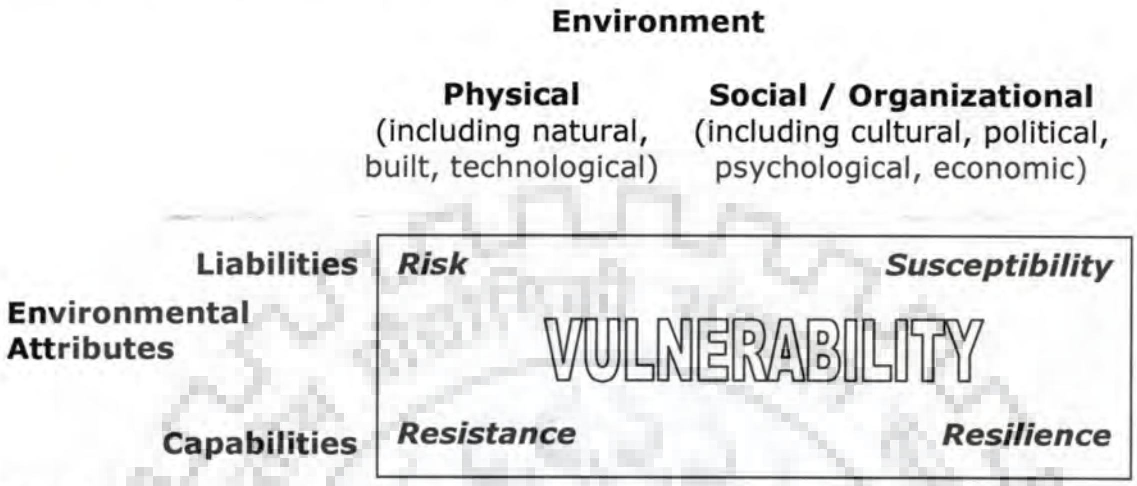


Figure 1.28: Risk, susceptibility, resistance and resilience aspects of vulnerability
Source: McEntire (2005)

Two types of vulnerabilities given by Sandi (1982) as mentioned by Coburn and Spence (2002) are predicted vulnerability and observed vulnerability. These are particularly physical vulnerability in terms of buildings. The authors state that:

> 'Predicted vulnerability refers to the assessment of expected performance of buildings based on calculation and design specifications, or, if no other method is available, on judgment based on assessor's experience. Observed vulnerability refers to assessment based on statistics of past earthquake damage. The former method is suitable to use primarily with engineered structures and facilities, where a reasonable estimate of earthquake resistance may be made, but for which only a limited amount of damage data, if any, is available. The latter method is more suitable for use with non – engineered structures made with low – strength materials such as timber or un-reinforced masonry, whose earthquake resistance is more difficult to calculate, but for which substantial statistical damage data may be available.

Apart from building damage, vulnerability can also be a result of indirect factors like lack of resources and access as given by WHO (2002) (Figure 1.29). The report also gives principal community characteristics determined in vulnerability analysis taken from WHO (1999) as given in Table 1.11.

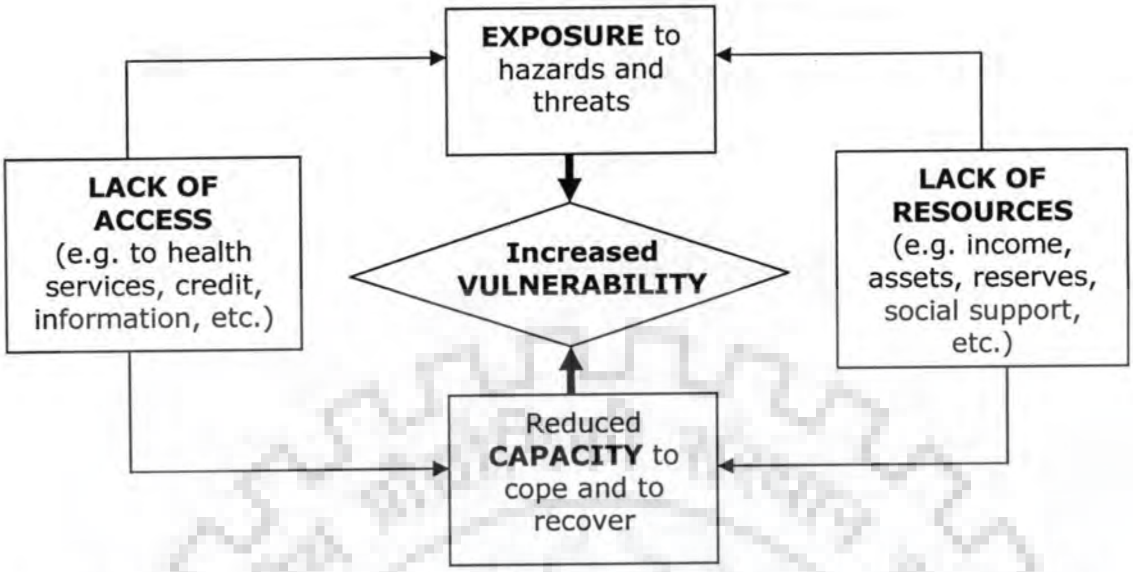


Figure 1.29: Disaster vulnerability as a function of exposure to hazards and threats and reduced capacity to cope and recover. Source: WHO (2002)

Table 1.11: Principal Community Characteristics determined in Vulnerability Analysis.

Demography	Culture	Economy	Infrastructure	Environment
Population and age distribution Mobility Useful skills Hazard Awareness Vulnerable Groups Health Level Education Level Sex Distribution	Traditions Ethnicity Social Values Religion Attitudes to hazards Normal Food Types Eating Habits Power Structures	Trade Agriculture / Livestock Investments Industries Wealth	Communication networks Transportation networks Essential services Community assets Government Structures Resource Base	Landforms Geology Waterways Climate Flora and Fauna

Source: WHO (1999)

1.8.2 Loss Estimation

Estimating losses should be the most important step for reducing the losses. Hence, the most important objective of earthquake risk modeling is loss estimation. It pertains to estimation of probable future losses in any likely earthquake event in the region. Loss estimation studies have traditionally been using individual scenario earthquakes as the basis for planning and decision making (Lindholm *et. al.*, 2006). Loss estimation is of great importance to all stakeholders related to earthquake mitigation. Coburn and Spence (2002) opines:

> 'Because of uncertainty of the knowledge available about earthquakes and their recurrence patterns, all loss estimates are necessarily extrapolations into the future of the observed statistical distribution of earthquakes and their effects in the past, and are based on attempts to determine the earthquake risk on a probabilistic basis.'

The authors have given three types of loss estimation studies, which are used depending on the nature of the problem and the purpose of the study. They include:

- *Scenario studies:* Calculation of the effects of a single earthquake on a region. Often a 'maximum probable' or 'maximum credible' magnitude earthquake is assumed, with a best – guess location, based on known geological faults or probabilistic seismic source zones. Scenario studies are used to estimate the resources likely to be needed to handle the emergency, i.e. for preparedness planning. The number of people killed, injured, buried by collapsing buildings or made homeless is estimated. From these can be estimated the resources needed to minimize disruption, rescue buried people, accommodate the homeless and minimize the recovery period.
- *Probabilistic risk analysis:* Calculation of all potential losses and the probability of those losses occurring from each of the different sizes and locations of earthquakes that can occur. For an individual building or a portfolio of buildings or other assets in a region, this generates a loss exceedance probability (EP) curve, defining the level of loss that would be experienced with different return period. With sufficient detail in the calculation, the likely effect of mitigation policies on reducing earthquake losses can be estimated and costed. The relative effects of different policies to reduce losses can be compared or the change in risk over time can be examined.
- *Potential loss studies:* Mapping the effect of expected hazard levels across a region or country shows the location of communities likely to suffer heavy losses. This shows the priorities for loss reduction programmes and which are likely to need most aid or rescue assistance in the event of a major earthquake.

Guidelines for developing a earthquake scenario are also given by EERI (2006) which include, training of management groups; assumption of an earthquake; estimation of damage and impacts; and response and community recovery. The report identifies HAZUS (FEMA, 2007) as an important tool for this procedure.

Ray (2003) have given four popular risk analysis tools, viz. hazard analysis (HA), failure modes and effect analysis (FMEA), fault tree analysis (FTA) and probabilistic risk analysis (PRA).The author states that the risk assessment requires:

- Identification of risk;
- Estimation of risk, where identified risk are assessed and their importance, likelihood, severity and impact are determined;
- Analysis and evaluation of risk, where acceptability of risk is determined and action that can be taken to make risk more acceptable are evaluated.

These days, importance of earthquake loss modeling is widely realized and many sophisticated computer models are being developed. In recent years Artificial Neural Networks (ANN) have proved to be efficient tools that are used to solve complex problems in many fields (Pandya *et. al.,* 2002). Pathak et. al. (2002) have developed an ANN based model for prediction of peak ground accelerations (PGA) by utilizing the available strong motion data recorded in the Himalayan region. The author states:

> 'Predictions made by ANN based model are found to be superior for all the Indian earthquakes, when compared with the available empirical attenuation relations.'

Sindhu and Gupta (2002) have generated a earthquake loss scenario for Delhi following a moderate earthquake using a Damage Probability Index (DPI). Although the results are fairly reasonable, to improve the results the authors suggest a need to develop appropriate inventory of the structures and infrastructures and also modification of DPI to suit truly Indian conditions and constructions.

According to Sharma and Priya (2001)

> 'Proper physical planning is an important tool, which one should utilize to regulate urban development as per the extent of damage anticipated.'

One of the considerable challenge in the field of earthquake loss estimation is the need of reliable data base on the temporal distribution of past damaging earthquake events. According to Narula (2002)

> 'Most of the countries do not have complete and reasonably long duration data bases for assessment of frequency and generating capabilities for large magnitude earthquakes. Hence to bridge this gap, a lot of research is being carried out to follow the geological route for establishing the seismogenic faults and their generating capabilities'

Risk assessment studies are carried out by Prasad *et. al* (2006) for Dehradun city, mentioning the fact that at present no empirical or analytical vulnerability functions are available for Indian constructions. These studies are based on two Intensity scales, namely, MSK Intensity scale and Parameterless Seismic Intensity (PSI) scale and the results are compared. The results showed that the PSI results in direct economic loss estimates are quiet close to the lower bound estimates from MSK scale. However, the loss estimates from PSI are almost double the upper bound estimates using MSK scale (Table 1.12)

Table 1.12: City wide Risk Assessment for Dehradun

Estimated Parameter	MSK Intensity Scale		Parameter Less Scale of Intensity (PSI)	
	Night time	Day time	Night time	Day time
Life Loss	555 -1090	360 - 705	1,964	1,428
Injuries	10,931 – 16,895	7,388 – 11,411	15,098	11,549
Direct Economic Losses (Rs)	1,322 – 1,894 crores		1,225 crores	

Source: Prasad *et. al.* (2006)

The authors opine:

> 'This is because of a relatively narrow distribution of damage probabilities obtained from the damage description in MSK intensity scale.'

Raju and Sandri (2006) mentions about risk modeling in the field of insurance that started was introduced in the late 1980s beginning with the Hurricane model for the United States and followed by other hazards. Authors have given a AIR catastrophe modeling technology stating

> 'AIR was the first to develop a cutting edge modeling technology based on sophisticated simulation procedures and powerful computer models of now natural catastrophes behave and act upon the man made environment.'

The basic building blocks of AIR catastrophe modeling are given in Figure 1.30.

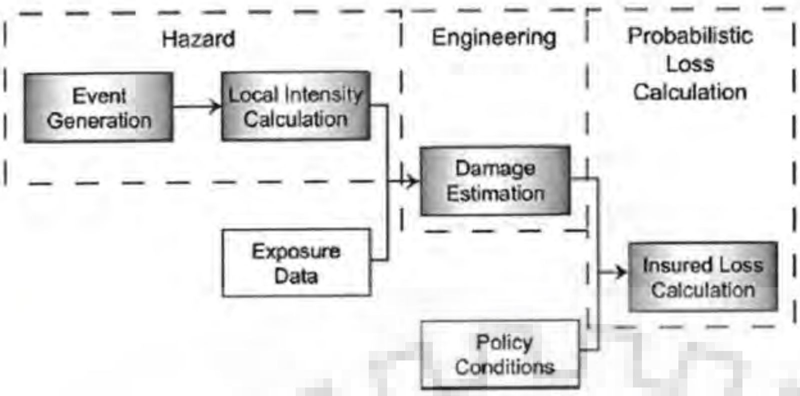


Figure 1.30: AIR Catastrophe modeling technology framework, Source: Raju and Sandri (2006)

1.8.3 Casualty Estimation

Since the ultimate objective of any earthquake mitigation activity is to save life, estimation of possible casualties becomes very crucial. The studies related to estimation of casualties are importantly conducted by Andrew Coburn and Robin Spence.

Coburn and Spence (2002) have given an approach of determining the 'lethality ratio' for estimating casualties due to earthquakes. The authors have defined lethality ratio as:

> Lethality ratio is defined as the ratio of the number of people killed to the number of occupants present in collapsed buildings of that class.

The authors state that the lethality ratio depends on a number of factors including building type and function, occupancy levels, type of collapse mechanism, ground motion characteristics, occupant behaviour and SAR effectiveness. Methodology is given for estimating the lethality ratio for each building class using a set of parameters defining the expected proportions of occupants who are trapped, the proportion of those trapped who are subsequently rescued, and the injury distribution in each group. A set of M-parameters is given to estimate the proportions of people rescued and trapped at each stage and the injury distribution among them (Figure 1.31). Distribution of population to different building types i.e. the occupancy levels are also demonstrated by Aditya and Sinha (2006) as shown in Figure 1.32.

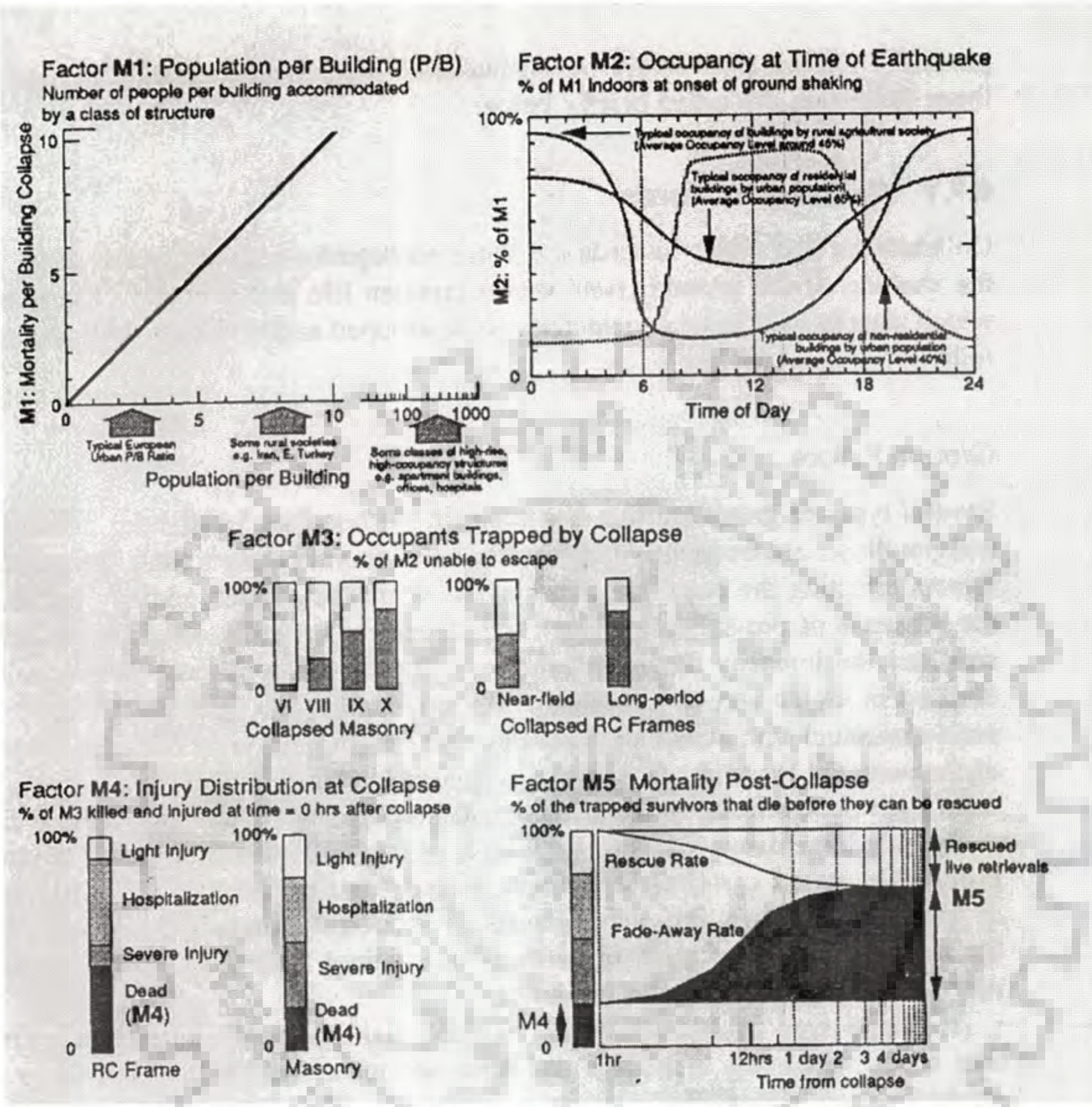


Figure 1.31: Estimation of number of human casualties likely to occur in an earthquake using factors M1 to M5, Source: Coburn and Spence (2002)

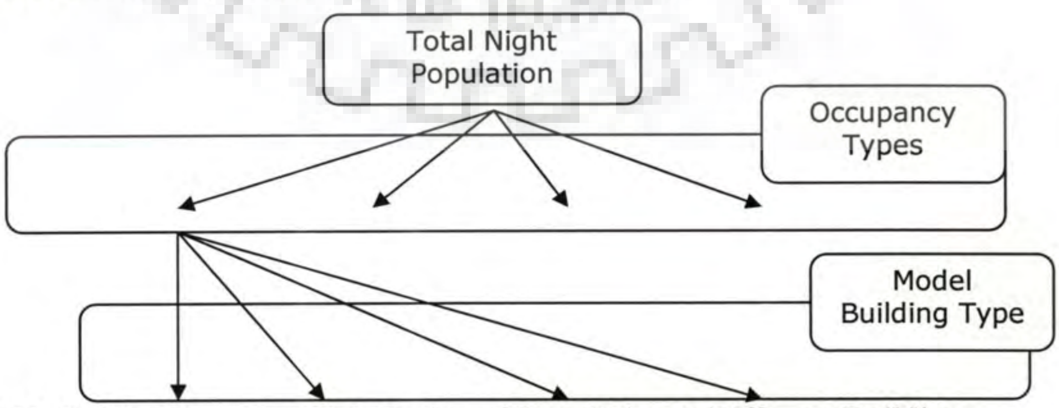


Figure 1.32: Methodology for Distribution of Population to Different Buildings

Source: Aditya and Sinha (2006)

Dowrick (2003) has given a model developed by Coburn and Spence for estimating the number of people killed due to structural damage (K_s) for a class of building b. The number of people killed is expressed as

$K_{sb} = D5_b \text{ X } [M1 \text{ X } M2 \text{ X } (M4 + M5\ (1 - M4))]$

Where $D5_b$ is the total number of collapse buildings (damage level 5) of buildings clabb b, and M1 to M5 are a range of modifiers to a potential mortality figure, such that
M1 = population per building;
M2 = occupancy at the time of earthquake;
M3 = occupants trapped by collapse;
M4 = injury distribution at time of collapse;
M5 = mortality post - collapse

A logic tree which also defines the parameters M3 to M6 is shown in Figure 1.33.

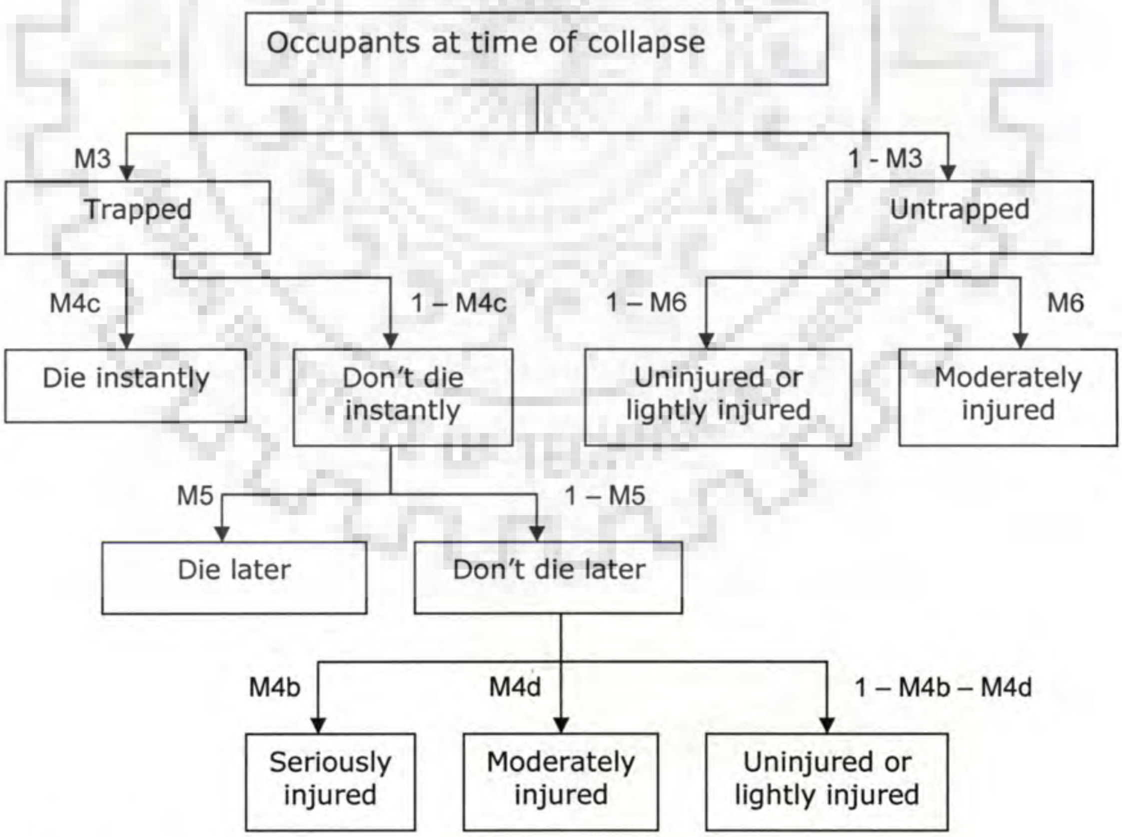


Figure 1.33: The definition of occupancy and casualty parameters M3 to M6
Source: Dowrick (2003)

On the basis of this, Dowrick (2003) has given casualty estimation of two Mw 7.5 earthquake scenarios on the Wellington. These two scenarios consist of different times of day i.e. one on a workday at 11 a.m. and other at night –time 2 a.m. It has to be noted that the number of casualties during workday 11 a.m. is found to be much higher than night – time 2 a.m. event. However, these conditions should be exactly opposite in rural Indian situations as per experience of past earthquakes in India.

1.9 EARTHQUAKE RESISTANT CONSTRUCTIONS

In view of earthquakes striking at regular intervals in India in the recent past, there has been a wide spread concern over the existing structures which do not comply with recent codes. The existing procedures for evaluating structures for its seismic resistance adopted in other countries need some alterations if they have to be implemented in India (Mrunal and Patil, 2006). The observations of earthquake damage should result in the seismic vulnerability assessment of buildings and changes and improvements in building codes should be proposed (Sinha and Bose, 2002; EERI, 2004). However, lot of research is being conducted in the aspects of seismic resistance evaluation and retrofitting aspects in India (Rai 1997; Kumar and Paul, 1997; Bose. *et. al.,* 2002b; Vinayak *et.al.,* 2006; Shariq *et.al.*, 2006)

The vulnerability atlas of India indicates the risk of damage to housing in the country, in various states and various districts in each State / UT. The risk of damage is defined at the five levels, viz. Very High (VH), High (H), Moderate (M), Low (L) and Very Low (VL) (Arya, 2006). Table 1.13 gives the risk of damage to various building types in India for ready reference, wherein the risk of damage under cyclonic winds as well as floods is also indicated.

Aditya and Sinha (2006) have given building vulnerability function for different structural types as shown in Figure 1.34.

Table 1.13:Damage Risk to Buildings of India (Various Building Types by Wall Material)

Wall Type	No. of Housing Units		Damage Vulnerability				
	Census 2001		MSK Intensity			Flood Prone	Cyclone 50 & 55 m/s
	Millions	%	VII	VIII	IX		
Earthen Walls (mud, unburnt brick)	73.80	29.63	M	H	VH	VH	VH
Stone Walls	25.48	10.23	M	H	VH	VH	VH
Burnt Brick Walls	111.89	44.93	L	M	H	H	H
Concrete Walls	6.54	2.62	VL	L	M	H	L
Wood and Ekra walls	3.19	1.28	VL	L	L	VH	H
GI & Other Metal Sheets	1.99	0.80	VL	VL	L	VH	VH
Bamboo, Thatch, Leaves, etc.	26.18	10.51	VL	VL	L	VH	VH
Total	**249.07**	**100**					

Source: Arya (2006)

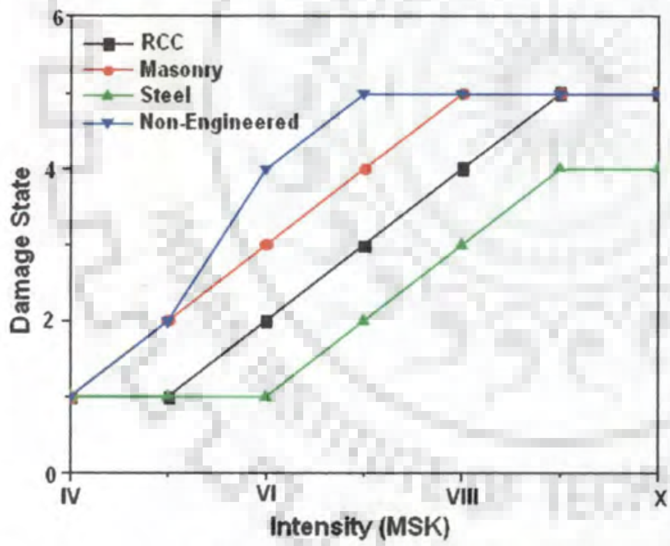


Figure 1.34: Building Vulnerability function for different structural types
Source: Aditya and Sinha (2006)

Most of the casualties and destruction suffered as a result of earthquake in India are caused by the collapse of seismically unsafe non-engineered masonry buildings (Sharma, 1997; Gupta, 1997a; Mistry *et. al.,* 2001; Coburn and Spence, 2002)

According to Arya (2006)

'The earthquake risk arises mainly due to unsafe constructions, the number of which is continually increasing since most new constructions are not made earthquake resistant and add to the already existing huge stock of unsafe buildings and structures.'

To mitigate the vulnerability due to unsafe constructions in India Arya (2006) has suggested a number of initiatives namely, establishment of techno-legal and techno-financial regimes, capacity building of architects, engineers and masons through extensive and intensive training programmes. Author suggests that some of these initiatives have been started but they need to be followed rigorously and made mandatory for the various sectors of the society through well conceived awareness and sensitization programmes.

Ministry of Home Affairs, Government of India, which is the nodal ministry for disaster management is implementing various measures for reducing earthquake vulnerability of our buildings (MHA, 2005). The important initiatives are as given below:

- Review and amendment of building byelaws to incorporate the BIS seismic codes for construction in the concerned zone;
- Enforcement of building byelaws;
- Evaluate the seismic safety of existing life-line buildings and buildings which host mass assemblies.
- Awareness generation
- Training programmes for building capacities of architects and engineers for earthquake resistant constructions.

National Information Centre of Earthquake Engineering (NICEE) at Indian Institute of Technology Kanpur, India plays a very active in the field of earthquake risk reduction (NICEE, 2004). NICEE has published guidelines for earthquake resistant engineered and non-engineered constructions. NICEE also conducts various national programmes for training of architects and engineers for earthquake resistant constructions through various short term courses.

1.10 EMERGENCY MANAGEMENT

The major earthquakes are often followed by extremely chaotic situations.

During emergency phases of various past earthquakes, it has been seen that activities are generally uncoordinated, there is poor communications among different groups of communities and the population is unaware of the actions which needs to be taken (Coburn and Spence, 2002). The efficiency of emergency response depends on the nature of the type of emergency and the effectiveness of mitigation / preparedness measures (WHO, 2002). PERI (2006) gives many aspects, important checklists and roles and responsibilities of emergency managers for effective emergency management for any community. For ensuring a most efficient emergency response for earthquake it is vital to understand various crucial aspects of emergency management as discussed in this section.

1.10.1 Technology for Emergency Communications

It is realized most often that the communication systems occupy the most important position in the emergency management. These objectives can now be much effectively achieved due to the technological advancements in emergency communications and advancement in Information and communication technology (ICT) in the form of internet, GIS, remote sensing, satellite based communication links. The review of relevant literature suggests that these technologies have tremendous applications in the field of preparedness, response and mitigation of disasters (Scott, 1997; NCDM, 2005).

Information and Communication Technology (ICT):

National Disaster Management Division (2005) while describing the ICT has stated that

> 'ICT tools are being widely used to build knowledge warehouses using internet and data warehousing techniques. These knowledge warehouses can facilitate planning and policy decisions for preparedness, response, recovery and mitigation at all levels. Similarly, GIS based

systems improve the quality of analysis of hazard vulnerability and capacity assessment, guide development planning and assist planners in the selection of mitigation measures.'

National Disaster Management Division (2005) has given the Indian experience of ICT for disaster risk reduction. It states that

> 'Information co-ordination and management is seen as one of the major challenges in India due to large geography and diversity of language / cultures. The GoI-UNDP DRM programme addresses these issues very carefully by using Information and Communication Technology tools for faster response, effective decision making and develop well informed practitioners.'

The development of remote sensing technologies during past few years and their applications in the field of disaster management which includes improved spectral and spatial mapping systems with improved spectral and spatial mapping capabilities are being given by Jain (2005).

A knowledge based (KB) approach (Nikolopoulos, 1997) for military operations is given by Baijal *et. al.* (2002). The paper when reviewed brought out an interesting fact that many aspects of military operations resemble earthquake emergency operations for e.g. moving to certain places at a very short notice, mobility of men and machines, crossing obstacles, replenishment of ammunition, fuel and other supplies, selection of sites for launching bridges, selection of sites for helipads, identification of tactically important roads etc. The author states that

> 'Command, Control, Communication, Co-ordination and Information (C4I) are one such system where Remote Sensing, GIS and artificial intelligence technologies can be effectively used. Knowledge based (KB) expert systems take into account the experience and knowledge of terrain analysts and other experts to convert them into a set of rules, which can then be applied to digital data to derive a number of thematic maps that can in turn be used in emergency planning.'

Hence it is very clear that knowledge based approach should be particularly useful for the hilly terrains during earthquake emergency management.

Earthquakes lead to emergencies and in any such situation, the role of reliable Decision Support System is very crucial for effective response and recovery. As explained by National Disaster Management Division (2005), Geographic Information System (GIS) provide most versatile platform for Decision Support by furnishing multilayer geo-referenced information which includes hazard zoning, incident mapping, natural resources and critical infrastructure at risk, available resources for response, real time satellite imagery etc. (Lavkare and Krovvidi, 2001). GIS based information tools allow disaster managers to quickly assess the impact of the disaster / emergency on geographic platform and plan adequate resource mobilization in most efficient way. Such database would also play a fundamental role in planning and implementation initiatives (Mansor *et. al*., 2004). However, applications of GIS technologies in India for disaster management face many challenges given by Jain (2005) as:

> 'Compiling an urban GIS takes a major resource commitment in time and funding. One major cost is constructing the database information that is associated with the maps. It is estimated that up to 80 percent of time and costs involved in developing GIS are spent on database acquisition and integration.'

The author advocates the use of high – resolution imagery to meet the demand for current and accurate data for dynamics of different settlements, their density and the type.

The process of geo-computation can also find wide applications in the field of spatial analysis leading to disaster mitigation (Banger, 2002). According to Tsou (2005) internet GIS is getting more and more popular for its awareness and new computing technologies. In coming times it might have enormous applications in the field of disaster management.

Chakraborty (2005) illustrates an important system viz. DRIS- District Resources Information System to handle complex problems of resource allocation and decision making.

Web based interfaces to geospatial information have emerged over the past years as an alternative to using the complex interfaces of GIS (Aghai, 2005). The recent web GIS tend to be a hybrid model, whereby the benefits of both server and client centric models have been adopted for decentralized data management responsibilities (Pandey, 2005). A challenge for the development of internet GIS is to enable interoperability among heterogeneous systems and geospatial data, which is mitigated through web services, service oriented architecture and geospatial semantic web (Peng, 2005).

One important initiative in India is development of India Disaster Resource Network (IDRN) which has been initiated by Ministry of Home Affairs (MHA) in collaboration with United Nations Development Program (UNDP). IDRN is a nation wide electronic inventory of essential and specialist resources for disaster response, covering specialist equipment, specialist manpower resources and critical supplies from district level to state level to provide availability of resources for disaster response, so that disaster managers can mobilize the required resources within least response time (National Disaster Management Division, 2005).

Fujiwara and Watanabeb (2005) describes an ad-hoc networking scheme for routing protocol for emergency communications, with the objective to collect damage assessment information quickly and stably in a disaster. The network is configured with a hybrid wireless network, combining ad-hoc networks and a cellular network to maintain connectivity between a base station and nodes even in a disaster. In the event that a direct link between the base station and a node is disconnected due to damage or obstacles, the node switches to the ad-hoc mode and access the base station via neighbouring nodes by multi-hopping. The research can have enormous importance during emergencies where communication is most critical.

GoI and UNDP (2003) have suggested measures to be implemented in 12 identified disaster prone states for strengthening state and district disaster management information Centers. The document states that:

> 'Necessary support will be provided in terms of equipments such as computer with internet facilities, HAM equipments, FAX etc to the district control room and state control room and training to the functionaries to handle the equipments during emergency..'

Communication Technology:

An inventory of various modes of communication which would be useful in the pre and post disaster phase and analysis of their merits and demerits can help in deciding the most appropriate modes of communication to suit the existing conditions. Such an inventory of modes of communication as given by Scott (1997) is given below:

' 1. **Terrestrial Telecommunication:** Traditional terrestrial communications have often been costly to install, difficult to repair and vulnerable to disruption or extensive damage, particularly in remote areas of developing countries. Accordingly, such systems have not been reliable in areas where geography or climate inhibits their installation and maintenance. Thus, although they may play a role during pre disaster phase, they may not be reliable for continued use during a disaster event.

2. **Fixed Satellite Service:** Fixed satellite service is at its best in populated urban areas of the world, where the numbers of users and the variety of uses can sustain the high capital costs as well as the cost of maintenance and training. It is of less use in the field where similar levels of use do not exist. In many instances it provides the external telecommunications linkages that are marked by national Postal, Telephone and Telegraph agencies (PT & Ts). It can usually be relied upon in early warning situations, at least up to the onset of the event. Fixed satellite services are susceptible to damage or destruction at the onset of a disaster. For this reason, national governments should be strongly encouraged to strengthen their terrestrial and Fixed Satellite links and to make them resilient to the type of disasters to which their area is vulnerable. For this same reason, national governments and disaster managers should not rely solely on these systems for warning and post-onset applications.

3. **Mobile Satellite Service:** Mobile Satellite Services are less expensive than traditional fixed satellite services. They are easily transportable and are not technologically dependent on terrestrial telecommunications infrastructure. They are far less vulnerable to natural disasters and because they can be used reliably to call anywhere in the world, their use in the field has grown rapidly in recent years. Though lower in cost than fixed services, they are not expensive and are still used almost exclusively by UN agencies and larger Non-government Organizations (NGOs).

4. **Single Sideband (SSB) High Frequency (HF):** Disaster managers in the field most frequently communicate over long distance using HF radio. This communication is point – to –point and permits voice and low speed data communications between and among fixed installations at field headquarters and regional offices. Mobile HF SSB units can also be used in a similar manner (although frequently these "mobile" units are too heavy and cumbersome to be considered portable). A significant advantage of HF SSB networks is that hardware costs are minimal ($4,000

- $5,000) and use is free. The effective distance of HF voice communications is 2,000 – 3,000 kilometers, typically sufficient for communications between field operations and national headquarters.

5. **VHF Hand Held Radio Communication:** For short distance communication among staff or local facilities, and within cities or regions, the use of VHF hand held radios is common among national authorities, UN Agencies and NGOs. Like HF radios for longer distances, VHF radios are inexpensive to purchase and free to operate. However, the use of VHF equipment is subject to the delivery of a license with assigned frequencies requiring a significant amount of negotiation with telecommunications authorities. In the absence of regular telephone communications these VHF radios provided a basic and vital administrative function. Another important function which they provide is security, or maintaining contact with traveling staff.
6. **Amateur Radio:** Historically, amateur radio operators have frequently established and operated communication networks locally for governmental and emergency officials as well as non-commercial communication for private concerns affected by the disaster. Amateur radio facilities can generally be characterized as having a high survival capability. Although amateur radio operators are most likely to be active after disasters that damage regular lines of communication such as power outages and destruction of telephone lines, they frequently support the delivery and relay of warning information. They are frequently well prepared for work under often extreme conditions encountered during acute emergencies, where both solid technical knowledge and the ability to improvise are required. The International Amateur Radio Union (IARU) coordinates the activities of the service and actively supports its introduction in those countries where its value has not yet been fully recognized.'

Apart from these the Emergency Communications Network (2004) gives information about the CodeRED™ Emergency Telephone Calling System as an extremely high-speed telephone communication service available for emergency notifications. CodeRED™ employs a one-of-a-kind Internet mapping capability for geographic targeting of calls, coupled with a high speed telephone calling system at the rate of up to 60,000 calls per hour. CodeRED™ subscribers control their emergency broadcasts from anywhere in the world via a secure Internet Portal. CodeRED™ offers an unprecedented level of security, robustness, performance, and ease-of-use for government agencies, communities, and businesses. (Emergency Communications Network, 2004)

1.10.2 Search and rescue operations

Search and rescue operations are very crucial for saving lives of trapped occupants of collapsed buildings. According to Coburn and Spence (2002)

> 'The principal factors determining the number of people killed and seriously injured after a building collapses are the proportion of people who are trapped by collapse, their injuries and the length of time they are able to survive with those injuries, and how quickly they are able to be rescued and receive medical attention. The number of people trapped in a collapsed building depends on the size and type of building, the extensiveness of collapse, how long it took to collapse and how easy it was to escape from the building. The fade –away time i.e. time for which the trapped victims would survive, depends on their air supply and level of injury, the medical evidence of these for different types of injury is complied in Figure 1.35.'

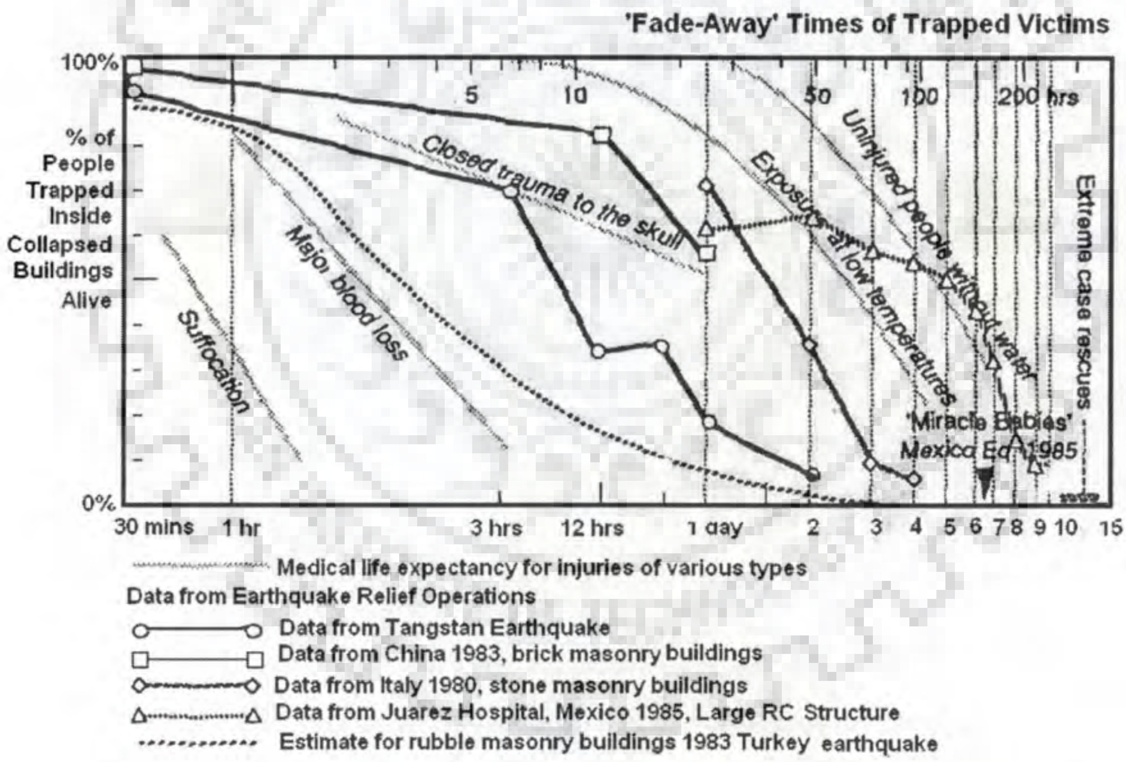


Figure 1.35: Survival Rate with Time for Victims Caught in Building Collapse

Source: Coburn and Spence (2002)

Prakash (1995) state that the aim of rescue operations is to save life, minimize further injury to persons and damage to property in times of disasters. The author gives three categories of rescue workers as given below:

'1. **Survivors**: The first group to start rescue work at a disaster site consists of those survivors still capable of doing so. The potential for good is enormous but the danger inherent in rescue work by untrained personnel is also enormous.
2. **Untrained Personnel:** The second wave of rescue workers is drawn from people either witnessing the event or from the vicinity of the event, drawn to the site by curiosity and for many, a desire to assist the victims. The danger in utilizing untrained personnel is worth considering but on the positive side they often bring necessary resources with them and can be very effective if properly supervised.
3. **Trained Personnel:** The last group to arrive at the scene is the trained rescuers. Police, Fire, Paramilitary forces etc. It takes some time for various emergency services to mobilize and arrive at the scene. If well trained, the teams will know what to do, how to utilize the available resources, materials and untrained personnel, in efficiently carrying out the necessary task in a systematic manner. Once as search and rescue organization of trained personnel has arrived, a plan for setting up a search and rescue services must be developed.'

Planning of a search and rescue service given by The International Civil Aviation Organization, as summarized by UNDRO (1984) gives important points to be considered by the head of the SAR service when planning. These are:

a) Precise delineation of the area of responsibility of the SAR service;
b) Determination of the facilities, personnel and equipment required by the SAR service and definition of their search and rescue functions;
c) Conclusion of agreements with authorities providing facilities and services not under the direct control of the head of the SAR service, and with neighboring SAR services regarding mutual assistance;
d) Designation of the area of responsibility of the SAR service as a Search and Rescue Area (SRR) or division of the area of responsibility into a number of SRRs and establishment in each SRR of:
    i) A rescue co-ordination center (RCC);
    ii) Rescue sub-centers (RSC), if necessary;
    iii) Rescue units; and
    iv) Alerting posts.
e) Establishment of training pragrammes.

A five phase strategy published by Coburn and Spence (2002) as shown in Table 1.14 is used successfully by many rescue teams.

Table 1.14: A Five Phase Strategy for SAR Operations

	Phase	Search	Rescue
1	Reconnaissance and immediate rescue / evacuation	• Assessment of the collapse area, building type and damage patterns • Hazard analysis: potential further collapses, falling debris, gas, fire, etc. • Interview witness and victims for location of further victims	• Immediate rescue • Pick up hurt and easily accessible victims • Mark hazardous areas, No rescue work in unsafe areas
2	Search and light rescue	• Search slightly damaged areas • Search accessible areas • Extended interviews • Objective: assessment of the entire site, knowledge about possible victims and their positions	• Rescue easily liberated victims • Initiate observation of indicators for building stability: gaps, tilted walls, etc. • Prepare for heavy tools and equipment, shoring, stabilisation
3	Search areas with expected victims, heavy rescue	• Search all voids and accessible areas with probable locations of victims • Extended use of floor plans and other info • Only trained personnel, canine search and with listening devices • Objective: search of all voids except under rubble	• Penetrate and advance to entrapped victims • Open voids with the possibility of finding survived victims inside • Remove obstacles but mind the weakened structure • Stabilisation • Only trained rescue personnel in hazardous areas
4	Search in rubble and voids below, heavy rescue, specific clearing	• Specific search based on information from witnesses, observations, floor plans, etc. in rubble and small sized debris	• Penetrate/advance to voids with expected victims in rubble and unstable debris, tunneling • Mind danger to victims by rearrangement of debris (crush) and fine material trickling (asphyxiation)
5	Final clearing	• Regular stops of clearing work for search in the debris and recently uncovered voids	• Carefully clearing • Help of cranes and excavators directed by rescue personnel • Avoidance of debris destabilisation

Source: Coburn and Spence (2002)

1.10.3 Medical aspects of emergency management

All the disasters are primarily described in terms of numbers of lives lost. This suggests that health outcomes are the most important indicators of measuring the extent of the disaster and hence should be given most attention by the disaster management personnel (Mostafa *et.al.*, 2004; Alahi and Izadkhah, 2004; ADPC, 2005). The earthquake leaves many people killed and injured and at such times provision of medical assistance to the injured should start immediately after the earthquake strikes and needs great amount of research and preparedness. According to Kessler (2005)

> 'There is a need to broaden the analysis to examine how health effects could have been reduced, or how they should be reduced in the future.'

WHO (2006) gives a 14 modules toolkit for analyzing disrupted health sector consisting of background studies, needs assessment, policies, financing, health care provision, management networks, human resource, pharmaceutical area, strategies, producing a health sector profile and resources. The toolkit offers ready to use guidelines for disaster situations. It is extremely useful for the emergency health personnel for analysis and actions because of its practical and experience based approach.

The broad notional definitions and norms for setting up of Health Facilities as mentioned by Kadikodi and Kulkarni (2006a) are given below:

> '1. A Primary Health Center (PHC) serves approximately 30,000 population. The PHC will be supplied with drugs worth Rs. 30,000 annually. (All India Norm). A PHC will have one doctor. Sub-centres serve approximately 5,000 people the plains and 3,000 in hilly and tribal areas. A sub-centre is managed by a Junior Health Assistant (Female), Junior Health Assistant (Male), (All India Norm).
>
> 2. A Community Health Center (CHC) serves 1 lakh population. Generally one CHC is attached to 4 PHCs. It is the policy of the government to upgrade all taluka level institutions to 30 bed hospitals and talukas located at sub-divisional headquarters to 50 bed hospitals. (All India Norm).

3. District Hospitals are at each district headquarters. The district hospital will have following specialists in medicine, surgery, obstetrics and gynecology, pediatrics, orthopedics, ophthalmology, ear, nose and throat, pathology and bacteriology, skin and STD, radiology, anesthesia and dental.'

These studies about existing health and medical care facilities in India at macro economic level carried out by Kadekodi and Kulkarni (2006a) highlighted many important aspects, which are worth mentioning here. They state that compared to China (24.9%) or Sri Lanka (45.4%), India spends just about 17.3 percent of total health expenditure on public health. The central budgetary allocation for health over the period 1990 to 1999, as a percentage of the total central budget has been stagnant at 1.3 percent, while that in the states taken together has declined form 7.0 percent to 5.5 percent, which is definitely alarming. The authors have pointed towards another matter of concern as growth of health manpower and infrastructure. It is important to maintain some kind of balance in the development of both infrastructure and manpower. The government should be more careful to see that the health care delivery system is not affected by the funding mechanisms.

Sinha (2006) has highlighted the importance of health services in post-disaster situation followed by various critical issues viz. emergency procedures, buildings, equipment and administration. The author indicates that the reasons of seismic vulnerability of health facilities are their complexity of facility due to multiple functions, high occupancy levels, dependence on critical supplies, availability of basic facilities, careful handling of hazardous material present and presence of a number of heavy objects and machinery. The author has provided guidelines and recommendations for assessing and reducing vulnerability of health care facilities in terms of structural vulnerability, non-structural vulnerability, administrative / organizational vulnerability and functional vulnerability.

Alahi and Izadkhah (2004) have listed various critical problems in terms of structural and non structural components and distribution of all these problems in 110 hospitals of

Tehran is given. Guidelines are proposed into two phases viz. planning for the needs and conducting the plans for both structural and non structural aspects. Recommendations for formation of specialized teams viz. support, team, information management team, search team, relief and temporary shelter team, fire extinguishing team, recovery team, reconstruction team could be important if implemented.

Kadekodi and Kulkarni (2006a) have provided measures for the development of health sector, stating that it will be dependent on the advancement of technology, inflow of foreign capital, imports of drugs etc. The authors opines that

> The shortcomings of the present day status of health facilities in India is most importantly uneven access to and benefits from the public health system which needs to be corrected. It is estimated that the shortfall in sub centers, primary and community health centers is going to be about 16 percent (as against the norms). Inadequate public health facilities are such that less than 20 percent of the population which seeks OPD services and less than 45 percent of that which seeks hospitalization avail of such services in public hospitals. This reflects the imbalance in the development of the public health manpower and infrastructure in India.

In another study by Kadekodi *et. al.* (2006b) analyzed the supply and demand side of health care facilities. It is stated that the supply side scenario can be captured and analyzed in terms of the provisioning of health care facilities, while for demand side analysis, it is very important to analyze the voices of the people regarding access and utilization of health care facilities in the public and private domain. The report presents a very detailed and comprehensive primary survey and findings in terms of comparative analysis of health facilities in the states.

Pesigan (2005) provides information about PHEMAP. It says that, in 2001, the WHO Regional Offices for the Western Pacific (WPRO) and South East Asia (SEARO) collaborated with the ADPC and the Japan International Corporation for Welfare Services (JICWELS) to develop an international programme to respond to a perceived need for staff training at ministries of health. Because of its regional focus, the programme was called Public Health and Emergency Management in Asia and the Pacific (PHEMAP). The training courses are being conducted annually with participation from Western Pacific and South East Regions. PHEMAP is designed as a series of integrated courses covering the technical, managerial and policy aspects of emergency management in the health sector

As per information provided by Abrahms (2005) Asian Disaster Preparedness Center is also conducting training programmes on the Basic Emergency Response Course (BERC) which are aimed at developing national capacities to respond to medical emergencies.

Stopford (2005) provides information about the most important initiative in the field of emergency medical care i.e. the development of the National Disaster Medical System (NDMS) as an asset of the Federal Emergency management Agency (FEMA) under the Department of Homeland Security, by the United States government in 1998. NDMS is composed of approximately over 8000 personnel and 108 specialty response teams comprised of a combination of civilian and uniformed service health and medical professionals, who serve as part-time federal employees while training or deployed. NDMS response team members include nurses, physicians, paramedics, emergency medical technicians, veterinarians, funeral directors, psychologists and other professionals integral to health and medical response capabilities. Various specialized teams under NDMS consist of disaster medical assistance teams (DMATs), disaster mortuary teams (DMORTs), Veterinary Medical Assistance Teams (VMATs), International Medical Surgical Response Teams (MSRTs), National Nurse and National Pharmacist Response Teams (NNRTs and NPRTs), National Medical Response Teams: Weapons of Mass Destruction (NMRTs) and Joint Management Team (JMT) (Stopford, 2005).

Owens et. al. (2004) has provided information about an International Medical Surgical Response Team – East (IMSuRT-E) which is developed by health care providers in the Metro-Boston area as multiple resources for the NDMS. IMSuRT-E has responded to provide aid in other disasters, such as after a super typhoon struck Guam in 2003. As stated by the author:

> The IMSuRT-E is a highly specialized team that is capable of establishing a fully capable free-standing field surgical facility anywhere in the world. It deploys with medical supplies, pharmaceuticals, surgical equipment and a Deployable Rapid Assembly Shelter / Surgical Hospital (DRASH).

The Drash is a self contained field hospital complete with triage, operating room (OR), and intensive care unit (ICU) areas. At the time of deployment, the IMSuRT-E was the only team with a field hospital suitable for international deployment. The DRASH is a successful model to use in an immediate post-earthquake environment.

Owens *el. al.* (2004) has also described the challenges of designing, maintaining and keeping a Deployable Rapid Assembly Shelter / Surgical Hospital. The important ones being preparation in terms of supplies / equipment, international travel, creating field hospital having water supply, electricity, sanitation, oxygen supply and setting up operating room with surgery table, instrument "back" table, anesthesia and others. Challenges with field surgery would be general hospital set-up, surgical personnel, surgery schedule and maintaining sterility.

WHO (2002) give a detailed report of planning for health care facilities for emergency situations. The report deals with general aspects of disasters, emergencies and response and technical aspects suggesting methodologies for short term sheltering, water supply, sanitation, food safety, vector and pest control, control of communicable diseases, mortuary services, handling of dead, health promotion and community participation and human resources involved in the emergency management for health care. The report provides very realistic guidelines for dealing with health care during emergencies.

1.10.4 Relief operations

Relief distribution is very important aspect of emergency phase which comes next to the life saving activities. Needs of different relief materials varies with types and nature of disaster, local conditions etc. however, an analysis carried out by 'A League of Red Cross Societies' of 106 disaster appeals between 1965 and 1974 (including 29 floods, 26 earthquakes, 15 refugee situations, 13 famines, 12 epidemics and 11 cyclones or typhoons) indicated the frequency of requests for specific items as given in Figure 1.36 (UNDRO, 1984)

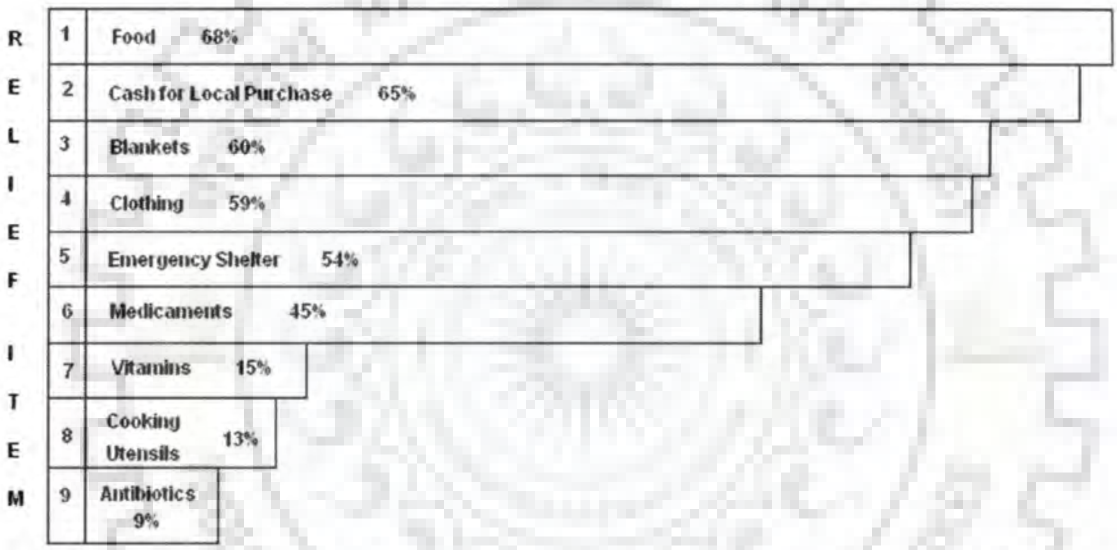


Figure 1.36: Item wise frequency of relief request, Source: UNDRO (1984)

According to Sharma (1997) the co-ordination of relief material by voluntary agencies is very important since it pours in large quantities after an earthquake.

UNDRO (1984) also gives six categories of emergency assistance and data required for the identification of relief sources, as given in Table 1.15.

It was also important to study the format given by UNDRO (1984) for information collection and needs assessment for the post – disaster phase as provided in ***Annexure III***.

Table 1.15: Data required for the identification of relief sources

Health (i) Hospitals, clinics, other health facilities, public or private. Names, addresses, phone numbers of responsible officials; number of beds, ambulances, availability of any special equipment; number of doctors, trained nurses and nurses' aides. (ii) Medical supplies, with particular reference to wide-spectrum antibiotics, anti-diarrheal medicine, fracture supplies and surgical equipment. Names, locations, telephone numbers of government or private medical supply store-houses; pharmaceutical companies or associations; laboratories for vaccines or anti-venom serums. **Food** (i) Resources: Location, telephone numbers and capacities of grain silos, food storage sheds or warehouses, commercial importers, food wholesalers, markets. WFP and other donor food stocks in country. (ii) Supplementary data: Food habits and customs; population estimates of cities, towns, provinces; average family size; prepare sample ration card for use by host country officials, if ration systems not already established practice. **Transport** (i) Roads: Using reliable maps, identify essential roads with best alternative routings. Where bridge load-capacities may be a limiting factor on truck traffic, these should be indicated. (ii) Government and private truck fleets (with contact information) available either on loan from government or on commercial contract. (iii) Railways: Track gauge, loading gauge, daily capacities on various lines. (iv) Ports: Harbour depths, quay lengths, cargo-handling equipment, size of covered and open storage areas. (v) Airports and air strips: Length, width and surface of runways for each, load classification number and largest type aircraft able to be accepted; fuel availability, both avgas and jet fuel; cargo-handling equipment availability. (vi) Water-craft available either on loan on contract for rescue work and relief supply deliveries.	**Construction Equipment** (i) Names, addresses, telephone numbers of road construction and building contractors. Include for each approximate availabilities of bulldozers, drag-lines, hoists, cranes, hydraulic jacks, portable generators, pumps, etc. (ii)Names, location and telephone numbers of government sources, i.e. Ministry of Public Works, Defence, etc. **Other Disaster Relief Supplies** (i) Names, address, telephone numbers of producers, large wholesale and retail outlets for tents, tarpaulins, polyethylene sheeting, construction materials (roofing, cement, lumber, etc.), blankets, sandbags; indicate usual stock levels normally on inventory. (ii)Quantities of above supplies which may be maintained in government stocks. **Other Disaster Relief Supplies** (i) Names, addresses, telephone numbers of producers, large wholesale and retail outlets for tents, tarpaulins, polyethylene sheeting, construction materials (roofing, cement, lumber, etc.), blankets, sandbags; indicate usual stock levels normally on inventory. (ii)Quantities of above supplies which may be maintained in government stocks. **Additional Communications** (i) Possible resources: Embassy radios, police headquarters and stations, fire stations, military stations, telephone and telegraph offices, Red Cross headquarters, amateur radio operators. (ii) Supplementary data: Address and telephone numbers for each contact; kind of equipment and frequencies for each; identify frequencies which can be allocated at once to incoming relief teams.

Source: UNDRO (1984)

1.11 COMMUNITY INVOLVEMENT IN DISASTER PREPAREDNESS

According to Arya (2006)

> 'To achieve effective earthquake risk reduction, we have a long way to go and all sectors of the society have to be made aware as well as sensitized to play their role in this national task.'

There has been an increasing realization over past two decades about the importance of community awareness regarding disaster preparedness for reducing the community vulnerability. Risk of damage could be increased by adverse forms of development and living style which are an affect of lack of awareness in any community. Hence, training and education of public is critical (EERI, 2004). Tarafdar *et. al* (2002) opines:

> 'Disaster awareness starting from grassroots (households) and moving up to the highest power structures (politicians), needs to be internalized in the daily livelihood patterns and development efforts.'

Earthquake mitigation initiatives at higher levels pay little attention to community dynamics, perceptions or priorities and hence are often inappropriate. Also, local communities are often unaware of these formal disaster management interventions. It is at the local level that the physical, economic and social risks faced by the poor can be adequately assessed and managed (GFDR, 2005). As per IFRC (2007)

> 'If we focus only on needs and vulnerabilities, we remain locked in the logic of repetitive responses that fail to nurture the capacities for resilience contained deep within every community. Three things need to happen. First, we must understand what enables people to cope with, recover from and adapt to the risks they face. Second, we must build our responses on the community's own priorities, knowledge and resources. Third, we must scale up community responses, by creating new coalitions with governments and advocating changes in policy and practice at all levels'

In India, the most important initiative for community based disaster preparedness is the Government of India / United Nations Development Programme, which aims at community based disaster preparedness and risk reduction through participation of communities and local self governments. The vital output of this project is multi-hazard risk management and sustainable recovery plans at community, Panchayat and other administrative levels

(Block/Taluka, District and State) in some of the most multi-hazard prone states and districts, and strengthening institutions responsible for sustainability and replication of these efforts (MHA, 2002 -2007; GoI and UNDP, 2003). It is important to recognize the coping mechanism of the community and integrate it with local agencies and administration (Blakie *et.al.,* 1994).

According to Gupta (1997a and 1997b) if demonstration projects for disaster reduction programme are combined with the training, giving chance to people who are going to derive benefit to participate in planning of programme its chances of success gets enhanced. The message gets across easily and continuity of the programme could be ensured.

Peterson (1999) talks about programmes on local recovery from disasters, with a purpose to develop a framework through which small teams of recovery experts would be deployed to disaster-stricken communities to aid their recovery efforts. The report gives theoretical and applied literature covering all aspects of recovery planning by community perceptions and assistance and existing programs for providing technical assistance. Many important aspects like the institutional development, pre-disaster recovery planning, short term response and long term recovery combined with sustainable development, give very clear picture of community as a most valuable resource for recovery from disasters.

To ensure the community participation in disaster reduction process Nathe *et. al.* (1999) details out characteristics of an effective public education program by positing a problem and then say how to solve it--over and over again. The authors suggests the introduction of general public to earthquake hazard, the process and the roles of various agencies for the same as the most important aspects of public education. The authors opines:

> 'Even though public education involves colorful pamphlets, eye-catching posters, and provocative public interest announcements on TV and radio, even more valuable is an understanding of the dynamics of human behavior, effective ways to change it, and a systematic approach to carrying it out over time.'

United Nations (2004) also advocates the importance of disaster risk reduction measures at local levels involving the residents, local authorities and local leaders.

Izadkhah and Hosseini (2005) points towards the difficulties in educating all levels of societies of developing countries due to lack of expertise and educational materials. The authors suggest that one of the best ways of publicising awareness programmes can be the integration of these initiatives into children's activities. The authors opine

> 'Since over half of the population in many developing countries is under 18 years of age, it is possible to convey vital information to most of the population via the knowledge, skills and enthusiastic motivation of children.'

The disaster preparedness and response of Himalayan communities can be best achieved by building community and local level capacities. Murshed (2006) proves it from the experience of Oct 08, 2005 Kashmir earthquake and emphasizes the need to establish relationship between the authorities and the communities in order to have access to the mainstream relief system in case of a disaster.

1.12 ROLE OF DIFFERENT ORGANIZATIONS

For a comprehensive disaster management structure in the country, the roles of all stakeholders should be identified and the capacities should be developed. This section provides a discussion on the roles of various important organizations in the disaster management setup of the country. According to Arya (2006)

> 'All sectors of society including common man will need to be made aware to the disastrous impact of earthquakes and by appropriate prior action of safer construction as well as preparedness. Their impact can be minimized to a large extent, that is life as well as property losses can be very much minimized as has achieved in some of the developed countries namely, U.S.A., New Zealand and Japan.'

1.12.1 Role of voluntary organizations

Disaster management calls for a multi-disciplinary response requiring intervention many times at extremely short notice lending a new dimension and complexity to disaster response mechanism (NCDM, 2001a). The voluntary sector provides an effective alternative in helping to meet such challenges. The non-government sector, including the vital community based organizations (CBOs) that operate at grass root level can be useful for community involvement, due to its linkage with the government, linkage with the community and flexibility in procedural matters (Goel and Sinha, 1992). Sharma (1997b) opines that the voluntary agencies must be regulated and utilized for effective management of calamity by the administration. The help of such agencies can be sought by training them for organizing proper co-ordination. Also, the selected organizations can be trained in different aspects of disaster management for immediate response.

Different Types of NGOs and their importance with reference to disasters

NGOs can be of different sizes, with different areas of operation and different fields of expertise. Though organic in nature and unorganized in character, the NGO sector covers a whole range of activities, through its various types of organizations. It was seen during past earthquakes that the NGOs are better dealing with field level and community issues, and act as the most effective means of achieving an efficient communication link between the disaster management agencies and affected communities (Sharma, 1997a). In several cases, it has been observed that the effective pre-event collaboration can increase the potential strength and capacity of NGOs during and post disaster relief and rehabilitation activities. Sharma (2000) stressed the NGO-Government collaboration with specific focus on the training of the NGOs, making partnership through joint project initiatives, and sharing appropriate information. Some major types of NGOs as given in NCDM (2001 a) are given below:

'1. **NGOs with Dedicated Field Operations and Resource Backup:** These are large organizations, such as the International / national Red Crescent, International / Indian Red Cross Societies, have specific areas in which they carry out field operations. They have access to large resource bases, and have the capability to extend material financial, as well as technical support. In times of disaster, their roles are very laudable as they garner support and resources from all over the world and come to the rescue of the affected persons almost immediately.
2. **Development Technology Related NGOs:** These are NGOs involved in developing and propagating development technologies. These NGOs are active in times of peace, carrying out their development projects, and can be called upon at times of emergency due to natural disaster for providing the affected community with immediate physical infrastructure that they may require. Even in non-disaster times their services are useful for retrofitting in areas of building technology, so as to minimize death and destruction in future disasters.
3. **Educational Institutions:** Educational institutions such as schools and colleges also play a crucial role in disaster management. Their prime responsibility in this regard is to spread awareness on natural disasters, and prevention action needed to minimize damage due to them, as well as on immediate relief and rescue methods.'

Different Types of CBOs and their importance with reference to disasters

CBOs are usually small and grassroot agencies, with informal structures. Due to their very nature of arising from the community base itself, they are very closely linked with local population and conditions. They serve as the last link in the disaster management chain. Some major types of voluntary agencies as given in NCDM (2001 a) are discussed below:

'1. **Interest Groups:** These are CBOs, though formed with the objective of sharing interests, such as the Rotary Club. However, such interest groups are very active, and have come forward to help disaster victims in times of need. They can play a major role in resource mobilization for relief aid and rehabilitation purpose.
2. **Associations of Local Occupation Groups**: Such associations are formed on the basis of common occupational backgrounds, and could include groups such as doctors' associations, traders associations, Army wives associations etc. Such groups as with interst groups, can play a major role in resource mobilization, and also in providing specialized services to the disaster victims.
3. **Local Residents' Associations:** These associations are formed by the local residents to look after the interest of those living a shared community life in the area. They can be very useful tool for getting across the message of community participation at the ground level.

4. **Religious Bodies:** Religious bodies are one of the most important CBO groups that come to the immediate rescue and relief of the disaster victims. These bodies have a large and dedicated following of the community. They often have infrastructure to feed mass gatherings, which becomes very useful in times of disaster.

Areas of Contribution

Voluntary agencies can strengthen the disaster management efforts by contributing in following areas suggested by Goel and Sinha (1992); Sharma (1997); NCDM (2001a).

1. **Communication with community:** NGOs and CBOs have a better link with the community and also have presence in the field, which puts them in a comparatively advantageous position to assess, decide and implement relief operations during disasters.
2. **Communications with Government and Donor Agencies:** NGOs and CBOs can effectively communicate with government agencies and the donor agencies and convey the requirements of affected communities.
3. **Coordination:** The voluntary organizations can play the important role of coordinating all the emergency activities because of their link with community and the government.
4. **Manpower:** The manpower available with the voluntary sector is very large, and highly motivated as it comprises basically of volunteers. There are no procedural problems such as those of maintaining rolls and handling related legal issues.
5. **Finances and Materials:** Voluntary agencies have very flexible means of mobilizing resources and a number of them specialize in just resource mobilization to be able to fund the activities of other NGOs/CBOs working in the field.
6. **Professional and Technical Services**: A number of specialized technical services can be made available directly to the community by NGOs, which would otherwise be too expensive and inaccessible to the people.

1.12.2 Role of armed forces

The military and civil defense resources of any country are often best organized and managed to provide support during disasters. They can react quickly and respond rapidly in fully self contained, self sufficient and highly mobile fashion. The assistance likely to be available to civilian authorities is summarized in the following broad categories (Prakash, 1995):

1. Administration;
2. Communication;
3. Debris Clearance;
4. Evacuation;
5. Serial Search and Rescue;
6. Food Supply;
7. Health, medical and sanitation;
8. Insect and Rodent control;
9. Housing administration;
10. Pollution control;
11. Protection of life and property;
12. Streets, Roads and Bridges; and
13. Transport and traffic control.

1.12.3 Role of media

Effective and reliable communication is vital to disaster reduction. Communication technologies, skills and media are essential for the various important roles they perform in disaster management. Those roles given by NCDM (2001a) are:

1. To link scientists, disaster mitigation officials and the public;
2. To educate the public about disaster preparedness;
3. to check approaching hazards;
4. To alert authorities;
5. To warn the people most likely to be affected;
6. To assess damage;
7. To collect information, supplies and other resources;
8. To co-ordinate resource and relief activities;
9. To account for missing people; and
10. To motivate public, political and institutional responses.

1.12.4 Role of Corporate sector

The involvement and association of the corporate sector with national risk reduction and risk management initiatives and with dissemination of appropriate and practical structural and non-structural disaster prevention and mitigation measures necessary for their safe and disaster-free functioning has been accorded priority as part of a strategy to systematically mainstream holistic disaster management into the functioning of the corporate sector. (MHA and CII, 2006).

Sanker and Kitamoto (2006) mentions that the global dimensions of disasters seen from the perspective of development mechanism include the important aspect of Corporate Social Responsibility (CRS) The authors propose and stress that new development paradigm must include the disaster reduction, through enhanced coordination mechanism and effective stakeholder participation, as an instrument for global sustainable development. The authors also emphasize a Platform for Public Private Partnership (P4PPP) as an important strategy for disaster mitigation.

The corporate sector can contribute for disaster mitigation in the field of risk assessment, spreading awareness, technological advances, availability of advanced equipments, financial assistance, insurance etc. (Sreeramalu, 2006; Smolka and Allmann, 2006; Sanker, 2006; Prasad, 2006; Ambulkar and Sharma, 2006).

1.13 RESEARCH GAP

The concept of disaster management is relatively new to India (Mistry *et. al.,* 2001). There is no enactment either by the central or the state government to deal with management of disasters (UNDP, 2005). Despite the progress achieved, much more is required to implement institutional changes that will help in the evolution of a disaster reduction culture (UNISDR, 2004). Action plans to deal with the disaster situations are being formulated for many districts. But these action plans (DMMC, 2003 a) for disaster preparedness, when reviewed often show shortcomings like incomplete parameters and coverage, quantity and location specific plans, detailed schedule of task assignments, etc., which make them difficult and unimplementable. Also, the review of literature suggests that there is not much research carried out at the sub district level for rural areas especially in the hills. The situation presents a crucial research gap as given below, which underlines the need for in-depth work in this area of earthquake disaster management at settlement level.

1. **Local community needs and involvement**: Although it is evident from the literature that the importance of community involvement in the disaster management activities is well recognized and proved, but still guidelines for the same are not very clear. Moreover the disaster management plans often show less consideration for community needs. According to Verma and Bhushan (2002)

   'Disaster plan at state and district level exists but there is a lot of scope for improvement at the grass root level in order to match the community needs.'

   Hence, there is need to carry out research at the micro level of development block, kshetra / gram panchayat and individual settlements, so that our disaster management plans are realistic and practicable by being responsive to the local community needs and conditions.

2. **Need for standardized methodology for preparedness planning:** Though there have been a host of models / structures / flow charts and theoretical approaches for tackling emergency management including aspects of vulnerability analysis, reduction and preparedness planning, there has not been any clear spelt out planning methodology indicating sequencial steps / stages to be followed, the analysis studies and techniques to be used and the requirement of specific planning data.

3. **Need for a common seismic risk indicator:** There is requirement of a common indicator for seismic risk for rural hilly settlements of India falling under same earthquake zone, for the purpose of comparison of settlements to enable decision making (Alexander 2005).
4. **Need for increased focus on Himalayan human settlements:** Despite the high share of the Himalayan ranges in the number of earthquake events, which are often followed by disasters, the rural settlements of the Himalaya are not drawing enough attention and resources for preparedness measures. The reason appears to be their low economic vulnerability. However, the high physical and social vulnerability of these settlements creates an immediate need for advanced research and measures to be taken in the field of disaster management.
5. **Role of Planners and Architects:** Although the architects and settlement planners have the required background to carry out vulnerability analysis, resource potential analysis, infrastructure development etc., it is observed that the research carried out by them with their capacities is very minimal in India. Hence there exists a scope for exploring the architectural and planning aspects of earthquake disaster management, particularly related to disaster preparedness planning. The last fifteen years have witnessed an increasing pace of settlement and sub-regional planning activity in India which needs to incorporate disaster vulnerability and management considerations in the planning process to deal with specific regions and sub-regions of high earthquake vulnerability.

1.14 AIM

Formulation of a practical and holistic earthquake disaster preparedness plan based on scientific approach, for a micro region of Himalayas.

1.15 OBJECTIVES

The objectives formulated for the research work are as follows:

1. To evolve a suitable methodology for formulation of disaster preparedness plan and action plan, on the basis of literature survey, case studies and database.
2. To carry out vulnerability analysis, resource potential analysis and activity analysis for settlements of the selected sub region.
3. To estimate the likely damage and emergency needs at the settlement level through creation of hypothetical earthquake scenario and develop a suitable indicator for comparing seismic risk of similar settlements.
4. To evolve practical and comprehensive disaster preparedness plan and emergency action plan for the selected sub region.
5. To suggest national policy recommendations for earthquake disaster preparedness and emergency management.

1.16 SCOPE AND LIMITATIONS

The thesis deals with studies including data collection, analysis, hypothetical scenario generation, loss estimation, preparedness plan measures and general policy recommendations for earthquake disaster management within a selected sub region in Himalayan ranges. The scope and the limitations of the studies are given below:

1. The studies deal with disaster induced only due to earthquake hazards.
2. The scope of the studies are limited to data collection, detailed investigations and proposals for a selected sub-region i.e. Narendranagar block of a Himalayan district viz. Tehri Garhwal district.

3. The studies deal with preparedness for emergency phase of earthquake disaster. The reconstruction and rehabilitation aspects of disaster management are not covered.
4. Vulnerability analysis is carried out only for physical and social vulnerability.
5. Only one most likely earthquake scenario is generated for the selected region and the impacts / effects in terms of damage to residential buildings and human casualty estimation is carried out.
6. Detailed preparedness measures are provided only for the selected most urgent activities of emergency phase viz. preliminary damage assessment, search and rescue, emergency relief operations, provision of medical assistance and restoration of transport routes.
7. Economic aspects of the impacts of potential disasters and the proposed preparedness measures are not taken into account.

1.17 ANALYTICAL TOOLS AND TECHNIQUES

Questionnaires for village level information and organizational information are developed using survey techniques obtained from *stratified sampling* techniques (Gupta 1997c). *Topographic sheets* developed by Survey of India are used for contour analysis. GPS is used for altitude studies during field visits. *MS Excel* software is used for data storage, processing and analysis. *GIS software (Geomedia)* is used for data storing, spatial analysis and graphical output. *Autocad software* is used for making drawings of residential buildings for seismic analysis. *Critical Path Method (CPM) network* is used for planning of crucial activity of preliminary damage assessment.

1.18 METHODOLOGY

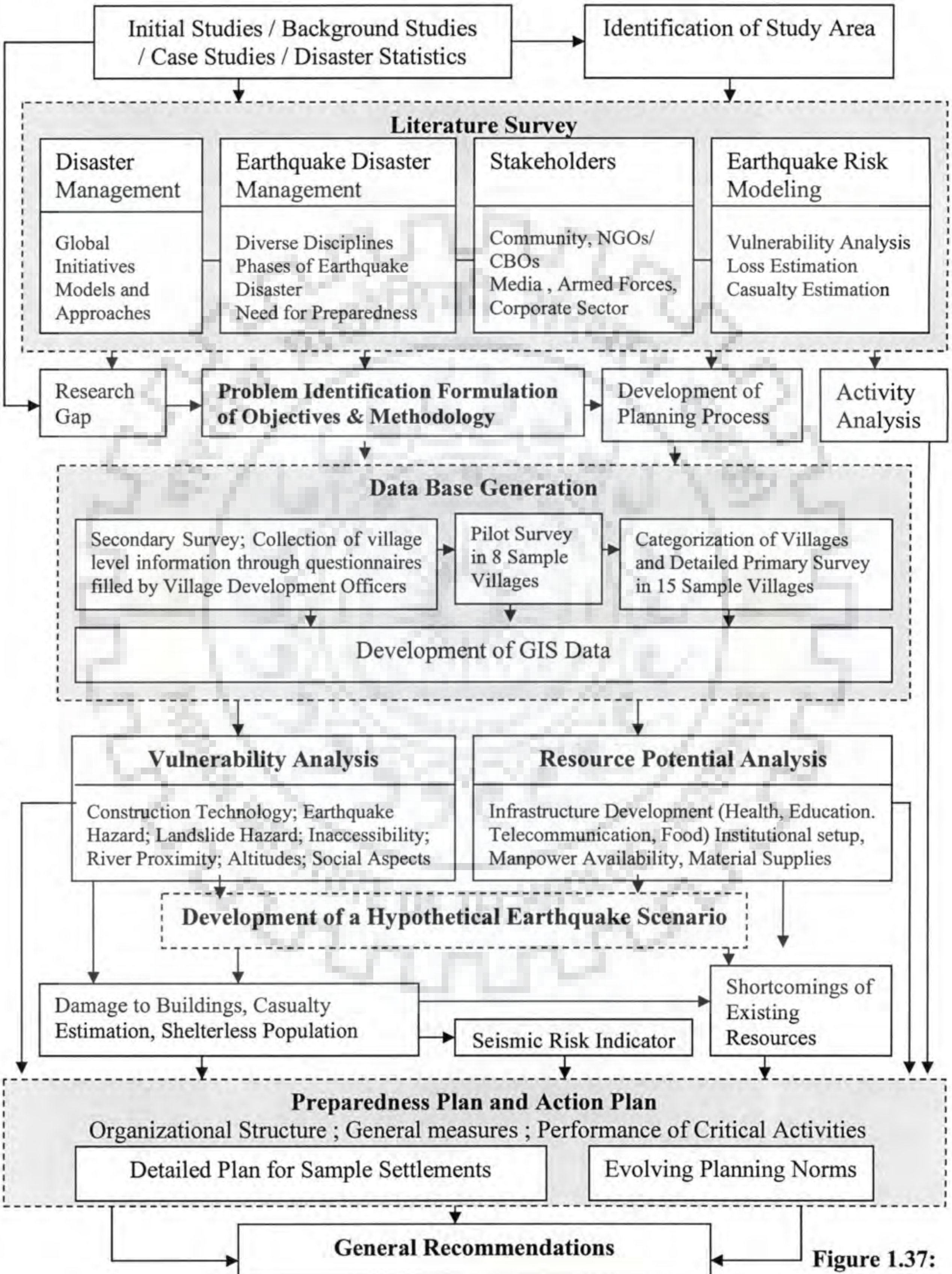


Figure 1.37: Methodology

1.19 CHAPTER OUTLINE

Chapter 1 presents the review of literature carried out for the research work, research gap identified and formulation of objectives and research methodology with scope and limitations.

Chapter 2 gives the planning process evolved out of literature consisting of guidelines and steps to be followed through component parts of the planning process.

Chapter 3 gives the profile of selected study area, on the basis of data collected from primary and secondary sources.

Chapter 4 deals with the analysis of physical and socio-economical vulnerability of the selected sub region and the analysis of potential of existing resources.

Chapter 5 deals with generation of a hypothetical earthquake scenario within the sub region, estimation of the losses induced in terms of building damage and human casualties and development of seismic risk indicator for the settlements. The shortcomings of the existing resources to deal with the destruction caused are also discussed.

Chapter 6 gives the general preparedness measures for vulnerability reduction of the selected sub-region and specific preparedness measures for 5 most critical activities of the emergency phase. Detailed settlement level plans are given for 3 selected settlements. The chapter concludes with general measures suggested for disaster management in India.

Chapter 7 lists the significant conclusions out of the research work and scope for further research.

1.20 CONCLUSIONS

Natural disasters are constantly on increase in terms of their intensity and frequency. Asia bears a high percentage of damages induced by natural disasters as compared to rest of the world. India is prone to almost all kinds of natural disasters with earthquakes drawing attention due to their increasing frequency. The settlements of Himalayas are at increased risk due to their construction typologies, landslide hazard, poor infrastructure development etc.

Significant research is being carried out in the field of risk assessment, vulnerability reduction, emergency management etc. Many important initiatives are being taken at the national and global level by various national and international agencies. Various models for disaster management give understanding of disasters and offer guidance for counter measures.

Earthquake disaster management is a complex, multidisciplinary and multidimensional affair involving experts from many vocations. Earthquake risk of settlements can be modeled by carrying out (i) vulnerability analysis, considering physical and socio-economic aspects and analysis of resource potential; (ii) scenario studies leading to estimation of loss and resource needs; (iii) casualty estimation as consequent to building damage estimation. Most important aspect of earthquake disaster reduction is ensuring earthquake resistant constructions within a region, because most fatalities due to earthquakes are caused by collapse of seismically unsafe buildings. Emergency phase of earthquake disaster management is the most crucial one, requiring utmost preparedness. The critical aspects of emergency management are communication systems, search and rescue operations, medical assistance, relief operations and temporary sheltering. Various sectors with important role in disaster management are community, voluntary organizations, armed forces, media and corporate sector.

The research gap identified points out low participation of community in the disaster mitigation efforts, lack of standardized methodology for comparing vulnerability of similar settlements, infrastructure inadequacy of rural hilly settlements and the marginal involvement of architects and planners in the field of earthquake disaster mitigation. The identified aim and objectives of the research accomplished, adopting the identified methodology within the limitations in the subsequent chapters.

CHAPTER 2

ANALYTICAL FRAME WORK

2.1 INTRODUCTION

The research which is being carried out at the global level in the various sub-fields of disaster mitigation as reviewed in previous chapter facilitates formulation of an analytical framework to arrive at the most appropriate approach for disaster preparedness plan for the selected study area within Himalayan ranges. Various models have studied as part of literature review, mainly to identify suitable methodology for the research. The actual methodology that has been formulated has not been based on any one particular model, but derives its inputs from theoretical postulations and models suggested by many authors. The framework evolved comprises mainly of three types of analysis viz. activity analysis, vulnerability analysis and resource potential analysis for the study area. The analytical methods formulated and described in this chapter are followed in actual analytical work of this research. Generation of a most likely hypothetical earthquake scenario including calculation of consecutive building and human damages are carried out as further steps after this analytical framework. The development of a Seismic Risk Indicator (SRI) is proposed, which could be used for all Indian Himalayan settlements.

2.2 PLANNING PROCESS FOR PREPAREDNESS

Planning for earthquake preparedness is an activity, which is multidisciplinary and multi dimensional in nature, requiring large scale intervention at short notice, hence, a logical analysis of the situation should be carried out which will form the basis of planning (Singh. B, 1999). Three most important types of analysis involved in the earthquake disaster preparedness planning as given by Shankar and Gupta (2005) are:

1. **Activity analysis**

   It gives an understanding of all activities to be performed in the sub region during the emergency phase, the agency / personnel responsible and the time limits.

2. **Vulnerability analysis**

   It gives understanding of measures of expected losses an earthquake would cause within the sub region, which is important for formulating the preparedness plan.

3. **Resource Potential analysis**

   It identifies the capacity of the resources of the sub region for earthquake mitigation and the shortages, which could be taken care of during the pre-disaster phase.

An earthquake preparedness plan for any region formulated on the basis of these three analyses comprises of mainly a preparedness plan and an action plan. Figure 2.1 shows the planning process for earthquake preparedness, the details of which are discussed in the following sections.

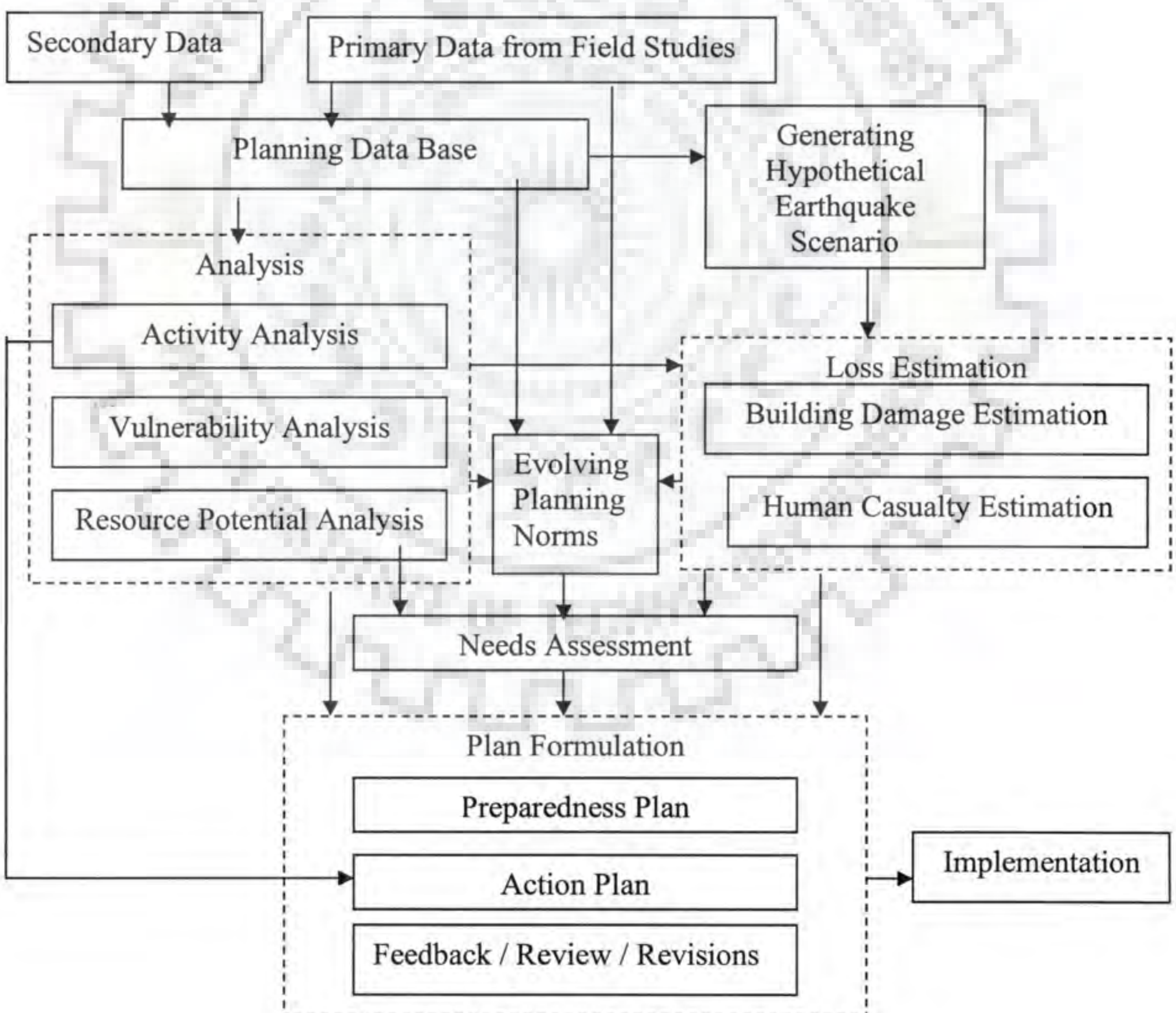


Figure 2.1: Planning process for earthquake preparedness

2.3 ACTIVITY ANALYSIS

Planning for earthquake preparedness and mitigation starts with the analysis of all the activities that have to be carried out in the emergency phase. Arya (2001) has given a list of various activities to be performed in the emergency phase. These activities are modified and categorized as per their urgency and priority into three categories viz. 'most urgent', 'urgent' and 'less urgent' as given in Table 2.1.

Table 2.1: Activities to be performed in the emergency phase

MOST URGENT	URGENT	LESS URGENT
(To be started immediately after the earthquake and take place within first 24 hours or continue if required)	(To be started within first 24 hours and continue up to 72 hours)	(To be started within 72 hours and continue till completion)
1. Preliminary damage assessment;	1. Interim damage assessment;	1. Maintenance of law and order; *
2. Organizing manpower for relief operations;	2. Disposal of dead bodies;	2. Detailed damage assessment;
3. Search and Rescue Operations.	3. Provision of temporary shelters to the victims;	3. Restoration of drainage system, solid waste management etc.
4. Restoring transport routes;	4. Preventive steps against chain reactions;	
5. Supply of food and water;	5. Restoration of essential services like: - water supply; - electricity; - Tele-communication.	
6. Relief Distribution;		
7. Provision of medical assistance to the injured.		

(Note: * Maintenance of Law and Order is an integral part of all other activities. This activity which is less urgent normally can become most urgent or urgent depending on local conditions)

Source: Shankar and Gupta (2005)

This is a general set of activities, which have to be performed in the emergency phase of a typical earthquake disaster scenario. However, certain activities can be added to or discarded from the table depending on the specific region for which plan is being prepared. All these activities are interdependent and interlinked with each other (Figure 2.2).

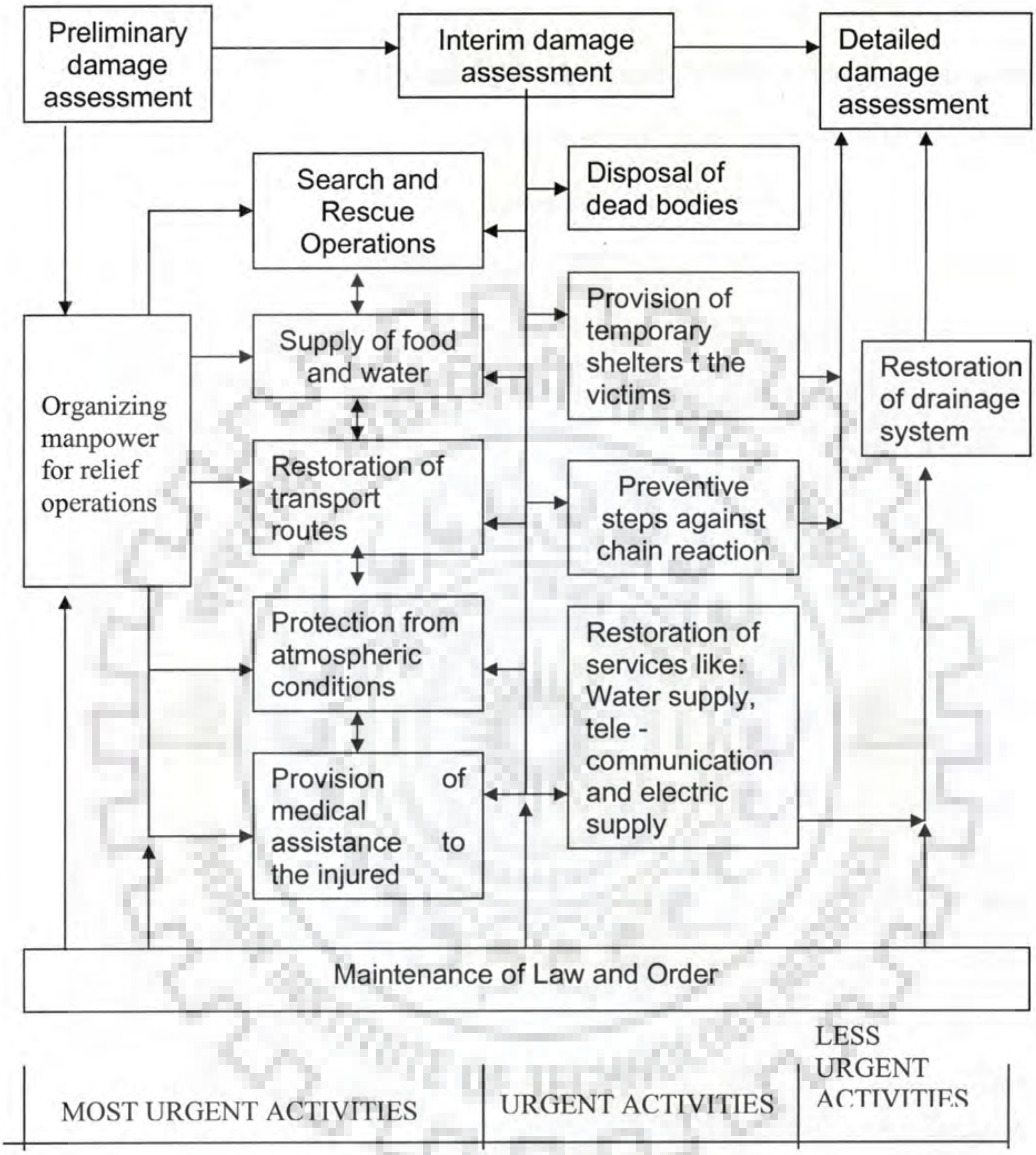


Figure 2.2: Inter-linkage of activities (Shankar and Gupta, 2005)

After listing the activities and understanding the linkages the detailed analysis of all activities has to be carried out in terms of tasks to be performed, requirements for the tasks, persons / agencies responsible for performance, ideal start time and end time for all the tasks. The level at which the activity analysis is being carried out i.e. district level, block level, Kshetra / gram panchayat level etc. has to be considered, because the activities would differ at various administrative levels. A brief discussion of all the activities follows next, including reference to the lessons learned from past experiences of earthquake emergencies in India.

2.3.1 Preliminary Damage Assessment

Preliminary damage assessment is rough estimation of losses caused due to earthquake. It is of critical importance because by gaining quick overview of extent of building damage and loss of life with actual locations of occurrence all the other operations like rescue, relief distribution etc could be started. Preliminary damage assessment must start immediately after the earthquake strikes and should be completed within 3-4 hours. The assessment must be objective. It can be done by links established with the pre appointed representatives in the affected areas. In India government setup reaches up to village level which can be gainfully used in getting the preliminary information on earthquake damage. Media can also play an important role in this activity. For effective preliminary damage assessment, the emergency communications network is most crucial to ensure the flow of information, track emergency needs and deployment of the emergency personnel. Satellite images may also be used to save time and get reliable first hand information.

It may be mentioned in this context that in Gujarat earthquake, the communication link with Bhuj could be restored only two days after the earthquake, and even after 10 days, communication with Bhuj was not back to normal. The cellular network in the state failed. A large part of the state remained completely disconnected. The lack of communications hampered information flow and seriously affected relief operations. The situation was similar to the Orissa cyclone or the Marmara (Turkey) earthquake in 1999, where the disaster-affected areas were completely cut off from the rest of the country due to communications breakdown, delaying the rescue and relief efforts (Vatsa, 2001).

2.3.2 Organizing Manpower for Relief Operations

Organizing manpower for relief operations deals with regularization of all the human resource available for assistance in the post earthquake scenario. This activity is important for its valuable contribution to all other critical activities. It should start as early as possible after the earthquake strikes. The substantial manpower required to perform the urgent and enormous tasks of emergency phase can be obtained from various government agencies, voluntary organizations, private organizations, neighbouring regions and volunteers from affected community itself (Goel and Sinha, 1992; Gupta, 1997a; Peterson 1999; NCDM, 2001a). The volunteers substantially contribute to manpower that needs to be organized and trained. Nucleus of volunteers needs to be created through local agencies and associations.

During Gujarat earthquake a major role was played by 'Abhiyan' which is a collaboration of 22 NGOs most active in disaster management in Kutchh district (Government of Gujarat, 2001; Ray, 2001).

2.3.3 Search and Rescue Operations

Search and rescue operations essentially deal with saving lives of several people trapped due to collapsed buildings. Since life saving is the most important objective of any disaster reduction programme, search and rescue becomes most important. The first 48 hours are most crucial for the survival of trapped victims without food, water and enough air or no air (Coburn and Spence, 2002) and hence they need to be rescued within that time. There is absolutely no time to waste, and any little delay here can cause loss of several precious lives. Usually this phase is started immediately by the survivors of the quake, but due to the lack of necessary equipment and expertise only surface causalities can be saved (Prakash, 1995). This activity requires a great deal of light and heavy rescue equipment and trained manpower. Because of the time constraints in this phase, it requires a precise minute-to-minute planning and a well-prepared management for equipment and manpower (UNDRO, 1984).

After Gujarat earthquake, the search and rescue operations were hampered due to shortage of advanced rescue equipment like cranes, gas cutters and earth moving equipment (Ray, 2001). Murshed (2006), from the experience of Oct 08, 2005 Kashmir earthquake, mentions that many communities which got cut off, would have been able to save hundreds of lives if they had been better equipped and trained.

2.3.4 Restoring Transport Routes

Restoration of transport routes ensures the physical connectivity of all affected regions which gets broken as a result of earthquake. It is most urgent because disruption to transport routes always hinders or actually stops the rescue, relief distribution etc. Hence, the actions should be immediately taken for restoration work. The disruption can be due to cracks in the roads, breaking of bridges, collapse of buildings or landslides resulting in the blockage of roads etc. In crucial times there are so many vehicles on the road for rescue, relief distribution, medical teams, volunteers and mostly the desperate people trying to reach their relatives or going away from the quake hit area in panic. This traffic gets blocked if the roads are not cleared in time. In emergency situations the alternate transport in terms of helicopters or ropeways in case of hills or river navigation in certain stretches needs to be explored.

During 2001 Gujarat earthquake the roads were relatively less affected but the Surajbari Bridge which connects Gujarat to Kutch district experienced substantial damage. For about 15 days only light commercial vehicles were allowed over the bridge (Vatsa, 2001). In Uttarkashi earthquake many roads were disrupted due to landslides triggered by the earthquake. The restoration of these hampered the rescue and relief distribution activities (TARU, 1991; GSI, 1992; Jain *et. al.*, 1992).

2.3.5 Supply of Food and Drinking Water

Residents of collapsed buildings need to be provided with food and drinking water after an earthquake. It is most urgent and important because any shortage or delay in this activity will cause malnutrition amongst the population, which may result in spreading of diseases and deaths. Supply of food and drinking water to the victims of earthquake must start within few hours after the earthquake. The type of food to be provided, its quantity and the quantity must be pre-decided depending upon the damage assessment report considering climatic conditions and needs of victims of the quake (UNDRO, 1984). Usually, the female survivors collectively cook the food for the community during disasters. For this food material has to be supplied. Various organizations work for the provision of food and water to the victims, but the efforts of such organizations need to be coordinated. Victims also need water for other uses, which should also be provided. This activity of food and water supply should continue till the water supply system is restored and the community is finally independent for food needs.

During Gujarat Earthquake of 2001, disparity was observed when food was supplied in adequate quantities at Bhuj through many NGOs and government, whereas remote villages had to go to the nearby towns to avail food. Many other severely affected areas like Bhachau, Rapar, Halwad etc. did not receive any relief for more than 48 hours (Ray, 2001; Vatsa, 2001).

2.3.6 Distribution of Other Relief

Apart from food and water, victims of earthquake also need to be provided with other relief like clothing, blankets, tents, tarpaulins, medicines, cash for local purchase etc. If the climatic conditions are very harsh like extreme cold, very hot sun or rains, then this activity becomes most crucial. A delay in this activity or shortage of relief can even charge numerous lives. Help regarding this comes from several sources like state government of affected area, central government, other state governments and a number of private agencies or NGOs, hence a meaningful and quick regulation of the relief material to the areas where it is short is required. During Uttarkashi earthquake the road network was disrupted and relief distribution and rescue became extremely difficult. During the initial times the relief material was air dropped to the village till the road network was restored (Jain et. al. 1992).

2.3.7 Provision of Medical assistance to the Injured

After an earthquake several people get injured due to crumbling buildings needing immediate medical assistance in the emergency phase. Hence this activity should immediately start with setting up of medical camps in various areas. These medical assistance camps should be well organized, to avoid any pandemonium caused by panic-stricken and traumatized people. There are so many specialized requirements of the activity, which require a great deal of preparedness to serve speedily. Secondary activities like maintenance of records, provision of medicines for epidemic control etc. also are very important to be taken care of (UNDRO, 1984; Wisner and Adams, 2002). The health facilities are of critical importance during emergencies and hence special attention has to be provided for their earthquake resistance (Allahi and Izadkhah, 2004).

In Gujarat earthquake the civil hospital of Bhuj underwent heavy damage and it was seen that a large number of deaths took place due to collapse of schools and hospitals (Vatsa, 2001).

2.3.8 Interim Damage Assessment

Interim damage assessment needs to be carried out within first 24 - 72 hours, to get a more reliable and detailed information about damage caused due to earthquake. By this time the informers themselves get a clearer idea about the quake and hence the information is more reliable and detailed. Other means of getting damage information can also be acquired in the mean time and the information procured should be conveyed to all concerned authorities. All the activities planned on the basis of preliminary assessment can be modified if required on the basis of interim damage assessment.

2.3.9 Disposal of Dead Bodies

The buildings collapsed due to earthquakes cause death of many human and cattle lives and hence the bodies need to be cremated / buried. Delay or non performance of this activity can cause spreading of diseases in the area, which makes it urgent. Although not immediately but this activity can start a few hours later after the disposal site is made ready, material is collected and the dead bodies are brought to the site. The religion of the dead people and their traditional methods should be considered. It is always desirable to pre-decide about the disposal site and be prepared for the cremation material. Maintenance of records also plays an important role for provision of compensations to the relatives of dead.

Disposal of dead bodies faced many problems during 1991 Uttarkashi earthquake due to the paucity of firewood for cremation. Orders were issued for cremating the dead bodies locally. Many dead bodies were thrown into the dam water. In a cleaning up operation 45 bodies were found floating and were removed by the district administration (TARU, 1991).

2.3.10 Provision of Temporary Shelters to the Victims

Temporary shelters need to be provided to the number of people rendered homeless after the earthquake. If the atmospheric conditions are very harsh like extreme cold, high temperatures or rains, such accommodation should be provided within 24 hours. This accommodation can be community wise or family wise, as per the availability of the accommodation. The erection of temporary structures for individual families and their allocation may take a longer time of 4-5 days after the quake.

During Kashmir earthquake of Oct 08, 2005, the major challenges faced for provision of temporary shelters were damage to school buildings, people's trauma, inaccessibility of settlements, shortage of labour, severe weather conditions and lack of government support to voluntary organizations (Murshed, 2006).

2.3.11 Preventive Steps against Chain reactions

Usually an earthquake event is followed by number of chain reactions like landslides, formation of temporary dams on the rivers resulting in floods, slumping etc, as seen in Uttarkashi earthquake (TARU, 1991; GSI, 1992). These chain reactions many times prove to be more hazardous than the actual event. Hence, in order to avoid such losses to lives and property a check has to be kept on the probable chain reactions and preventive steps must be taken in advance to avoid the chain reactions or to minimize the effects caused by them.

2.3.12 Restoration of Essential Services

Water supply: To release the burden on the emergency water supply activity of the relief distribution, existing water supply system of the affected area must be restored. The water demand on the very first day can be very low as it is only confined to drinking water. But as time passes people need water for other uses like washing, bathing, cleaning etc. It becomes impossible to supply such great quantity of water everyday and everywhere. Hence to solve this problem the water supply system should be restored within 72 hours from the quake.

Electricity: Many activities take place at a very slower speed because of absence of electricity. In present times electricity has become such an important factor of everyday life that it becomes almost impossible to manage the situations in its absence. Hence within 72 hours after the quake the electricity must be restored to speed up all the other activities for disaster mitigation.

Telecommunication: To open up a proper communication link in the affected area the existing telecommunication system must be restored within 72 hours form the quake. This enables the appropriate flow of information and hence connects various areas. Panic-stricken people can get in touch with their relatives and can get their information. The activities of disaster mitigation would also ease up due to the restoration of telecommunication links.

2.3.13 Detailed Damage Assessment

This activity is aimed to get detailed information about the damage caused by the earthquake and can start after 72 hours from the quake. A group comprising of a civil engineer and a photographer move from house to house in the assigned affected area and record the damages caused to the buildings. Many such teams work to cover a large area in the specified period of time. This assessment should be strictly objective and the results are used for allocating the compensations against damage to the victims.

2.3.14 Maintenance of Law and Order

This activity forms a part of all other activities and plays a very important role in the emergency phase. In this phase due to factors like panic, fear, desperation, hunger etc. people are not expected to maintain discipline themselves. Hence certain measures should be taken while detailing out each and every activity for maintenance of law and order.

2.3.15 Restoration of drainage system, solid waste management etc.

Restoration of drainage system and solid waste disposal becomes very important in the later stage to maintain hygienic conditions and to avoid spreading of decease in the affected area. This activity can start within 72 hours from the quake and should be completed as fast as possible. If some serious problems are detected then the victims should be provided with some alternate, safe and hygienic method till the system is restored.

2.4 FIELD SURVEYS

After reconnaissance survey and pilot study of settlements of the region, sample settlements should be selected representing categories, decided on the basis of accessibility, size, location and infrastructural conditions, for detailed study. The main purpose of the field survey is to gather primary data, apart from cross checking of secondary data. The primary data needs to be collected on construction typologies of buildings, infrastructural condition and availability and other resources. The data input comes primarily out of these field surveys, for vulnerability analysis, resource potential analysis and hypothetical earthquake scenario generation and subsequent estimation of losses.

2.5 VULNERABILITY ANALYSIS

Vulnerability is defined as 'the extent to which a community, structure, service or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrain or a disaster prone area.' (NCDM, 2001) Hence, vulnerability analysis is a process to identify physical, social and economic conditions susceptible to the effects of hazards of given intensity.

Different elements vary significantly for their vulnerability to damage or disruption according to intensity of hazards. The basic types of vulnerabilities are physical, social, economic and environmental as described by United Nations (2004). Factors affecting these are given below:

2.5.1 Physical vulnerability:

Physical vulnerability is material oriented and determined from land use planning, engineering and architectural aspects. Physical aspects refer mainly to considerations and susceptibility of location and the built environment. (United Nations, 2004) Physical vulnerability may be determined by assessing the construction quality and earthquake resistance of all buildings and infrastructural facilities like transportation system, telecommunication and the public utilities like water supply and electricity. Agriculture is also physically vulnerable if prone to landslides on account of loss of crops, trees, livestock etc.

The factors primarily affecting physical vulnerability which are selected for analysis due to their relevance with the selected study area are given below:

1. **Earthquake Vulnerability:** Earthquake vulnerability of any region is determined from the presence of major tectonic elements. The earthquake microzonation studies carried out for the region could be readily used for determining the earthquake vulnerability.
2. **Construction technology:** Construction technology prevailing in a region is one of the most important indicator of physical vulnerability. In rural areas construction technologies depend upon the availability of local materials and local skills such as stone construction with weak mortars. Such constructions are likely to get affected severely during the earthquakes. Hence poor construction techniques without earthquake resistant characteristics increase the vulnerability.
3. **Landslide hazard:** The hilly areas have different vulnerabilities for landslides depending upon various factors like slope, drainage, land-use etc. Earthquake can be the triggering event for the landslides. They can cause massive destructions, and hence their studies are very important. Such studies are carried out by earth-scientists, geologists especially working in research institutes or universities. Knowledge about the vulnerability of any

area for landslides helps planners for taking certain preventive steps to minimize the destructions and to decide the land use plan for future development.

4. **Accessibility:** In hilly terrains aceesibility conditions of many settlements are such that after an earthquake the rescue equipment or the relief material cannot reach them. Many villages are located away from the roads at distances as far as 10-15 kms, requiring long treks for access. Hence, such conditions increase the vulnerability of the area because of the unavailable service of rescue and relief operations.
5. **Proximity to rivers and dams:** The close proximity of any hilly region to river increases its vulnerability after earthquakes. This is because the debris falling in river as a result of landslides usually form temporary dams on river blocking its flow. Such dams burst with time and can cause flash floods in the settlements. If the area prone to earthquake is also having any small or big dam then the earthquake resistance of the dam structure is a very important consideration. Hence such proximity adds up to the vulnerability of the area to a great extent because during an earthquake shock, if such dam structure fails then large surrounding areas will have to face massive destructive floods.
6. **Altitude:** It is proved from the experiences of past earthquakes that the settlements located on high altitudes suffer more damage as compared to the settlements located in valleys. Hence these high altitude settlements are more vulnerable than the lower settlements.
7. **Proximity to hazardous industries:** In certain areas various hazardous industries may be located which handle explosives etc on large scales. Such industries increase the vulnerability of the areas to a great extent because in the event of earthquake if any damage is caused to such industries and activities like explosion take place, then extent of damage caused in the area multiplies manifolds.

2.5.2 Social Vulnerability

Social vulnerability is the extent to which a community is likely to be affected socially by the impact of an earthquake. Social vulnerability is linked to the capacity of individuals, communities and societies for coping with disaster situations. Factors affecting social vulnerability are poverty; limitation of resources or options; public awareness; density of population; percentage of vulnerable population like elderly, disabled, children etc.; employment level; education and literacy levels; leadership, extent of coherence and effective governance; existence of peace and security; access to basic human rights; social equity; and overall collective organizational system. According to United Nations (2004)

> 'Some groups are more vulnerable than others. People less privileged in class or caste structures, ethnic minorities, the very young and very old, and other disadvantaged and marginalized segments of the population are more likely to be exposed to greater risk. Gender issues, particularly the role of women, are also important. Public health, concerning physical, mental and psychological well-being, is a critical aspect of social vulnerability. The disabled, of whom there are hundreds of millions worldwide, are particularly susceptible, as their evacuation and continued care is severely hampered during disasters. Predisposition to infection, exaggerated exposure to communicable diseases, and lack of defensive mechanisms represent individual conditions of vulnerability.'

Traditional knowledge systems, as well as cultural aspects such as indigenous beliefs, traditions and ways of coping are important determinants in risk perception. Deeply rooted beliefs that are destiny oriented or which pose a fatalistic vision of disasters can reflect a religious or ideologically inherited sense of vulnerability. Such views may present a great challenge in moving towards the acceptance of a culture of prevention and protection. According to Murshed (2006)

> 'In the aftermath of Kashmir earthquake a range of social groups become specially vulnerable due to various socio-political factors and were unable to access relief; e.g. female headed households, young children who had lost their parents and family members. Also ethnic and political minority communities were not able to access relief due to the lack of access to the

mainstream relief system, which was dependent upon local political leaders for verification and recommendation of the victim families and individuals to be eligible to receive assistance.'

Social vulnerability is also linked with other politically-oriented societal factors, such as social power relations. Institutional organizations and governance structures also play an important role in the level of social vulnerability. Social cohesion and regulation improve coping capacities, whereas social insecurity increases vulnerability. (United Nations, 2004)

The factors affecting social vulnerability selected for the analysis of selected sub region are:

1. **Size and density of settlements:** The size of settlements directly affects the social vulnerability. More the number of persons present more is their cumulative vulnerability. Hence bigger settlements are more vulnerable than the smaller settlements. Similarly, denser settlements are more vulnerable than sparsely populated ones.
2. **Literacy:** The literacy increases the awareness of the persons and makes them capable for acting more effectively in pre and post disaster activities. Hence the higher number of literate people in any settlement makes it more capable and less vulnerable.
3. **Awareness:** The population aware about natural disasters, various government efforts for disaster mitigation and actions to be taken in the post disaster scenario is less vulnerable. The aware population can take measures for disaster reduction and reduce its vulnerability.
4. **Missing link in local disaster management efforts:** The disaster management initiatives taken by the government at higher levels have to percolate at grass root level through local disaster management efforts. If this link is missing, the population would remain vulnerable in spite of the numerous efforts being taken by government.
5. **Gender issues:** The social setup of the Himalayan settlements is peculiar because of the active involvement of womenfolk in all household as well as agricultural activities. The migration of menfolk to plain areas for employment leaves the more vulnerable women in the villages. Hence the gender issues are more important for consideration in these areas.

6. **Age Groups:** The phenomena of migration of male adults to the plains in search of job, witnessed in Uttarakhand, causes the rural population to consist mainly of women, children, elderly and disabled, all of which are very vulnerable in a disaster situation.

2.5.3 Economic vulnerability

It has been seen that the levels of vulnerability are highly dependent upon the economic status of individuals, communities and nations (Sapir et. al. 2004). The poor are generally far more vulnerable than economically better off segments of society. This relates both to the possibility of higher proportional losses among the poor when a disaster strikes, and to their generally more limited capacity to recover from disasters. Economic vulnerability also includes levels of individual, community and national economic reserves, levels of debt and the degree of access to credit, loans and insurance. An economy lacking in diversity is generally more vulnerable. Similarly, inadequate access to critical and basic socioeconomic infrastructure, including communication networks, utilities and supplies, transportation, water, sewage and health care facilities, increase people's exposure to risk (United Nations, 2004).

The economic vulnerability of any region is determined by the physical and social characteristics. The prevailing construction technology and resource potential of the community indicate the economic development of the region which are studied .

2.5.4 Environmental Vulnerability

According to United Nations (2004) the key aspects of environmental vulnerability include the extent of natural resource depletion, landslide hazard and the state of resource degradation. Also, a lack of resilience within ecological systems and exposure to toxic and hazardous pollutants are important elements that shape environmental vulnerability. Increasingly vulnerable environmental conditions such as diminished biodiversity, soil degradation or growing water scarcity can easily threaten food security for people dependent on the products of the land, forests, pastures, and marine environments for their livelihoods. A polluted environment also increases people's exposure to health risks. Over a period of time environmental factors can increase vulnerability further by creating new and undesirable patterns of social discord, economic destitution and eventually forced migration of entire communities (United Nations, 2004).

The environmental vulnerability on account of landslide hazard is being analyzed under section 2.4.1. However, since the focus of the research is on emergency management, the other aspects are not considered.

The vulnerability analysis gives very clear indicators of the risks faced by different sub regions. Hence, the results would highlight the areas of greater risk for earthquake disaster. These areas should be kept on high priority for inducing preparedness measures and during the emergency phase provision for better relief distribution and services should be made in the action plan for these areas. The type of vulnerability should also be considered while planning for the emergency. For instance, areas with higher physical vulnerabilities should be prioritized for rescue operations, while areas with higher social vulnerabilities should be prioritized for relief activities. Such prioritization should be logical and systematic.

2.6 RESOURCE POTENTIAL ANALYSIS

Every region has certain resource potential to cope with the disasters. This potential has to be analyzed for utilization for earthquake preparedness and mitigation activities. The deficiencies discovered should be taken care of beforehand, for better earthquake preparedness. The resource potential of any region can be analyzed under the categories of a) Infrastructure b) Institutional setup, c) Manpower and d) Supplies (Shankar and Gupta, 2005).

2.6.1 Infrastructure

The existing level of development of infrastructure plays a very important role in coping up with the disaster situation in the affected area. It essentially includes health facilities, educational facilities, food Supplies, telecommunication and road network.

The lifelines such as electricity, water supply system and drainage system are also critical during the emergency phase of earthquake disaster. Vulnerability analysis of these infrastructural facilities is important because it has been seen that they often collapse after the earthquakes and become unusable during emergency period. Wisner (2003) states, for collapsed schools and hospitals

> 'It is not a sectoral matter to do only with how buildings are constructed, but one that impinges overall upon development strategy, both nationally and locally, to do with human rights, social and political disadvantagement, political will and political integrity.'

The result of potential analysis indicates the capabilities of all the sub regions to deal with the emergency situation. When studied along with vulnerability of the region, we can understand the shortage of resource potential in the highly vulnerable sub regions and provision should be made accordingly for preparedness. The sub regions with high vulnerability demand high potential capabilities. Potential should also be provided specifically in terms of institutional setup, manpower, supplies and infrastructure, depending on type of vulnerability the sub region exhibits. From the case study of October 08, 2005 Kashmir Earthquake, Murshed (2005) emphasized the need of improving infrastructure particularly roads and telecommunication to develop better conditions for emergency response.

2.6.2 Institutional Setup

It includes all the agencies working in the area under public or private sector, which may have some role to play in any activity of disaster management. The civic administration of the area is also included in this. The whole administrative setup of the area has different roles to play in disaster management at state level, district level, tehsil level, block level, kshetra / gram panchayat level and village level. It is very important to keep the efforts of all these agencies well coordinated. Various agencies can be broadly categorized as government organizations, non-government organizations; community based organizations and private organizations.

These organizations may be working in different fields during the pre-earthquake phase. But after the occurrence of earthquake event they all may contribute for management. If all such agencies would be pre identified and pre assigned with certain responsibilities during the emergency phase, the execution of the emergency phase activities would become easier.

2.6.3 Manpower

The mitigation of earthquake disaster in the emergency phase requires substantial manpower. Hence, an inventory of manpower available in the selected region with various capacities has to be made. Prakash (1995) gives the three types of manpower need as given below:

'1 **Technical Manpower:** Technical manpower is required to carry out various specialized activities. Such people should be assigned their tasks in advance to perform during the emergency phase. Many technicians may also be required from the areas other than the affected areas and should be assigned their jobs prior to the earthquake and should be positively expected whenever and wherever they are needed. If such technicians are affected by the earthquake and are not in a position to do their job, provision of substitutes should also be done.

2.a. Non-Technical Manpower: Such manpower forms a very essential part in carrying out many activities. They are usually engaged as helpers in many activities. They can be of two types:

b. Trained personnel: Such people although non-technical are given training to tackle certain activities. Manpower from Police, Fire, Paramilitary Forces etc. comes under this category. If well trained these people will know what to do, how to utilize the available resources, materials and untrained personnel in efficiently carrying out the necessary tasks in a systematic order. People trained for giving first aid to the injured in quake are also included in this category.

c. Untrained Personnel: People engaged for helping the trained personnel are included here. These can also be pre assigned the tasks to be performed during the emergency phase.

3. **Volunteers:** Volunteers are usually the survivors from the quake, who have witnessed the event or people from the vicinity of the event, drawn to the site by curiosity and for many a desire to assist the victims. The efforts of such volunteers should be well co-ordinate and utilized for carrying out necessary tasks in systematic order.

2.6.4 Material Supplies

This includes all the material resources that are available in the area, which could be made available during the emergency phase of earthquake mitigation. The material resources consist of various items as mentioned in section 1.12.4. An inventory of all available items in the selected sub regions should be made.

2.7 HYPOTHETICAL EARTHQUAKE SCENARIO

A hypothetical earthquake has to be assumed with hypocenter at a most likely location (Coburn and Spence, 2002). Since, both over preparedness and under preparedness are not desirable, a optimum magnitude should be considered.

The locations of tectonic elements and microzonation studies should be used for this purpose (Sinvhal et.al. 1990 and 1991). Since effect of earthquakes on structures can be best computed from PGAs, these should be computed for different hypocentral distances using accepted methodologies (McGuire, 1977). Iso-acceleration countours should be plotted for the hypothetical earthquake for different hypocentral distances covering the entire selected subregion. These iso-acceleration countours should be used to determine intensity of settlements using established relationships (Bolt, 2000 and Wald 1999) and considering the effect of topography, because of hilly terrain (Celebi, 1987, Geli, et.al. 1988, Jibson, 1987, GSI, 1991 and NSET & DEQ, 2000). Damages can be computed on the basis of intensities thus determined.

2.8 LOSS ESTIMATION

The hypothetical scenario thus generated would have its effect on buildings, roads, other infrastructural facilities and human beings. The computation of the building damage should be done by using appropriate intensity scale (IS 1893-2002 and Reiter, 1990). Number of buildings with different damage grades should be computed for all settlements. Population rendered homeless as a result of damaged buildings should also be computed (ISET, 2001). The damage to infrastructure facilities should be estimated. The disruption of roads due to possible landslides should be imagined (NRSA, 2001 and Mehrotra, 1992). The impact of collapsed buildings on the occupants should be computed using established relationships. The number of trapped victims and casualties under different grades of injuries ranging from dead persons to persons with light injuries should be computed (Coburn and Spence, 2002).

2.9 DEVELOPMENT OF SEISMIC RISK INDICATOR (SRI)

The identified research gap-stating the need for a seismic risk indicator common for rural hilly settlements of India can be developed as an outcome of estimated losses suffered by the settlements. Since saving human lives is the most important objective of any earthquake disaster reduction activity (Prakash, 1995), the expected number of human lives lost due to earthquakes could be the ideal indicator representing the seismic risk of the settlement. Moreover, since number of lives lost are determined from the number of buildings damaged (Coburn and Spence, 2000) the SRI also represents the damage to buildings within the settlements.

The number of lives lost per 1000 population is an accepted representation for disaster information, which can be referred in various sources dealing with disaster data (EMDAT, 2007 and UN-ISDR, 2005). Hence, this depiction is used for identifying the SRI of the highly earthquake prone settlements of rural hilly regions of India.

2.10 PLAN FORMULATION

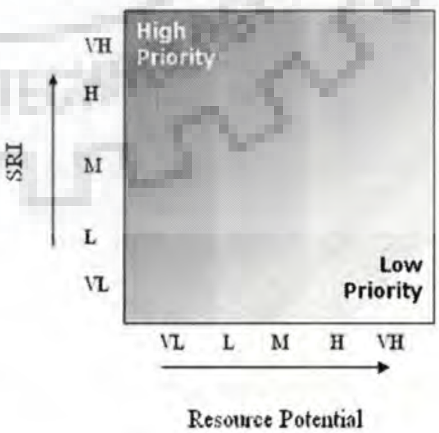
Planning for earthquake preparedness is carried out on the basis of activity, vulnerability and potential analysis. For preparing any region for earthquakes, vulnerability and potential analysis should be studied together. It must be remembered that vulnerability of any region is specific to that region, while potential existing in any region could be utilized by the neighboring regions also. The resultant preparedness plan deals with two components:

1. **Vulnerability Reduction Plan:** It deals with general measures to be taken to reduce the overall physical and socio economical vulnerability of the region, so as to minimize the losses caused due to possible earthquake.
2. **Preparedness Plan:** It deals with provision of all infrastructure, material, manpower and institutional requirements for being prepared for an earthquake situation.
3. **Action Plan:** It deals with all activities to be carried out, time schedules for the activities, all the requirements for the performance of that activity and personnel / agency responsible to perform that activity.

The preparedness plan and the action plan both should be based on prioritization of the sub regions for their vulnerability and potential levels. Methodology for the prioritization is given below.

Prioritization

Prioritization of areas for relief activities confirms better assistance for the more vulnerable areas with fewer resources. Hence settlements with highest SRI and lowest resource potential should be given highest priority followed by the lesser ones (Figure 2.3).



Index	
VL	Very Low
L	Low
M	Moderate
H	High
VH	Very High

Figure 2.3: Prioritization of the sub-regions for preparedness measures and action plan

2.11 CONCLUSIONS

Preparedness for earthquake disaster needs a comprehensive analytical framework consisting of activity analysis, vulnerability analysis and resource potential analysis. Activity analysis deals with an inventory of all activities which have to be carried out on different priority basis as experienced from the past earthquakes. Vulnerability analysis for physical and social factors would identify the different elements at varying risks. Analysis of resource potential in terms of infrastructure facilities, manpower, institutional setup and material brings out their shortage or adequacy for use during disaster situation. A most likely hypothetical earthquake scenario developed within the selected sub region would give a measure of expected losses in terms of buildings, infrastructure and human lives. The guidelines for the development of a Seismic Risk Indicator (SRI) for comparing earthquake risk in rural hilly settlements of India, on the basis of human casualties, would be useful for prioritization of mitigation efforts. The analytical framework outlined so far, facilitates formulation of earthquake vulnerability reduction plan, preparedness plan and an action plan to deal with the earthquake disaster in a more systematic and effective manner. The variations in the vulnerability and resource potentials of different regions and sub-regions characterize individual plans which would vary in content and working details.

CHAPTER 3

STUDY AREA PROFILE AND CONSTRUCTION TYPOLOGIES

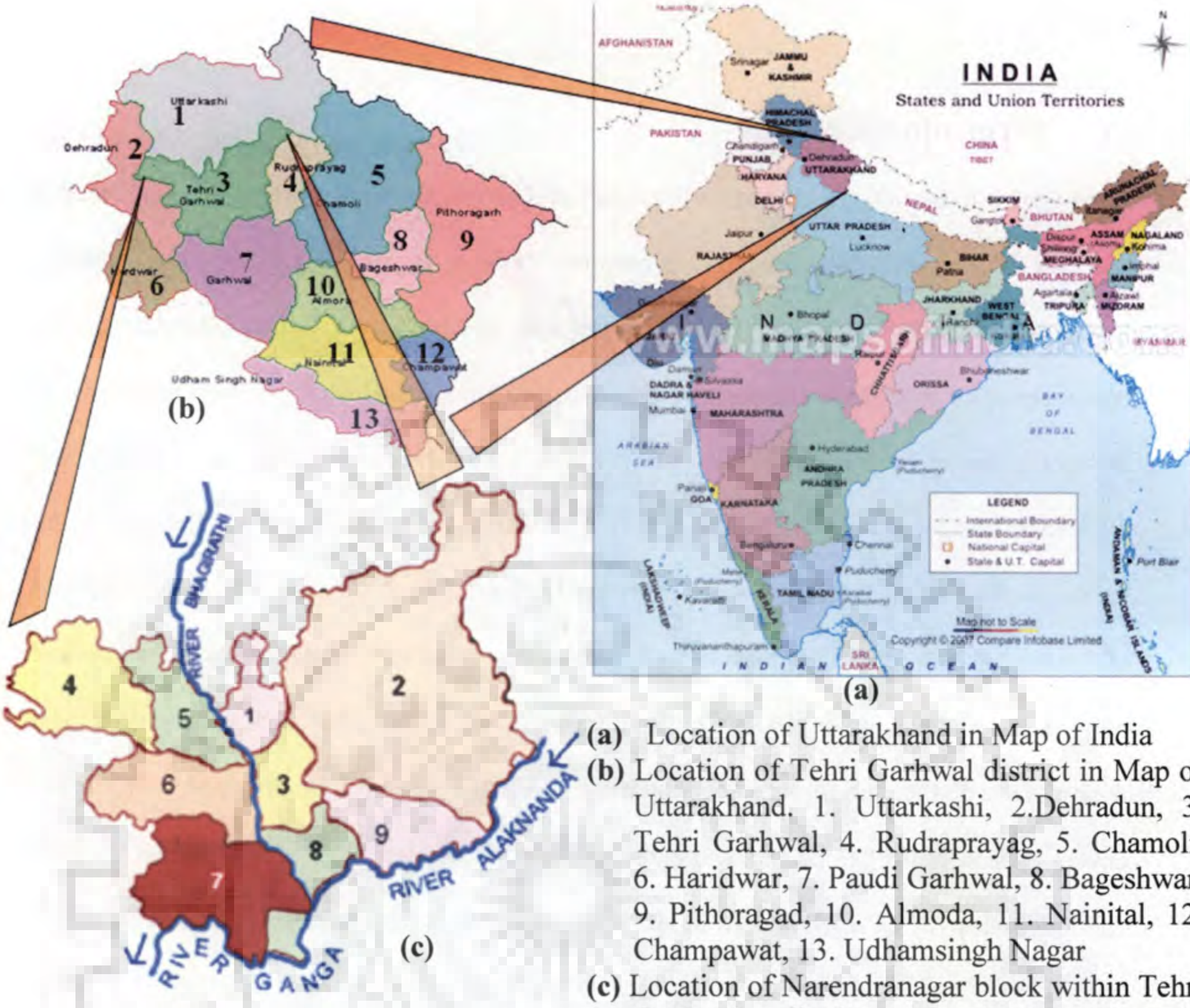
3.1 INTRODUCTION

Tehri-Garhwal district, which was earlier a part of Tehri State, became a part of Uttar Pradesh state on 1st August 1949. Since 9th November 2000 it became a part of newly formed Uttaranchal state (Figure 3.1 a). The Uttaranchal state which is now called as Uttarakhand state comprises of 13 districts and is ensconced between Himachal Pradesh to the west and Nepal in the east. (Figure 3.1 b). District Tehri-Garhwal extends between latitudes 30^0 30'10"N and $30^0$5'45"N and longitudes $78^0$8'15"E and $79^0$2'45"E (Survey of India, 1973). The area of the district is about 545240 Hectares (Government of Uttaranchal, 2002). The district is composed of 5 *tehsils*, which in turn are formed by 9 *development blocks*. For detailed investigations and proposals, one development block i.e Narendranagar block which occupies the southern most region of the district and forms a *tehsil* by itself is selected (Figure 3.1 c). Narendranagar block covers an area of 76,123 hectars and extends between latitudes 30^0 5' 45"N and $30^0$18'45"N and longitudes 78^0 14'35"E and $78^0$35'50"E (Government of Uttaranchal, 2002 and Survey of India 1973). The block consists of 40 *kshetra panchayats* which are divided into 103 *gram panchayats*. A population of 1,03,032 live in 214 villages and 17 market towns (Government of Uttaranchal, 2002). The chapter presents profile of Tehri Garhwal district in general and Narendranagar block in particular. The construction typologies prevailing in Narendranagar block and their seismic response are discussed in detail.

3.2 TEHRI GARHWAL DISTRICT – AT A GLANCE

3.2.1 Historical Perspective

The earliest known ruling dynasty of Garhwal was that of the Katyuri kings who ruled here up to 11th century. At the end of their reign, the region split into fifty two *'garh'* or principalities. The Parmar kings ruled over Garhwal up to 1804 in which year the Gurkha forces took over. However, the Gurkha rule was short lived.



(a) Location of Uttarakhand in Map of India
(b) Location of Tehri Garhwal district in Map of Uttarakhand. 1. Uttarkashi, 2.Dehradun, 3. Tehri Garhwal, 4. Rudraprayag, 5. Chamoli, 6. Haridwar, 7. Paudi Garhwal, 8. Bageshwar, 9. Pithoragad, 10. Almoda, 11. Nainital, 12. Champawat, 13. Udhamsingh Nagar
(c) Location of Narendranagar block within Tehri Garhwal district. 1. Pratapnagar, 2. Bhilangana, 3. Jakhnidhar, 4. Jaunpur, 5. Thauldhar, 6. Chamba, 7. Narendranagar, 8. Devprayag, 9. Kirtinagar

Figure 3.1: Study area location

In 1815, with the help of the British, the Gurkhas were ousted; consequently, Garhwal was divided into two parts. Most areas west of Alaknanda and Mandakini rivers were restored to the late king's descendant Sudarshan Shah, which together came to be known as Tehri Garhwal state. As the result of the split the erstwhile capital Srinagar came under British Garhwal in 1815. The same year Sudarshan Shah located his new capital at Tehri. After Sudarshan Shah, five of his descendants also ruled Tehri state. In addition to ruling from Tehri, three of the descendants settled new townships at Pratapnagar, Kirtinagar and Narendranagar. Manvendra Shah was the last ruler of the Tehri Garhwal state, from October

1946 to August 1949 when it merged with the Indian Union to become a part of the Uttar Pradesh State. The centers where the rulers lived naturally grew to be the hub of other activities including trade and commerce (RHUDO and USAID, 1994). The overall development of the region has not been significant since independence, though as a separate state it is beginning to show signs of development.

3.2.2 Regional Linkages and Importance

The district is well linked with other districts with road transport routes. Due to the hilly terrain railway facility is not available in the district. The nearest railway station is at Rishikesh which is 31 kms from Narendranagar town (Indian Railways, 2007).The only airport of Uttarakhand is located near Rishikesh at Jolly Grant. The National Highway 58 from Delhi to Uttarkashi, passes through the district and act as major transport route (MORTH, 2005). Rishikesh, an important religious center of India is at very close proximity and caters for many services. The other religious centers like Uttarkashi, Kedarnath, Badrinath etc. are also not very far. The routes leading to these places pass through the district, giving it religious and tourist importance. Proximity to important tourists places like Mussoorie, and Dehradun also have significant impact on the district (Figure 3.2).

3.2.3 Geophysical and Climatic Conditions

Topography: Tehri Garhwal is a hilly district of Garhwal Himalayas with numerous rivers. Physiographically Garhwal differs from Kumao region or Himachal Pradesh state, because it is more rugged with steep sloping mountains. Most of the district falls within the lesser Himalaya zone, though outer Himalaya and higher Himalaya also touch it briefly in the southwest and the northeast portions respectively. The altitude of the district ranges from 500 meters to 6900 meters (Survey of India, 1973).

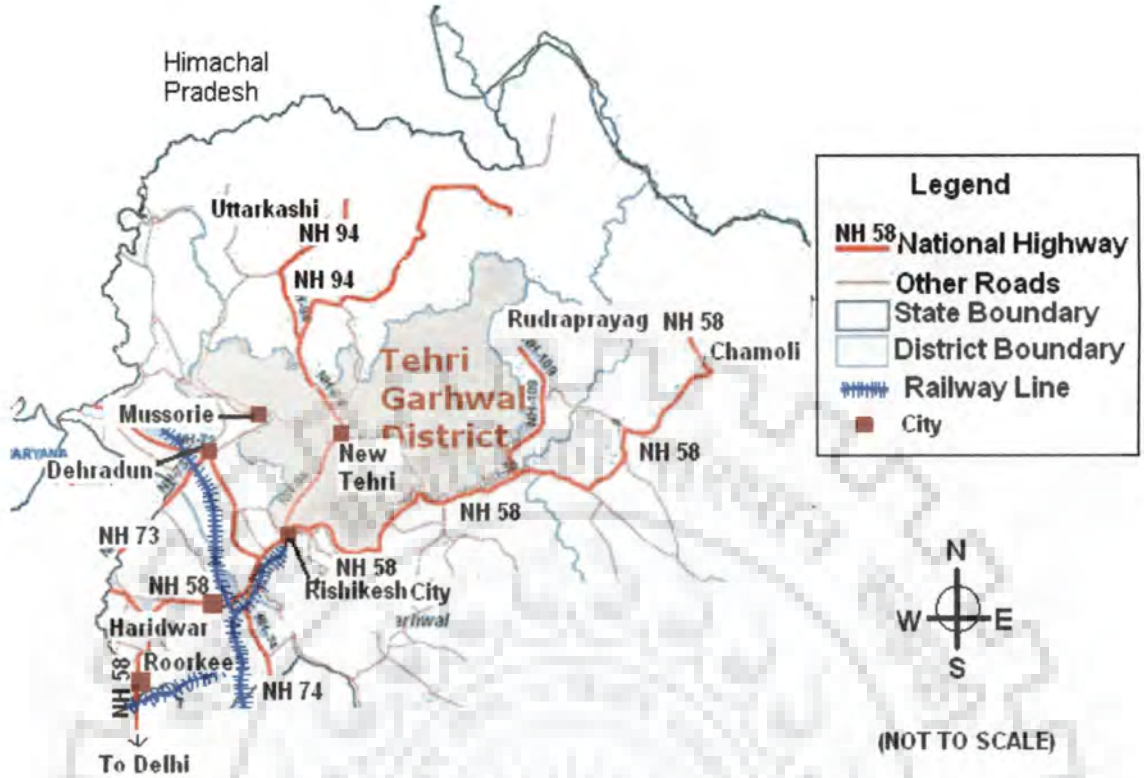


Figure 3.2: Regional linkages of Tehri-Garhwal district
(after: MORTH, 2005; Indian Railways, 2007)

Rivers and Drainage System: Himalayan rivers are generally snow fed and as such perennial. The maximum discharge is during the monsoons (June to September). Tehri-Garhwal is drained mainly by the Ganga river system with its western extreme area by the Yamuna river system (Figure 3.3). The Ganga comprises two major sub systems Bhagirathi and Alaknanda. Bhagirathi, along with its main tributary Bhilangana drains the major part of the district. Bhagirathi rises in the Gangotri glaciers in the Uttarkashi district, while Bhilangana rises in the Bharatkunth ranges in the Northeast part of the district. The two rivers meet at Ganeshprayag (old Tehri). Among Bhilangana's tributaries are Balganga and Dharamganga. Bharirathi flows from Tehri to Devprayag where it is met by Alaknanda and there onwards the river is known as Ganga. Within the district, Alaknanda drains its southeast portions between Rudraprayag and Devprayag. The district's eastern areas are drained by Mandakini, which meets Alaknanda and Rudraprayag. Yamuna is in the west of the district; Barigad and Aglar are its two major tributaries, which rise in the Nagtibba and Surkanda Mountains respectively. (Survey of India, 1973 and RHUDO and USAID 1994)

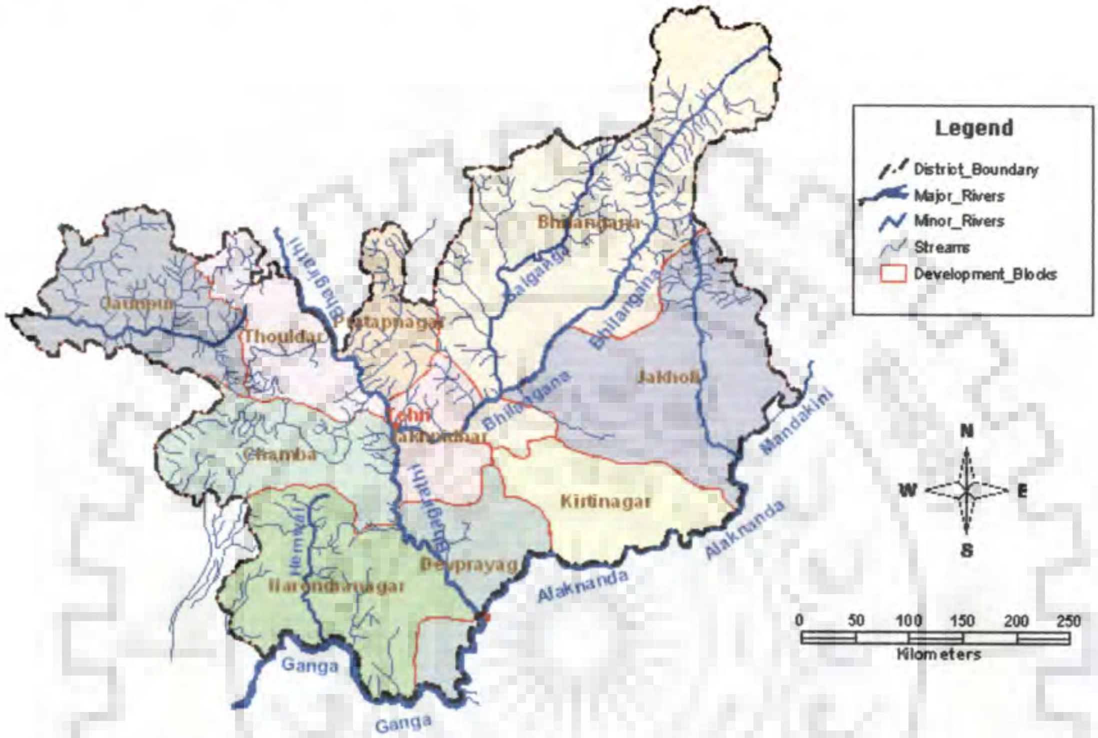


Figure 3.3: River drainage system of Tehri-Garhwal district
Source: Survey of India (1973)

Climate: As is generally observed in most parts of the Himalayas, the climate of the district too is locale-specific, and characterized by the area's elevation, aspect and proximity to factors like snow peaks, glaciers, forests, ridges etc. Climate of the district ranges from very hot in the valleys to very cold in the high mountains providing a range of climatic conditions. There are three main seasons: summer, monsoon and winter. However, as distinct from the climate in the plains, the summers here are short and less severe, the monsoons have high precipitation and the winters are colder and prolonged. The rainfall too varies and the general trend there is more rain on the ridges than in the valleys. The amount increases with altitude but only up to a point beyond which it begins to decrease again, the maximum being recorded in 1200-1300m. altitude zone. Devprayag (450m) gets about 102 cm. on the other hand, south facing ridges such as Narendranagar (1080m) with 318 cm and Pratapnagar (1800m) getting 242cm. receive higher precipitation annually. The average rainfall in the entire district is 94 cm. (Survey of India, 1965a; IMD, 1999).

3.2.4 Natural Resources:

The region has not been endowed with mineral resources of any significant value, as compared to the rest of the Himalayan ranges. Only limestone, gypsum and phosphorite are mined in the district.The large-scale network of waterways offers immense potential for generation of hydel power. The wealth of district's forests (63% of the total area) has also burdened the district with the responsibility of protecting it from further depletion. Decades of ruthless exploitation of forests, the most important environmental resources of the Himalayan region, for over a century had rendered the mountains barren and triggered off a chain of adverse environmental impacts. The region also offers the potential for the growth of high-altitude, high value horticulture and floricultural crops, and medical plants. The high altitude alpine pasturelands offer scope for the development of animal husbandry. The high quality wool and the rich traditional weaving skills of the inhabitants can also be exploited. (RHUDO and USAID 1994)

3.3 ADMINISTRATIVE SET-UP OF TEHRI GARHWAL DISTRICT

The headquarters of Tehri Garhwal district is at New Tehri Township. At district level the District Magistrate is the highest functionary. The local administration's tasks may be broadly classified as Revenue, Development, Law and Order.

The organization at sub – district level is varied. The revenue division range from the *tehsils* to *gram panchayats*, which have sub – divisional Magistrates, *Tehsildars, Naik*

Tehsildars and *Patwaris* involved in maintaining land records and in collection of revenue, if any. The district is sub divided in to development blocks for development administration. Tehri Garhwal district consists of 5 *tehsils*, 9 blocks, 762 *Gram Panchayats* and 1,814 populated villages, as per statistics published on March 2002 (Government of Uttarancha, 2002) (Table 3.1; Figure 3.5). Each development block is administered by a Block Development Officer. This executive network extends to the Village Development Officer too.

Besides there are six towns in the urban area category viz. Tehri, Narendranagar, Muni-ki-reti, Devprayag, Chamba, and Kirtinagar with a total population of 33,849 (Government of Uttaranchal, 2002). Out of these Narendranagar and Muni-ki-reti have *Nagar Palika Parishad* while Devprayag, Chamba and Kirtinagar have *Nagar Panchayats*.

Table 3.1 Administrative divisions of Tehri Garhwal district

District	Tehsil	Block	Number of Villages
Tehri-Garhwal	Tehri	Chamba	220
		Jaunpur	259
		Thouldar	171
	Pratapnagar	Pratapnagar	122
		Jakhnidhar	151
	Ghansali	Bhilangana	268
	Devprayag	Devprayag	256
		Kirtinagar	154
	Naendranagar	Narendranagar	213
Total	5 Tehsils	9 Blocks	1,814 Villages

Source: Government of Uttaranchal (2002)

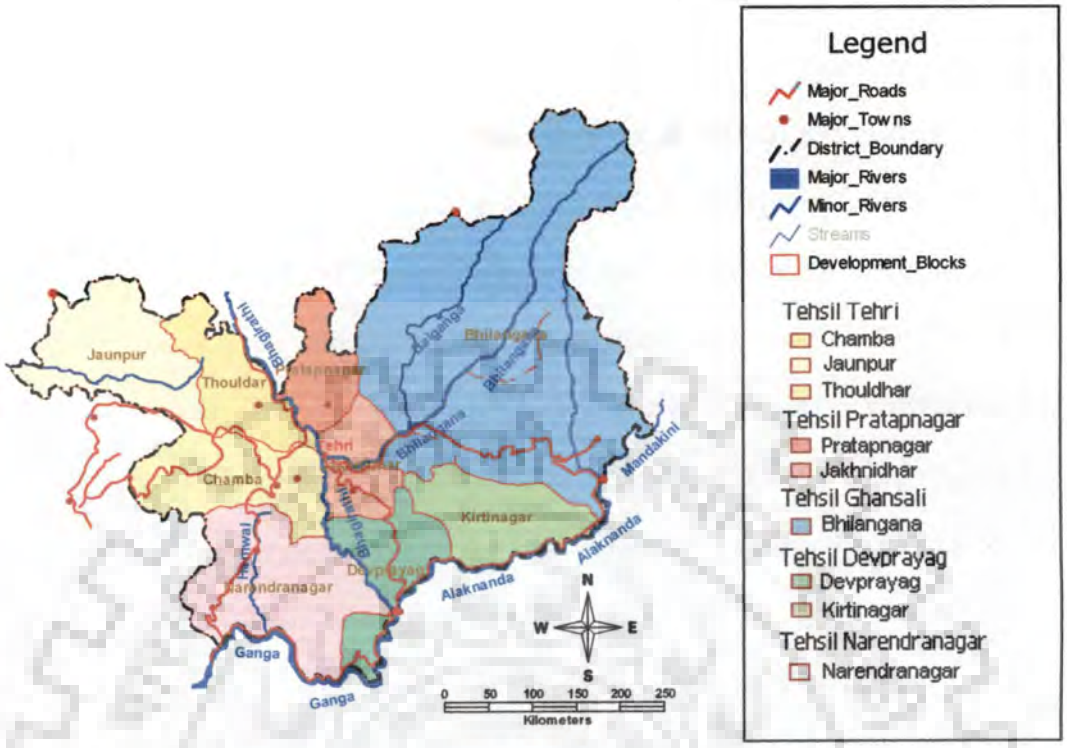


Figure 3.4: Administrative divisions of Tehri-Garhwal District
(after: Government of Uttaranchal, 2002)

3.4 LAND USE OF TEHRI GARHWAL DISTRICT

The hilly terrain of the district has total reported area of 545240 ha. A major percentage of total reported area of Tehri Garhwal district (almost 67.5%) is occupied by forest cover. The other land uses are given in Table 3.2.

It is seen that only the area under forest cover and the irrigated land show decreasing trend whereas all other land uses are showing an increasing trend. The rapidly decreasing forest area showing a loss of 29302 Hectares of forest cover, from the total district area, just within a span of 3 years is indeed a matter of concern, as it leads to environmental imbalance causing landslides and other hazards.

Table 3.2: Landuse of Tehri-Garhwal district

Land - Use	1997 - 98		1998 - 99		1999 - 2000	
	Area	(%)	Area	(%)	Area	(%)
Forest Area	397199	69.13	397199	69.13	367897	67.47
Non-Irrigated	74362	12.94	77013	13.40	78515	14.40
Irrigated Land	67692	11.78	63783	11.10	61569	11.29
Fallow Land	8627	1.50	8934	1.55	9108	1.67
Barren Land	12482	2.17	12927	2.25	13179	2.42
Grazing Land	2911	0.51	3015	0.52	3074	0.56
Gardens and Orchids	23	0.00	24	0.00	24	0.00
Other Uses	11246	1.96	11647	2.03	11874	2.18
Total	574542	100	574542	100.00	545240	100.00

Source: Government of Uttaranchal (2002)

3.5 DEMOGRAPHIC CONDITIONS OF TEHRI-GARHWAL DISTRICT

Tehri Garhwal district has a total population of 604608 (Census of India, 2001) distributed in nine development blocks. The demographic conditions of the district indicate the human development of the region. The important indicators of the demography viz. population growth, age - sex distribution, religion, cast structure, languages spoken, occupation structure and literacy levels are discussed in this section.

3.5.1 Population Growth

The decadal population growth rate of Tehri Garhwal during 1991-2001 was 16.15%. This is much lower than National average of 21.34 percent and Uttarakhand state (19.20%) (Census of India, 2001). It is also lower than the average pop density of adjoining Himalayan state of Himachal Pradesh which is 17.53%. Over the century, the decadal increase in population has swung from a low of 4 percent (1941-51) to a high of 25 percent (1971-81). However, the rural population displayed a very lower growth of merely 2.12 % during 1991. The reason for this may be the increasing migration of rural population. (Government of Uttaranchal, 2002).

3.5.2 Urban – Rural Percentage

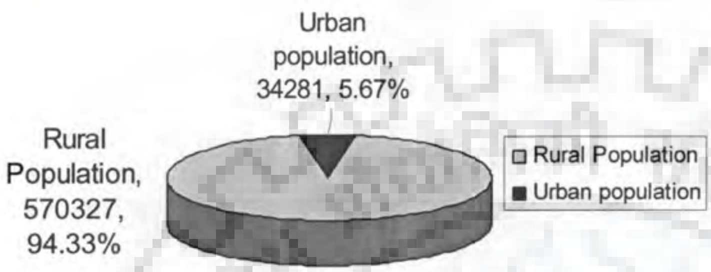


Figure 3.5: Percentage of urban and rural population in Tehri Garhwal district
(after: Government of Uttaranchal, 2002).

A significant 94.33 percent of total district population is rural while merely 5.67 percent is urban (Figure 3.5) (Government of Uttaranchal, 2002). This illustrates the dominance of primary sector economy in the Himalayan region.

3.5.3 Population Density within Tehri Garhwal District

The density of population in district is low with 148 persons per sq. k.m. It is lower than that of Uttarakhand state which is 159 persons per sq.km. and much lower than the national average density of 324 persons per sq.km. However, this population density is higher than that of the adjoining Himalayan state of Himachal Pradesh, which is 109 persons per sq. km. (Census of India, 2001). The population densities of different blocks of district are given in Table 3.3. It is seen that the

Table 3.3: Population densities in 9 development blocks of Tehri-Garhwal district

Block	Pop Density (Persons /sq. k.m.)
Chamba	118.01
Jaunpur	103.79
Thouldar	210.82
Pratapnagar	228.79
Jakhnidhar	192.00
Bhilangana	72.63
Devprayag	117.47
Kirtinagar	225.82
Narendranagar	251.39

Source: Government of Uttaranchal (2002)

Narendranagar block is the most densely populated block owing to its close proximity to plains and important cities like Rishikesh and Dehradun. Also, the presence of bigger settlements viz. Muni-ki-reti, Dhalwala and Tapowan makes the block most densely populated. On the other hand, Bhilangana block occupying the opposite extreme location in the district with reference to Narendranagar block shows the least population density. The difficult topographic conditions with high altitudes and steep slopes contribute for the same.

3.5.4 Male – Female Ratios

Male Female ratio is very significant in the district. The district has 1057 females per 1000 males, which is significantly high as compared to the national figure of 933 females per 1000 males and the Uttarakhand state with 964 females per 1000 males (Government of Uttaranchal 2002). This ratio becomes more interesting if looked at the urban and rural male female ratio. In rural areas the district has 1097 females per 1000 males, whereas in urban areas the district has merely 563 females per 1000 males (Table 3.4). This is indicative of the migration of the male population to the urban centers of the region in search of jobs.

Table 3.4: Male female ratio of urban and rural population of Tehri Garhwal district

Area	Total Population	Male Pop	Female Pop	Female Pop per 1000 Males
Rural	5,47,258	2,60,889	2,86,369	1097
Urban	32,895	21,045	11,850	563
Total	5,80,153	281934	298219	1057

Source: Government of Uttaranchal (2002)

3.5.5 Age Profile

The age profile of the district population shows that almost half the total population is under the age of 19. Table 3.5 shows the age and sex distribution of the district population including urban and rural areas. It can be noted that there are more males in the population under age 19 than females in the districts. However above age 19 the number of females is higher than males. The difference again reduces above the age of 50. This is because a significant number of men folk in the working age group particularly from rural areas have migrated outside the district for jobs. As a result the womenfolk has to take the responsibility of the primary production activities like cultivation, livestock etc.

Table 3.5: Age and sex distribution of population

Age Group	Male Population		Female Population	
	Number	Percentage	Number	Percentage
00 to 04	37900	6.53	36320	6.26
05 to 09	40721	7.02	40453	6.97
10 to 14	37250	6.42	36910	6.36
15 to 19	29050	5.01	28726	4.95
20 - 24	20675	3.56	27611	4.76
25 - 29	18761	3.23	22184	3.82
30 to 34	15390	2.65	18232	3.14
35 tp 39	14220	2.45	16984	2.93
40 to 44	13161	2.27	14814	2.55
45 to 49	11147	1.92	12220	2.11
50 to 54	11590	2.00	11920	2.05
55 to 59	8767	1.51	8010	1.38
>= 60	23302	4.02	23835	4.11
All Ages	281934	48.60	298219	51.40

Source: Government of Uttaranchal (2002)

3.5.6 Religion, Caste Structure and Languages Spoken

The most predominant religion in the district is Hindu with a share of 99% of total population. Although rare but the other religions seen in the district, are Muslim, Sikh, Christian, Jain, Buddhism and others (Table 3.6).

The percentage of scheduled caste population in the district has remained fairly constant for years 1971 to 1991 with 13.97% for the year 1991. However, the percentage of schedule tribe population although very low, has shown sudden decrease in the year 1981 and then sudden rise again in the year 1991 (See Table 3.7).

A very high percentage of district population i.e. 98.81 % uses Hindi language for communication, whereas the rest 1.19 % population also speaks other languages like Urdu, Punjabi, Bengali etc.

Table 3.6: Religions in Tehri Garhwal district

Religion	Population			Percentage in total Population
	Total	Rural	Urban	
Hindu	574330	543464	30866	99
Muslim	4818	3386	1432	0.83
Christian	285	165	120	0.05
Sikh	412	83	329	0.07
Buddhism	70	45	25	0.01
Jain	139	16	123	0.02
Other	99	99	0	0.02
Total	580153	547258	32895	100

Source: Government of Uttaranchal (2002)

Table 3.7: Percentage of scheduled caste and scheduled tribe population in Tehri Garhwal district

Year	Scheduled Caste		Scheduled Tribe	
	Total Pop	% in Total District Pop	Total Pop	% in Total District Pop
1971	52156	13.12	435	0.11
1981	63540	12.76	68	0.01
1991	72674	13.97	608	0.12

Source: Government of Uttaranchal (2002)

3.5.7 Occupational Structure

The occupational structure of the district shows that agriculture is the most predominant occupation with almost 70% workers involved in agricultural activities (Table 3.8). The off-farm employment has been largely confined to wage employment on construction, road maintenance etc. another significant source of employment during May-October has been the provision of services to pilgrims / tourists.

Table 3.8: Occupational structure of Tehri Garhwal district

Workers	Occupation	Numbers	% with Total Workers
Main Workers	Farming	161464	68.54
	Farm labour	1950	0.83
	Animal Husbandary / Forestry	2770	1.18
	Mining	106	0.04
	Household Industry	549	0.23
	Non-Household Industry	2532	1.07
	Construction	9415	4.00
	Business and Commerse	6055	2.57
	Transportation and Communication	2451	1.04
	Other	21333	9.06
	Total	208625	88.56
Marginal Workers		26938	11.44
Total Workers		235563	100.00

Source: Government of Uttaranchal (2002)

3.5.8 Literacy

A total of 48.47% population of Tehri Garhwal district is literate. The percentage of literate males is 72.06%, while that of literate females is 26.34% (Census of India, 2001). This ratio is lower than the national average which shows 64.8% total literacy rate, with 75.3% male literacy and 53.7% Female literacy (Census of India, 2001). This shows that on account of significant role women have to play in farm and household activities they loose the opportunity to get educated.

3.6 SETTLEMENT SIZE

The average population size of villages is very low because the hilly terrain is not conducive for the formation of very large settlements. Table 3.9 gives number of villages with different population ranges for the years 1971, 1981 and 1991 which shows that there is an increase in the number of villages with larger populations, while the number of small villages is decreasing because of population growth. The reduction in the total number of villages between 1971 and 1991 can be explained by the empirical fact that in many instances, two or three villages merged to become a large village.

Table 3.9: Number of villages classified on the basis of total populations for the years 1971, 1981 and 1991 in Tehri Garhwal District

Population Range	1971	1981	1991
Less than 200	1214	1008	876
200 – 499	642	754	671
500 – 999	97	167	212
1000 – 1499	5	24	23
1500 – 1999	-	-	8
2000 – 4999	-	-	-
5000 and more	-	-	1
Total	1958	1953	1791

Source: Government of Uttaranchal (2002)

The existence of half the number of settlements having a population less than 200, makes provision of basic infrastructure unviable.

3.7 INFRASTRUCTURE DEVELOPMENT IN TEHRI GARHWAL DISTRICT

The physical and social infrastructural facilities in the district indicate the overall development of the region. The Himalayan settlements, on account of their isolated nature, face inadequacy of such facilities as contrast with the plain regions. The statistics regarding existing cumulative quantities of infrastructural facilities published by the state government are insufficient because of lack of consideration of distance between the facilities and settlements. Such studies are provided for the Narendranagar block selected for detailed investigations and proposals in the consecutive sections.

3.7.1 Health Facilities

The cumulative numbers of health related facilities available in the Tehri Garhwal district for the year 2001-02 are as given in Table 3.10.

Table 3.10: Health facilities in Tehri Garhwal district

Allopathic Health Services		
	Number of Allopathic Hospitals / Dispensaries	45
	Number of Primary Health Care Centers	25
	Number of Family Welfare Centers	25
	Number of Family Welfare Sub Centers	128
	Total Number of Beds	338
	Total Number of Doctors	63
	Total Number of Paramedical Staff	404
	Total Number of Other Staff	363
	Number of Allopathic hospitals / dispensaries and PHCs per one lakh population	11.72
	Number of beds in Allopathic hospitals / dispensaries and PHCs per one lakh population	46.06
Ayurvedic / Homeopathic / Yunani Health Services		
	Number of Hospitals / Dispensaries	67
	Number of Beds	102
	Number of Doctors	50

(Government of Uttaranchal, 2002)

3.7.2 Education

As per the statistics for the year 2001-02 the number of government approved educational facilities in the Tehri Garhwal district are: 1457 Junior Basic Schools, 394 Senior Basic Schools, 180 Higher Secondary Schools and 10 Inter Colleges. A total 176108 students study in school from class 1 to 12, while 3311 students study in colleges. These figures reveal that about 90% of the school / inter college going population is enrolled to study. Total school teachers are 6383, while total college teachers are 81. Number of Junior Basic Schools per 1 lakh population are 288.47. Number of Senior Basic Schools per 1 lakh population is 78.13. Number of Higher Secondary Schools per 1 lakh population is 33.93. (Government of Uttaranchal, 2002)

3.7.3 Roads

In the district the different types of roads which exist and their total lengths are: National Highways (211 kms.), State Highways (74.31 kms.), Main District Roads (136.65 kms.), Other District Roads (136.65 kms.) and Rural Motorable Roads (74.35 kms.) (PWD, 2004). The accessibility provided by the roads to the villages of Tehri Garhwal is given in Table 3.11, which indicates that, almost one third of the villages i.e. 603 villages (33.25%) are located beyond 5 kms from roads. These are usually small villages and so the analysis of populations with different accessibility conditions becomes important. Such detailed studies are given for Narendranagar block.

Table 3.11: Distance of villages of Tehri Garhwal district from roads

Distance of Villages from Roads	Number of Villages	Percentage
0 to 1 km	502	27.65
1 to 3 kms	374	20.63
3 to 5 kms	335	18.47
> 5 kms	603	33.25

Source: PWD (2004)

3.7.4 Electricity, Water Supply and Other

A total of 84.49% villages out of total populated villages of Tehri Garhwal district are electrified as per 2000-01 data. Total number of villages with water supply through taps / hand-pumps is 1758. Total population supplied with water is 490997. District has total 10377 telephone connections and 261 PCOs. District has 990 fair price shops and 6 police stations. (Government of Uttaranchal, 2002)

3.8 DISASTERS IN TEHRI GARHWAL DISTRICT

The district on account of its topographical conditions is vulnerable to a variety of natural and man made disasters (Government of Uttaranchal, 2006). The common natural disasters are earthquakes, landslides, floods, droughts and cloud bursts whereas, the man made disasters are the frequent road accidents in the hilly terrain (DMMC, 2003a). The district lies on the seismic zone V and IV, the first two most vulnerable zones identified on Seismic zoning map of India (BIS: 1893-2002). The brittle Garhwal rocks are more prone for landslides, which are a common feature during rains (NCDM, 2001a and Valdiya, 2002). The various major and minor rivers in the district experience frequent floods and the settlements on higher altitudes face acute shortage of drinking water and fodder especially during summers (Uttaranchal Water Institute, 2004). Table 3.12 gives chronological list of various natural disasters faced by the district in the past twenty years.

Table 3.12: Chronology of disasters faced by Tehri Garhwal district in the past twenty years

Year	Types of Disaster	Brief Description of Losses
1987-88	Drought	Agriculture and horticulture got affected and lack of drinking water and fodder resulted in serious situations
1991 (Oct 20)	Earthquake	63 people and 71 cattle died and 70,000 buildings got totally or partially damaged
1998	Cloud Burst, Landslides	Human casualties and damage to agriculture and buildings
1998 (Oct 16, 17)	Floods in Aglad and Hemwal River	Loss to irrigated agricultural land, human losses, cattle loss and damage to buildings
1999 (March 28-29)	Earthquake	5 people died and 72 injured. 18 cattle died and 70,100 buildings got totally or partially damaged
2000-01	Drought	Loss to agriculture and acute shortage of drinking water and fodder
2001 (Aug)	Landslides	Due to cloud burst and landslides 7 people lost their lives and 10 killed, 11 buildings were totally collapsed and 10 partially collapsed. There was significant loss of cattles.
2002	Drought	Agricultural loss of 50% to 95% in six blocks and less than 50% in three blocks.
2002	Excess rains, Cloud Bursts, Landslides	Serious loss to agriculture, 38 buildings totally collapsed and 151 were partially damaged. 28 people lost their lives and 28 got injured. Total 99 cattle died.

Source: DMMC (2003a)

3.9 INTRODUCTION TO NARENDRANAGAR BLOCK

Narendranagar block of Tehri Garhwal district in Himalayas is chosen for micro level studies due to several reasons. These are: (i) It lies in seismic zone IV, that is the second most vulnerable of all zones identified on Seismic zoning map of India (BIS: 1893-2002). (ii) Earthquakes of damage potential more than MSK VIII and accelerations of 0.25g can be expected in this region. (iii) Narendranagar block lies within the most vulnerable zone on the seismic micro-zoning map (Sinvhal et.al. 1990, 1991) and is prone to earthquake effects like landslides, ground fissures, damage to human settlements, casualties and injuries (DMMC, 2003). (iv) Narendranagar block has the highest population density in this hilly district. A population of 1,03,032 is spread in 214 villages and 17 market towns (Government of Uttaranchal, 2002). (v) The close proximity of Narendranagar block to IIT Roorkee, a distance of about 90 kms, makes it approachable, which gives an additional advantage in frequent field visits for collection of data.

3.10 SURVEY OF NARENDRANAGAR BLOCK

An important recommendation made by Murshed (2006) for improved emergency response in the Himalayas is documentation of communities and storage of such information at the local, provincial and national levels in order to create redundancy, and making it available through internet if possible. In absence of such documentation, the information for the research work is collected through primary and secondary surveys about the vulnerability of settlements due to physical and social conditions and resource potential available in the settlements in terms of infrastructure, institutional setup, manpower availability and material supplies. Thus, the results of survey give a complete picture of vulnerability and disaster preparedness situations prevailing in Narendranagar block at grass root level.

3.10.1 Collection of Secondary data

The entire Narendranagar block is covered by Survey of India topographic sheet number 53J on scale 1:250,000. Further details of Narendranagar block are available on topographic sheets 53 J 7, 8, 11 and 12 on 1:50,000 scale.

A secondary survey was carried out for procuring information about Narendranagar block. All relevant offices, facilities and other agencies from Narendranagar (Block Functional headquarter), Fakot (Block Administrative Headquarter), Tehri (District Headquarter) and Dehradun (State Capital) were extensively visited from January to June 2004.

Interactive sessions were held with the village development officers during monthly meetings at the block headquarters for earthquake awareness generation. A village information questionnaire was developed and its copies in Hindi language were distributed to Village Development Officers during February 2004. The filled questionnaires were collected back during the next monthly meeting (***Annexure V***). The information about all villages was thus procured which although showed many shortcomings due to incomplete filling of questionnaires by many officers, provided important grass root level information.

Other information was collected in the form of records, technical and official reports, books, special publications, lists, abstracts from interviews with officials etc. All this collected information was analyzed, tabulated and stored village wise in MS Excel software.

3.10.2 Pilot Survey of Narendranagar Block

Pilot survey was carried out with the objective of collecting primary data to fill the gap in secondary data and for cross checking the accuracy of secondary data. Total ten sample villages were selected on the basis of their total population; accessibility from road and altitude. The selected villages were Kodarna, Malas, Maun, Berni badi, Pokhri, Loyal, Jamola, Kharsad, Timli and Tapovan as shown in Figure 3.6.

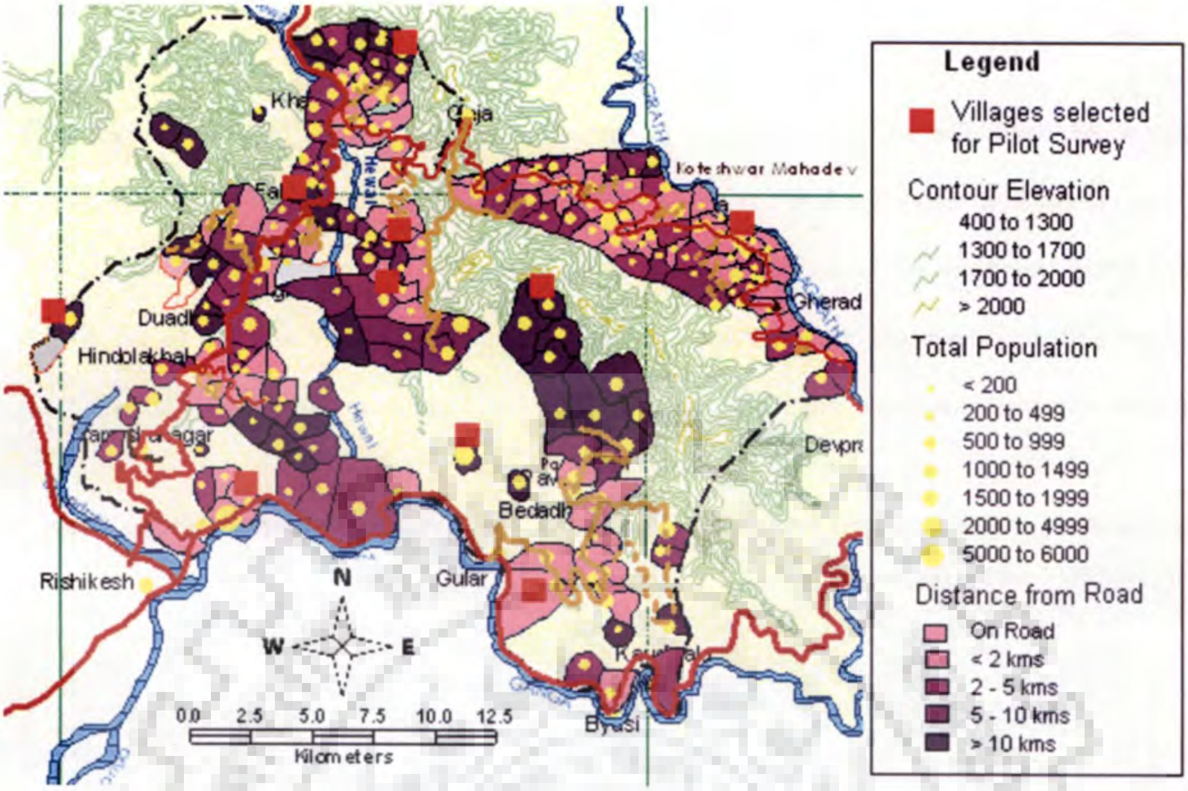


Figure 3.6: Villages selected for pilot survey

The procedure adopted for selection of villages on the basis of three criteria is given below:

1. **Total Population:** The villages of Narendranagar block have low populations ranging from 20 to 2350. All these villages are categorized into five different population groups. The categories of the population groups, number villages in those categories and the villages selected from those categories are given in Table 3.13.

2. **Accessibility from road:** The villages of Narendranagar block are located at distance of 0 to 24 kms from all weather metal roads. Many villages can be approached by katchha motorable tracks which usually become unusable during rainy seasons. Jeeps and mules move on these roads during summer and winter seasons. Beyond the motorable stretches of these roads, the villages are approached on foot by walking from 1 to 6 kms. The settlement accessibility is a crucial factor in post disaster operations. Hence these villages are categorized into five different accessibility conditions as given in Table 3.13.

3. **Altitude:** The altitude of villages in Narendranagar block range from 350 meters to 1800 meters from mean sea level. Altitude affects the micro climatic conditions, agriculture and living conditions of the residents. Altitude also affects the intensity of earthquake where higher altitude villages experience greater damage than the lower altitude villages. Hence, five altitude categories are made which are shown in Table 3.13 along with number of villages.

Table 3.13: Villages selected for pilot survey on the basis of total population, road accessibility and altitude

	Category		Number of Villages	Names of selected villages
Total Population	I	Less than 200	98	Malas, Pokhri
	II	200 – 400	73	Berni badi, Jamola
	III	400 – 700	29	Kodarna, Kharsad
	IV	700 – 1000	9	Loyal, Maun
	V	More than 1000	5	Tapovan, Timli
Total			214	10
Road Accessibility	I	On road	44	Tapowan, Loyal
	II	Less than 2 kms	63	Malas, Kharsad
	III	2 – 5 kms	59	Berni badi, Maun
	IV	5 – 10 kms	29	Kodarna, Timli
	V	More than 10 kms	19	Pukhri, Jamola
Total			214	10
Altitude	I	Less than 800	30	Tapowan, Kharsad
	II	800 – 1100 m	45	Berni badi,
	III	1100 – 1200 m	39	Kodarna, Timli
	IV	1200 – 1400 m	64	Pokhri, Jamola Loyal
	V	More than 1400 m	36	Malas Maun
Total			214	10

(after: Census of India, 2001; PWD, 2004; Survey of India, 1965a, 1965b, 1967a, 1967b)

The pilot survey underlined many discrepancies of available secondary data with actual ground conditions. Some of them are mentioned below:

- There were differences in the locations of few rural roads and connected villages as mentioned in the Public Works Department maps and hence the maps were corrected. In the narrow, hilly rural roads, if a wrong road is taken, there is no space for turning back and one has to go as far as 10 -15 kms to find place for turning back. This situation can adversely affect the relief operations.
- At many places the condition of the so-called motorable roads was so bad that it was not possible to move on those roads by car or by motorcycle. The narrow road width was completely covered with loose stones. Only one or two jeeps moved on those roads per day.
- The medical facility available in some villages is non operational because of non availability of doctors, medicines or any other facility. The villagers have to walk as far as 10 to 15 kms in hills to avail any kind of medical facility.

3.10.3 Comprehensive Primary Survey of Narendranagar Block

The most important observation of the pilot survey is that, the accessibility condition of villages is the most influential factor on the construction technology seen in those villages. Hence accessibility conditions of the villages were categorized for the study of construction technology. The hierarchy of roads seen in the block is:

1. National Highways (Rishikesh – Narendranagar – Tehri - Uttarkashi Road and Rishikesh – Devprayag – Badrinath Road)
2. Other district road (Jajal – Gaja – Devprayag Road)
3. All weather rural roads (vehicular)
4. Fair weather rural roads (vehicular)
5. Pedestrian tracks (cemented)
6. Walk ways

All villages of Narendranagar block can be accessed by one of the above mentioned roads. The villages are categorized for their accessibility conditions as given in Table 3.14.

Table 3.14: Re-categorization of accessibility of villages

Cate-gory	Descrip-tion	Accessibility Condition	No. of Villages	No. of Households	Total Population	Percentage Population
A1	Very good	Villages up to 1 km from National Highway; Villages up to 1 km from other district roads;	58	6215	28,611	40.34
A2	Good	Villages up to 1 km from vehicular all weather and fair weather rural roads	42	1989	11,086	15.65
A3	Mod-erate	Villages situated 1 to 3 km from National highways and Other district road	48	2191	11,282	15.90
A4	Poor	Villages located at 1 to 3 km from vehicular all weather and fair weather rural roads	31	1647	7,811	11.01
A5	Very Poor	More than 3 km from any vehicular road and approached by pedestrian track.	35	2180	12,132	17.10
Total			214	14222	72362	100

(Based on information from PWD, field observations and secondary sources)

Three sample villages are selected from each accessibility category for detailed survey which is given in Table 3.15. The locations of these 15 villages are shown in Figure 3.7.

These 15 villages were surveyed extensively and observations were made regarding various aspects like the construction technology, landslide hazard, social setup, infrastructure, manpower, institutions and material supplies availability etc. Along with the villages, observations were also made in all market towns except Bedadhar and Gheradhar.

Table 3.15: Villages selected for detailed survey

Accessibility Category	A1	A2	A3	A4	A5
Name of Selected Village	Shivpuri	Tamiyar	Soni	Mathiyali	Barathali
	Maroda	Lodsi	Aamsarigaon	Odada	Kyara
	Jimangaon	Rampur	Banali	Mindath	Than

The questionnaire used for primary data collection is given in ***Annexure VI***. Detail village survey reports were made for each village visited. Report on one village 'Odada' is given as ***Annexure VII***.

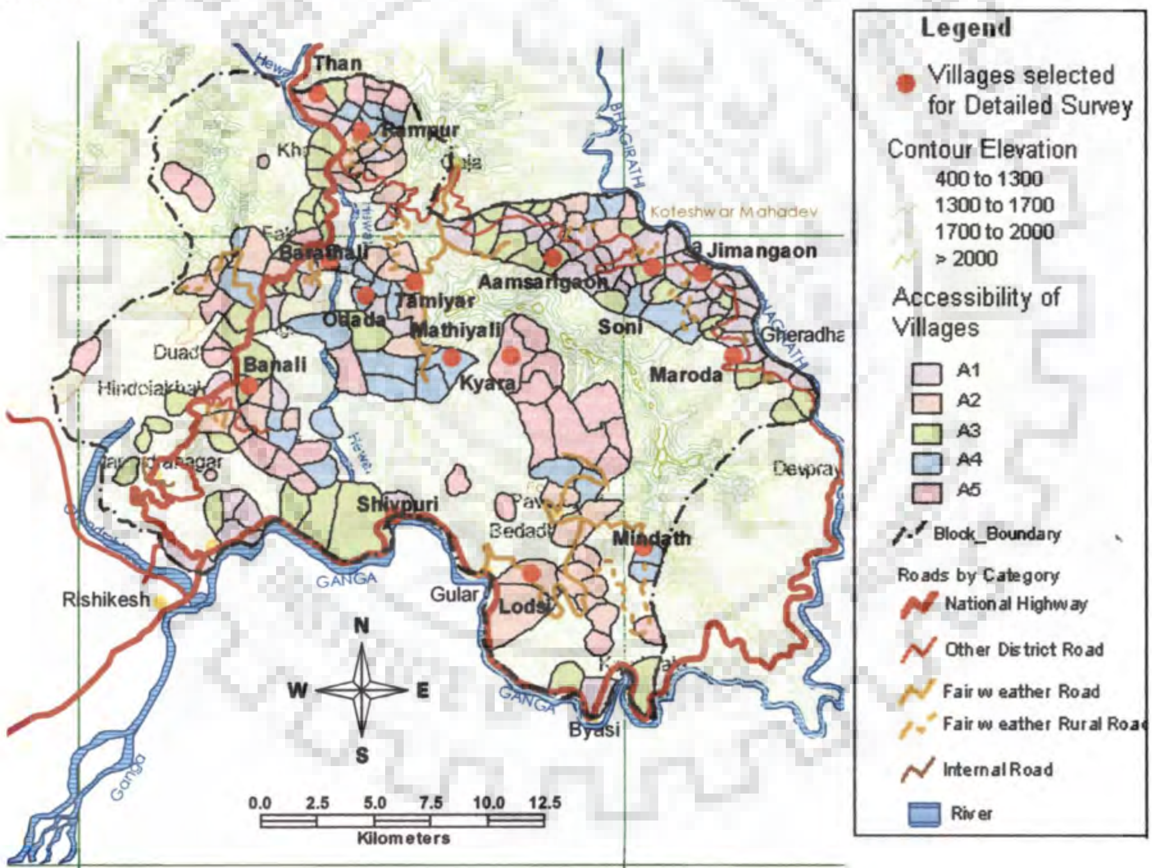


Figure 3.7: Villages selected for detailed survey

3.11 GEOGRAPHICAL SETUP

Villages of Narendranagar block are located on mountains of Garhwal Himalayas. They are generally situated away from roads requiring treks of upto 8 kms. Agriculture is the main occupation. The altitudes of villages vary from the lowest of 380 meters in valleys to 1800 meters on ridges (Figure 3.8; 3.9a; 3.9b). These villages are generally located on comparatively low slope regions for the benefit of terrace farming. However villages situated on steep slopes also exist (Figure 3.9c; 3.9d). The houses within the villages are generally grouped together but in many cases they are scattered or the villages are a combination of grouped and scattered houses (Figure 3.9e; 3.9f). Some villages are composed of smaller villages or hamlets. These hamlets have different names and are situated at distances ranging from 0 to 3 kms from each other. The populations of these hamlets are very low. Hence, for administrative purpose they have been named after the biggest hamlet.

3.11.1 Layout of Villages

The layout of villages is generally defined by the contours on which the village is situated. It is seen in almost all villages that the houses are build in rows along the contours. There is mostly a single road running along the contours providing pedestrian access to all the houses (Figure 3.10a; 3.10b; 3.10d). In very few villages vehicular access is provided to the individual houses. The community facilities of the villages viz. schools, health facilities etc. are mostly located on the access routes where vehicular connectivity is present.

In some villages the residential areas are scattered with houses constructed into groups located away from each other. The reason being houses are constructed as near the farms as possible, whereas in many villages houses are grouped together and also the farms (Figure 3.10c).

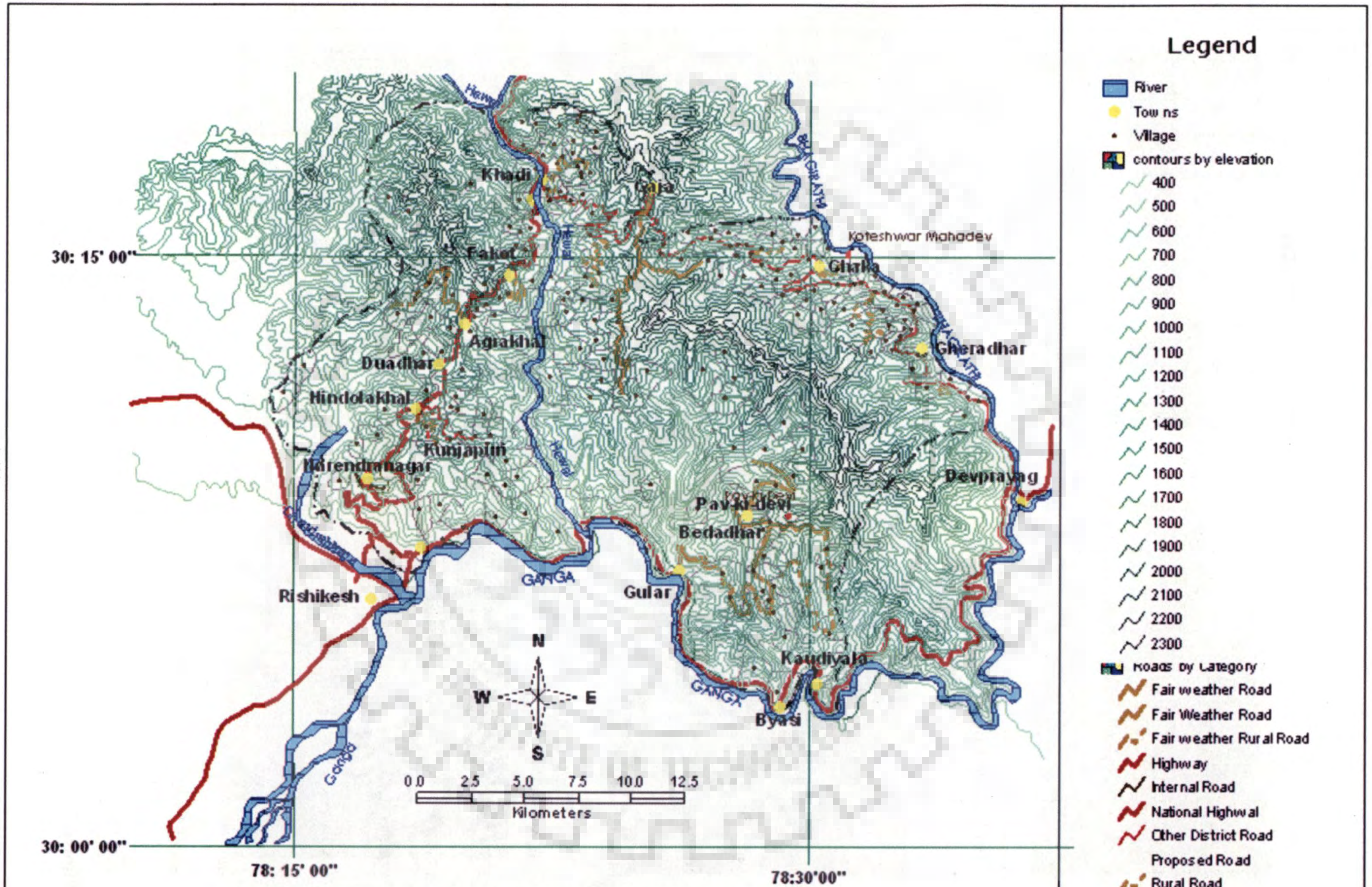


Figure 3.8: Topography of Narendranagar Block

(a) Village Loyal situated on ridge

(b) Village Hadisera situated on the bank of river Hemwal

(c) Village Rampur Occupying very low slope region

(d) Village Malas occupying steep slope

(e) Clustered Houses of Village Odada

(f) Scattered Houses of Village Tamiyar

Figure 3.9: Geographical setup of villages of Narendranagar block

(a) View showing layout of village Kharsad

(b) View showing layout of village Banali

(c) Village Lava with housing grouped together and farms located at one place

(d) View showing layout of village Saundi

Figure 3.10: Typical layout of villages of Narendranagar block

3.11.2 Access to villages

The villages of Narendranagar block can be approached by vehicular roads or by pedestrian paths connecting the vehicular roads to villages which could be situated as far as 10 to 12 kms from any kind of vehicular road. Figure 3.11 shows different types of access to various villages of Narendranagar block.

(a) Village Pokhri situated on a vehicular road

(b) Steep walkway approaching village Malas starting from vehicular road

(c) Village Guriyali accessed by a small steep walkway starting downwards from vehicular road

(d) Village Jamola approached by a long pedestrian path

Figure 3.11: Access to villages of Narendranagar block

3.11.3 SETTLEMENT SIZE

The size of settlements of Narendranagar block shows a similar trend as that of the district. The block has maximum number of villages in the smallest population category owing to the hilly terrain (Figure 3.6; Table 3.16). It is seen that although the number of villages in the least population category is very high, the total population living in all these villages is merely 15.59%. It would be interesting to know that the total population of these 100 villages is nearly equal to the population of single village Dhalwala which occupies the plain area near the city Rishikesh. The names of other big villages with populations more than 1000 and their respective populations are Tapowan (2320), Timli (1566), Mindath 1235, Mathiyali (1055) and Lava (1013).

Table 3.16: Population wise number of villages in Narendranagar block (1991, 2001)

Population Range	1991 (No. of Villages)	2001		
		Number of Villages	Total Population	Percentage of Population
Less than 200	99	100	11279	15.59
200 – 499	83	81	24686	34.11
500 – 999	21	26	17764	24.55
1000 – 1499	4	3	3303	4.56
1500 – 1999	-	1	1566	2.16
2000 – 4999	-	1	2320	3.21
5000 and more	1	1	11444	15.81
Total	208	213	72362	100

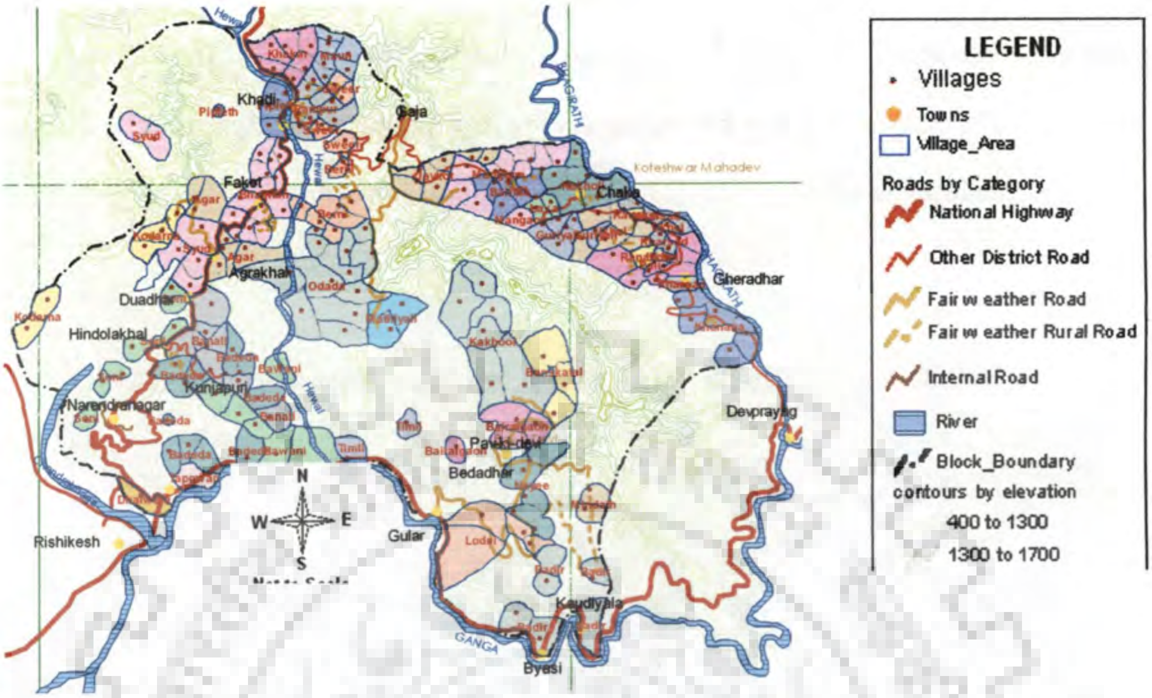
Source: Government of Uttaranchal (2002)

3.12 ADMINISTRATIVE SUB-DIVISIONS OF NARENDRANAGAR BLOCK

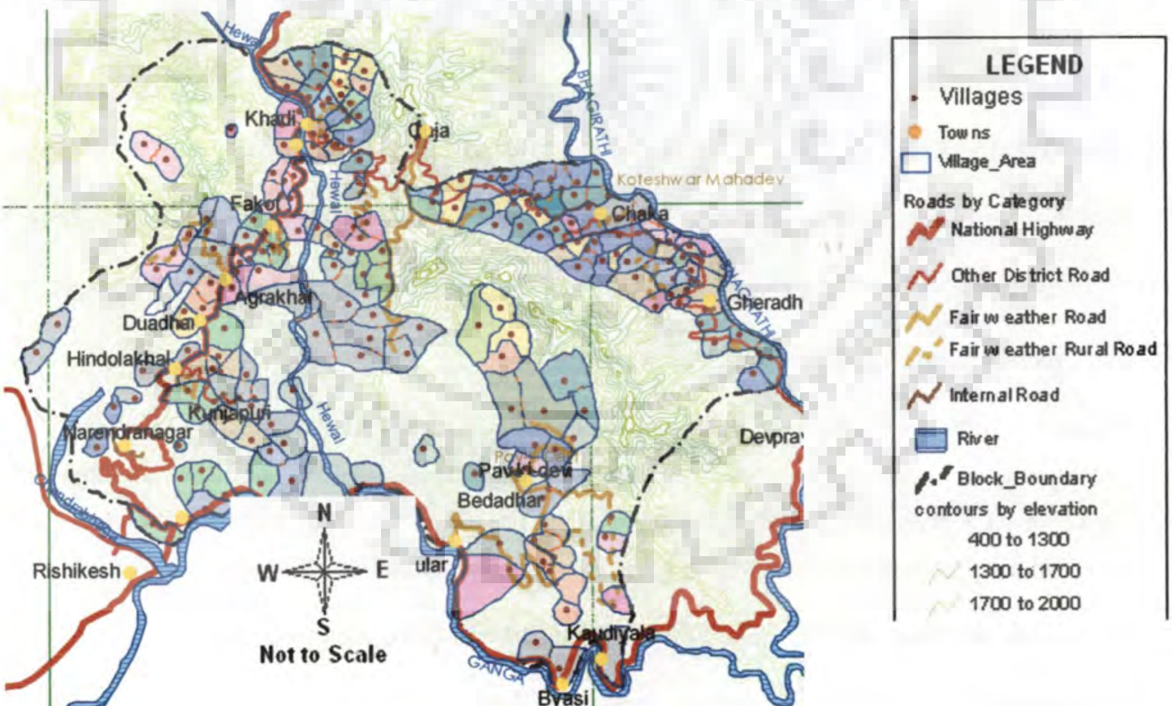
Narendranagar block is subdivided into 37 Kshetra Panchayats which are further divided into 103 Gram Panchayats formed out of 214 villages (Figure 3.12a; b). There are total 17 market towns. According to RHUDO and USAID (1994)

> 'A market town is a census town or a nodal village (Rural Central Place) having (1) a minimum of 20 perennial commercial establishments for trade (functional units), (2) not less than three government offices and (3) serving a dependent population of at least 2000 excluding its own.'

The 17 market towns are Narendranagar, Muni-ki-reti, Duadhar, Bedadhar, Hindolakhal, Fakot, Agrakhal, Jajal, Khadi, Gaja, Gular, Chaka, Pav-ki-devi, Kunjapuri, Gheradhar, Byasi and Kaudiyala. The detailed information about all Kshetra Panchayats, Gram Sabhas, Villages, Market towns in Narendranagar block and their populations are given in ***Annexure IV***. The spatial Locations of all villages of Narendranagar block are shown in Figure 3.13.



(a) 37 Kshetra Panchayats of Narendranagar Block



(b) 103 Gram Panchayats of Narendranagar Block

Figure 3.12: Administrative sub divisions of Narendranagar block

3.13 LANDUSE-PATTERN

Narendranagar block has a total reported area of 76123 hectares in which a major percentage (66.56%) is occupied by forest cover. The other land uses are given in Table 3.17 which shows that the block displays a higher level of agricultural activity as compared to the rest of the district. This is because of better proximity to major rivers like Ganga and Bhagirathi and minor river Hemwal and absence of very high altitudes and steep slopes like Bhilangana block.

Table 3.17: Land-use of Narendranagar block

Land - Use	1997 - 98		1999-2000	
	Area (Hectares)	(%)	Area (Hectares)	(%)
Forest Area	50669	66.56	50111.8	65.83
Non-Irrigated	12726	16.72	12583.1	16.53
Irrigated Land	7497	9.85	7414.38	9.74
Fallow Land	1571	2.06	1552.91	2.04
Barren Land	2160	2.84	2139.06	2.81
Grazing Land	590	0.78	586.147	0.77
Gardens and Orchids	4	0.01	7.6123	0.01
Other Uses	1751	2.30	1727.99	2.27
Total	76123	100	76123	100

Source: Government of Uttaranchal (2002)

3.14 DEMOGRAPHIC PROFILE OF NARENDRANAGAR BLOCK

People of villages are adapted to hard lives since they are settled in remote locations with very less facilities available. Mules are the most efficient modes of transport and used for carrying goods to the villages. Agriculture and cultivation are the main occupations of the villagers.

3.14.1 Population Growth and Density

The rural population of Narendranagar block has shown a drastic increase of 26.45 % during 1991, which was against the district average of mere 2.12%. This rise was highest in all nine development blocks, the second highest being Pratapnagar with 15.23%. The reasons for this fact could be the proximity of Narendranagar block to plains, better accessibility of villages as compared to other blocks, less difficult terrains and better agricultural activities as compared to rest of the district. Narendranagar block has the highest population density (251.39 persons / sq. km) among the nine development blocks of the district (Table).

3.14.2 Urban Rural Ratio

In Narendranagar block only Narendranagar Town and Muni-ki-reti town fall under urban area category, whereas all other 15 identified market towns fall under rural settlements category. Considering this a population of 13184 staying in Narendranagar and Muni-ki-reti which forms 12.8% of total block population is urban, while the remaining population of 89848 which is 87.2% of total block population is rural. This percentage of urban population is considerably high as compared to district average which is 5.67%.

3.14.3 Literacy Level

Total 47.81% population of Narendranagar block is literate (Census of India, 2001). The percentage of literate males is 71.83 %, while that of literate females is 25.38 %. This shows that women in the Narendranagar block are getting lesser opportunities for education as compared to males.

3.14.4 Male Female Ratio

Narendranagar block also follows the same trend of male female ratio as the district. The block has 1012 females per 1000 males which is lesser than district but still higher than the national average (Government of Uttaranchal 2002; Census of India, 2001). In rural areas the district has 1062 females per 1000 males, whereas in urban areas the district has 725 females per 1000 males (Table 3.18).

Table 3.18: Male female ratio of urban and rural population of Narendranagar block

Area	Male Pop	Female Pop	Female Pop per 1000 Males	Total Population
Rural	43558	46290	1062	89848
Urban	7,640	5,544	725	13,184
Total	51198	51834	1012	103032

Source: Government of Uttaranchal (2002)

3.14.5 Occupational Structure

The occupational structure of the block shows that agriculture is the most predominant occupation with almost 60% workers involved in agricultural activities (Table 3.19). Although the land use displays a higher percentage of land under agricultural use than the district average, but the percentage of workers involved with agricultural activities is considerably lesser than the district average. This indicates greater landholding of the workers in the block. Other remarkable observation is the percentage of marginal workers (almost 18%) which is considerably higher than the district average (11.44%).

Table 3.19: Occupational structure of Narendranagar block

Workers	Occupation	Numbers	% with Total Workers
Main Workers	Farming	16381	60.19
	Farm labour	179	0.66
	Animal Husbandary / Forestry	213	0.78
	Mining	3	0.01
	Household Industry	71	0.26
	Non-Household Industry	932	3.42
	Construction	1133	4.16
	Business and Commerse	708	2.60
	Transportation and Communication	492	1.81
	Other	2232	8.20
	Total	22344	82.10
Marginal Workers		4872	17.90
Total Workers		27216	100.00

Source: Government of Uttaranchal (2002)

3.15 INFRASTRUCTURE DEVELOPMENT IN NARENDRANAGAR BLOCK

The availability of infrastructural facilities in the block forms the important resource potential. A few important indicators of the infrastructural development are given in the Table 3.20.

Table 3.20: Indicators for infrastructural development in Narendranagar block

'Roads	Block	District
Length of vehicular roads per one lakh population (kms)	429.15	366.19
Length of vehicular roads per 1000 sq kms area (kms)	1078.84	482.13
Health Facilities		
Number of Allopathic hospitals / dispensaries and PHCs per one lakh population	8.25	11.72
Number of beds in Allopathic hospitals / dispensaries and PHCs per one lakh population	46.22	46.06
Number of PHCs per one lakh population	4.95	4.52
Education Facilities		
Number of Junior Basic Schools per one lakh population	237.68	288.47
Number of Senior Basic Schools per one lakh population	74.28	78.13
Number of Higher Secondary Schools per one lakh population	31.36	33.93
Bank		
Total Population per Branch of any commercial bank	10098	12470
Fair Price Ration Shops		
Total Number of Fair Price Ration shops in the block	99	990

Source: Government of Uttaranchal (2002)

These development indicators show that the availability of roads in Narendranagar block is much higher than the district average. Whereas, the availability of health facilities is similar to that of the district, educational facilities are much less than the district average. The availability of bank and fair price shops are higher than the other blocks in the district. The consideration of these numbers would be incomplete without the spatial analysis of location of facilities and the distance of settlements from the facilities which is given in next chapter.

3.16 BUILDING CONSTRUCTION TECHNOLOGY AND MATERIALS

In earlier times the building material used in the region were locally available long thick wooden logs, stones, slates and clay (BMTPC, 1992). The judicious use of all these had made those constructions earthquake resistant (Rautela, 2005). These days, all over India, the traditional practice of house construction is being replaced by modern construction practices and technology (Sinvhal and Bose 1995; Bose *et. al*, 2001). This is importantly because of increasing restrictions imposed due to environmental protection. A traditional right to felling of trees has been curbed, which has led to its scarcity, growing demand and increase in price due to these and transportation costs. Quarrying of stone has also met the same fate (Rautela, 2005). Earlier constructions in the area were restricted to single story buildings but with the growing populations two to three story buildings have also been constructed. At places, the old buildings have also been raised to higher stories without altering the foundation and design of the single story building. Preliminary field survey in the block revealed that more than 90% buildings in the block are of residential category. At present the housing units in Narendranagar block are largely low rise stone masonry, load bearing buildings. Various residential buildings existing in Narendranagar block with reference to their materials, construction style and seismic performance during past earthquakes is discussed in the following sections (BMTPC, 1992; GSI, 1992; Jain *et. al.*, 1999; NSET and DEQ, 2000; ISET, 2001). The structural conditions of other categories of buildings particularly institutional buildings are discussed in the next chapter.

3.16.1 Rural Building Typologies

Houses in villages are mostly single storied or double storied, small and simple. The rooms of houses are usually placed in row. All rooms have one external door. In many houses there is no internal connection in the rooms. The open space in front of the rooms is used as a utility space for household works. There are separate sheds for cattle near the house. (Figure 3.14; 3.15; 3.16). Majority of residential buildings are found to be load bearing stone, brick or concrete block masonry. The seismic performance of load bearing masonry structures depend heavily on the structural characteristics (strength, stiffness and ductility) of surrounding walls and diaphragms. They rely on walls to resist in plane and out of plane inertia forces and on the diaphragm (floors and roofs) for resisting the shear forces and to distribute the forces to vertical elements (walls) and maintain the integrity of structure (NSET and DEQ, 2000).

(a) Typical single storied house in Malas

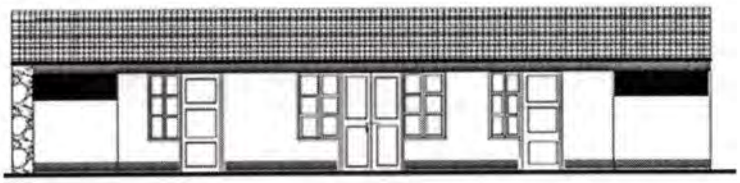
(b) Typical single storied house in Tamiyar

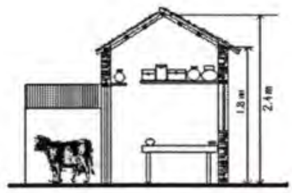
Figure 3.14: Typical Single Storied Houses in Narendranagar Block

(a) Typical double storied house in Maroda

(b) Typical double storied house in Guriyali

Figure 3.15: Typical double storied houses in Narendranagar block





(a)

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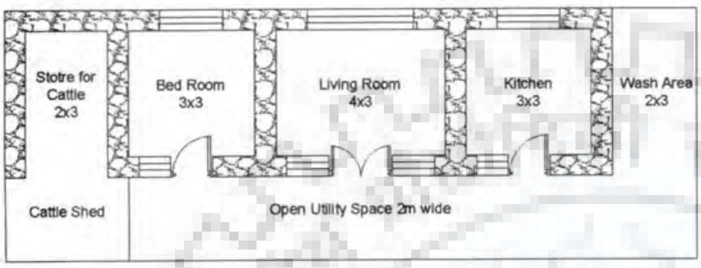

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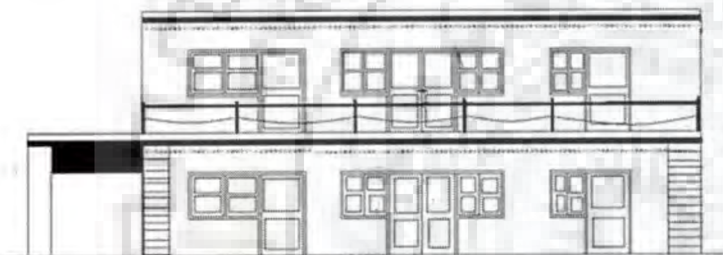

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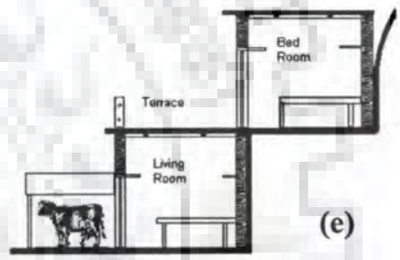

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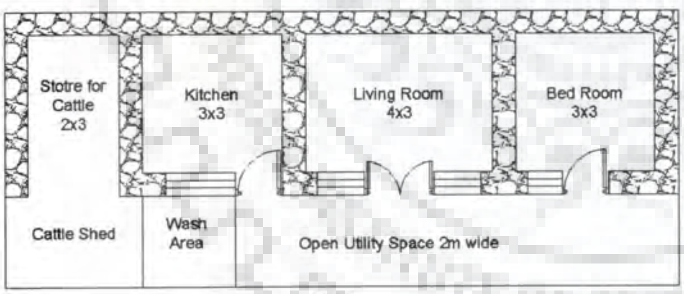

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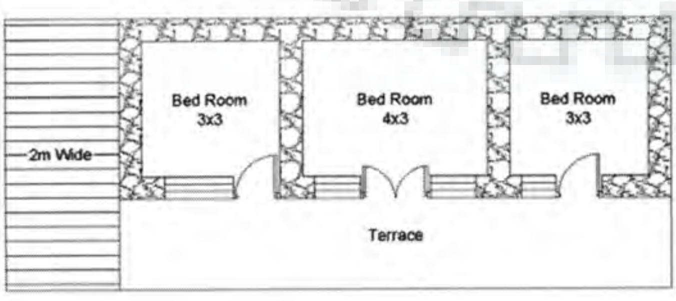


(g)

(Not to Scale)

(a) Front elevation of a typical single storied house

(b) Cross section of a typical single storied house

(c) Plan of a typical single storied house

(d) Front elevation of a typical double storied house

(e) Cross section of a typical double storied house

(f) Ground floor plan of a typical double storied house

(g) First floor plan of a typical double storied house.

Figure 3.16: Elevation, section and plan of a typical single storied and two storied village house

3.16.2 Building Construction Materials

The most common building material for the wall is rubble stone in mud mortar; timber, earth for floors; timber, mud and slate for roof construction (INTERTECT and University of Mexico, 1984; BMTPC, 1992; Rautela, 2005). Cement, steel bars, clay bricks, concrete blocks and corrugated galvanized iron (CGI sheets) are relatively new construction materials and their use is growing in urban / market areas and along the highways as these materials are to be transported from the plains. These new construction materials and technologies have not reached major part of the area.

3.17 WALL CONSTRUCTIONS

It was observed that the predominant walling material used in the Narendranagar block is stone followed by bricks. Earth walls are also seen although rarely. In some cases mixed constructions are seen, where extensions in original stone walls are made with brick walls.

3.17.1 Stone Masonry Walls

Stone masonry is constructed in many different forms which have shown varying degree of performance in the past earthquakes. Common rock types which are used for building constructions are sand stone, limestone, quartzite and slate, which are internally very durable building materials (BMTPC, 1992; NSET and DEQ, 2000). Some forms of stone masonry have performed well during past earthquakes, while some are extremely vulnerable to earthquakes.

Positive aspects of stone walls:

- Most abundant local material does not require much transportation to building site.
- Good insulation from cold due to large wall thickness
- Very durable and fire resistant (BMTPC, 1992; ISET, 2001).

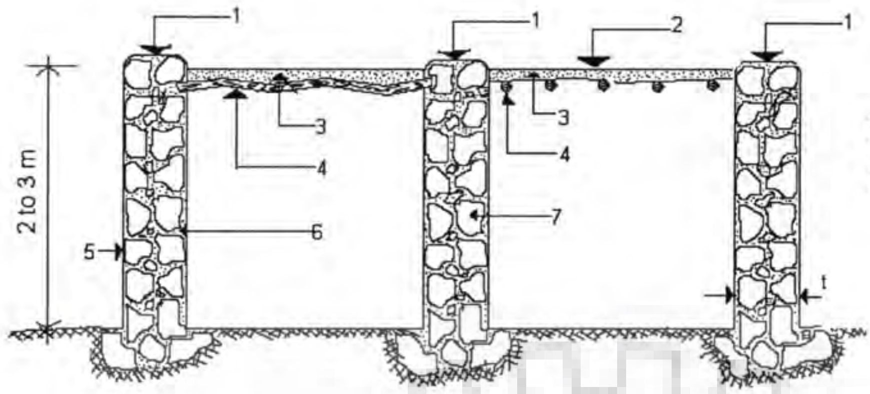
Defects of stone walls:

- Weak in tension and shear; the unstable configuration of stones when shaken from initially constructed position makes the wall collapse due to heavy vertical loads.
- Very weak bond between walls at right angles to each other leads to very easy separation of walls.
- Delamination of wall into separate outer and inner walls due to absence of bond stones.
- Easy shattering and collapse of stone gables.
- Flexible floors and roof have little binding effect on walls and no diaphragm action. (BMTPC, 1992; ISET, 2001).

Stone in mud mortar

In Narendranagar block, rubble stone in mud mortar is the most common walling material. The walls thus constructed are generally 450-900 mm thick. In general, the quality of wall construction is not good: there is no positive bond between walling units of each wythe, and also between the wythes. As a general practice, through stones are not used, and the gap between wythes is filled with small stone pieces and mud. The resulting thin slender wythes behave as independent members, without any structural connection between the external and internal wythes. (Figure 3.17; 3.18). These buildings are up to two stories in height. Floor height in general is small (about 1.8 - 2.4 m). Dressed stone in mud mortar is also rarely used. (BMTPC, 1992; NSET and DEQ, 2000)

The stone masonry prevalent in the Narendranagar block can be grouped in the following two categories based on construction forms.



1 – Stone wall with mud mortar
2 – Mud fill at roof and floor 150 to 300 mm thick
3 – Branches, reeds
4 – Log beams
5 – Hammer dressed face
6 – Chip and mud filling
7 – Random rubble
t – Wall thickness 0.6 to 0.9 m

Figure 3.17: Schematic cross section through a traditional stone house, Source: ISET (2001)

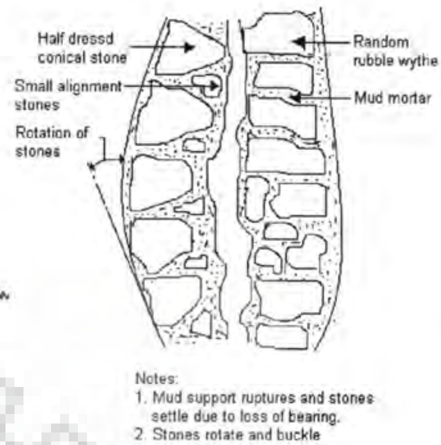
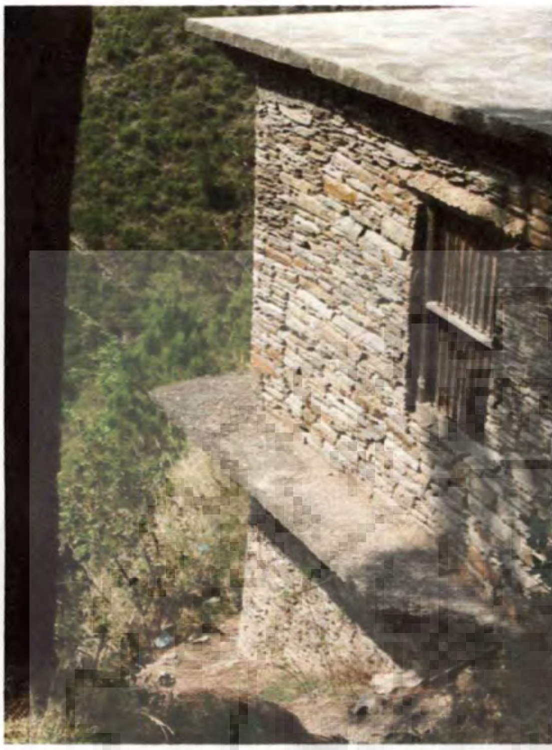


Figure 3.18: Wall delaminated with buckled wythes. Source: ISET (2001)

1. Stone and slate masonry

As seen in old houses, traditionally, the stone masonry is laid in mud mortar which contained large amount of clay and a "course" is made up of large sizes of stone blocks sandwiched between many thin wafers of slate and small stones are filled in the depressions of large stones to create an "even" course and finished outer (exterior) surfaces (Figure 3.19 a to e). The resulting stone masonry is different from typical random rubble (R/R) masonry. The wall thickness can vary from about 450 to 750 mm, consisting of two wythes each of 200 to 300 mm thick separated by filler material. The filler material is loosely packed small stones and slates embedded in mud mortar. In well constructed houses where quality of workmanship is good, through stones are also used frequently to bind both wythes.

The damage to such masonry in past earthquakes had been high to moderate, depending on the quality of masonry and workmanship (BMTPC, 1992; Jain *et. al.*, 1999) (Figure 3.20).



(a) Double storied house in Chaka

(b) Single storied house at Jimangaon

(c) Single room house in Maun

(d) Slate and stone masonry wall in Pokhri

(e) Fair price shop at Guriyali

Figure 3.19: Stone and slate masonry in Narendranagar Block

(a)
Collapse of slate and stone masonry wall with poorly designed RCC construction

(b)
Collapse of typical stone and slate wall with slate roof

Figure 3.20: Damage to stone and slate masonry during Chamoli earthquake

Source: Jain *et. al.* (1999)

Many layers of jointing material (mud mortar in most cases) provide a very large area for accommodating relative movements between masonry units (stone boulders and large number of thin slates) during the ground shaking and thus, dissipating energy through friction and material hysteresis. Furthermore, even weak mortar provides large lateral shear resistance through adhesion from large surface area available from many layers of jointing. However, its use has been declining because it is very time consuming to lay thin layers of slate. As a result, very few and thicker slates are being used with much larger pieces of stone and in some cases, the mud mortar is being replace with weak cement – sand mortar. These masonry walls have experienced more damage during past earthquakes, however, the use of cement – sand mortar has helped in many cases. (GSI, 1992; NSET and DEQ, 2000).

2. Random Rubble (R/R) stone masonry

In general, Random Rubble (R/R) stone masonry has no layers of thin slates to fill in the undulating contours of large stones to create even "courses". These walls are composed of two wythes with total wall thickness varying from 450 to 750 mm. Undressed stones are laid in mud mortar and plastered in cement – sand mortar to provide finished surface (Figure 3.21). Such structures, especially the older ones have suffered heavy damages during the past earthquakes (BMTPC, 1992; Jain *et. al.*, 1999) (Figure 3.22).

(a) Random rubble stone masonry with mud plaster

(b) Random rubble stone masonry with cement plaster

Figure 3.21: Random rubble stone masonry in Narendranagar block

Stone in Cement Sand Mortar: Cement – sand mortar is not common for stone masonry: only a few government buildings, urban area dwellings and those along highways can be seen constructed with stone masonry laid in cement – sand mortar. Walls are thick up to 450 mm and the mortar mix is 1:6 or leaner. Floor and roof of these buildings are generally, cast in situ RC slab (Figure 3.23). The performance of such buildings during earthquakes should be moderate to low

(a) Damage to random rubble stone masonry
During Chamoli Earthquake
Source: Jain *et. al.* (1999)

(b) Damage to random rubble stone masonry at Anjar during Gujarat Earthquake 2001
Source: EERI

Figure 3.22: Damage to random rubble stone masonry

Figure 3.23: Stone in cement and sand mortar

3.17.2 Clay Brick and Concrete Block Masonry Walls

Fired brick and cement concrete blocks are rather new building materials in the area. Cement – sand mortar is used in these walling units. Their recent use appears to have been encouraged by Uttarkashi (1991) and Latur (1993) earthquakes, where stone masonry walls have shown poor performance and were responsible for larger number of deaths (Sinvhal and Bose, 1995; Bose *et. al.,* 2001). In general, wall thickness is 230 mm in case of brick units and 200 mm in case of concrete block. These buildings often have been provided with lintel and roof bands (Figure 3.24). Brick walls are composed of fired bricks, prepared in different sizes by hand moulds or machine moulds and fired in different types of clamps and kilns. The standard nominal size including mortar joints in India is 238 mm X 114 mm X 76 mm. Brick masonry is not only used for small dwellings but also for schools, dispensaries and other community buildings. Although the National Building Code of India gives the procedures of 'calculated' masonry, wall thickness is rarely calculated. For earthquake safety, these buildings need special design and cannot rationally be covered by general rules as applied to houses due to longer spans of walls and larger heights.

Concrete blocks are made from cement, sand (fine stone powder, when sand is not available in high reaches) and coarse aggregate in various dimensions. Typical dimension being approximately 300 mm X 225mmX 150 mm. Concrete blocks are laid in cement- sand mortar and are used in load bearing as well as infills in weak RC frame construction. Very minor damage to such masonry walls was observed. Many factors have contributed to growing usage of concrete blocks such as unavailability of new quarries, time consuming and labour intensive activity of laying stone and slate masonry, uneconomical due to large quantity of cement – sand mortar required per unit volume of masonry, transportation of clay bricks from the plains, and in general, poor performance of stone masonry.

(a) Brick walls without RC frame in Gaja

(b) Brick wall with RC frame in Tapowan

(c) Brick construction on stilts near Byasi

Figure 3.24: Brick walls in Narendranagar block

Positive aspects of brick and concrete block walls:

- Durable construction with minor levels of maintenance
- Comfortable interiors, reasonable insulation against heat and cold
- Resistant to rains and flooding if erosion from the surface of mud mortar is prevented with cement / lime pointing / plaster or if cement / lime mortars used in construction.
- Fire resistant
- Well constructed and integrated wall enclosures provide good stability against vertical as well as lateral loads. (BMTPC, 1992; ISET, 2001).

Defects in the brick and concrete block buildings:

- Poor strength of material in tension and shear, particularly where mud mortar or lime – sand mortar weaker than 1:3 or cement mortar weaker than 1:6 is used.

- Toothed joints cause a vertical plane of weakness between perpendicular walls.
- Large openings and their placement too close to the corners can cause failures
- Very long rooms having long walls unsupported by cross walls fail in bending or overturning.
- Unsymmetrical plan of building, with too many projections. (BMTPC, 1992; ISET, 2001).

The performance of brick buildings during earthquakes is related with the type of roof, the mortar used and the quality of construction. Performance has been poor with pitched roofs having no binding effect on walls, poorer with mud or weak mortars and still poorer with bad quality construction. Buildings with rigid slab roofs have generally behaved much better than others due to their binding effects on walls by diaphragm action by which lateral load is transferred to shear walls. Cracking is frequently observed in diagonal or cross form in the masonry piers between the openings (Figure 3.25), vertical cracks near the corners leading to separation of perpendicular walls through toothed joints and horizontal bending cracks in the walls which are at right angles to the predominant direction of the earthquakes.

During past earthquakes shear failure of brick masonry walls was noticed which developed X or diagonal cracks, since clay bricks are much weak as compared to stones. Almost all brick buildings which used RC slabs for roofs and floors; have beams and columns though not necessarily capable of developing frame action; and / or have lintel and roof bands; have performed satisfactorily, even when bricks walls themselves are weak. Also, very minor damage to concrete block masonry walls was observed.

(a) Damaged unreinforced brick masonry wall in Muzaffarabad

(b) Little Damaged concrete block masonry constructed over stone and slate masonry wall during Chamoli Earthquake
Source: Jain *et. al.* (1999)

Figure 3.25:
Damage to brick and concrete block masonry walls during past earthquakes

3.17.3 Earth walls

Earthen walls are not common in the block and are usually seen in the very remote villages. The basic material for earth construction is well graded earth compressed in soil-block pressed or rammed in wooden forms. Locally available soil is used with or without admixtures like chopped straw or cement. For one storied houses the walls are from 23 – 35 cm thick in compressed blocks and adobe, 40 – 50 cm thick for rammed earth. The room sizes are usually of small dimensions 3m X 5m in plan particularly when pitched roofs are used (Figure 3.26). A variation of earth houses are pitched roof of thatch or slate supported on independent on wooden posts on the outside of the walls.

Figure 3.26: Earth walls in Narendranagar block

Positive aspects of earth buildings:

- Cheap initial and energy costs, particularly if constructed with self help community activity.
- Good thermal insulation against cold and fire resistance.
- Wooden wall plates in continuous runner form provide integrity to the enclosures as a box against lateral forces. (BMTPC, 1992).

Defects of earth buildings:

- Poor strength of material in tension and shear.
- Poor bond between walls meeting at right angles.
- Large openings being too close to the corners.
- Small bearing length of lintels across openings. (BMTPC, 1992).

The performance of earth houses during earthquakes of MM VII or more has been generally poor: wide cracks in the walls and separation of walls at corners. Complete collapse of walls, roofs and floors leading to death and injury to the residents are also common. Due to heavy mass of debris, the rescue of buried people becomes difficult (BMTPC, 1992; GSI, 1992).

3.18 ROOF CONSTRUCTIONS

The materials for Roofs are mainly slate, timber, mud, RCC and thatch. CGI sheets are used at some places for cattle sheds etc. Mixed constructions are also seen in some cases, where extensions in original slate roof houses are made with RCC roofs.

3.18.1 Flexible Roofs

These roofs are inherently weak in shear and can not tie the walls together even when they are properly connected to them. They are heavy when slates are used attracting large inertia forces and often slates were observed to be dislodged even when the roof supporting structure survived the shaking. Most of roof failures can be attributed to a combination of deficiencies such as loss of support of roof trusses and rafters due to failure of masonry walls and failure of roof itself due to failure of joints and / or members forming the truss or other roof supporting structure. Given below are few types of flexible roofs seen in the region.

Slate roofs: Roofs of these houses are composed of slates over timber frames, which gives them flexibility to certain extent. Slates are most common roofing material which is typically about 25 – 50 mm thick depending upon local availability. Slates are laid on 50 – 75 mm thick layer of mud to keep weather out. Mud is laid on fire wood or planks supported by beams generally spanning gable to gable wall. Slates are not tied up with structure (Figure 3.27 a). In some buildings wooden planks are placed on rafters to support the roofing material. Corrugated Galvanized Iron (CGI) sheets have also been used as a roofing material in many cheaply built school buildings and road side shops.Slate roofs are the most popular roof types in the hilly area. People prefer this roof type because of easy availability of material and their inherent knowledge of repair and maintenance of these roofs. Slates are easily reusable and a market for recycled slates exists, especially among the poorer households. During past earthquakes the local people found that the slate roofs often collapse in segments, allowing people to escape relatively easier than when they were pinned under an RCC slab.

Thatch roof: These roofs are constructed of thatch with timber frames. They are always used over small sized rooms with stone or earth walls. They are used for very poor households or cattle shed (Figure 3.27 b).

(a) Slate roof

(b) Thatch roof

(c) Floor diaphragms

(d) Corrugated Galvanized Iron (CGI) Sheet Roof

Figure 3.27: Types of flexible roofs in Narendranagar block

Floor Diaphragms: Floor diaphragms are usually constructed of mud laid on wooden planks or firewood supported by timber joists. Joists at ends simply rest on the wall without any anchorage or tie. Moreover, in general, the joists do not fully penetrate the entire wall in order to protect it from rain (Figure 3.27 c).

CGI sheet roof: These roofs are composed of CGI sheets mounted over timber frames. These are mostly used for non-residential use like cattle sheds, small shops along roadside etc (Figure 3.27 d).

3.18.2 Rigid Diaphragms (RCC roofs)

Flat cast-in-situ reinforced concrete slabs are recent substitute for old fashioned pitched roofs and wooden flooring systems. The quality of RCC roof construction was found to be bad, largely because of low quality materials and lack of knowledge of RCC technology. Stone aggregate and sand is dirty, badly graded and aggregate often contains rounded stones. Water cement ratios are not maintained. Slabs are typically over reinforced and supporting columns under reinforced, with inadequate bar spacing. Cover is rarely maintained and tamping is inadequate leading to exposure of bars and voids in the concrete. The net result is that a large number of slabs leak and the reinforcement corrode. The local solution is to use bitumen tar to fill the cracks.

(a)RCC roof over brick wall (b) RCC roof over stone wall

Figure 3.28: RCC roofs in Narendranagar Block

3.19 LIGHT REINFORCED CONCRETE (RC) FRAME

RC buildings are present particularly in urban areas. They are gaining popularity because of better utilization of space and general perception that these are "stronger". However, most of the framed buildings are non-engineered. They typically consist of a weak RC frame, that is, at most capable of carrying vertical gravity loads, and infilled walls of brick or concrete block in cement sand mortar. The construction of frames can both precede and follow the construction of masonry infill walls. Frames are usually light with column size 230X230 mm with four to six number of 12 mm diameter reinforced bars (Fe 415). Even use of 10 mm diameter bars was also observed. Stirrups are typically 6 mm diameter bars at 200-250 mm spacing. The columns spacing in each principal direction of the building varies from 3 to 4.5 m. It is usual to have shops on the ground floor, with large openings on one or adjacent faces. In most cases floor heights are about 2.7 m, but occasionally are up to 3.0 m. Floors and roofs are constructed of cast-in-situ RC slab (Figure 3.29).

(a) Rc Frame structure near Tapowan (b) RC Frame structure at Gaja

Figure 3.29: Reinforced Concrete (RC) Frame Structures in Narendranagar Block

Performance of these buildings during earthquakes is more like hybrid structures, where infills play a major role in resisting seismic loads, especially before the cracking of masonry (Figure 3.30). Frame action is only possible when the infill masonry is cracked and lost its strength and stiffness considerably.

(a) Damage to RC framed railway station during Gujarat Earthquake, 2001
Source: EERI

(b) Damage to RC framed apartment building during Gujarat Earthquake, 2001
Source: EERI

Figure 3.30: Performance of RC framed structures during past earthquakes

3.20 COMPOSITE CONSTRUCTIONS

These are type of construction with mixed features. The outer face of the wall is built in burnt bricks laid in mud mortar, the inner is built from unburnt bricks or adobe. This although seen very rarely, is a better quality construction than traditional adobe one. The outer layer protects the wall from erosion during the rain and helps in carrying part of the vertical loads of the upper floors and roof.

The composite constructions are also seen for same houses where different set of building materials and construction technology is used. These are essentially extensions in the original construction with more modern materials and construction practice (Figure 3.31).

(a) Composite wall construction of slate and bricks

(b) Brick masonry wall constructed over slate and stone masonry wall

(c) Concrete Block masonry wall constructed over slate and stone masonry wall

(d) Brick wall being constructed in front side of a stone building

Figure 3.31: Composite constructions in Narendranagar block

3.21 FOUNDATIONS

Two types of foundations are seen in the block as described below:

Stone Foundation

Foundations are normally constructed in stone but where exposed rock is available on surface, the construction is started from the rock itself. Thicknesses vary from 45 cm to 75 cm. a few variations in the house types are:

- Single story house with two way pitched roof. Walls about 2m high with gables in stone masonry. Rooms 3m X 4m,
- Single story stone house with RCC slab roof. Rooms 3.5m X 4m. Typical height 2.4 m.
- Two story house with stone gables, an attic floor, intermediate floors of wooden joists and boards with clay – cow dung flooring. Rooms up to 3m X 7m.

Brick Foundations

Foundations normally consist of stepped strip footings over rammed earth and brick bats. Second class bricks, slightly under or over burnt, are used in foundations. The plinth masonry is kept half a brick thicker than the walls at ground floor. The first class construction, the base may be made using lime concrete with brick aggregate or lean cement concrete of 1:4:8 mix.

3.22 CONCLUSIONS

Tehri Garhwal district of Uttarakhand state of India is prone to many natural and man made disasters including earthquakes, floods, droughts, cloudbursts, landslides, road accidents etc. This Himalayan district is comparatively less developed as compared to other regions of India. Narendranagar block of Tehri Garhwal district selected for detailed studies is investigated extensively through secondary and primary surveys. The settlements are found to be isolated with different topographic and accessibility conditions. Rural settlements contribute to 87% population. The male female ratio of 1012 females per 1000 males which is much higher than the national and state average shows the dominance of womenfolk in agriculture and household activities and migration of men in search of employment. The construction technology existing in the Narendranagar block varies in villages with different accessibility conditions. The villages and towns with better accessibility conditions show more influence of modern construction materials and techniques, whereas the inaccessible villages seem to use locally available material. The traditional techniques of light weight earthquake resistant constructions are now being replaced by more vulnerable constructions in the entire region. The behavior of most of the building elements during past earthquakes was not satisfactory. The overall development of the Narendranagar block is indicated by the infrastructure availability which is analyzed in detail in subsequent chapters.

CHAPTER 4

ANALYSIS OF VULNERABILITY AND RESOURCE POTENTIAL

4.1 INTRODUCTION

Narendranagar block of Tehri Garhwal district is analyzed for its vulnerability and potential to cope with any earthquake situation. The factors considered for vulnerability analysis are physical and social. At the settlement level the economic wellbeing is reflected in construction of buildings which is analysed under physical vulnerability and the availability of infrastructure facilities which are analysed under resource potential. The Narendranagar block is devoid of economic assets of significant value. Hence economic vulnerability of the sub-region is not analyzed separately. The resource potential assessment is carried out for four categories viz. infrastructure availability, institutional setup, manpower availability and material supplies. The shortage of resource potential availability in turn indicates vulnerability of the region. The spatial analysis is carried out in GIS environment.

4.2 ANALYSIS OF PHYSICAL VULNERABILITY

The critical factors considered here for analysis of physical vulnerability are vulnerability of the sub – region to earthquake hazard, prevailing building typology, landslides, inaccessibility of the settlements, river proximity and altitude.

4.2.1 Earthquake Vulnerability

Narendranagar block is infested by the Main Boundary Fault (MBF), which is manifest as several large tectonic elements e.g. Tons Nayar thrust, Krol Thrust and Garhwal Thrust (Jain, 1987). The river Ganga winds in a sinusoidal fashion in the southern boundary of the block, indicating its tectonic control in this region. (Figure 4.1)

The micro level seismic zoning map for the region identified four areas of vulnerability considering various geological factors viz. magnitudes, number of major thrusts, distance of extremity of a major thrust, number of minor lineaments, number of intersection of lineaments, total length of drainage and number of epicenters. These four zones are named Zones D3, D2, D1 and D. D3 was the most vulnerable zone followed by D2, D1 and D (Sinvhal *et. al.* 1990). Southern most part of the Narendranagar block lies in Zone D3 (Figure 4.2). The information of all the settlements and populations located on

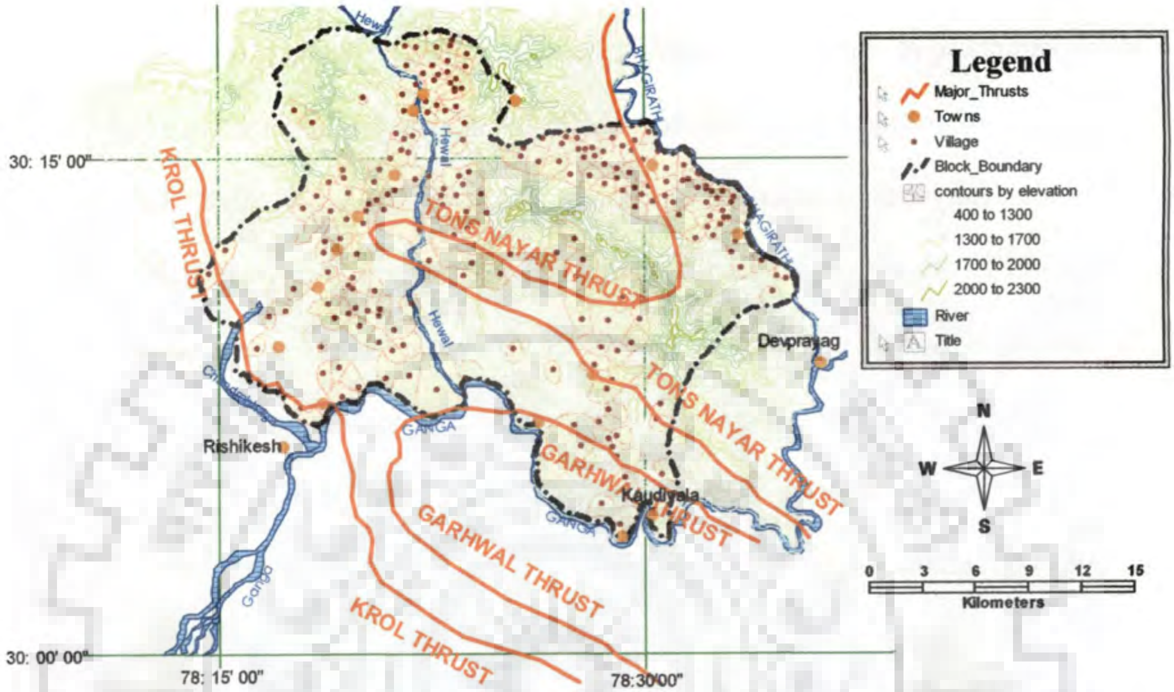


Figure 4.1: Major tectonic elements in the region (after Jain, 1987)

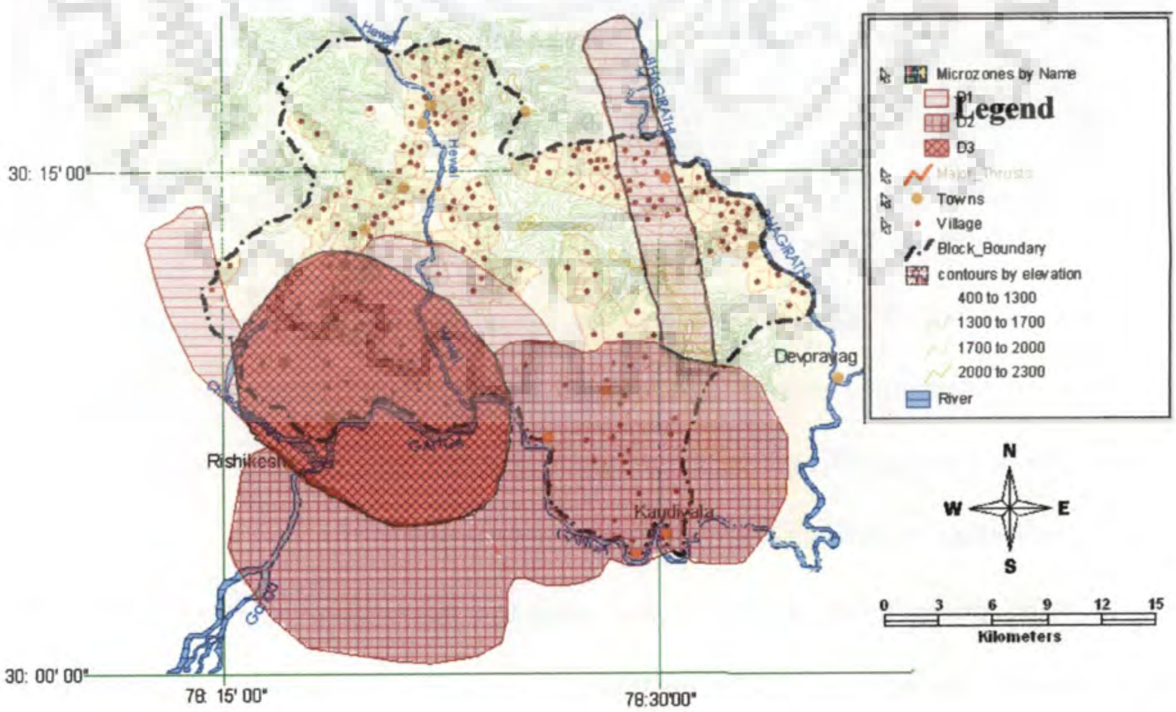


Figure 4.2: Seismic microzones D3, D2 and D1 superimposed on map of Narendranagar block (after Sinvhal. et. al., 1990)

Table 4.1: Settlements located on earthquake microzones

Vulnerability Zone	Villages		No. of Market Towns		Total Pop	% Population
	Number	Population	Number	Population		
D3	79	12940	7	18884	31824	30.88
D2	24	7157	4	4167	11324	10.99
D1	23	4690	1	1590	6280	6.09
D	88	47575	5	6029	53604	52.04
Total	214	72362	17	30670	103032	100

Table 4.1 shows that population of 31824 (30.88%) from 79 villages and 7 market towns is located on very high risk zone (Zone D3); population of 11,324 (10.99%) from 24 villages and 4 market towns is located on high risk zone (Zone D2) and population of 6,280 (6.09%) from 23 villages and 1 market town is located on moderately high risk zone (Zone D1). This shows that approximately 50 % of block population is living on higher risks area.

4.2.2 Vulnerability of Residential Buildings

The different construction typologies prevailing in Narendranagar block as described in chapter 3 are categorized as per structure categories mentioned in MSK scale (IS 1893-2002). The descriptions of structure categories provided by MSK scale are as given below.

Medvedev – Sponheaer – Karnik (MSK) Intensity Scale (1964)

Types of structures described:

Structure A: Buildings in field – stone, rural structures, adobe houses, clay houses.

Structure B: Ordinary brick buildings, buildings of the large block and prefabricated type, half timbered structures, buildings in natural hewn stone.

Structure C: Reinforced buildings, well built wooden structures.

From the past experiences we know that structure A stands for the most vulnerable category, structure B stands for moderate vulnerability, whereas structure C denotes low vulnerability constructions. All types of constructions seen in the block are categorized into above mentioned three categories on the basis of discussions with experts of earthquake engineering (Table 4.2).

Table 4.2: Categorizations of existing types of construction on the basis of wall and roof combinations

Roofing Material / Walling Material	Slate	RCC	Others (thatch, timber, CGI)	Composite
Earth walls	Structure A	Structure A	Structure A	Structure A
Stone in mud (single story / double storied)	Structure A	Structure A	Structure A	Structure A
Stone in cement (double storied)	Structure A	Structure A	Structure A	Structure A
Stone in cement (single storied)	Structure B	Structure B	Structure B	Structure B
Brick / Concrete block	Structure B	Structure C	Structure C	Structure B
Composite (Stone and Brick)	Structure A	Structure B	Structure B	Structure A
Composite (timber and stone)	Structure A	Structure B	Structure B	Structure A

Source: Gupta, *et. al. (in press)*

In this manner, the numbers of different types of constructions observed in the sample villages are tabulated. However, structural category is occasionally modified depending on the vulnerability of construction due to other factors like:

- Improper stilt construction on the slopes (Figure 4.3a),
- Construction of upper story on weak lower stories (Figure 4.3 b),
- No proper joints in composite constructions breaking the integrity of structure (Figure 4.3 c),
- Dangerous locations. (Figure 4.3 d).

The final percentage of structure A, B and C in all of 15 villages selected for primary survey is calculated and rounded off to the nearest whole number (Table 4.3; Figure 4.4). The resultant percentage of types of constructions according to the village accessibility category is given in Table 4.4.

(a)

(b)

(c)

(d)

Figure 4.3: Commonly observed construction defects

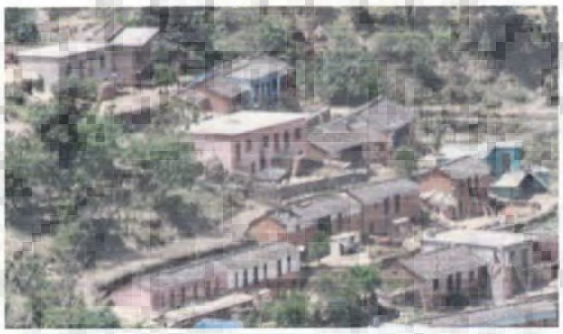
a) Category C Structure modified to Category A due to Improper stilt construction on slope
b) Category B Structure modified to Category A due to Construction of upper story on weak lower stories,
c) Category B Structure modified to Category A due to lack of proper joints in composite constructions breaking the integrity of structure,
d) Category C Structure modified to Category A due to its Dangerous locations

Table 4.3: Percentage of structure types in surveyed villages with different accessibility conditions

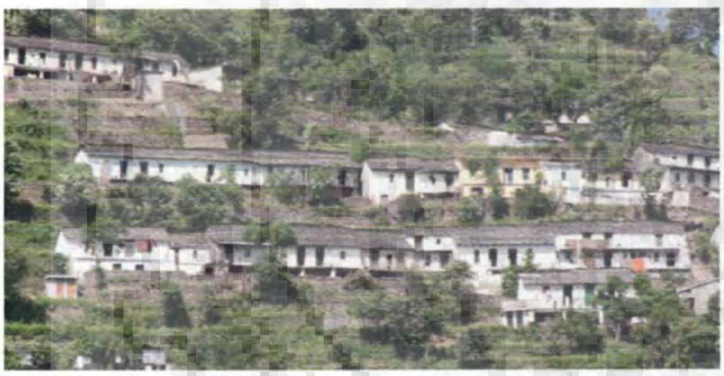
Village Category / Structure Category	Percentage of Residential Structures in Rural settlements accessibility wise (%)					
	A1	A2	A3	A4	A5	Market Towns
Structure A	10	25	40	50	60	20
Structure B	50	50	50	40	20	30
Structure C	40	25	10	10	20	50
Total	100	100	100	100	100	100

(a) Village Jimangaon of A1 Accessibility Category

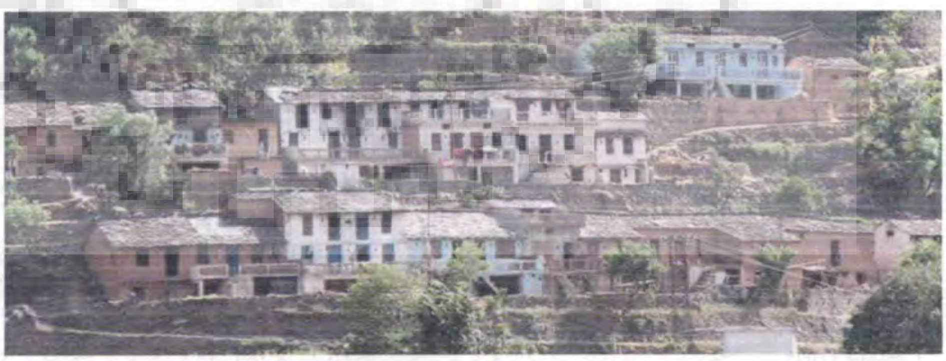
(b) Village Lodsi of A2 Accessibility Category



(c) Village Soni of A3 Accessibility Category



(d) Village Mathiyali of A4 Accessibility Category



(e) Village Kyara of A5 Accessibility Category

Figure 4.4: Types of constructions in villages with respect to accessibility category

The number of structure A, B and C in all villages are calculated on the basis of computed percentages using Microsoft Excel software. The total number of different types of structures in the block and their respective percentages are given in Table 4.4.

Table 4.4: Total number of different types of constructions in Narendranagar block.

Village Category / Structure Category	Number of Residential Structures in Rural settlements accessibility wise							
	A1	A2	A3	A4	A5	Market Towns	Total Nos.	Total %
Structure A	622	497	876	824	1308	1328	5454	26.14
Structure B	3108	995	1096	659	436	1992	8284	39.71
Structure C	2486	497	219	165	436	3320	7123	34.15
Total	6215	1989	2191	1647	2180	6639	20861	100

Table 4.4 shows that significant percentage (26%) of residential buildings of Narendranagar block show high vulnerability for earthquakes. Almost 40% of the buildings are moderately vulnerable to earthquakes while almost 34% of buildings are of low vulnerability.

4.2.3 Structural Vulnerability of Health Care Buildings

Strengthening structures of health care facilities for confronting earthquakes is one of the most crucial issues that should be emphasized as a top priority in the disaster management planning (Alahi and Izadkhah 2004). Narendranagar block has total 52 health care facilities located in 29 settlements. The details of type and capacities of these facilities are discussed in **section 4.4.2**. An analysis of structural vulnerability of health care facility structures was conducted through field survey and through information collected from employees of the health facilities. (Figure 4.5)

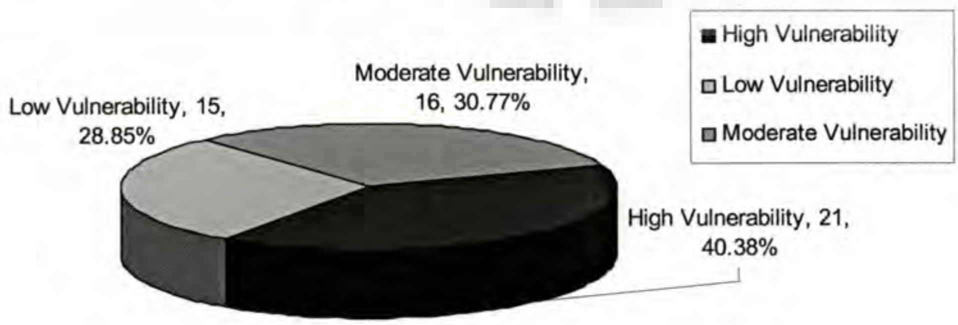


Figure 4.5: Structural vulnerability of health care buildings

It is known that 21 (almost 40%) health facilities have high structural vulnerability, 16 (almost 31%) have moderate structural vulnerability, and only 15 (almost 29 %) have low structural vulnerability. If these vulnerable health facilities collapse after earthquake then the medical preparedness plan for the region would fail.

4.2.4 Structural Vulnerability of Educational Buildings

Narendranagar block has a total of 152 Jr. Basic Schools, 85 Sr. Basic Schools, 56 High Schools and 23 Inter Colleges. The structural vulnerability of these was determined through observations, secondary sources, interviews with officials and interviews with villagers. The results obtained are as shown in Table 4.5.

Table 4.5: Structural vulnerability assessment of educational buildings

Type of Structure	Jr Basic Schools		Sr. basic Schools		High Schools		Inter Colleges		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Structure A	35	23.03	20	23.53	8	14.29	0	0	63	19.94
Structure B	81	53.29	39	45.88	18	32.14	7	30.43	145	45.89
Structure C	36	23.68	26	30.59	30	53.57	16	69.57	108	34.18
	152	100	85	100	56	100	23	100	316	100

Table 4.5 shows that the higher level educational facilities are less vulnerable than the lower level ones. The reason for this is the location of higher level educational facilities in the market towns and bigger villages with good accessibilities; whereas the lower level educational facilities are also present in the remote villages.

4.2.5 Landslide Vulnerability

Narendranagar block, along with the entire hilly area of Uttarakhand state is prone to landslides because of being a part of fragile Himalayas (Pande, 2006a; 2006b). Landslides in Himalayas are basically of two types – one confined to the regolith (shallow landslides) and other affecting the rock (deep landslides) (Valdiya, 1975; 2002). According to Rautela and Pande (2006) the triggering factors for landslides in Uttarakhand state are basically rainfall, weathering and earthquakes. Analysis of landslide hazard for the selected region is already carried out by various sources (Mehrotra et. al. 1992; NRSA 2001). The various hazard maps hence published are superimposed on the block map to find out various landslide prone settlements and important infrastructure like roads.

The factors considered for landslide hazard analysis by Mehrotra et. al (1992) and NRSA (2001) are of two types. The first are geological / topographic factors viz. lithology, geological structures / lineaments, slope-dip relation, geomorphology, drainage, slope angle, slope aspect, slope morphology, land use, soil texture and depth and rock weathering. The second are triggering factors viz. rainfall, earthquake and anthropogenic factors.

Settlements prone to landslides

Various settlements prone to landslides i.e. the settlements which are located on severe to high landslide hazard zones of the given landslide hazard maps are considered to be highly vulnerable to landslides. (Table 4.6; Figure 4.6)

Table 4.6: Landslide prone settlements of Narendranagar block

Villages		No. of Market Towns		Total Pop	% Population
Number	Population	Number	Population		
65	15787	2	2345	18132	17.59%

Table 4.6 and Figure 4.6 show that total 17.59% population of Narendranagar block living in 65 villages and 2 market towns viz. Duadhar and Chaka is located on high and very high landslide hazard zone.

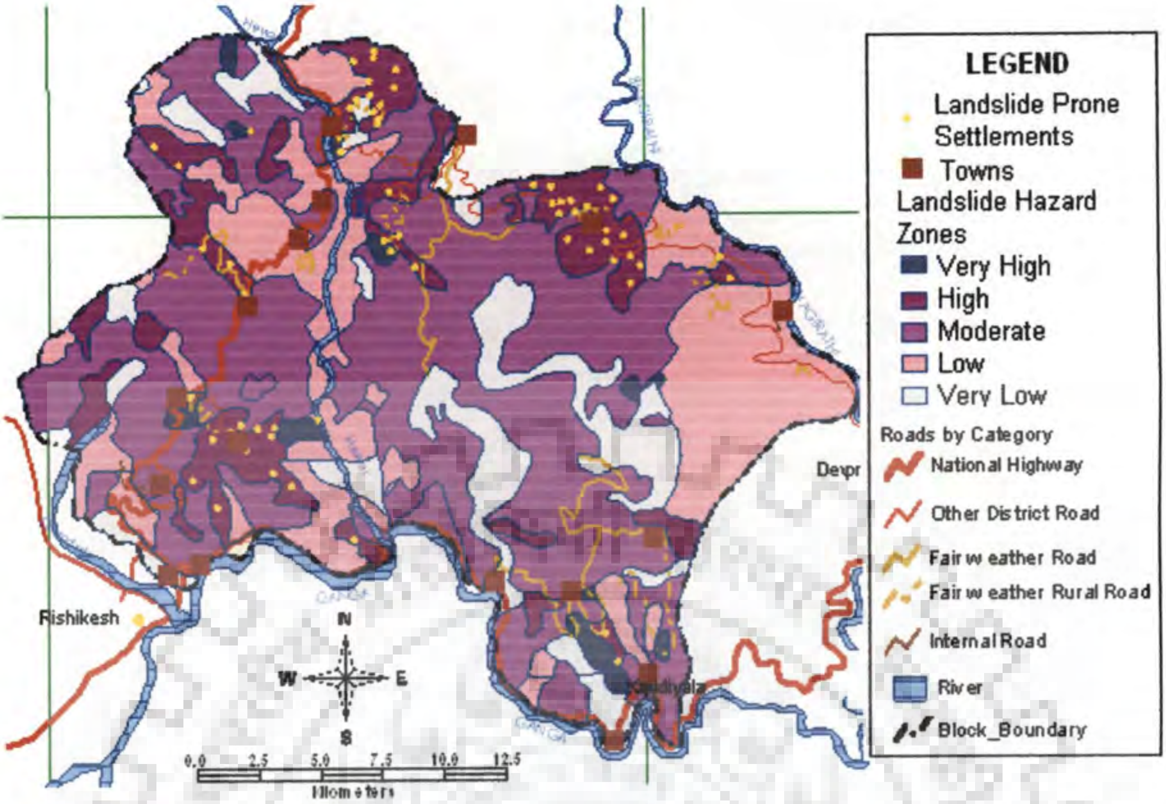


Figure 4.6: Landslide hazard in the block (after: Mehrotra 1992)

Access routes prone to landslides

These landslides in the sub region might block the existing road network and render many settlements inaccessible. NRSA (2001) has developed the landslide hazard maps along the major route corridors (Figure 4.7).

Figure 4.8 shows the existing road network within the block exposed to different grades of landslide hazard, which suggests that a total of 85 settlements with total population of 27462 are vulnerable due to probability of landslides blocking the access routes to them.

The numbers of stretches of roads under different landslide hazard zones are given in Table 4.7. Such landslides are often triggered by rainfall and photographs of some of the landslides along the major routes are shown in Figure 4.9.

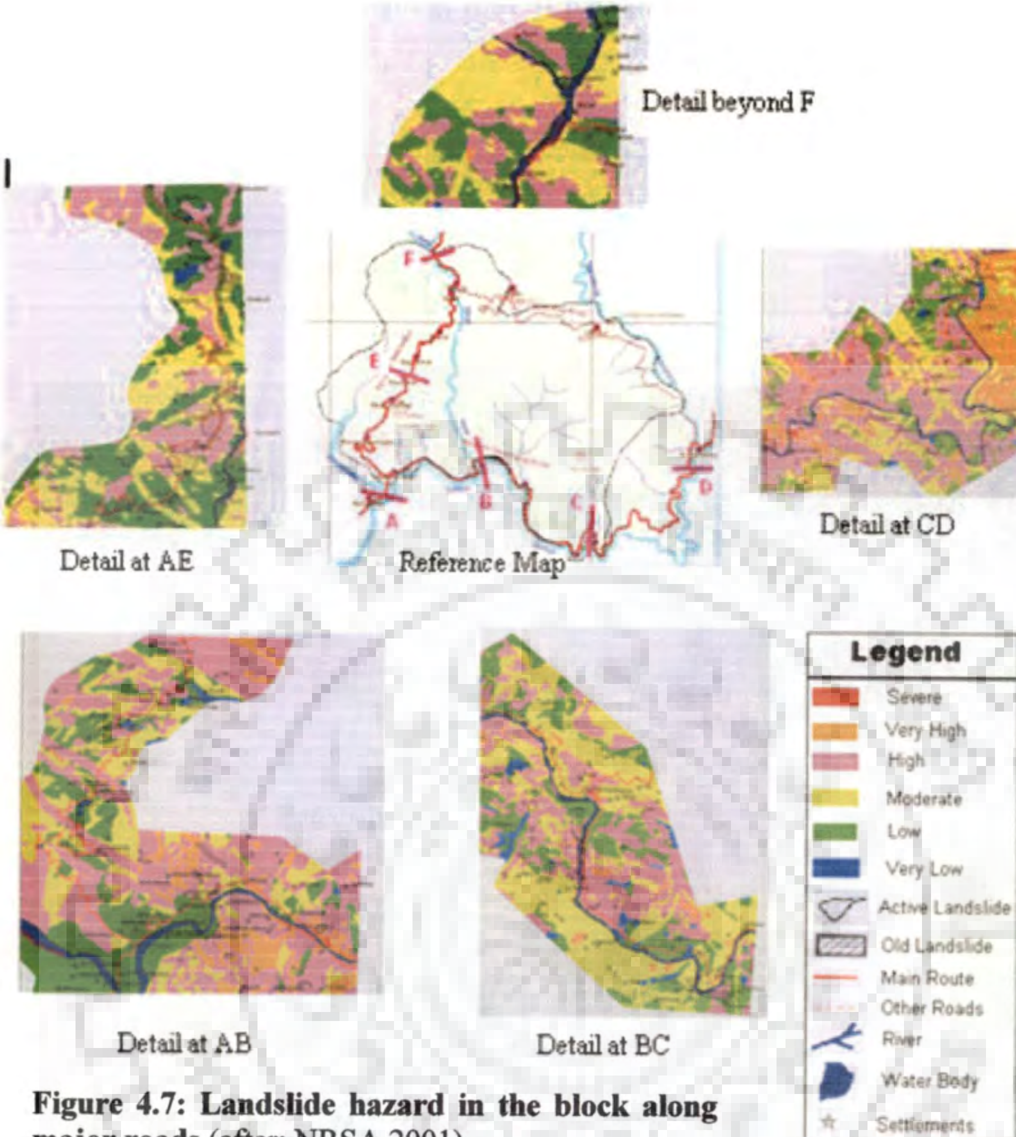


Figure 4.7: Landslide hazard in the block along major roads (after: NRSA 2001)

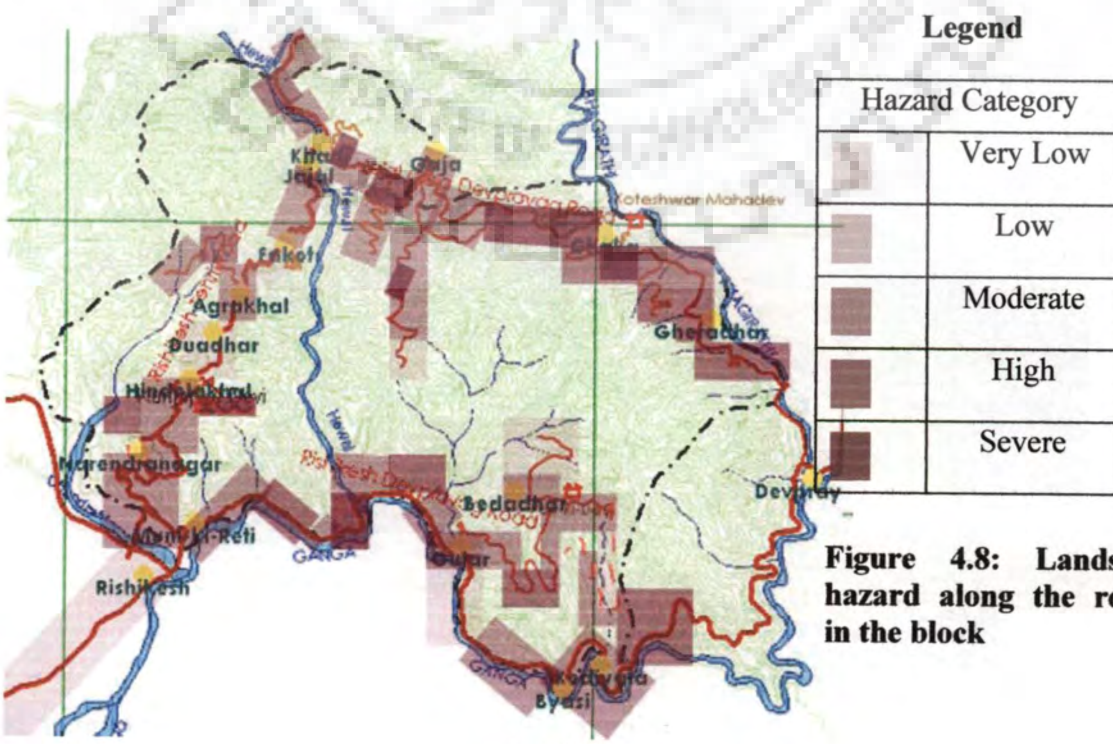
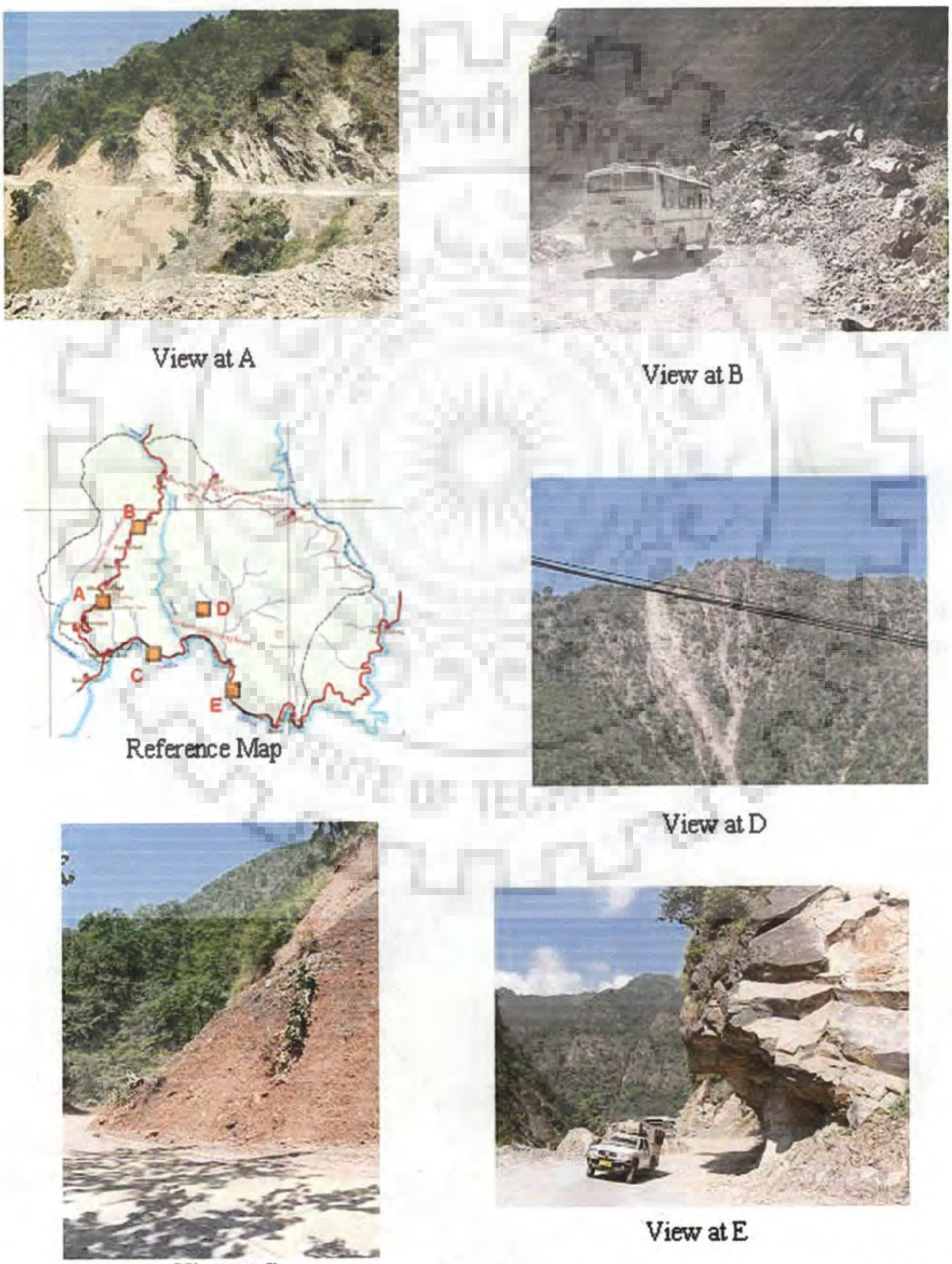


Figure 4.8: Landslide hazard along the roads in the block

Table 4.7: Number of road stretches under different landslide hazard zones

Landslide Hazard Zone	National / State Highways	Other District Roads	Fair Weather Roads	Rural roads
Very Low	4	1	2	1
Low	3	2	3	1
Moderate	10	3	2	2
High	3	2	3	0
Very High	1	2	1	0



View at A

View at B

Reference Map

View at D

View at C

View at E

Figure 4.9: View of landslides during October 2005

4.2.6 Vulnerability Due to Inaccessibility

As discussed earlier almost 28% of total population of Narendranagar block is located in inaccessible settlements, 16% on moderately accessible settlements and 56% of population is located in accessible settlements. The inaccessibility of settlements enhances their vulnerability. We have seen that construction technology predominantly used in the inaccessible settlements is more vulnerable to earthquakes. Apart from this, the inaccessibility of settlements makes them unapproachable for emergency assistance.

Locations of Helipads

At present the Narendranagar block has only one helipad at Hotel Ananda at Narendranagar. The block needs many more landing sites for helicopters, to ensure access to remotely located villages which can be rendered inaccessible due to landslides.

4.2.7 Vulnerability due to River Proximity

The settlements located very close to rivers are at risk of facing flash floods after earthquakes. The reason for this is - the debris falling into the river due to the landslides form temporary dams which eventually burst resulting in flash floods. This phenomenon was observed during Uttarkashi earthquake of (1991). However the blockage formed was cleared in time and the flash floods were prevented (TARU, 1991). Hence settlements located on rivers banks are more vulnerable (Figure 4.10; 4.11; Table 4.8).

Table 4.8: Settlements prone to flash floods after earthquakes

Villages		No. of Market Towns		Total Pop	% Population
Number	Population	Number	Population		
11	2103	6	7945	10048	9.75

A total of 11 villages and 6 market towns with total population of 10048, which is 9.75% of the total block population, are prone to flash floods after earthquakes. The flash floods due to formation of temporary dams if not cleared in time would eventually lead to flash floods. The bigger settlements of Narendranagar block like Tapowan and Muni-ki-reti could also be affected if the floods are severe.

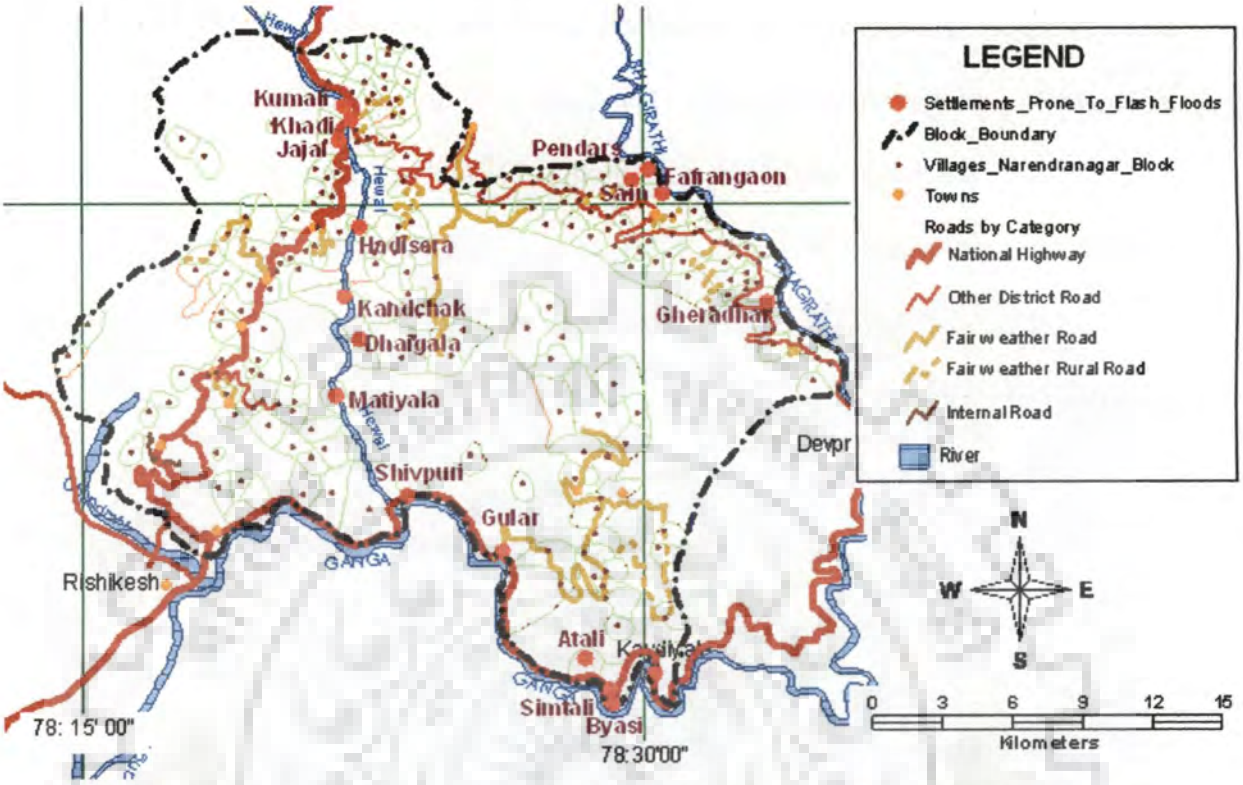


Figure 4.10: Settlements of prone to flash floods due to landslides after earthquakes

Figure 4.11: River Hemwal passing through market town, Khadi

4.2.8 Vulnerability due to Altitude

In the past earthquakes it has been observed that, the settlements located at higher altitudes often experience more damage than the settlements located in valley (Celebi, 1987; Geli *et.al.*, 1988; Jibson, 1987; GIS, 1992; NSET and DEQ, 2000). The villages of the Narendranagar block are located at different altitudes, which vary from 380 to 700 meters in the valleys; 700 to 1400 on the slopes and upto 1800 meters on the ridges. Hence the settlements located on high altitudes are more vulnerable than the settlements located on low altitudes (Figure 4.12 and Table 4.9).

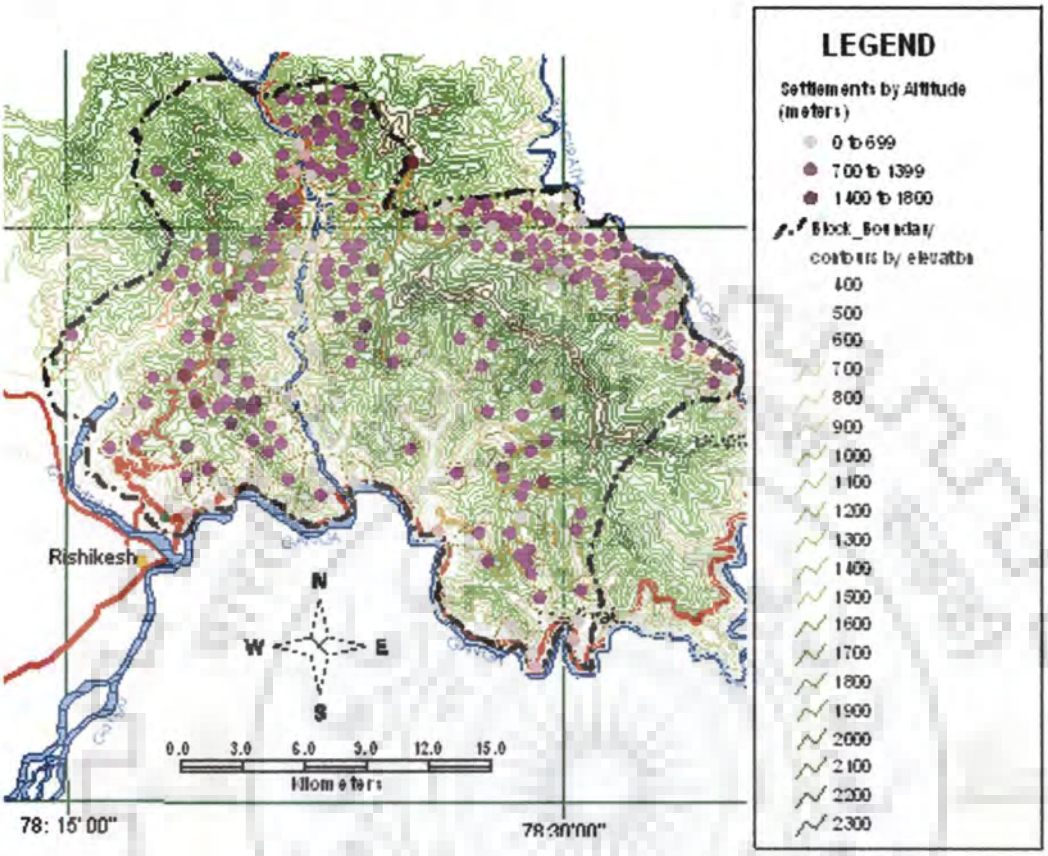


Figure 4.12: Altitudes of settlements of Narendranagar block

Table 4.9: Vulnerability of settlements due to altitudes

Zone	Villages		No. of Market Towns		Total	% Population
	Number	Population	Number	Population	Pop	
Below 699	24	16838	4	13696	30534	29.64
700 to 1399	161	47710	7	10368	58078	56.37
Above 1400	29	7814	6	6606	14420	14.00
Total	214	72362	17	30670	103032	100

Hence we know that 14% population is more vulnerable because of its high altitude; 56% is moderately vulnerable; while almost 30% shows low vulnerability.

4.2.9 Vulnerability due to Size and Density of Settlements

Vulnerability of settlements due to size and density indicates that more the number of people living in a village more would be the vulnerability. Hence bigger and denser settlements are more vulnerable than the smaller settlements.

4.3 ANALYSIS OF SOCIAL VULNERABILITY

Social vulnerability pertains to the degree at which the community is exposed to earthquake risk, on account of social and demographic features. There are various factors which can be used to determine the earthquake risk as discussed in section 2.5.2. In this section social vulnerability of Narendranagar block is assessed for selected factors.

4.3.1 Literacy

The literacy of the population represents the availability of educated manpower for pre and post earthquake activities. Hence the higher percentage of literate population in any village increases its potential for disaster risk reduction and hence reduces the vulnerability. The percentage of literate population in the village to the total population of that village varies from 15.45% in remote village Kyara to 51.2% in village Khedagad situated on National Highway near Narendranagar. Table 4.10 gives number of villages and market towns of Narendranagar block according to literacy levels.

Table 4.10: Percentage of literate population in settlements of Narendranagar block

Literacy	Number of Villages	No. of Market Towns
Up-to 25%	46	0
25 to 40 %	114	5
above 40%	54	12
Total	214	17

Source: Government of Uttaranchal, 2002

Hence we know that 46 rural settlements of Narendranagar block are more vulnerable as compared to other settlements due to their low literacy level.

4.3.2 Awareness about Earthquakes and Post Disaster Measures

During primary survey in the villages of Narendranagar block it was found that people are not aware about the vulnerability of their region to earthquakes and they have no idea about what actions should be taken as preventive measures. The community is totally unaware of what kind of assistance can be obtained from government and where to reach in case of emergencies to avail that assistance. Population has never been made aware about their possible roles and responsibilities during an earthquake event. In such situations it would be very difficult during any emergency phase to direct the affected population towards rescue, relief and other post disaster actions. These facts increase the vulnerability of Narendaranagar block population.

4.3.3 Gender Issues

As evident from section 3.14.4 and Table 3.18, the high number of womenfolk in the villages of Narendranagar block makes them more vulnerable. It was found that womenfolk in the villages take the extra burden of agriculture activities along with household responsibilities and do not get equal educational opportunities as men. During any emergency situation in India the womenfolk need to be provided with additional care and assistance. The men in the villages would form important manpower resource during disasters. Hence the lesser number of men and higher numbers of uneducated women increases the social vulnerability of the rural settlements of Narendranagar block.

4.3.4 Age Groups

As apparent from Table 3.5 showing the age structure of district population, that almost 50% population is under age 19, which makes it vulnerable. The male population in working age group (20 to 50) is only 18% of total population, due to their migration for jobs. This reduces the availability of important manpower for disaster situation which in turn increase the social vulnerability of settlements.

4.3.5 Missing link in local disaster management efforts

The result of primary survey shows that the missing link in local disaster management efforts is absence of broad-based village organizations. The complete Uttarakhand State, has lagged behind in summoning the constructive power of local level participatory organizations. Social fragmentation, disintegration of traditional values and institutions, and a general sense of social, economic and political alienation have been the obvious consequences (Pande, 2006d). This aspect makes the population more vulnerable.

4.4 ANALYSIS OF RESOURCE POTENTIAL

Every region has some resources and these resources have certain potential to cope with the disasters. Whereas, the vulnerability is specific to particular locations, the resource potential of district can be used by all the vulnerable locations for coping up with the disasters. The resource analysis is carried out for the existing infrastructure facilities at the block level and the analysis of institutional setup, availability of manpower and material supplies is done at district level. The analysis thus carried out provides valuable inferences for the preparedness and action plan for earthquake emergency management.

4.4.1 Infrastructural Facilities

Infrastructural facilities like health facilities, educational facilities, food storage, and telecommunication are critical during earthquake emergencies. An analysis of their existence in the settlements of Narendranagar block is given in the following sections.

4.4.2 Health Infrastructure

In the emergency phase of earthquake disaster scenario, provision of medical assistance to the injured becomes a vital activity, because several people get injured due to buildings crumbling within just few seconds. Hence the activity needs to immediately start with the setting up of medical camps at various locations. This medical assistance also needs to be well organized to avoid any pandemonium caused by panic stricken and traumatized people. There are many specialized requirements of the activity, which require great deal of preparedness to serve speedily. Secondary activities like maintenance of records and provision of medicines for epidemic control are also very important.

The shortcomings of health infrastructure of the selected sub-region to earthquake emergencies can be assessed from the existing emergency medical services (EMS). Pande (2006c) gives the present shortcomings of the EMS in Uttarakhand state with special reference to road accidents, which are also found to be factual for Narendranagar block, as:

> 'Absence of an integrated EMS; lack of facilities, infrastructure, trained man power; absence of a comprehensive policy at the state level; absence of a central coordinating body; health care facilities are generally not suitably prepared to respond to emergencies; emergency and pre-hospital care is not closely integrated with hospital care and rehabilitative care; non-availability/non-existence of data, surveillance, monitoring and/or analysis related to EMS; non-existence of emergency medicine as a specialty; lack of training facilities; improper/inadequate referral procedures/transportation; substantial cost of emergency care and low insurance coverage rate; lack of sustainable, administrative, financial and legislative mechanisms for emergency care; and lack of minimum / basic standards for EMS in terms of personnel, equipment and facilities.'

All types and locations of health facilities present in Narendranagar block are given in Table 4.11 and Figure 4.13 respectively.

District Hospital –Narendranagar (Suman Hospital)

Suman hospital at Narendranagar is the highest level of medical facility available in the region. The hospital building was constructed in year 1929 without earthquake resistant construction technology, however various extensions have been made in the older building for all these years. Over all condition of building is good, but requires retrofitting for some parts. The building is identified to be a combination of structure B and structure C type. The building exhibited minor cracks during past earthquakes which were repaired. The hospital lacks a surgeon. Information collected from Chief Medical Superintendent, Narendranagar about facilities available in the hospital are given in Table 4.12.

Table 4.11: Types of health facilities in Narendranagar block

Type of Facility	Numbers
District Hospital Narendranagar (Suman Hospital)	1
Ayurvedic hospitals	13
PHC	1
Additional PHC	2
State Ellopathic dispensary	1
Female hospital	1
Sub centers	14
Homeopathic hospitals	6
Veterinary hospitals	6
Medical relief posts	2
Leprosy hospital	1
Medicine shops	Many

(from Health Department, Narendranagar)

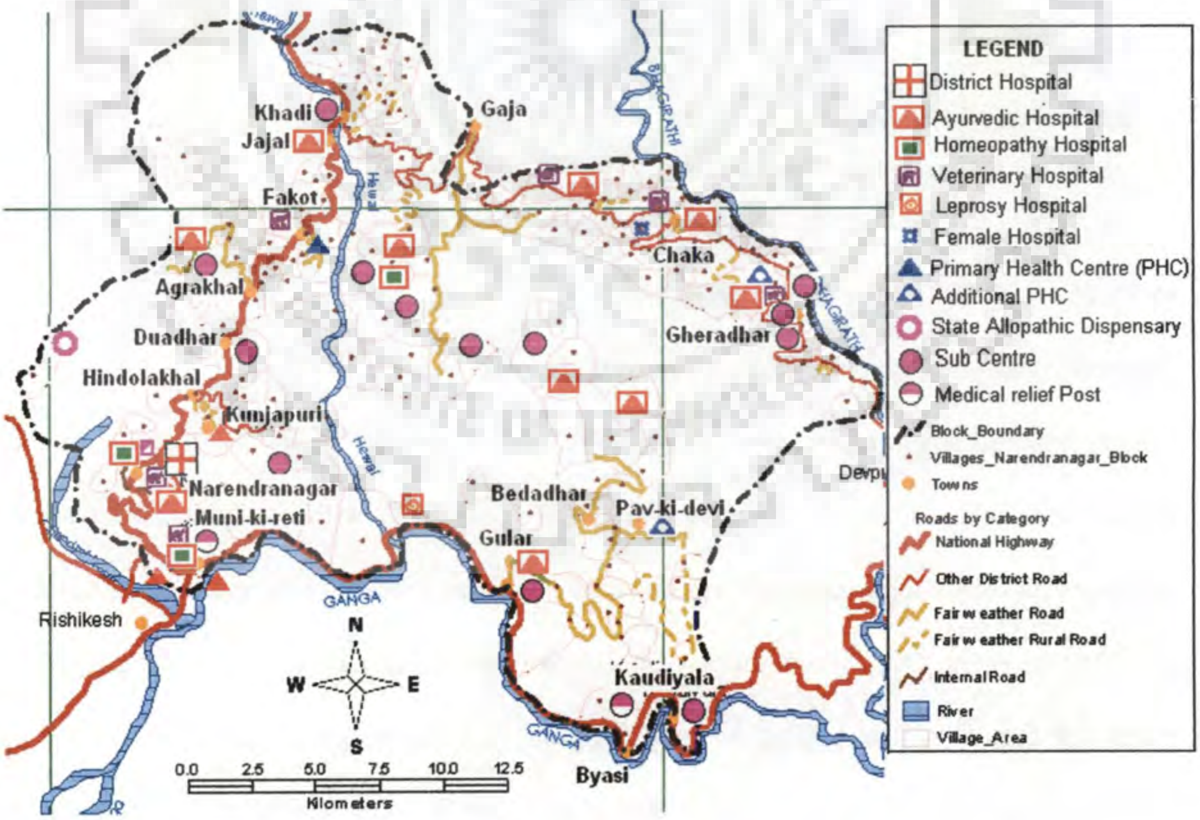


Figure 4.13: Locations of health facilities in Narendranagar block

Table 4.12: Facilities present in Suman Hospital Narendranagar

Facility	Beds	Doctors	Pharmacists	Technicians	Eye Assistant	Staff Nurses	Nursing Assistant	Ward Boys	Drivers	Ambulances	Stretchers	Structure Category
Quantity	40	13	6	1	1	7	1	8	2	2	4 (trolleys) 2 (canvas)	B & C

Source: Suman Hospital (2004)

Health Centers

Narendranagar block has one Primary Health Care Center (PHC), two Additional PHCs, one State Allopathic Dispensary and one Female Hospital. The facilities and resources available in these are given in Table 4.13.

Ayurvedic hospitals

The Narendranagar block has total 10 Ayurvedic hospitals and 3 Ayurvedic dispensaries. Their locations and resources are given in Table 4.14.

Table 4.13: Facilities at Primary Health Care Center and Additional Primary Health Centers of Narendranagar block

Facility / Location	Fakot (PHC)	Pav-ki-devi (APHC)	Ranakot (APHC)	Kodarna State Allopathic Dispensary	Chaka (Female Hospital)	Total
Number of beds:	4	4	4	4	4	20
Number of doctors	2	1	1	1	1	6
Pharmacists	1	1	1	1	1	5
Basic Health Worker (BHW)	2	1	1	0	0	4
Health visitors	2	0	0	0	0	2
Malaria supervisor	1	0	0	0	0	1
Ward boys	1	2	2	1	1	7
Computer person	1	0	0	0	0	1
Ambulance	1	0	0	0	0	1
Stretchers	10	2	2	2	2	18
Structure Category	B	A	A	A	B	-

Table 4.14: Locations and resources of Ayurvedic Hospitals in Narendranagar block

Location	Structure Category	No of Beds	Doctors	Pharmacists	Nurses	Stretchers
Narendranagar (Sah Ayukta Mukhyalaya)	C	15	2	2	0	2
Kunjapuri	B	4	1	1	0	2
Muni-ki-reti	C	4	1	1	0	2
Dhalwala	C	4	1	1	0	2
Deuli	B	4	1	1	0	1
Gular	B	4	1	1	0	1
Bhangla	A	4	1	1	0	1
Chaka	B	4	1	1	0	1
Berni	B	4	1	1	0	1
Banskatal	A	4	1	1	0	1
Jajal, Pokhri and Saundi (out door dispensary)	A,A,A	0	1 Each	0	0	0
Total	-	51	14	11	0	14

Sub Centers

Sub centers were earlier known as 'Family Welfare Centers'. They do not have hospital beds but have labor rooms for female patients. Sub centers do not have any facilities except one Female Basic Health Worker (BHW) is present in all sub centers. Buildings are either government buildings or rented buildings. Narendranagar block has 14 sub centers (Table 4.15) which are supervised by 4 supervisors (paramedical staff). These supervisors visit different villages and they are responsible for approximately 4 sub centers each.

Table 4.15: Sub Centers in Narendranagar Block

Place	Building ownership	Structure Category
Marodagad	Rented Building	A
Saundi	Rented Building	A
Pokhri	Government Building	C
Mathiyali	Rented Building	A
Odada	Rented Building	A
Khadi (Jajal)	Government Building	B
Diuli	Government Building	A
Duadhar	Government Building	B
Narendranagar	Government Building	C
Neer	No building rented 1 Room	A
Kaudiyala	Rented Building	A
Gular	Rented Building	C
Kyara	Rented Building	A
Gheradhar	Rented Building	B

Homeopathy Hospital

Narendranagar block has three Homeopathy hospitals in Odada, Muni-ki-reti and Narendranagar (Table 4.16). The homeopathy hospital in Odada lacks a doctor although it is the only health facility in neighboring twelve villages. The residents of all these villages go to Gaja which is 15 to 20 kms to avail medical facility.

Veterinary Hospital

Narendranagar block has 6 veterinary Hospitals. Out of these four have doctors while two are looked after by the store men. (Table 4.17)

Table 4.16: Homeopathy Hospitals in Narendranagar Block.

Place	Doctors	Pharmacists	Building Ownership	Structure Category
Odada	-	1	Rented	A
Muni-ki-reti	1	1	Government	C
Narendranagar (with Suman Hospital)	1	1	Government	C

Table 4.17: Veterinary Hospitals in Narendranagar Block.

Place	Doctor	Building Ownership	Structure Category
Chaka	1	Government	A
Fakot	1	Government	B
Narendranagar	1	Government	C
Muni-ki-reti	1	Government	C
Saundi	Store man center	Rented	A
Andarfigaon	Store man center	Rented	A

Leprosy Hospital

The leprosy hospital at Brhampuri of Narendranagar Block has 6 beds, 2 wardboys and 2 sweepers. This hospital is right now nonfunctional because of lack of doctor and nurses.

Medical Relief Post

In Narendranagar block 2 Medical relief posts are setup during yatra season from May to November especially for pilgrims (Table 4.18). These are held up in rented rooms. They have all emergency facilities like stretchers, oxygen cylinders etc. The staff for these posts goes temporarily from block.

Table 4.18: Medical relief posts of Narendranagar block

Place	Beds	Doctors	Pharm-acists	Supervisor	Watchman	Building ownership	Condition
Muni-ki-reti	1	1	1	1	1	Rented	Moderate
Byasi	1	1	1	1	1	Rented	Poor

Private Dispensaries and Medicine shops

Narendranagar block lacks private hospitals, however there are private dispensaries in many market towns and bigger villages of Tapowan and Dhalwala. One can find medicine shops at Chaka, Gaja, Pokhri, Khadi, Fakot, Agrakhal, Narendranagar and Muni-ki-reti.

Figure 4.14 shows photographs of some of the discussed medical facilities of Narendranagar block.

(a) Suman Hospital Narendranagar

(b) Ayurvedic Hospital, Narendranagar

(c) Ayurvedic Hospital, Chaka

(d) Ayurvedic Dispensary, Jajal

Figure 4.14: Health facilities in Narendranagar Block

(e) Primary Health Care Center at Fakot

(f) Closed Homeopathy Hospital at Odada

(g) Stone wall of Veterinary Hospital at Chaka

(h) Private Dispensary at Agrakhal

Figure 4.14: Health facilities in Narendranagar Block

Accessibility of Health Facilities

The distance of villages from the nearest health care facility in Narendranagar block varies from 0 to 21 kms. Many inaccessible villages have to trek as long as 10 kms to avail any kind of health facility (Figure 4.15). Hence it can be said that although the number of health facilities in Narendranagar block is adequate but the consideration of distance from health facilities and functionality make them inadequate.

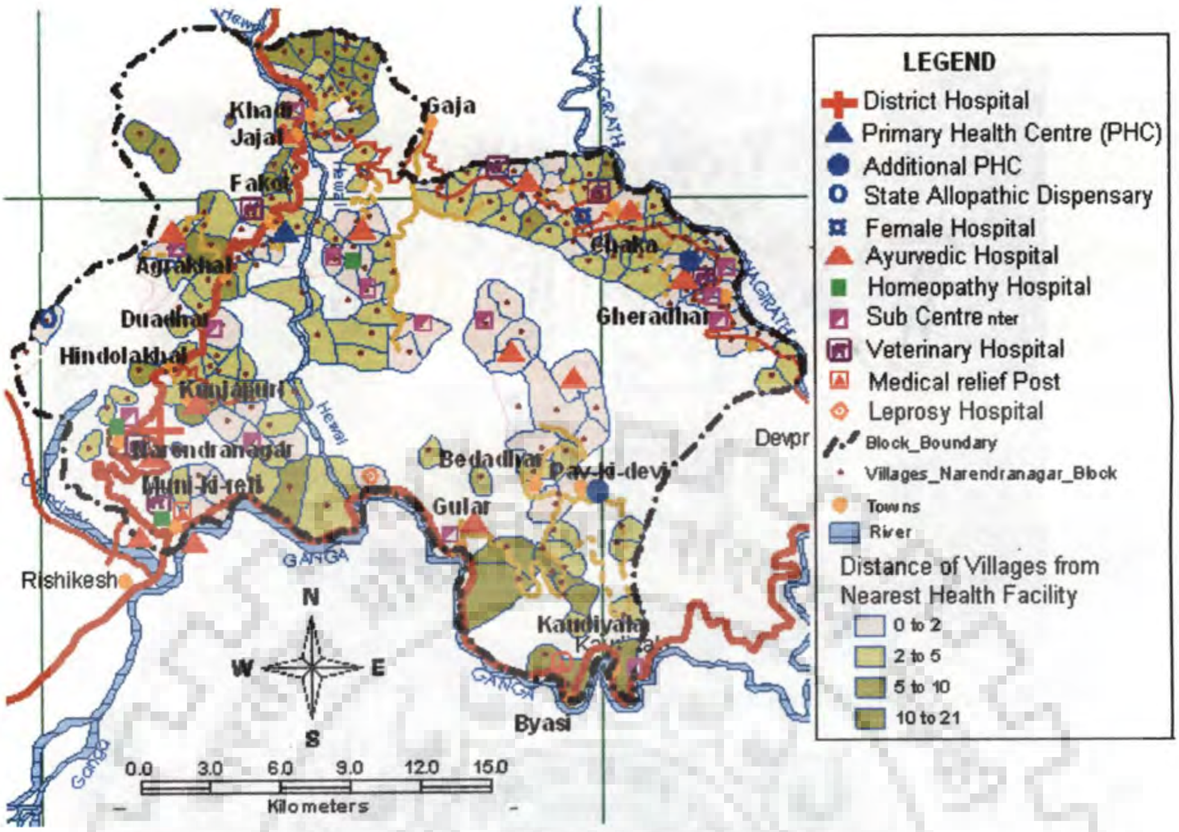


Figure 4.15: Accessibility of health facilities from villages

4.4.3 Educational Facilities

The presence of educational facilities in a region represents the overall development. During earthquake emergency the school buildings are often used as relief distribution camps, control rooms or for temporary sheltering of shelterless population. In Narendranagar Block the number of junior basic schools, senior basic schools and higher secondary schools per one lakh population for the years 1990-91, 2000-01 and 2001-02 are given in Table 3.20.

There are total 152 junior basic schools located in 113 villages and 17 market towns of Narendranagar block. The distance of nearest junior basic school from any village varies from 0 to 5 km. There are total 85 senior basic schools located in 62 villages and all 17 market towns. The distance of nearest senior basic school from any village varies from 0 to 8 km. There are total 56 higher secondary schools located in 38 villages and 17 market towns. The distance of nearest Higher Secondary School from any village varies from 0 to

10 km. Apart from these the block has 23 inter colleges and their distance from villages varies from 0 to 15 km. Only one degree college is present in the block which is Government Polytechnic College at Narendranagar.

Since junior basic schools are most commonly available educational facility in the block, the distance of villages from them is shown in Figure 4.16. There are 16 villages which have nearest junior basic school at a distance of 4-5 kms. These are small villages with total population of 1990.

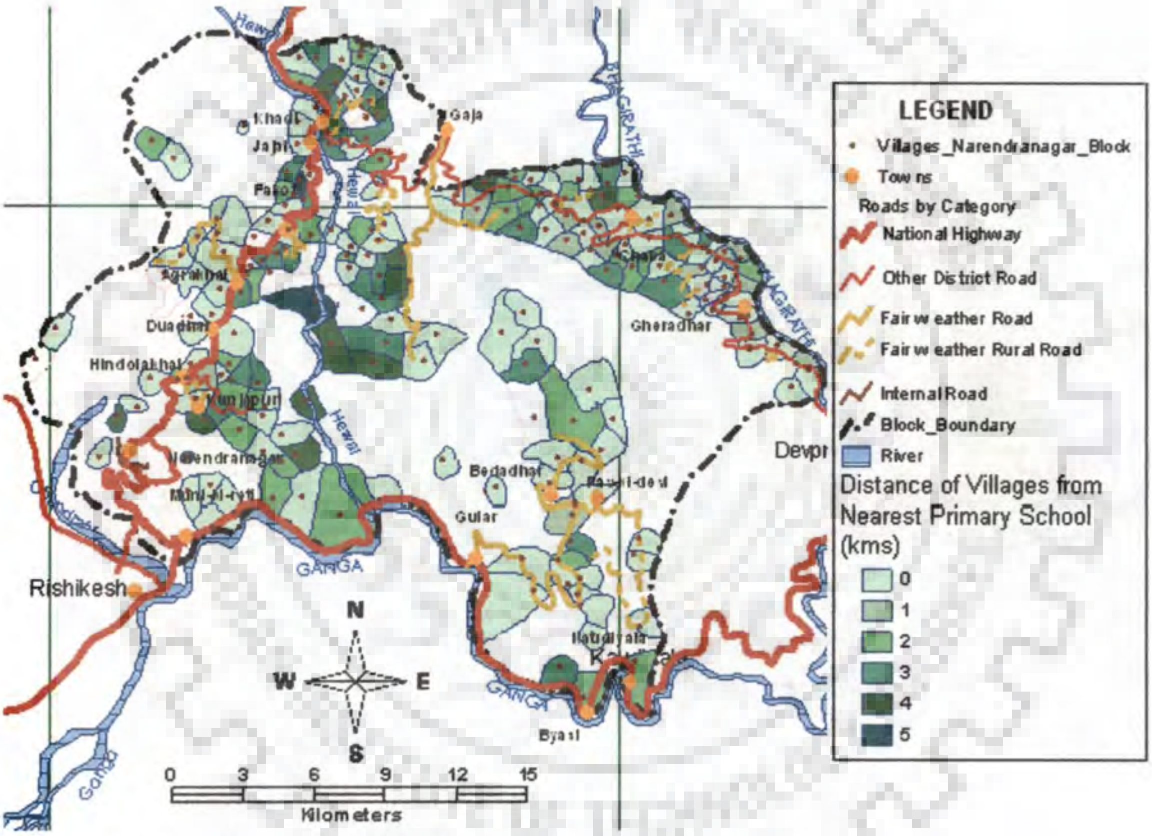


Figure 4.16: Distance of Junior Basic Schools from villages

There are 726 teachers, teaching in all educational institutes. They can be successfully used as a link between government and general public, for pre disaster activities of creating awareness and for post disaster activities during emergency management. The total 7595 primary school students, 2200 sr. secondary and high school children and 6446 inter college students can form an important link for the government policies and disaster management programmes to reach every household.

4.4.4 Food Supplies

There are total 5 food godowns at Narendranagar block at Gaja, Dhalwala, Gular, Gheradhar and Devprayag with capacities of 3155, 2800, 1890, 310 and 2980 quintals respectively. They distribute sugar, wheat and rice to 115 fair price shops in the block, located in 64 villages and 17 market towns. The locations of these food go-downs and the fair price shops are shown in Figure 4.17. In the event of earthquake emergency the food can be supplied to the population through these food go-downs and fair price shops.

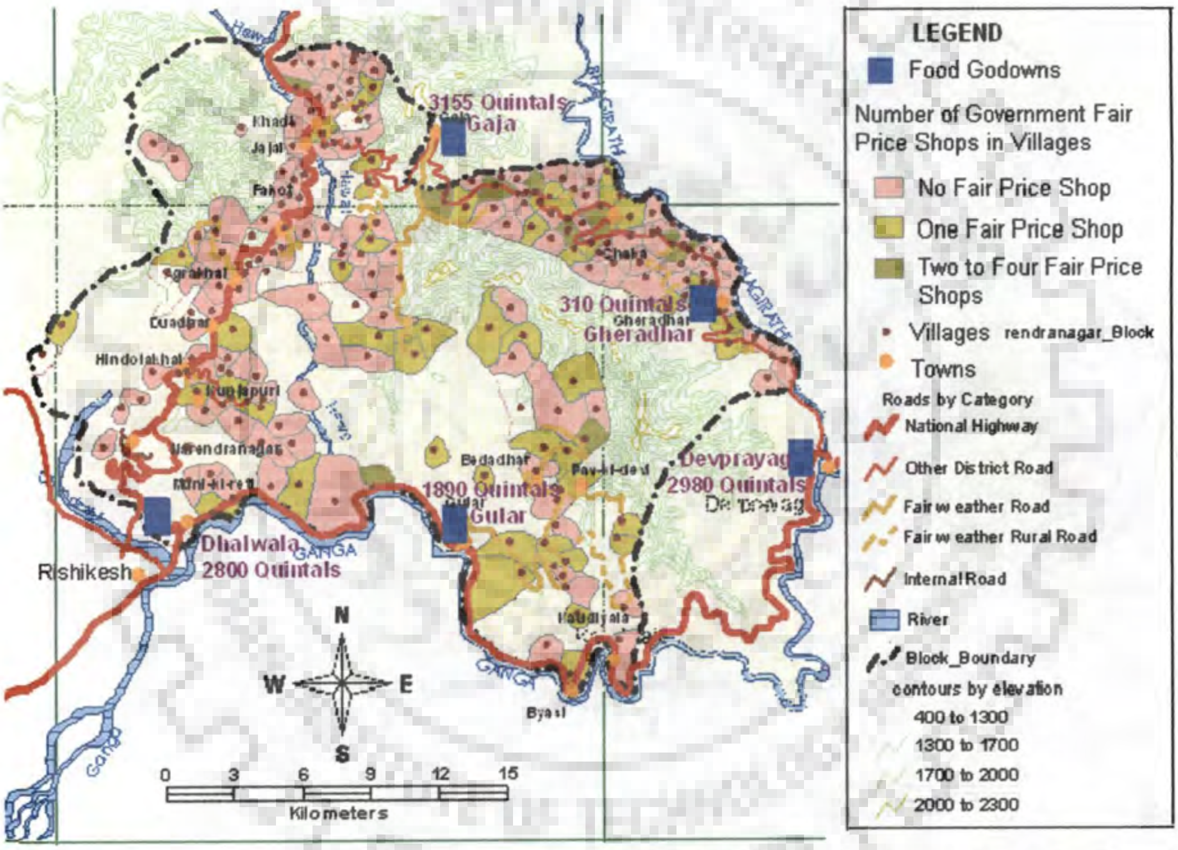


Figure 4.17: Food go-downs and government fair price shops in Narendranagar block

4.4.5 Telecommunications

Village level:

Based on the records maintained by telecom department, only 76 villages have telephone connections (Figure 4.18). These landline telephones are at high risk during earthquakes and as seen in past earthquakes, they often get disrupted. The mobile phone networks are provided only by Bharat Sanchar Nigam Ltd. (BSNL) and not by any private telecommunication company. The information about the villages under the coverage of these networks is not available at the block or district level telecom office. Primary survey in the villages suggested that settlements located on the Rishikesh – Narendranagar - Tehri highway have mobile connectivity. WLL technology has reached a few villages located near Devprayag and can be helpful if adopted in the villages.

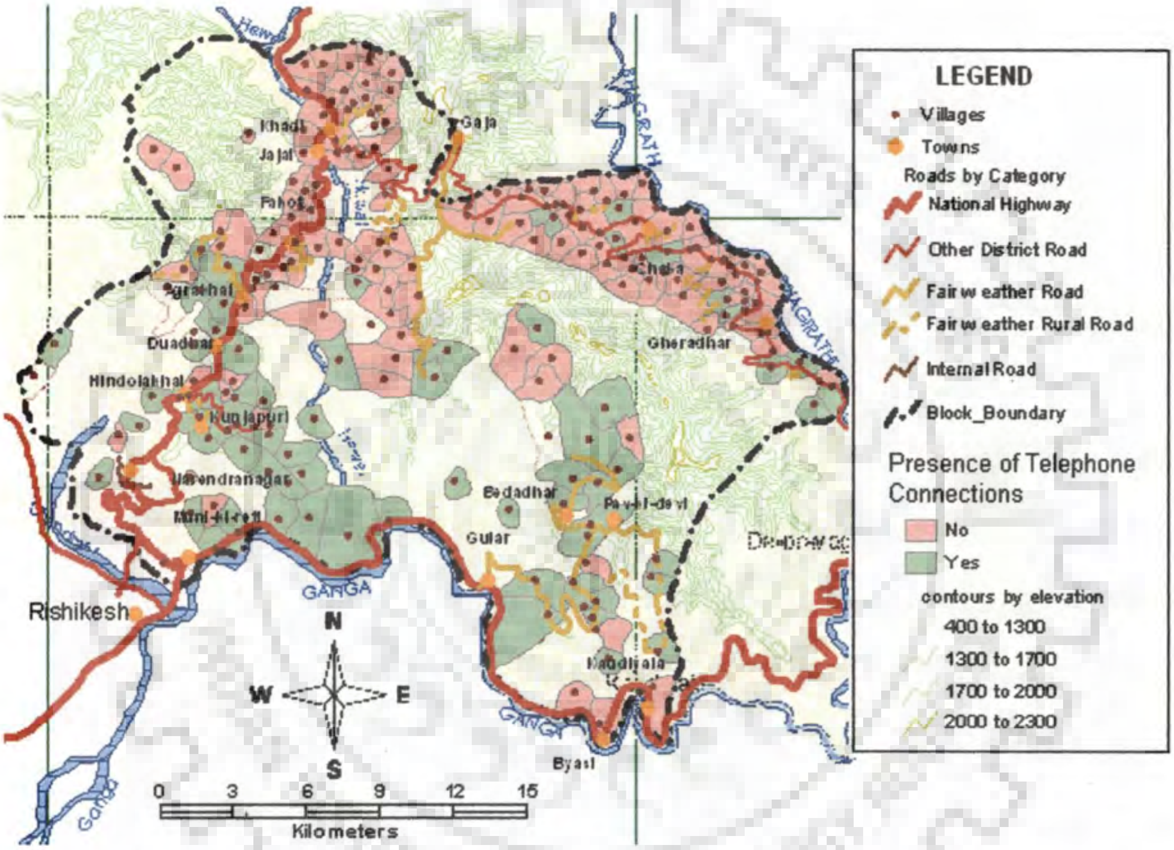


Figure 4.18: Telephone connections in villages of Narendranagar Block

Market towns:

All the identified market towns have telephone connections and mobile networks. There is no more reliable means of communication in case these are disrupted. There is total absence of any higher level communication facility.

Block Headquarters:

The emergency control room of Narendranagar block is identified at Narendranagar town. It is already equipped with facilities like internet and fax, but devoid of any more reliable communication facility. Also, applications of internet and fax during emergencies are not clear to the officials who would be responsible for communications. There are no clear check lists or roles and responsibilities for officials in the existing district disaster management plan.

4.4.6 Developable Land

Open flat land of suitable size will be required in close proximity to many villages to accommodate various relief activities including landing space for helicopters, during emergency phase of earthquake disaster. A preliminary survey of block through secondary and primary sources reveals that almost 160 villages, i.e. 75% of total villages have availability of such pockets of lands which could be used for the emergency operations.

4.5 INSTITUTIONAL SET-UP

All organizations functioning under the Disaster management Plan / Programme of Government of India, at the district, block and village levels have important role to play in disaster management and they collectively add up to the potential for earthquake disaster management. The district disaster management control room is headed by district magistrate and is required to start functioning immediately after an earthquake. The roles and responsibilities of DM are outlined in the district disaster management plan, although not in detail. The facilities available are radio sets, telecommunication, internet, GIS and fax. Various organizations functioning in the block and the district are given.

4.5.1 Government Organizations

Government organizations include the district administration as well as the other organizations, which have a role in the disaster management.

1. *District Administration*: The District Magistrate's office plays the most important role for disaster management. Immediately after any disaster, the department gets

ready for the management work. It has vast responsibilities to perform during the disaster period. Hence, information about the disaster and the damage has to be first given to District Magistrate's Control Room.

2. *Police Department*: At the time of earthquake disaster police department has a major role to play especially in the rescue and relief activities. During earthquake disasters first help is taken from police department for the rescue. District has 6 police stations and their choukis. Police line is located at Narendranagar.
3. *Public Works Department (PWD):* PWD mainly deals with the restoration of transport routes in case of earthquakes. The disruption of transport routes is a common problem seen from the experiences of past earthquakes. PWD caters to the smooth flow of traffic on roads of the district where no railway or air facility is available. The headquarters of PWD in the district is at New Tehri town and the block office is located at Narendranagar.
4. *State Electricity Board*: is responsible for the restoration of electricity in the district. District has ten electric sub stations responsible for electric supply through generators during the emergency period of the disaster in the affected areas. These 10 electric sub stations are located at New Tehri, Dobata, Chamba, Nainbag, Lambgaon, Muni-ki-reti, Tapowan, Devprayag, Bagwan and Ghansali.
5. *Telephone Department:* The district lacks sufficient communication facility. It has 288 PCOs, 4100 telephone connections and 29 telegraph exchanges. Narendranagar block has 6 telephone exchanges. Mobile phone connectivity is present in the villages located along the national and state highways.
6. *Jal Sansthan:* Jal Sansthan is responsible for water supply in the district during peace times. After earthquakes, the department is responsible for restoring the water supply in the district as early as possible.

7. *Border Roads Organization:* Border Roads Organization is responsible for maintenance of highways in the district.
8. *Health Department*: During emergencies the Chief Medical Officer at District Level is responsible for provision of emergency health services in the district.

4.5.2 Non-Government Organizations

The district is quiet undeveloped due to its hilly terrain, hence very few voluntary organizations work here. Some important NGOs in the district and the assistance expected from them are given below:

1. Christian Hospital, Chamba;
2. Jan Vikas Sansthan, Tehri-Garhwal;
3. Sasa Tipar and Society;
4. Mussoorie Dehradun Development Authority;
5. Adhyaksha Grahdesh Maitri Sangathan;
6. NGO of Maj. Karamchand Thapar, Tehri.
7. Bhartiya Gram Utthan Sansthan, Dhalwala

These NGOs, have supplied relief material like blankets, utensils, tents, flour, pulses, rice, sugar, salt, refined oil, clothes, sweater and other important material free of cost, in the past earthquakes.

Narendranagar block has 'Bhartiya Gram Utthan Sansthan, Dhalwala' as an important and active NGO working for rural development.

4.5.3 Community Based Organizations

It includes all the mahila mangal dals and nav yuvak mangal dals active in the district. There are total 16 mahila mangal dals and 14 nav yuvak mangal dals working in the district out of which 4 are working in Narendranagar in Bhaitan, Banali, Timli and Aampata.

4.5.4 Private Organizations

Two important private organizations work in the district. They are:

1. Jayprakash Company, Dobata, Tehri;
2. Thapar Company, Tehri.

These private organizations have trucks, ambulances and manpower which can be used during the emergency period of the disaster management.

4.6 MANPOWER AVAILABILITY

As an earthquake strikes any region numerous buildings collapse and hundreds of people are rendered homeless within just a few seconds. Massive rescue and relief operations need to be carried out for the earthquake victims. These operations require substantial manpower as discussed in section 2.5.2. The important manpower resources in the block are given.

1. *Army Cantonment Narendranagar*: Narendranagar has one Army regiment, which has lot of trained manpower and advanced equipments, which can be used for rescue and relief distribution purpose. The GREF deployment at Rishikesh and huge Army base at Dehradun can also reach Narendranagar quickly and hence can be used for carrying out relief operations in the block.
2. *Police lines Narendranagar:* At the time of earthquake disaster police department has a major role to play especially in the rescue and relief operations. During earthquake disaster in India first help is always taken from police department for the rescue. The block has only two police stations and 6 police posts, which is highly inadequate. There are usually 30 -40 villages under each police post. The policeman from the post gets the information from villages through villagers or patwaries personally or on phone and visits the village.

3. *Home Guards*: Home guards can be used for the rescue and relief operations in the block. The Home Guard Commander at block level is Sub District Magistrate. Total strength of Home Guards in the Block is 66 (62 home guards, 2 Platoon Commanders and 2 posts are presently vacant). There are 32 home guards under each Platoon Commander. Total strength of district – 429 (284 home guards, 11 Platoon Commanders, 134 posts are presently vacant)
4. *Anganbadi* members: Narendranagar block has 61 *Anganbadi* centers out of which 60 are functional (Figure 4.19). Total centers in Tehri Garhwal district are 559. Each center has one worker and one helper, who are local women from the village. Narendranagar block has a total of 59 workers and 56 helpers and the remaining posts are vacant. In villages workers do not operate from separate buildings. They operate from homes, from a room in panchayat bhawans or from a room in primary schools (CDPO, 2005).

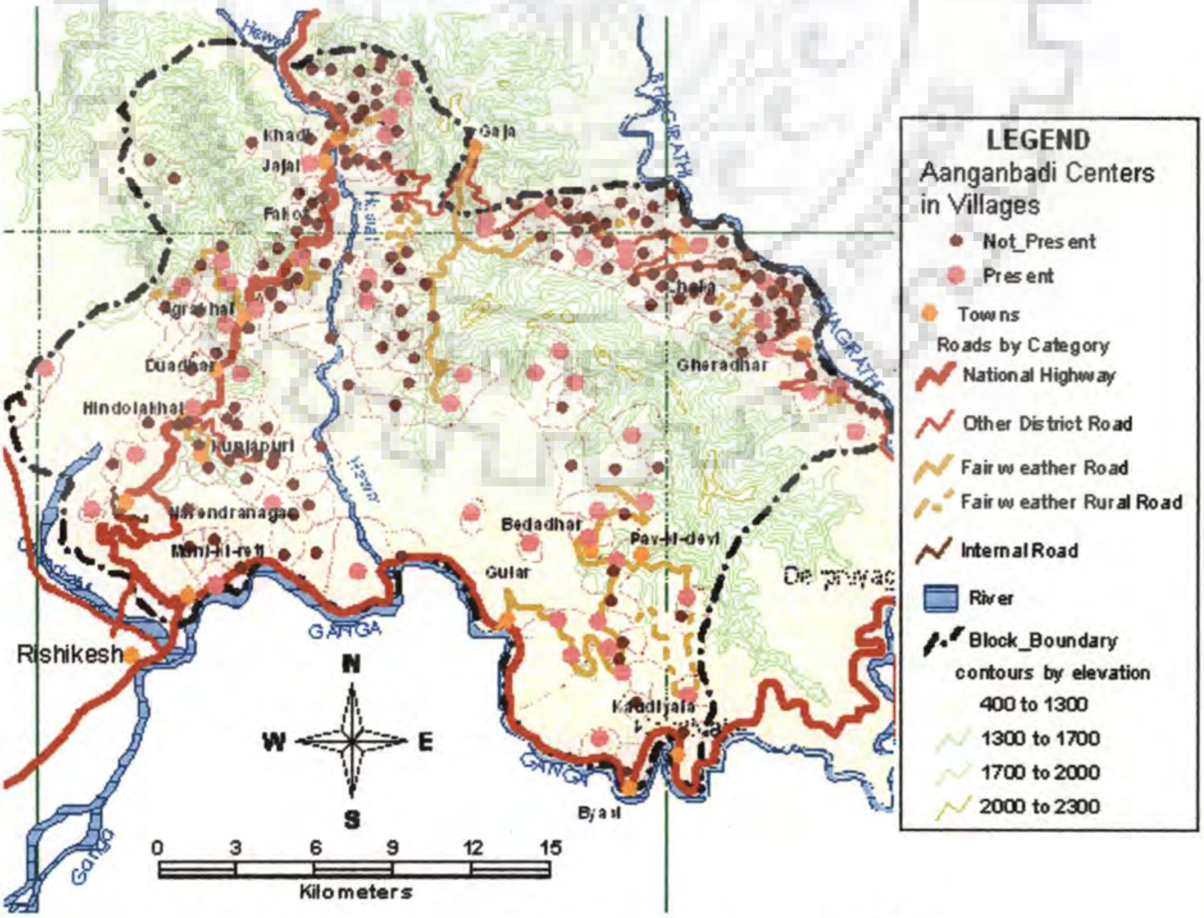


Figure 4.19: Aanganbadi centers in villages of Narendranagar block

5. *Masons / artisans:* Masons form an important manpower resource in the entire earthquake scenario. Based on the data collected from the sample villages during primary survey, the approximate number of masons in Narendranagar block is estimated to be 920. If trained suitably they can help the government in projects of retrofitting of existing housing stalk and critical infrastructure so that losses during earthquakes are minimized. The other artisans also can contribute for the same purpose
6. *Other Volunteers / Youths:* The youth of the Narendranagar block can be utilized as the important manpower resource for vulnerability reduction activities and during emergencies. The 2557 inter college students and the members of nav yuvak mangal dals could be trained for the purpose.

4.7 AVAILABILITY OF MATERIAL SUPPLIES

All the material supplies which can be used in the emergency phase of earthquake disaster, available in the district are given.

1. *Food material:* The district has a total 31 food godowns with total capacity of 8300 metric tons. In case of disasters this capacity is sufficient (DMMC, 2003a). (section 4.4.4)
2. *Tents:* Uttarankhand government has kept 250 tents to be used in disaster period by various districts, out of which 50 are at Pithoragarh, 50 at Almoda, 50 at Rudraprayag, 50 at Uttarkashi and 50 at Dehradun. As per information provided by the officials, Tehri-Garhwal district can use the tents allotted to Uttarkashi district. But tents being very less in number are hardly considerable. More tents can be supplied by the NGOs working in or outside the district.

3. *Transport:* For transport the district has sufficient number of buses and trucks. During emergency period if needed 400 more trucks and 50 more buses can be made available (DMMC, 2003a).
4. *Recovery Van:* District does not have any recovery van as administrative or private property. Only Army Cantonment at Narendranagar has a recovery van, which can prove to be very useful.
5. *Rescue Equipment:* District has a total of 25 dozer/rollers. Only 2 out of these are kept on the National highways, others are kept according to needs on the other roads. The number is sufficient (DMMC, 2003a).
6. *Ambulances:* District has total 10 ambulances available. These are kept at Primary Health Centers of Tehri and other tehsil headquarters. The private companies, Jayprakash company and Thapar Company of Tehri can provide more ambulances in the emergency period (DMMC, 2003a).
7. *Other Supplies:* Other supplies like clothing, blankets, utensils and other necessary supplies are not kept prepared by the government at district or block administration. These can be provided by NGOs in the district or outside the district. There is a need for keeping a stock of such materials prepared for the disaster. The proximity of the selected sub region to urban centers like Rishikesh and Dehradun can facilitate supply of emergency relief if required.

4.8 CONCLUSIONS

Several large tectonic elements passing through Narendranagar block and the coincidence of most vulnerable microzone indicate the earthquake hazard in the region. The vulnerability of residential buildings of Narendranagar block, indicate that a huge population of 28,573 (28%) lives in highly vulnerable buildings, 40,501 (39%) lives in moderately vulnerable buildings and 33,959 (33%) lives in low vulnerability buildings. The region is also highly prone to landslides and the landslide hazard zones suggest that they can directly destroy the settlements and agricultural fields besides rendering 85 settlements inaccessible after an earthquake, by blocking the access routes. Settlements are also found vulnerable due to their inaccessibility, river proximity, altitude and size. The settlements are socially vulnerable on account of illiteracy, poor awareness, gender aspects, age distributions and lack of local level disaster management efforts.

The analysis of resource potential of Narendranagar block is carried out. The infrastructure availability in terms of health facilities, educational facilities, food storage, and telecommunication highlights the inadequacy on account of the distance of settlements from the facilities. The manpower resources are adequate only if suitably trained in advance. The institutional setup needs to be strengthened with consideration for disaster management activities. The analysis of material supplies reveals the level of availability of various relevant materials in the block.

CHAPTER 5

DEVELOPMENT OF EARTHQUAKE SCENARIO AND DAMAGE ASSESSMENT

5.1 INTRODUCTION

The earthquakes vulnerability of Narendranagar block discussed in chapter 4 leads to the development of an earthquake scenario within the region. A hypothetical earthquake is imagined at the most likely tectonic location. Two different magnitudes are considered and the peak ground accelerations are calculated for the Narendranagar block. The higher magnitude is considered for calculation of total destruction in the area, in terms of building damage and human casualties. The calculations are done for the villages using MS Excel software.

The methodology adopted is derived on the basis of various related studies available which are suitably quoted. This hypothetical earthquake scenario gives rise to requirement of various critical infrastructure facilities and other resources in the block. These requirements when analyzed against the available ones as discussed in chapter 4, suggest the shortcomings of the Narendranagar block, for earthquake disaster management.

5.2 A HYPOTHETICAL EARTHQUAKE SCENARIO

A hypothetical earthquake scenario is developed for the Narendranagar block to assess the likely damage in the block due to earthquakes and check the existing preparedness levels. A most likely epicenter is assumed and Peak Ground Accelerations are calculated. These Peak Ground Accelerations are then converted into MSK intensity levels using the available conversions and the effect of topography observed during past earthquakes. The consecutive destruction experienced by the housing stock in different villages due to these is calculated on the basis of descriptions provided for different MSK intensities.

5.2.1 Assumption of Epicenter, Calculation of PGA and Iso-Acceleration Contours

The close proximity of three mega thrusts in Narendranagar block coupled with the fact that the river Ganga winds in a sinusoidal manner in this area plus the presence of more than 270 micro earthquake epicenters (EQ 86-2, EQ 87-16) in the time frame of 5 years indicate that tectonic stresses are building up in this area. This could be a possible location of a medium to large sized earthquake in the future.

The point of inflexion of the Ganga River, which coincided with the micro zone D3, seems to be the candidate area for an earthquake scenario. It could be noted that the epicenter of the recent Pakistan earthquake on Oct 8th, 2005 was also located on similar conditions (Sinvhal *et. al.,* 2005; GSI, 2006).

A hypothetical epicenter is considered near Tapowan at 30^0 08'10"N and 78^0 20'30"E. The date and time of occurrence of hypothetical earthquake is considered to be same as Uttarkashi earthquake of 1991 in the region, which is 02:53hrs on October 21st. Destructive earthquakes in the lower Himalayas are in the magnitude range 6 – 8.

Earthquake hazards in any region are best estimated by peak accelerations. These were computed (McGuire, 1977) for earthquakes of magnitude 7.0 and 7.5 for different hypo central distances, to cover the entire Narendranagar block (Table 5.1). The highest peak accelerations for magnitude 7.0 and 7.5 computed for a hypo central distance of 20 kilometers are 0.30 cm / sec^2 and 0.41 cm / sec^2 respectively. This is significantly higher than what is expected to occur in seismic zone IV, 0.25 cm / sec^2. This implies that in Narendranagar block earthquake damage can be expected to be much higher than what is expected as per the seismic zoning map of India. Iso-acceleration contours with these hypothetical earthquake scenarios were plotted for different hypo central distances. The contours were subsequently elongated parallel to the trend of Main Boundary Fault to account for regional tectonics. (Figure 5.1)

Table 5.1: Peak accelerations for earthquakes of magnitude 7.0 and 7.5 for different hypo-central distances

Hypo-central distance (km)	Peak accelerations (cm / sec^2)		Area (Sq. Km)	Length of Axis (km)	
	Mag 7.0	Mag 7.5		Long Axis	Short Axis
20	0.309	0.410	1257	50	20
25	0.269	0.365	1964	66	28
30	0.249	0.325	2828	82	36

Source: Gupta *et. al.* (2006)

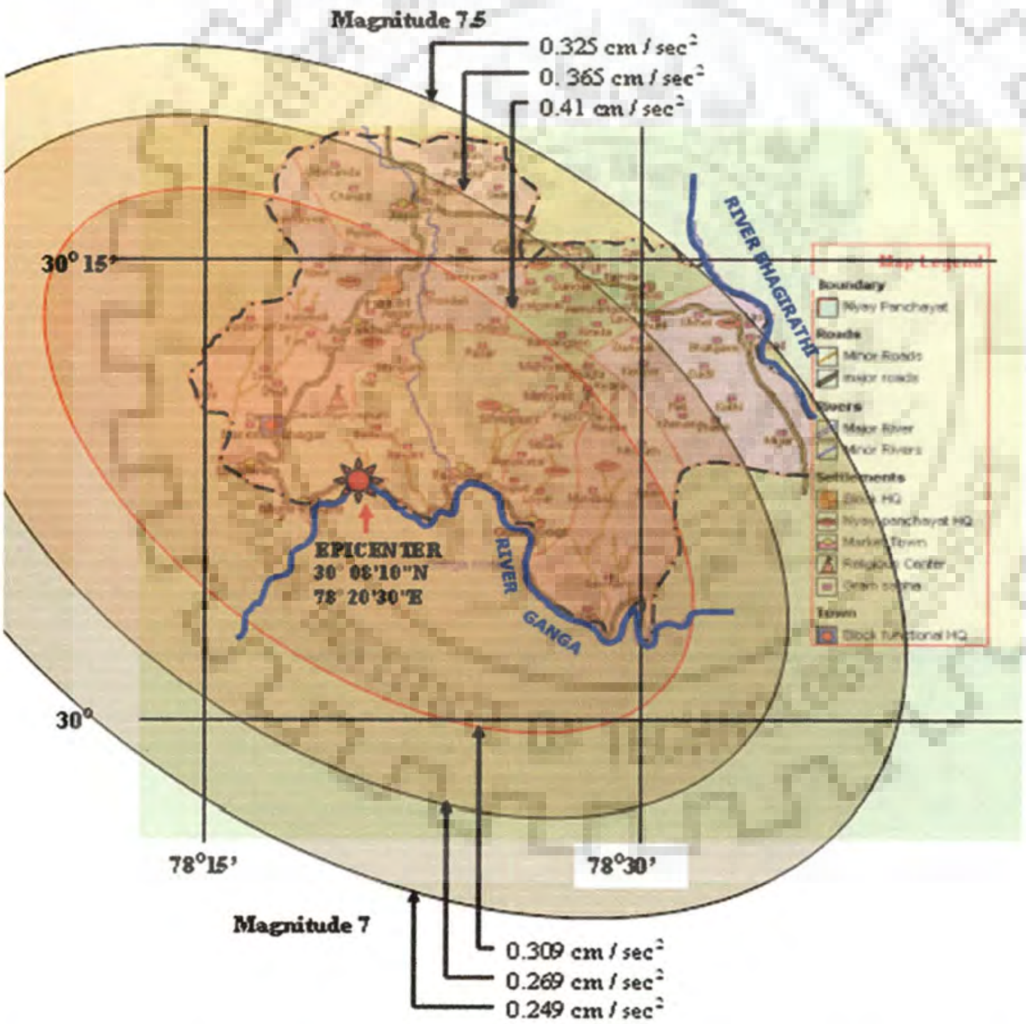


Figure 5.1: Acceleration contours with epicenter at Tapowan (30^0 08'10"N and 78^0 20'30"E) for different hypo-central distances elongated parallel to the trend of Main Boundary Fault, Source: Gupta *et. al.* (2006).

5.2.2 Methodology for Damage Estimation

The assumed hypothetical earthquake with computed PGAs is translated into consecutive damage within the settlements of Narendranagar block. The already established relationship of PGA and intensity are used for this purpose (Wald *et. al.*, 1999; Bolt, 2000). It is understood that such relationships would vary from place to place because of its dependence on vulnerability of constructions, local seismicity, terrain characteristics etc. But in absence of such relationships for any region similar to the selected region the available relationships are used. This methodology is reverse of the methodology usually followed for the earthquake related studies. The methodologies are briefly explained in the Figure 5.2 and Figure 5.3.

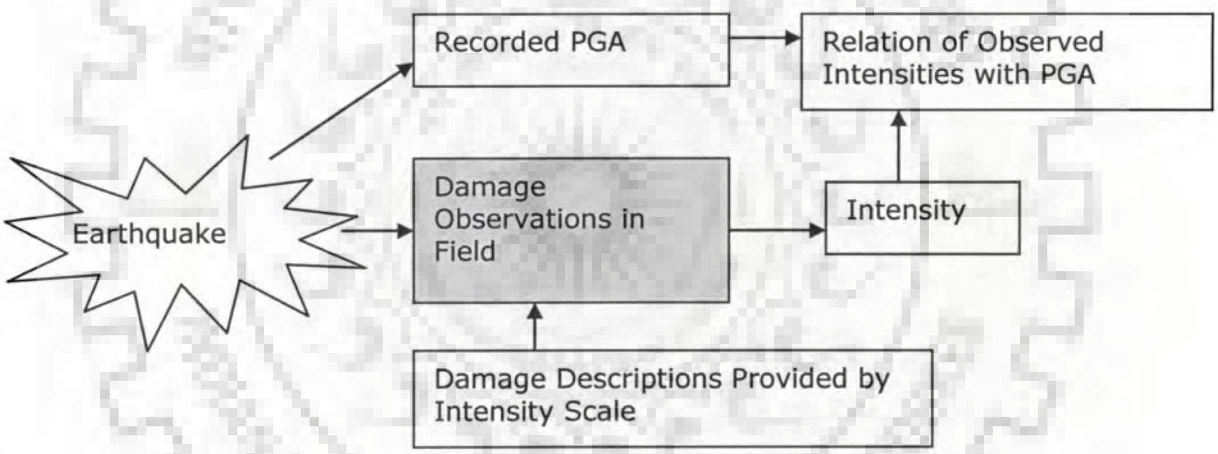


Figure 5.2: Methodology usually adopted during post earthquake scenario

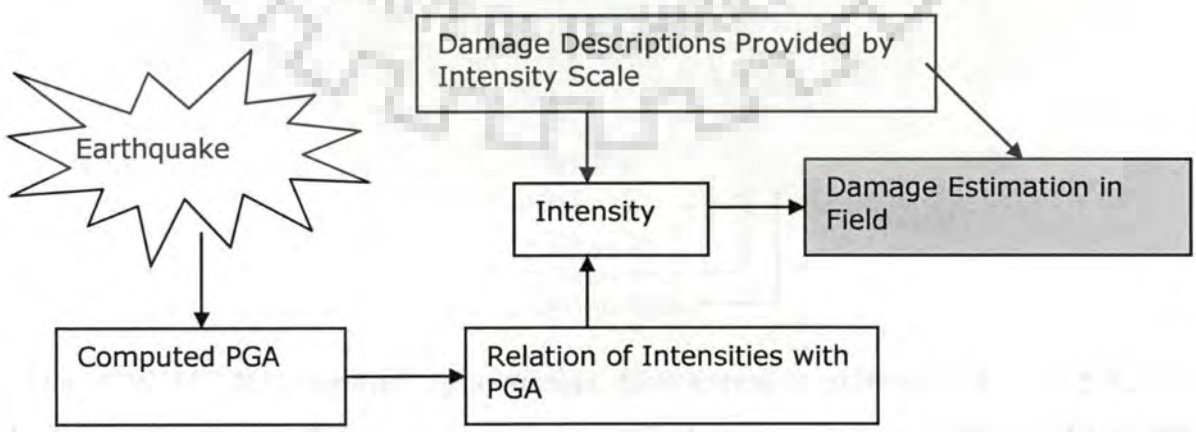


Figure 5.3: Methodology adopted for generating hypothetical earthquake scenario

A consecutive damage scenario is developed in the region for the higher magnitude i.e. 7.5, for ensuring higher preparedness standards. The MSK intensity scale (IS 1893 – 2002) is used for this purpose, since it is the most widely accepted scale in India and used by Bureau of Indian Standards.

5.2.3 Conversion of PGA into MSK Intensities

The entire Narendranagar block is covered by three iso-acceleration contours with PGA for higher magnitude earthquake (magnitude 7.5) being 0.41g, 0.365g and 0.325g. The relationships of PGA and MSK intensities are also provided by various sources (Wald *et. al.*, 1999; Bolt, 2000). The relationships of PGA with MM Intensities given by Bolt (2000) are used for the conversions (Table 5.2). According to Reiter (1990) MMI and MSK scales are the same at all intensity levels above intensity III. Hence, the given relationships are directly used for MSK intensities.

Table 5.2: Correlation of PGA with MSK Intensities

MM / MSK Intensity	PGA
I	-
II	-
III	-
IV	0.015g – 0.02g
V	0.03g – 0.04g
VI	0.06g – 0.07g
VII	0.10g – 0.15g
VIII	0.25g – 0.30g
IX	0.50g – 0.55g
X	> 0.60g
XI	-
XII	-

Source: Bolt (2000)

As, per the Table 5.2, the three iso-acceleration contours with PGA being 0.41g, 0.365g and 0.325g fall between intensity IX and intensity VIII and hence are assigned the intensity values VIII+++, VIII++ and VIII+ respectively.

5.2.4 Determination of Intensity of affected villages

Assigning intensity values to all villages in the block has been done considering the effect of topography on earthquake damage, as observed during the past earthquakes. It has been reported based on field observations and instrumental evidences that surface topography considerably affects the amplitude and frequency content of ground motion. (Celebi, 1987; Geli *et.al.*, 1988). The amplification near the crest of the ridge was measured in five earthquakes in Matsuzaki, Japan. The average peak crest acceleration was about 2.5 times the average base acceleration (Jibson, 1987). The intensity in a valley may be 1 – 2 scales lesser as compared with the surrounding, if it is free from the soil deposits.

It was observed in Uttarkashi Earthquake (1991) and Chamoli Earthquake (1999) that intensity of damage to houses located at lower levels is found to be less severe than those located at higher levels. (GIS, 1992; NSET and DEQ, 2000)

Considering this effect, the villages located at higher altitudes and on the crest of mountains are expected to suffer greater damage and hence are assigned intensity IX. The villages located at lower altitudes and in the valleys have probability of suffering lesser damage and hence are assigned intensity VIII. The intermediate villages are assigned the same intensity as was determined by the iso-acceleration contours. Figure 5.4 shows the different villages and market towns with different Intensity values. Table 5.3 gives total number of villages and population vulnerable to different intensities of earthquakes.

Figure 5.4 and Table 5.3 suggest that, 31 villages with 7.76% population would experience damage of intensity IX; 57 villages and 9 market towns with almost 30% population would experience damage of intensity VIII+++; 23 villages and 3 market towns with almost 10% population would experience damages of intensity VIII++; 52 villages and one market town with almost 14% population would experience damages of VIII+; and the rest 51 villages and 4 market towns with almost 38% population would experience damages of intensity VIII.

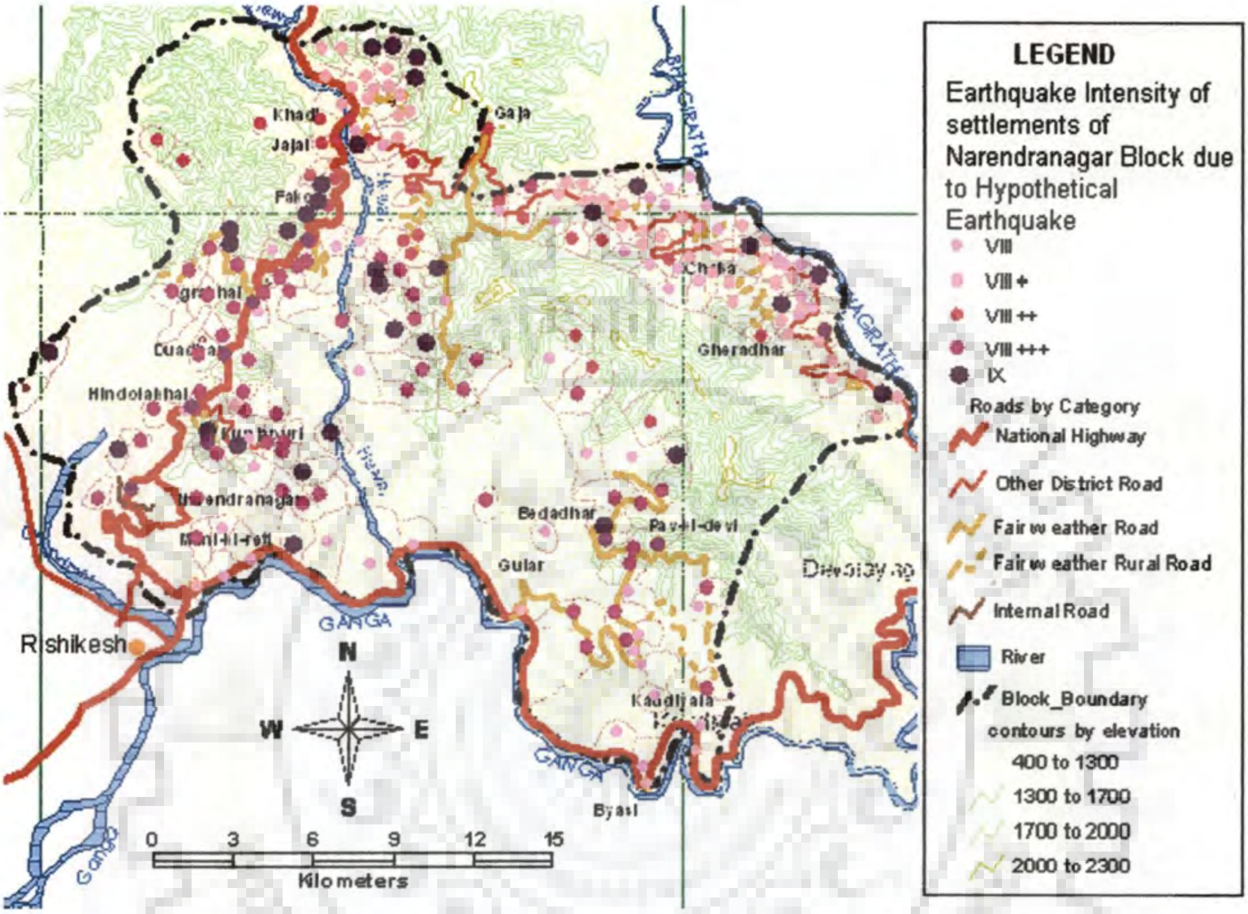


Figure 5.4: Villages and market towns with different intensity values

Table 5.3: Total number of villages and population facing different intensities of earthquakes

Intensity	Number of Villages	Market towns	Total populations	Percentage populations
VIII	51	Muni-ki-reti, Gular, Byasi, Kodiyala	38,925	37.78
VIII+	52	Chaka	14,784	14.35
VIII++	23	Gaja, Jajal, Khadi	10,617	10.31
VIII+++	57	Narendranagar, Duadhar, Agrakhal, Fakot, Gheradhar, Bedadhar, Pav-ki-devi, Kunjapuri devi, Hindolakhal	30,706	29.80
IX	31	-	8000,	7.76
Total	214	17	103032	100

5.3 BUILDING DAMAGE AS PER INTENSITY LEVEL

The percentages of different house constructions existing in sample villages are used to calculate number of different house constructions in the entire block (Section 4.2.2). The damages to the buildings as a result of this are grouped into five grades (G1 to G5), ranging from no damage to total collapse as given in MSK scale and calculated as per definitions and descriptions of quantities (Table 5.4).

Table 5.4: Damage to residential buildings of the Narendranagar block

Damage Grade	Description	Residential Buildings in Villages		Residential Buildings in market towns		Total Residential Buildings	
		Number	Percentage	Number	Percentage	Number	Percentage
G1	No damage	1490	10.5	1089	16.4	2579	12.36
G2	Minor damage	3904	27.4	2393	36.0	6297	30.18
G3	Moderate damage	4804	33.8	1979	29.8	6783	32.51
G4	High damage	3137	22.1	992	15.0	4129	19.79
G5	Collapse	887	6.2	187	2.8	1074	5.15
	Total	14222	100	6640	100	20862	100.00

Source: Gupta *et. al,* (in press)

The village wise number of buildings with damage grades G1 to G5 are given in ***Annexure VIII***. Table 5.5 shows number of villages and market towns experiencing different percentage of severely damaged buildings to total village buildings. The spatial distribution of these villages is shown in Figure 5.5.

Table 5.5: Percentage of severely damaged buildings (G4 and G5) to total buildings

Range (%)	Number of villages	Names of Market towns
0 to 10	16	Byasi, Kaudiyala, Muni-ki-reti, Gular
10 to 20	54	Jajal, Khadi, Gaja, Chaka
20 to 30	35	Narendranagar, Duadhar, Agrakhal, Fakot, Hindolakhal, Gheradhar, Bedadhar, Pav-ki-devi, Kunjapuri
30 to 40	35	Nil
40 to 50	15	Nil
50 to 60	41	Nil
> 60	17	Nil

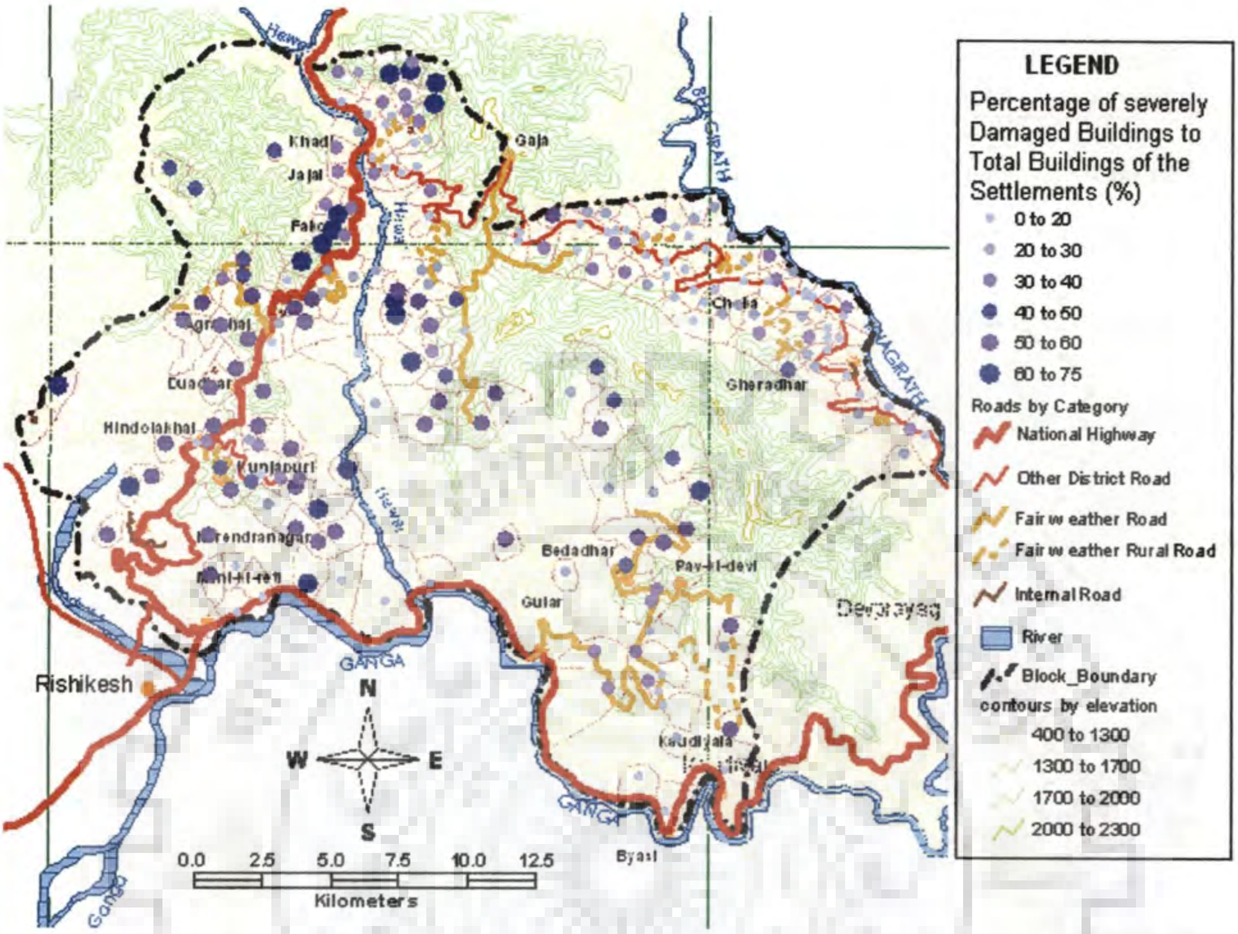


Figure 5.5: Villages with different percentages of severely damaged buildings to total buildings

5.4 SHELTERLESS POPULATION

The collapsed and damaged buildings thus calculated would render many people homeless, who need to be provided with temporary shelters on urgent basis. As per ISET Manual (2001), the residents of buildings suffering G4 and G5 damage grade should be immediately vacated since they are not safe to be occupied by the residents. The cumulative numbers at block level are given in Table 5.6 and village wise numbers are given in ***Annexure VIII*** and categories are shown in Figure 5.6.

Table 5.6: Information of residents of buildings suffering damage grade G4 and G5

Villages	Number of Buildings	4023
	Number of Occupants	21759
	Percentage of Occupants	30.07
Market Towns	Number of Buildings	1179
	Number of Occupants	5425
	Percentage of Occupants	17.69
Total	Number of Buildings	5202
	Number of Occupants	27184
	Percentage of Occupants	26.38

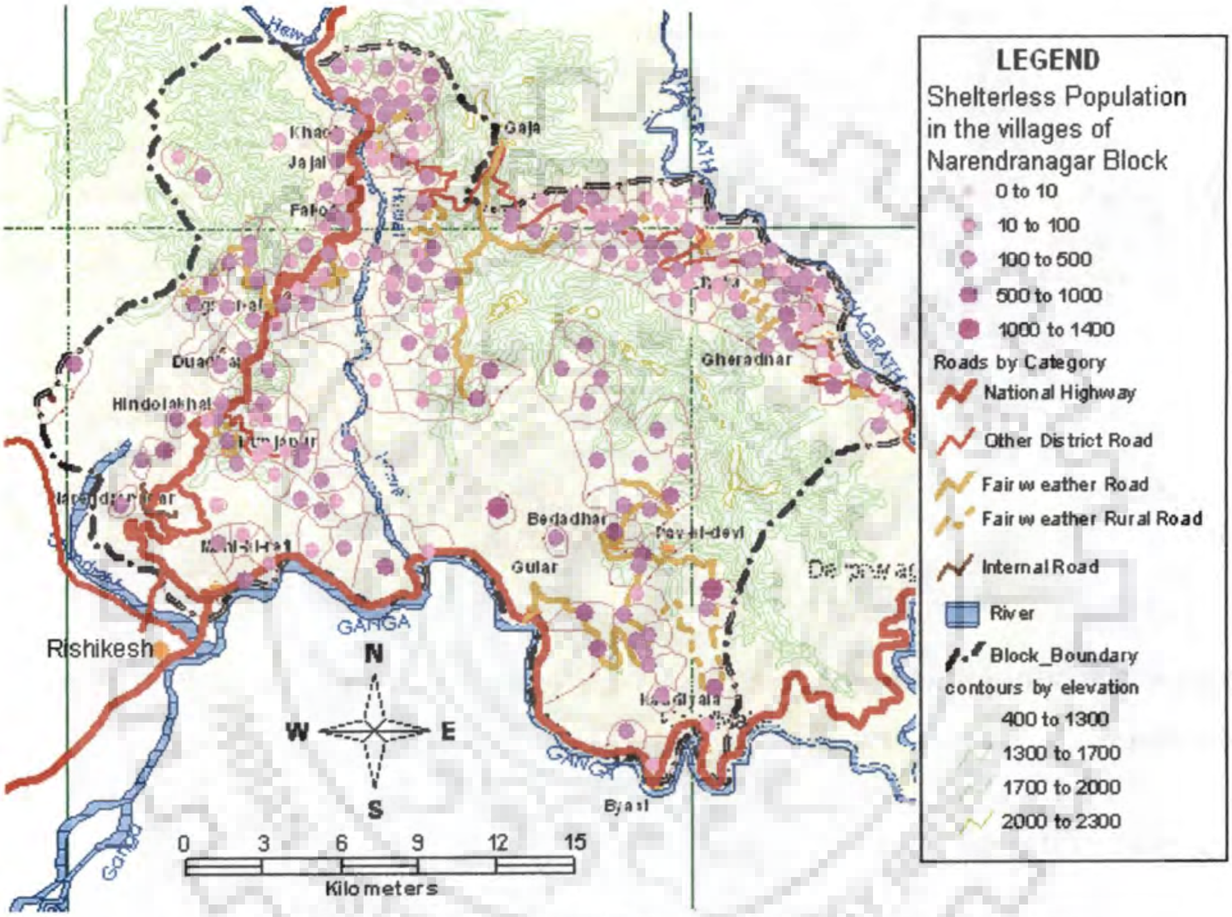


Figure 5.6: Shelterless population in the settlements of Narendranagar Block

Table 5.6 suggests that a huge percentage of population from Narendranagar block would render homeless and need to be provided with temporary shelters after earthquake. ISET manual (2001) mentions that the buildings suffering G3 damage grade are also not safe for habitation because of probability of collapse in the case of aftershocks. If residents of buildings with G3 damage grade also should be sheltered in temporary shelters then the burden on the authorities for provision of temporary shelters would be enormous. This fact substantiates the urgent need of improving the housing conditions in Narendranagar block through retrofitting projects, before the next earthquake occurs.

5.5 CASUALTY ASSESSMENT FOR DAMAGED BUILDINGS

The date and time of occurrence of hypothetical earthquake is considered to be same as Uttarkashi earthquake of 1991 in the region, which is 02:53hrs on October 21st. The winter night ensures almost 100 percent occupancy of buildings and as a result high casualty rates would lead to better preparedness in terms of health care facilities. Because of unavailability of relevant data documenting occurrences of life loss in earthquakes, the estimated standards suggested by Coburn and Spence (2002) for collapsed low rise masonry buildings are used for casualty estimation for hypothetical earthquake.

The statistics provided suggest that for collapsed masonry buildings up to three stories 30% of the occupants would be trapped in the villages affected by intensity VIII and 60% of the occupants would be trapped in the villages affected by intensity IX. Hence the percentages of trapped occupants assumed for intensity VIII+ VIII++ and VIII+++ are 34, 38 and 45 respectively. The numbers of trapped occupants are thus calculated for each village from the total occupants of buildings affected by damages of grade 5 and half the occupants of buildings affected by damage grade IV.

Coburn and Spence (2002) state that for masonry constructions, the injury distribution as percentage of the trapped occupants is as given below:

Dead or Un savable	20%
Life-threatening cases needing immediate medical attention	30%
Injury requiring hospital treatment	30%
Light injury not necessitating hospitalization	20%

Based on these values the numbers of trapped occupants under each triage injury category are calculated for all villages. The observations are summarized in Table 5.7. The numbers of injuries calculated to be suffered by individual villages and market towns are given in *Annexure VIII.*

Table 5.7: Total Casualties in Narendranagar Block

Injuries	Village		Market Towns		Total	
	No.	%	No.	%	No.	%
Dead or unsavable	801	1.1	189	0.6	990	0.96
Life threatening injuries needing immediate medical attention	1201	1.6	283	0.9	1484	1.44
Injury requiring hospital treatment	1201	1.6	283	0.9	1484	1.44
Light injury not requiring hospital treatment	801	1.1	189	0.6	990	0.96

Hence, out of total population of Narendranagar block (103032) 990 persons contributing 0.96% of total population would be dead because of collapse of residential buildings. This percentage is alarmingly high and emphasizes the need for earthquake disaster prevention measures in the block.

5.6 LANDSLIDE OCCURRENCE AND INACCESSIBILITY

The landslide hazard assessment within Narendranagar block emphasizes the need to predict the most probable landslides in the region and their effect on the emergency operations. The assumed earthquake has the potential to trigger many landslides in the region. The most probable landslides will be expected in the most hazardous landslide zones. The expected landslides in Narendranagar block triggered by assumed earthquake are given in Figure 5.7. These landslides would block the transport routes, hampering the rescue and relief activities.

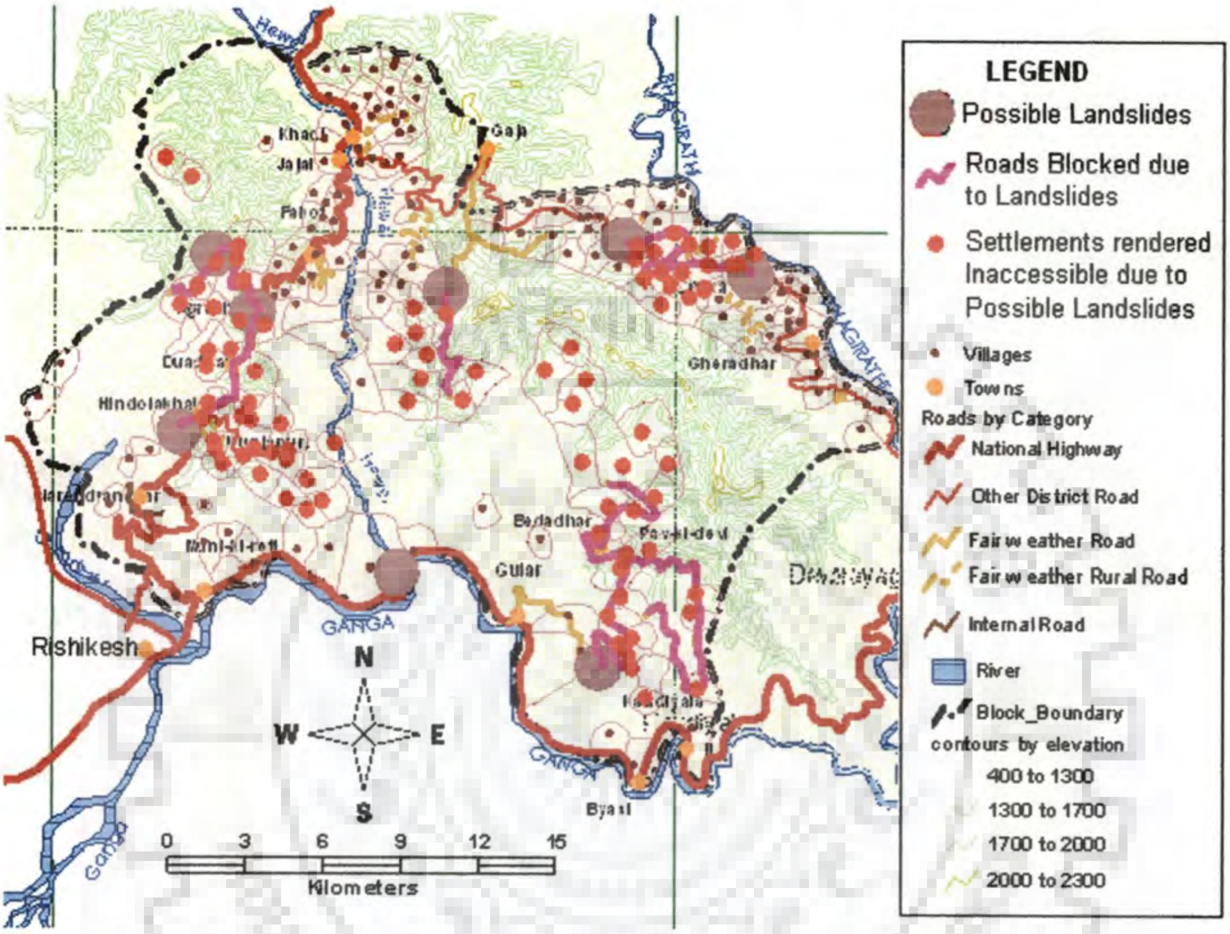


Figure 5.7: Possible Landslides in Narendranagar Block

As results of these landslides total 85 settlements with a total population of 27462 (26.65%) would be rendered completely inaccessible (Figure 5.7). It can be said that almost all other settlements would be rendered partially inaccessible because of landslides in the Narendranagar block. It indicates that actions should be taken on urgent basis to reduce the landslide hazard in the region.

5.7 SEISMIC RISK INDICATOR (SRI)

The calculation of human casualties in the settlements indicate a need to develop an indicator to compare the settlements in terms of fatalities. This indicator should be used to compare all the settlements of Narendranagar block and also the entire region for any possible earthquake, which would facilitate prioritization for taking preparedness measures. This Seismic Risk Indicator (SRI) is determined from the number of people dead per 100000 population at settlement level. The SRI value calculated for settlements found to be varying from 0 to 3030. The categorization is done as shown in Table 5.8. It is known that 12 villages of Narendranagar block viz. Maun, Kodarna, Kudi, Bhairgad, Khatiyad, Kakhoor (Badeda), Khakar, Malas, Odada, Talai (Odada), Matiyala and Lamoli are at very high risk, while 34 other settlements are also at high risk. SRI of all the villages is given in ***Annexure VIII*** and the locations of villages are shown in Figure 5.8. Immediate disaster prevention measures should be taken in such villages to reduce their vulnerability and resource potential of these identified villages should be immediately strengthen for post disaster activities.

Table 5.8: Seismic Risk Indicator (SRI) for settlements of Narendranagar block

SRI	Description	Range for SRI Value	Number of Villages	Number of Market Towns
I	Very Low Risk	≤ 699	76	5
II	Low Risk	700 – 1399	65	12
III	Moderate Risk	1400 – 2099	27	-
IV	High Risk	2100 – 2799	34	-
V	Very High Risk	≥ 2800	12	-
Total			214	17

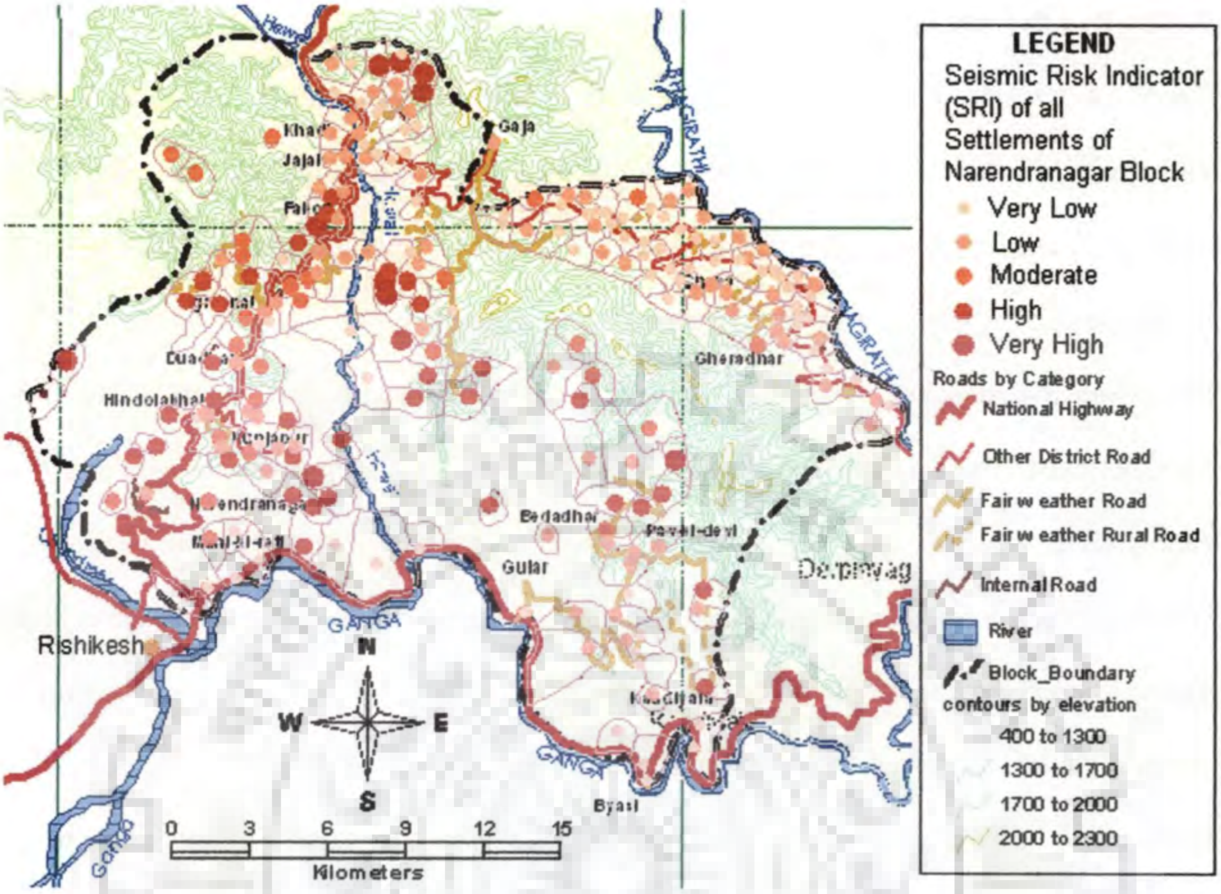


Figure 5.8: Seismic Risk Indicator (SRI) of settlements of Narendranagar block.

5.8 REQUIREMENTS AND AVAILABILITY OF CRITICAL INFRASTRUCTURE FACILITIES

The building damage and casualties caused in the settlements of Narendranagar block due to earthquake and landslides in the region signify the availability of critical infrastructure and resources. This requirement is analyzed against the available values to identify the gap, so that preparedness measures can be formulated.

5.8.1 Health Facilities

There are total 52 health facilities located in 29 different settlements and shared by 210 villages of the block. The structural vulnerability and accessibility of these health care facilities is already discussed in section 4.2.3 and section 4.4.2. In this section the capacity of health facilities is analyzed for the dependent population they might have to serve in case of the assumed earthquake. The analysis deals with 29 different settlements where health facilities exist. These health facilities might serve as medical camps for the victims of the earthquakes. These medical camps would have to serve the populations from the nearby villages, which have them as the nearest health facility. When these figures are analyzed against the existing health facilities it is found that the health facilities in the block are far below requirement during the assumed emergency situation. The total dependent populations under these 29 settlements with health facilities and the number of injuries they have to deal with, in case of any earthquake is given in Table 5.9.

The analysis results in an estimated requirement of 350 doctors against available 37, estimated requirement of 448 other medical staff against available 114 whereas estimated requirement of 2688 beds against the available 131. Table 5.10 gives these statistics for the 29 settlements with health facilities.

Although it is known that any existing setup can not be always equipped for emergencies but the analysis shows the scale of preparedness that government and institutions need to be informed about in advance and become capable of making them available in the event of a disaster.

Table 5.9: Service range of 29 settlements with health facilities

Code No.	Place	Facility	No. of settlements	Tot Dependent Pop	Injury distribution			
					Inj 4	Inj 3	Inj 2	Inj 1
1	Banskatal	AH	5	2054	42	63	63	42
2	Berni Badi	AH	10	1569	24	36	36	24
3	Bhangla	AH	2	687	13	21	21	13
4	Byasi	MRP	1	1026	3	5	5	3
5	Chaka	AH FH VH	20	6867	38	57	57	38
6	Dhalwala	AH	1	11444	17	26	26	17
7	Diuli	AH, SC	6	1571	32	48	48	32
8	Duadhar	SC	13	3672	54	82	82	54
9	Fakot	PHC, VH	22	5620	79	118	118	79
10	Gaja	PH	6	4937	32	48	48	32
11	Gheradhar	SC	1	565	6	8	8	6
12	Gular	AH, SC	8	5636	37	56	56	37
13	Jajal/Khadi	AD, SC	30	8688	104	157	157	104
14	Kodarna	AD	2	723	17	26	26	17
15	Kodiyala	SC	3	2788	24	36	36	24
16	Kunjapuri	AH	2	1230	12	18	18	12
17	Kyara	SC	2	968	12	17	17	12
18	Maroda	SC	6	1699	14	21	21	14
19	Mathiyali	SC	2	1680	37	54	54	37
20	Muni-ki-reti	SC	1	7880	24	35	35	24
21	Narendranagar	DH, AH, SC, VH, HH	10	7361	93	139	139	93
22	Neer	SC	12	2776	39	59	59	39
23	Odada	SC, HH	8	941	23	35	35	23
24	Pav-ki-devi	APHC	13	6574	93	139	139	93
25	Pokhri	AD, SC	15	3546	24	36	36	24
26	Ranakot	APHC	12	3371	33	50	50	33
27	Saundi	AD, SC, VH	11	1865	11	16	16	11
28	Shivpuri	VH	2	1788	37	55	55	37
29	Tapowan	PH	4	2811	6	10	10	6

AH- Ayurvedic Hospital
FH- Female Hospital
VH- Veterinary Hospital
SC- Sub-center
DH- District Hospital
AD- Ayurvedic Dispensary
HH- Homeopaphic Dispensary

PHC- Primary Health Center
APHC- Additional Primary Health Center
PH- Private Hospital
SAD- State Allopathic Dispensary

Inj 1- Dead or Unsavable
Inj 2- Life threatening injuries
Inj 3- Injuries requiring hospital treatment
Inj 4- Light injuries not requiring hospital treatment

Table 5.10: Shortage of Health Care Facilities in Narendranagar block

Place	Doctors		Beds		Staff	
	Available	Required*	Available	Required*	Available	Required*
Banskatal	1	15	4	116	2	20
Berni Badi	1	9	4	66	2	12
Bhangala	1	5	4	38	2	7
Chaka	3	14	8	105	5	19
Dhalwala	1	6	4	48	2	8
Diuli	1	11	5	88	4	16
Duadhar	0	20	1	150	2	27
Fakot	3	28	4	217	9	35
Gaja	0	11	10	88	3	16
Gheradhar	0	2	1	15	2	3
Gular	1	13	5	103	4	18
Jajal/khadi	1	37	1	288	3	40
Kodarna	1	6	4	48	2	8
Kodiyali	0	9	1	66	2	11
Kunjapuri	1	4	4	33	2	6
Kyara	0	4	1	32	2	5
maroda	0	5	1	39	2	6
mathiyali	0	13	1	100	2	15
Muni-ki-reti	1	8	0	65	2	11
Narendranagar	17	33	56	255	37	45
Neer	0	14	1	108	2	19
Odada	0	8	1	64	4	11
Pav-ki-devi	1	33	4	255	3	40
Pokhri	1	9	1	66	3	12
Ranakot	1	12	4	92	3	15
Saundi	1	4	1	30	4	5
Shivpuri	0	13	0	101	1	15
Tapowan	0	2	0	18	3	3
Total	37	350	131	2688	114	448

(* calculated as per adopted norms as given in section 6.6)

5.8.2 Temporary shelters

The hypothetical earthquake would cause a widespread building damage already calculated. This will create a need for temporary sheltering of population residing in unsafe residential buildings of damage grade G3, G4 and G5. This population can be sheltered in school buildings, community buildings or any other building of public use. The availability of such buildings in villages and their capacity to accommodate persons are calculated. The overall result is a population of 46,170 needs to be accommodated whereas the temporary shelter space is available only for 5,680 victims. The total shelterless population and the population that can be accommodated temporarily in villages are shown in Figure 5.9.

5.8.3 Telecommunications

Communications are most important after any disaster. It can be said that there is a requirement of at least one telephone connection in village where more than one person is expected to be dead. Although the landline connections are not reliable means of communication after earthquakes, they can play an important role in the pre-disaster activities of co-ordination of preparedness planning. For emergency use after earthquakes more reliable means of communications have to be provided in villages, which are now totally absent in Narendranagar block.

Figure 5.10 shows villages of Narendranagar block which already have telephone connections, which urgently need telephone connections and which do not need telephone connection on urgent basis owing to their low vulnerability.

It is known that out of 138 villages which do not have telephone connections, 88 villages require telephone connections on urgent basis, while 50 villages do not require telephone connections on urgent basis.

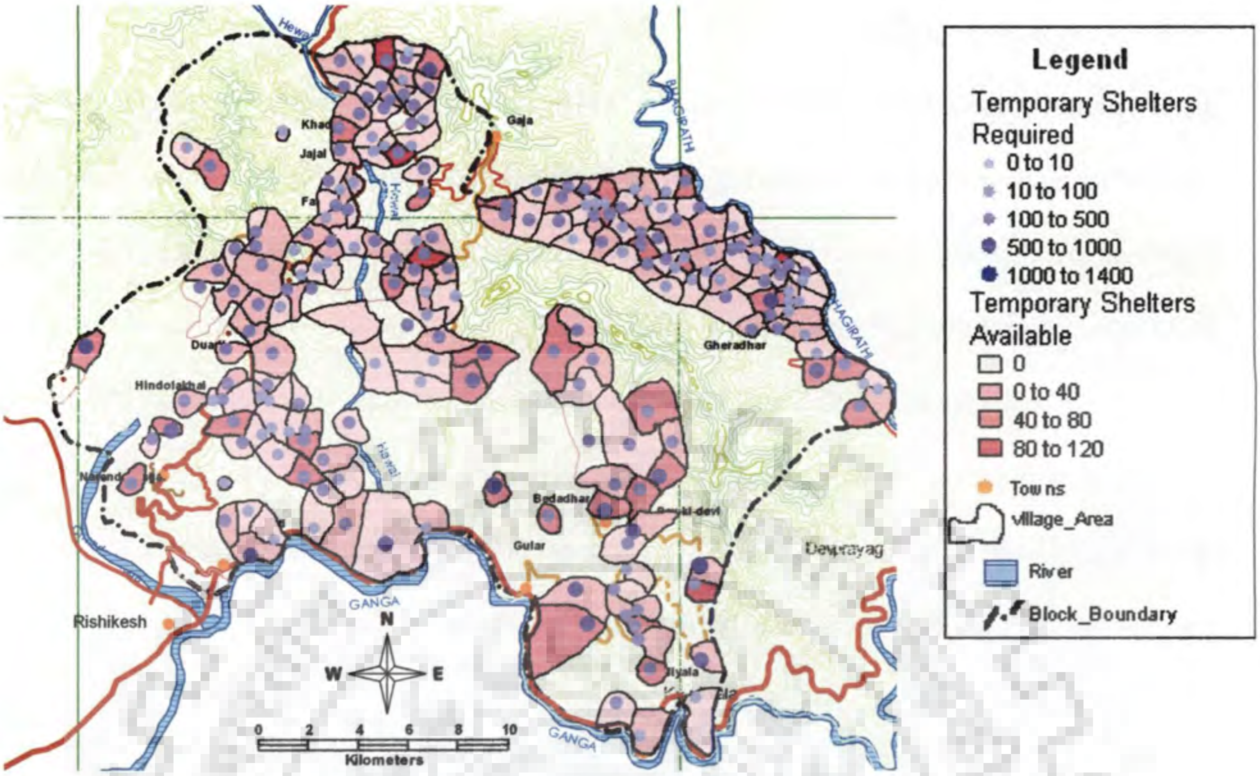


Figure 5.9: Required and Available Number of Temporary Shelters in Narendranagar Block

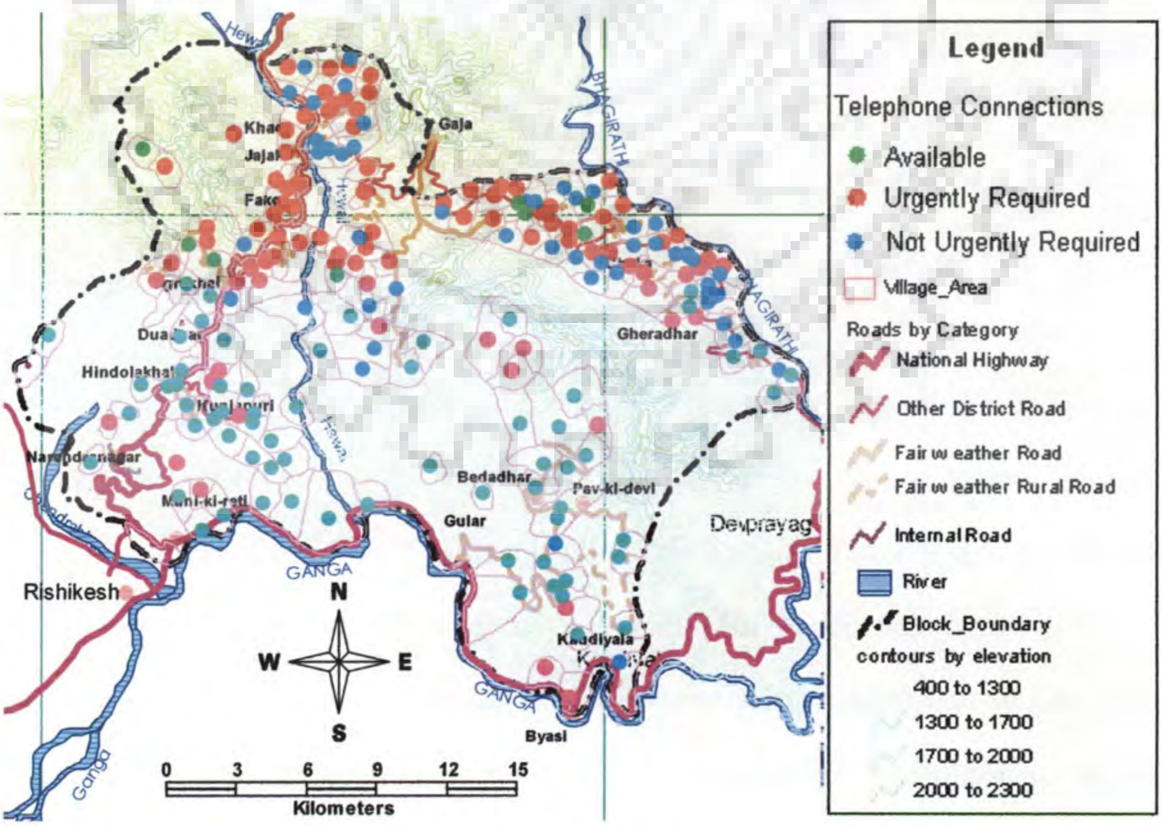


Figure 5.10: Availability and Requirement of telephone connections

5.8.4 Roads

The existing road network in Narendranagar block renders many villages inaccessible. This inaccessibility becomes a critical issue for the villages which are expected to experience high building damage and high consequent life loss. Figure 5.11 show villages with number of casualties and their accessibility conditions.

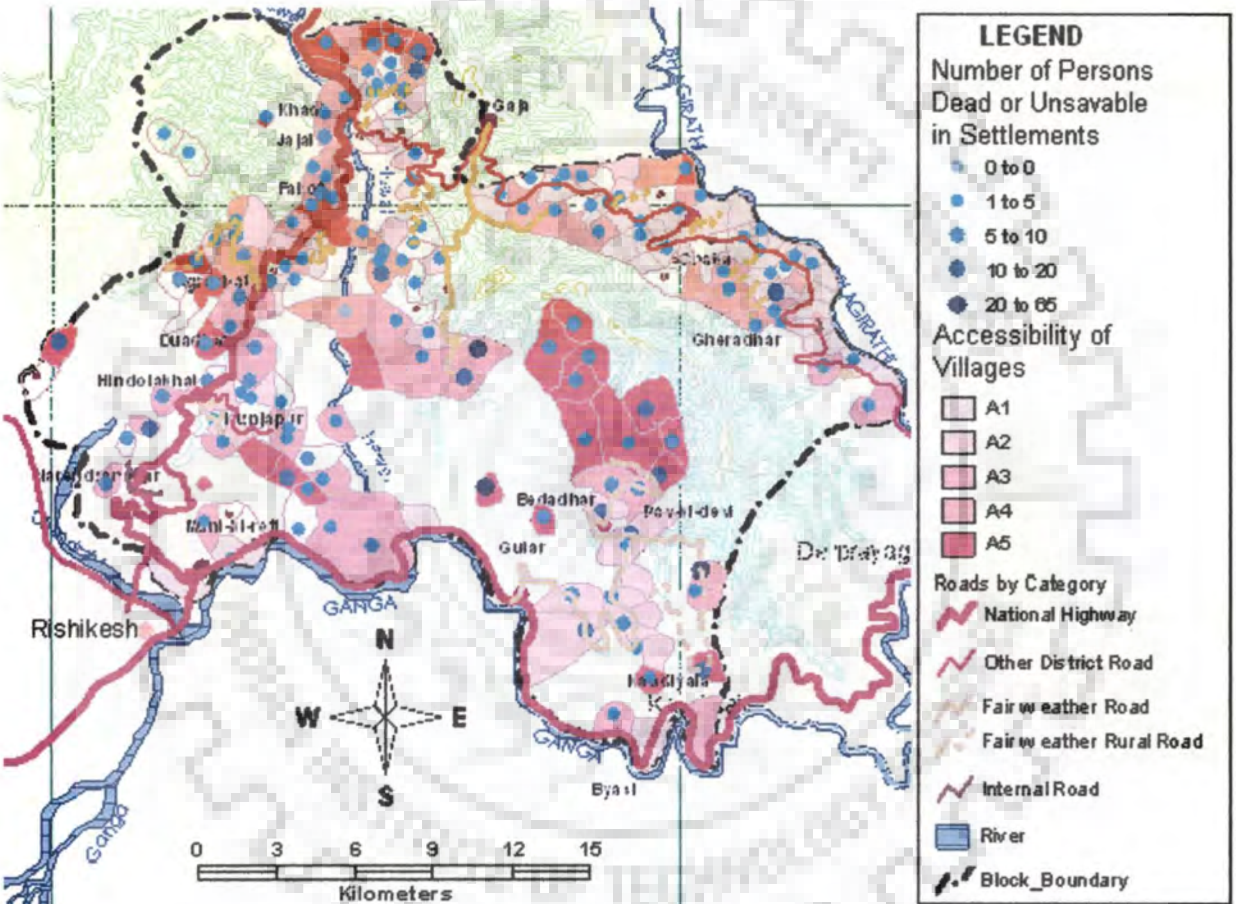


Figure 5.11: Villages of Narendranagar block showing estimated casualties with accessibility conditions.

Figure 5.11 shows that, the accessibility conditions of villages Banskatal, Neer, Ghigud, Kodarna, Sasman, Maun and Timli need to be improved on urgent basis, while better accessibility should also be provided to villages Kudi, Odada, Majiyadi, Mathiyali and Mindath because of their high estimated casualties.

5.8.5 Aerial Connectivity

At present only one helipad is present at Narendranagar, which is private property of hotel Ananda. Hence open spaces near highly vulnerable villages have to be identified and reserved for their use as helipads during emergency.

5.8.6 Organizational structure

The existing administrative hierarchy under Narendranagar block including kshetra panchayat, gram panchayat and villages which would be used for disaster management, displays many limitations. These are the extent of damage in villages, inaccessibility of kshetra panchayat and villages, distance of dependent villages and absence of infrastructure. An analysis of first two factors is given here, while the availability of infrastructure is discussed in section 4.4.

Extent of Damage in Villages under Kshetra Panchayats

The numbers of total casualties in villages under same kshetra panchayats vary significantly. The total of persons dead and persons with life threatening injuries vary from 8 in Tapowan to 128 in Soni (Figure 5.12). This wide variation would lead to complexities and confusion for decision makers at higher level especially during eemergency phase.

Inaccessibility of Kshetra Panchayats

The accessibility of keshetra panchayats village becomes very important because it has to serve as an important link in the relief distribution system. Figure 5.14 shows the accessibility conditions of the kshetra panchayat headquarter village analyzed against total number of critical casualties under the same. Figure 5.13 shows that, kshetra panchayat of Soni, Timli, Syud, Maun, Mathiyali, Mindath, Kodarna, Kakhoor, Banskatal and Badir are particularly not suitable for identifying as key settlements for relief distribution because of their inaccessibility and high estimated damage. The accessibility conditions of these settlements must be improved in order to make them a distribution center.

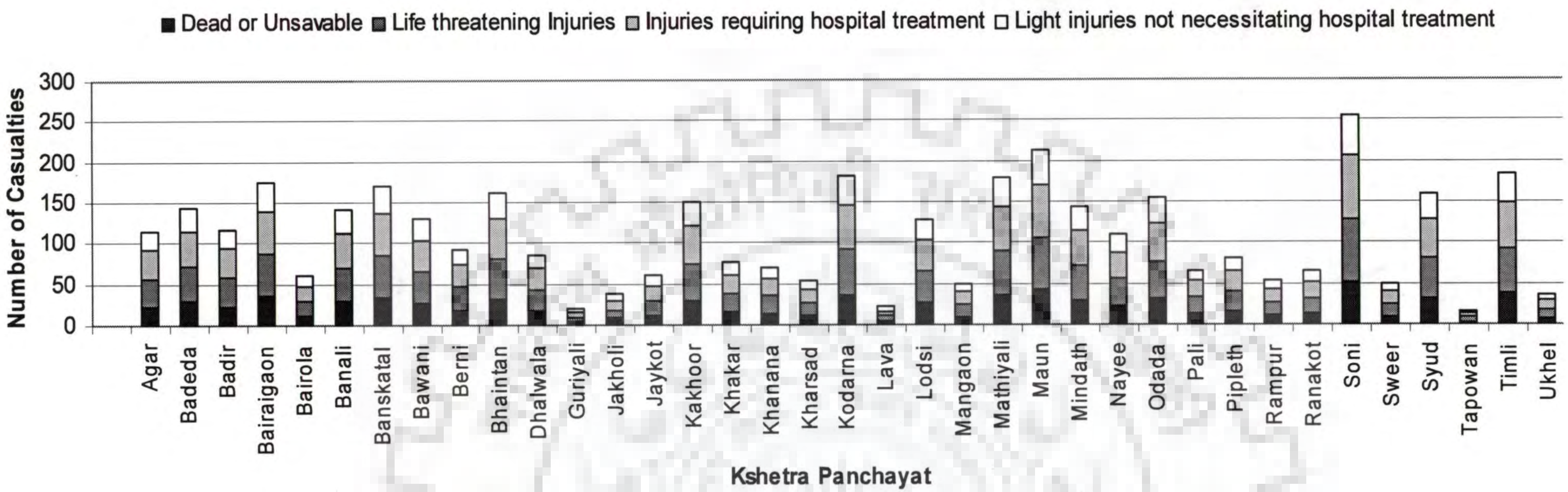


Figure 5.12: Distribution of Casualties in Kshetra Panchayats of Narendranagar

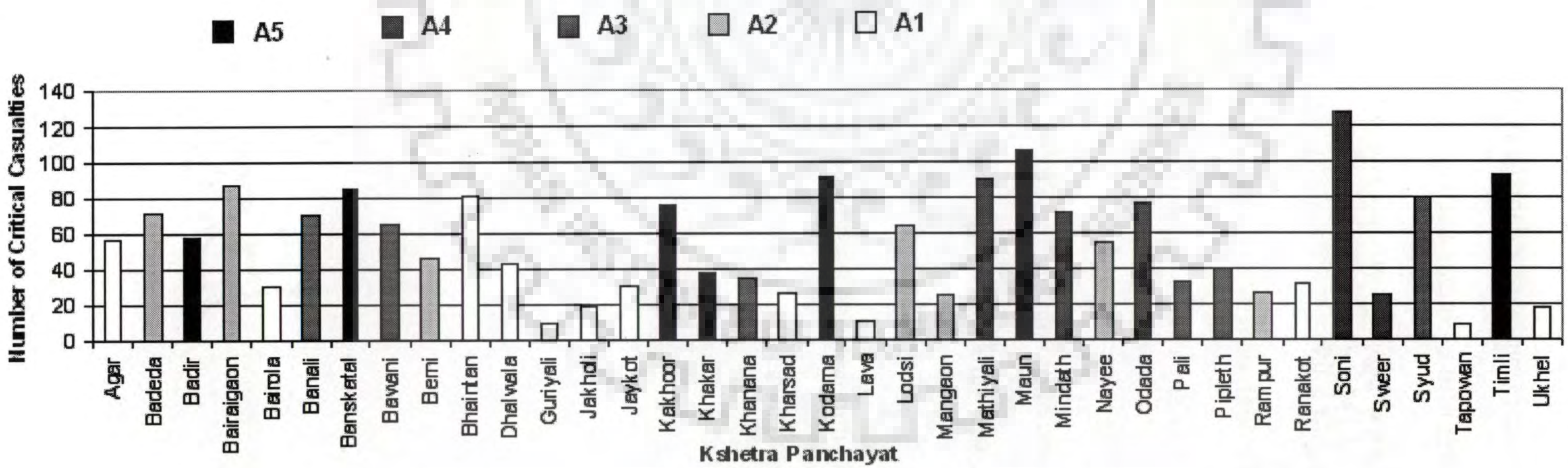


Figure 5.13: Accessibility of kshetra panchayat head quarter analysed against total critical casualties.

5.9 CONCLUSIONS

A hypothetical earthquake scenario developed for the Narendranagar block shows that in this sub-region earthquake damage is likely to be much higher than that is expected as per seismic zoning map of India. The calculated PGAs indicate that settlements of Narendranagar block would experience an intensity of VIII to IX as per MSK intensity Scale. Almost 28% residential buildings from villages and 18% residential buildings from market towns would suffer high damages and collapse. A total of 990 (0.96%) persons from the block would be dead or unsavable and other 1484 (1.44%) persons would suffer life threatening injuries needing immediate medical attention. The possible landslides might render 85 settlements with a population of 27462 (26.65%) completely inaccessible. Seismic Risk Indicator (SRI) developed for comparing earthquake risk in settlements identifies 12 settlements which are at very high risk. The shortage of critical infrastructure like health facilities, temporary shelters, telecommunications, roads, aerial connectivity and organizational structure confirm the urgent need to undertake earthquake preparedness measures in Narendranagar block.

CHAPTER 6

PREPAREDNESS PLAN AND ACTION PLAN

6.1 INTRODUCTION

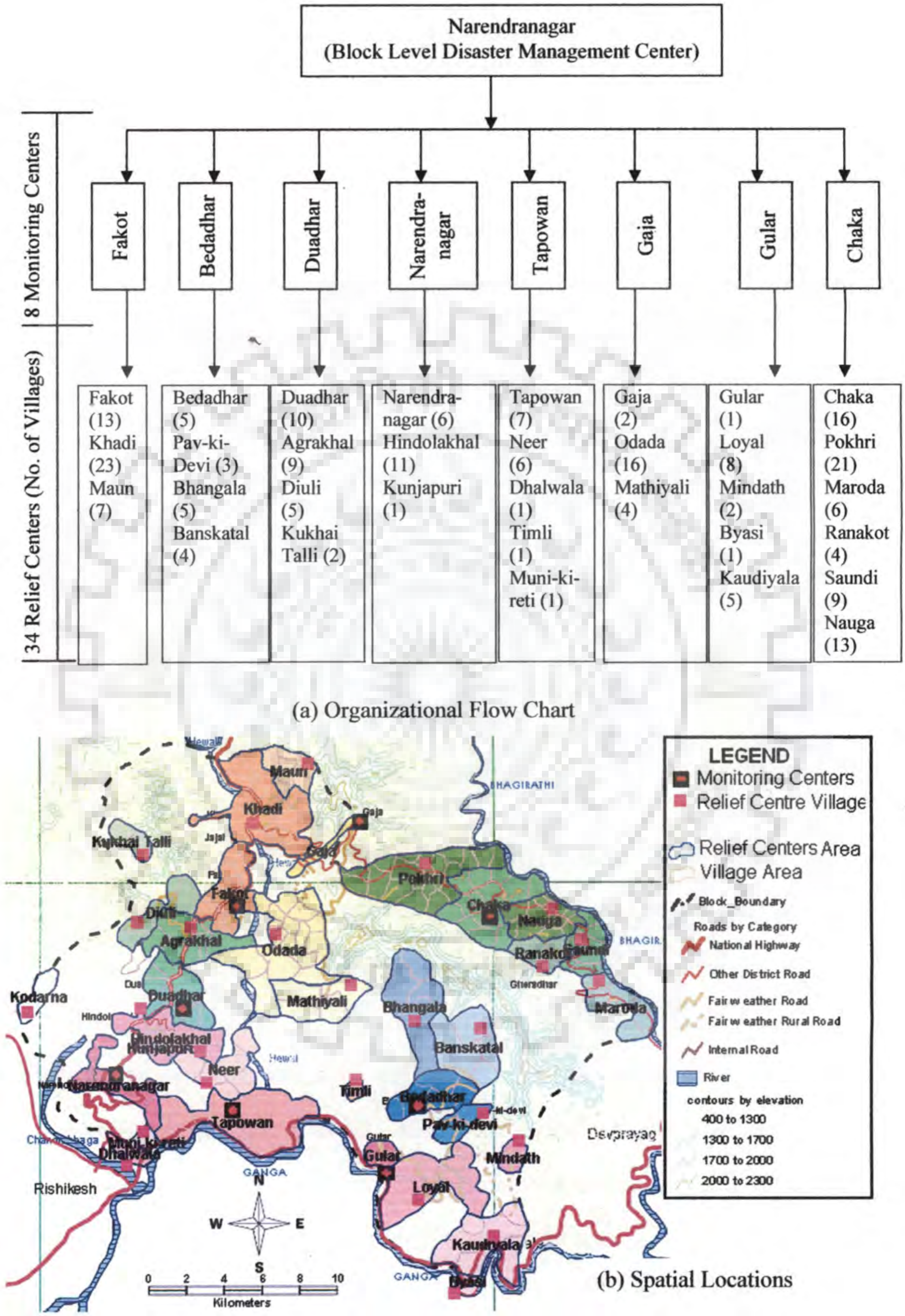
The vulnerability and resource analysis suggest that Narendranagar block is characterized by high earthquake vulnerability and low resource potential for emergency management. The hypothetical earthquake scenario generated within the block provides the basis for the measure of the likely losses and shortage of existing resources. Thus, it is necessary to guide the developmental activities towards earthquake preparedness with the twin goals of vulnerability reduction and strengthening resource potential.

The chapter details out general preparedness measures to be taken within the block and detailed planning of 5 most critical activities viz. damage assessment, search and rescue, provision of medical assistance to the injured, emergency relief distribution and provision of temporary shelters. Detailed preparedness measures are suggested for three selected sample settlements of the block. The important aspects for review, revision and effective implementation of plans are suggested to make it more reliable and easy to implement during emergencies. Finally general recommendations are suggested to strengthen the disaster management setup in India.

6.2 ORGANIZATIONAL STRUCTURE FOR DISASTER MANAGEMENT

One of the most important preparedness measures for emergency phase is the setting up of an organizational structure for earthquake disaster management with procedures for the reception and dissemination of information. The shortcomings of the present structure emphasize the need for alteration in existing organizational structure of disaster management in the Narendranagar block. Hence a hierarchy is proposed consisting of one block level disaster management center, eight monitoring centers and thirty four relief centers (Figure 6.1a; b). A list of all villages of Narendranagar block under different relief centers and monitoring centers is given in Annexure IX.

The block level disaster management center is located at Narendranagar, which is the present fuctional headquarter (Figure 6.2)



(a) Organizational Flow Chart

(b) Spatial Locations

Figure 6.1: Proposed organizational structure for disaster management in Narendranagar block

Figure 6.2: Block level disaster management centre, Narendranagar

6.2.1 Monitoring Centers

Monitoring centers are market towns of the block which are of strategic importance due to their accessibility, available infrastructure and uniform magnitude of damage within the dependent settlements. These monitoring centers would coordinate preparedness measures and would be important links in communication and relief distribution during emergencies. Eight market towns identified to serve as monitoring centers are Narendranagar, Duadhar, Fakot, Gaja, Chaka, Gular, Tapowan and Bedadhar (Figure 6.1a; b). The accessibility of all these identified market towns is of A1 category (very good accessibility) except for Bedadhar which is located on a fair weather road and falls in A2 category.

These towns have better infrastructure availability as analyzed in previous chapters. A wide variation in the cumulative damage experienced by the settlements under different monitoring centers would introduce complexities for higher level decision makers during emergencies. Uniform damage quantities would facilitate ease for resource allocation and formulation of policies for preparedness measures. The range of damage in terms of human casualties under each monitoring center is taken as 100 to 150 dead or un-savable persons and 150 to 220 life threatening cases. Figure 6.3 shows the number of critical casualties under each monitoring center. Figure 6.4 shows the views of the proposed monitoring centers.

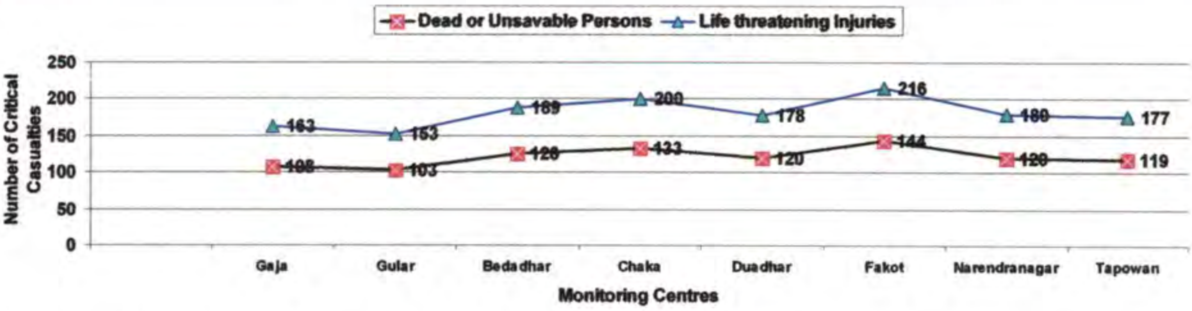


Figure 6.3: Distribution of critical casualties under monitoring centers of Narendranagar Block

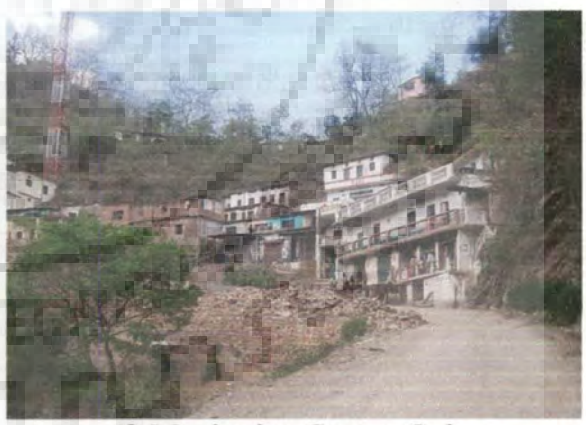
(a) Monitoring Centre, Fakot

(b) Monitoring Centre, Bedadhar

(c) Monitoring Centre, Duadhar

(d) Monitoring Centre, Tapowan

(e) Monitoring Centre, Gaja



(f) Monitoring Centre, Gular

Figure 6.4: proposed monitoring centers of Narendranagar block

(g) Monitoring Centre, Chaka

6.2.2 Relief Centers

The identified relief centers are the settlements which would act as central places for a group of rural settlements within easily approachable distance of 0 to 8 kms. These relief centers would host various important functions particularly relief camps and medical camps. A total of 34 relief centers are proposed for operation under the 8 monitoring centers (Figure 6.1a; b). The criteria for identifying the settlements as relief centers are:

1. *Accessibility conditions*: The settlements identified as relief centers have better accessibility conditions than the villages it would serve. This would facilitate easy procurement of relief material and easy transportation of material and injured people for the dependent villages.
2. *Part of same administrative sub division*: The existing administrative sub division of settlements is used as far as possible. This means villages under same gram panchayat or same kshetra panchayat are assigned to the same relief centers as far as possible.
3. *Distance of dependent villages*: The distance of dependent villages under each relief center is determined to be between 0 to 4 kms for walking distance and 0 to 8 kms for vehicular distance.
4. *Available facilities*: As stated in UNDRO (1984), "a plan must, so far as practicable, use existing structures rather than create new ones. In the atmosphere of crisis and pressure which commonly attend any disaster situation, it is better, whenever practicable, not to ask or require people to change habits of work or their professional associates". Hence, preference is given to the settlements where important facilities like health, education, food and other infrastructure already exist.
5. *Total Population and Extent of damage*: The total populations under relief centers range from 1500 to 2000 for highly vulnerable villages (SRI IV and V), while 2000 to 6000 for villages with low vulnerability (SRI I, II and III).This is decided on the basis of number of cumulative damage levels in terms of number of dead persons and number of persons with life threatening injuries. The number of villages under each relief center varies from minimum of 1 village (relief center Byasi) to a maximum of 23 villages (relief center Khadi). The damage level in terms of human casualties (persons with Inj 1) under relief centers vary from minimum 3 in relief center Byasi to 81 in Narendranagar. This wide variation is due to the consideration of all the above factors individually for all villages.

A list of all relief centers operating under monitoring centers with village wise total population and expected casualties are shown in Annexure IX. It should be noted that the relief center Kodarna would be under the monitoring center Bhopar, which is a part of adjacent Dehradun district.

6.3 GENERAL PREPAREDNESS MEASURES FOR NARENDRANAGAR BLOCK

General preparedness measures are the measures to be taken within the block at all administrative levels for vulnerability reduction and efficient emergency management activities. These include retrofitting plan for minimizing the losses during earthquakes, measures for establishment of emergency control rooms and provision of accessibility to the settlements in terms of communications, road accessibility and the aerial accessibility. The measures suggested by NRSA (2001) would reduce the landslide hazard along the highways in the block. Similar measures should also be formulated for the rest of the block. Relocation of settlements should be considered wherever the settlements are at very high risk of getting buried under the landslides.

6.3.1 Planning for seismic strengthening of Vulnerable Buildings

The most important objective of any earthquake preparedness plan is to minimize losses during earthquakes and ensure a speedy recovery from disaster situation. The losses in terms of lives and the buildings are always the top priority. Hence seismic strengthening of buildings acquires utmost consideration (Sharma, 1997). The damage surveys during past Himalayan earthquakes revealed that while most deaths and injuries were caused by collapse of buildings with random rubble masonry, those with lintel band showed excellent performance (Jain *et. al.,* 1999). The need of a programme to seismically strengthen the entire building stock in the region is well recognized (Jain *et. al*, 1999; Vatsa, 2001). Planning for the seismic strengthening of vulnerable buildings should be carried out as per guidelines for prioritization, also supported by Arya (2001), as given:

1. The buildings of critical importance include state secretariat, district headquarters, police and fire stations, hospitals, buildings that house emergency services and the ones which host assembly of large number of persons like schools, colleges, hostels, cinema halls, marriage halls etc. The unimpeded availability and functionality of these buildings immediately after a disaster is a top priority in disaster preparedness. In the case of these buildings, their public use and availability are far more important than the potential economic loss. Hence, such buildings should be made earthquake resistant on most urgent priority basis (Vatsa, 2001; Wisner, 2005).
2. Lifelines after an earthquake viz. communications, water supply, roads and bridges, electricity and other critical facilities are very essential to remain operational after earthquakes for immediate relief to the victims of earthquake. Hence, buildings and other structures connected with these services should be strengthened to withstand the earthquake shock (Wisner, 2003).
3. Since a huge percentage of buildings within the study area are non-engineered residential buildings special strengthening measures need to be incorporated. A lot of research is being conducted for various techniques and materials which could be used for seismic strengthening of buildings. ISET (2001) and IS (13828 – 1993) gives measures to be incorporated for seismic strengthening of such non-engineered constructions and general concepts of earthquake resistant design so that village artisans may innovate suitable measures on their own. For this purpose suitable encouragement, support and training should be provided to the residents.

The proposed organizational structure should include appointment of an official (junior engineer) at all monitoring centers with the responsibility to ensure earthquake resistant measures in all new constructions and monitoring retrofitting activities in villages under its jurisdiction. Some steps to be taken for housing improvement in the region should be:

1. *Awareness generation and Technical guidance*: One of the most important reasons for the existence of high and moderately vulnerable buildings in the Narendranagar block is the ignorance of population. The structural deficiencies of such residential buildings should be brought to the notice of the residents. The possible damage to such constructions during earthquakes could be shown through photographs of the similar constructions damaged in previous earthquakes. Since most of the village residences are built by residents themselves or by the local masons, they should be provided

technical guidance in adopting improved construction techniques by dissemination of information, demonstrations, exhibitions etc. The population can be reached through the school going children of the villages.

2. *Facilitation*: Financial assistance could be provided in the form of subsidy or loan on easy terms for improving earthquake resistance of village houses. It has been seen that the main cause of prevailing constructions is the availability of material. Hence, building material could also be supplied to them if possible free of cost or at low cost.
3. *Organizing communication*: A proper system of communication between research and development organizations and the village community should be established to bring to them the potentialities of new construction techniques for improving non-engineered housing. Research and development work should be undertaken in tackling local problems which affect improvements in rural construction in different regions.
4. *Institutional support*: Institutional arrangements should be made to organize, support and propagate improvements in non engineered constructions and to provide necessary financial and technical assistance.

Bamboo Structures: The Most Encouraged Construction Technology

The vulnerability of existing structures in Narendranagar block emphasized the need for light weight, flexible, easily transportable and buildable earthquake resistant structures in the sub region. The most appropriate technology for this purpose is found to be the structures made of bamboo, which is an enduring, versatile and renewable material (NMBA, 2007). The National Mission on Bamboo Applications (NMBA) in India promotes the innovative use of bamboo and bamboo-based composite materials with different construction techniques. NMBA is a Tenth Plan initiative of the Department of Science & Technology (NMBA, 2007). The bamboo structures set benchmarks of quality of construction, functionality, strength, safety and aesthetics. The important features of bamboo constructions which make it the most appropriate technology are that they are durable, earthquake resistant, fire resistant, aesthetically pleasing, easy to construct, low cost, eco friendly, supplied in modules, easy to transport, have good thermal and acoustic properties etc.

India is richly endowed with bamboo resources, with more than 120 million tonnes of growing stock on forest land, plantations and homesteads **In Uttarakhand state bamboo is available in total 139,410 hectars, whereas projects of further bamboo plantations are being taken by NMBA (NMBA, 2007). Various bamboo structures in the highly earthquake prone regions of India constructed by the support of NMBA are shown in Figure 6.5.**

(a) Bamboo Puff High Altitude Shelters in Leh

(b) Office Building in Guwahati

(c) Engineered Bamboo Structure 48'X20' in Leh

Figure 6.5: Bamboo structures erected by NMBA in other Himalayan regions,
Source: NMBA (2007)

The use of similar structures in the Narendranagar block for control rooms and buildings of critical importance is strongly recommended. The new constructions should be encouraged to use bamboo technology through incentives and special government assistance.

6.3.2 Establishment of Control Rooms

Establishment of control rooms immediately after earthquakes is the most important task for emergency communications and better co-ordination for rescue, relief distribution and other activities. The most important requirements of these control rooms are: they should be earthquake resistant; they should be equipped with reliable communication equipments; they should have generator sets to ensure electricity during emergencies; and demographic, spatial and infrastructural information on villages under its jurisdiction should be available. The communication links of these identified control rooms are shown in Figure 6.6.

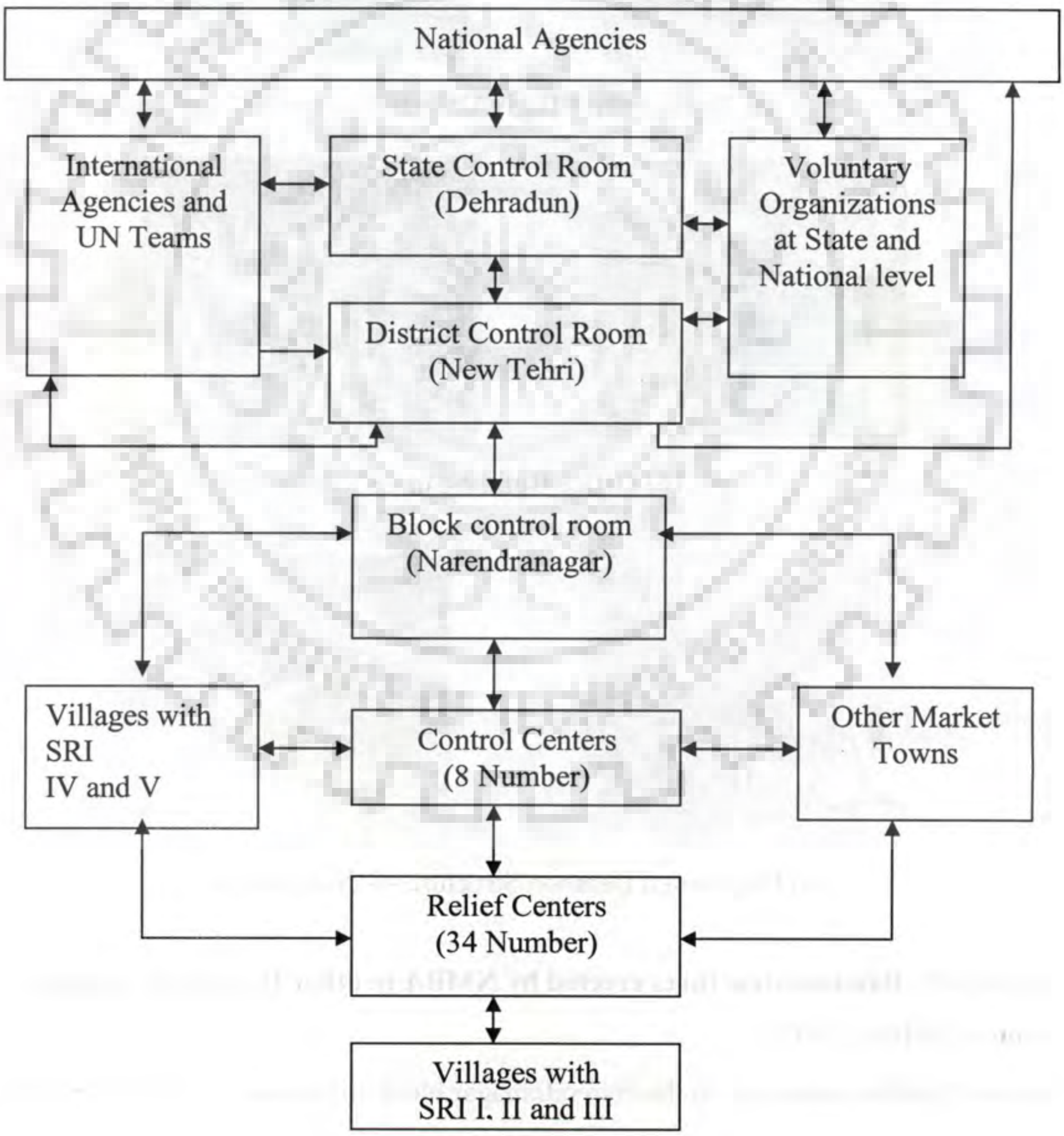


Figure 6.6: Communication network during earthquake emergencies in Narendranagar block

Control Rooms in Villages and Market Towns

An earthquake resistant control room should be setup in all 197 villages and market towns of Narendranagar block. The building for this purpose should be identified. It can be a room in school building, panchayat office, gram pradhan's residence, community hall, anganbadi center or any community building (Figure 6.7). The building thus identified should be made earthquake resistant by incorporating retrofitting measures. There are 30 villages which do not have any such building hence new earthquake resistant bamboo structures should be erected which, would serve as emergency control rooms (Figure 6.8). These emergency control rooms should be equipped with amateur radio sets for reliable emergency communication, besides normal telecommunication facilities and internet connectivity.

Control Rooms in Relief Centers

All relief centers should have an earthquake resistant building and open space for relief camp. This building can be an existing school building or any other public building which should be made earthquake resistant by retrofitting (Figure 6.9). The relief centers of Maroda and Bhangala do not have existing school building or any suitable public building. Hence, a new building is proposed to be constructed in these villages preferably near the existing open spaces. These control rooms should also be equipped with amateur radio sets for reliable emergency communications, besides normal telecommunication and computer based communication network.

Control Rooms in Monitoring centers

The relief centers identified as monitoring centers should have a larger area to host a bigger control room apart from the relief center requirements (Figure 6.10). These control rooms should be equipped with amateur radio sets as well as VHF hand held radio communication, for their additional responsibility of coordination, communication and relief distribution activities

(a) Gram Panchayat Office Syud

(b) Gram Pradhan's Residence, Palogi

(c) Secondary School at Lava

Figure 6.7: Locations for control rooms at villages Syud, Palogi and Lava

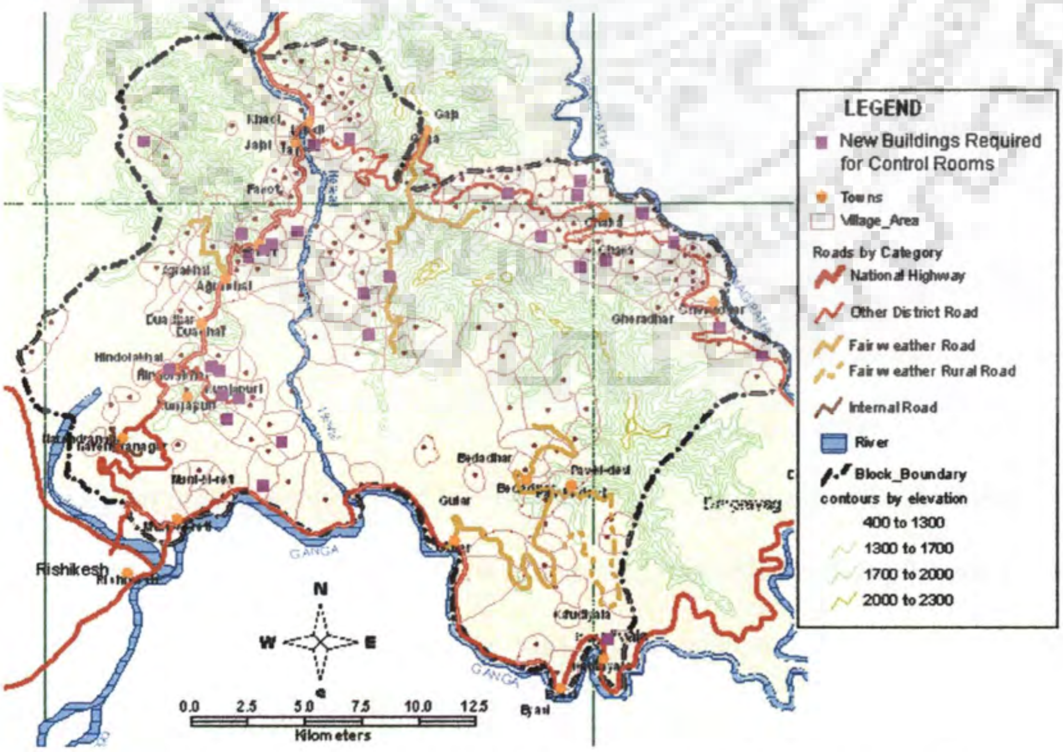


Figure 6.8: Settlements where New Buildings are required for control rooms

(a) Primary School Khadi

(b) Government Inter college Duadhar

Figure 6.9: locations for control rooms at relief centers Khadi, Duadhar and Nauga

(c) Secondary High School, Nauga

(a) BDO Office Fakot

(b) Office of Matruchhaya Parvatiya Vikas Samiti, Gaja

(c) Government Inter College, Chaka

Figure 6.10: locations for control rooms at monitoring centers Fakot, Gaja and Chaka

Block level Disaster management Centre and District Headquarters Control Rooms

The control room of block level disaster management center should be always ready in the Office of Sub-District Magistrate (SDM) and Tehsildar building in Narendranagar town (Figure 6.11). This control room should be equipped with communication facilities including amateur radio sets, VHF hand held radio communication and Single Sideband (SSB) High Frequency (HF) radio. They should also have facilities like internet, FAX, and GIS. the district control room at the office of District Magistrate should also be equipped with these facilities.

Figure 6.11: block level disaster management centre control room at SDM and Tehsildar Office, Narendranagar

6.3.3 Provisions for Improved Accessibility Conditions

The inaccessibility conditions of villages of Narendranagar block make them more vulnerable and hence needs to be improved. The road development plan prepared by Public Works Department (PWD) ensures the development of proposed roads by 2010. This will improve the accessibility conditions of many vulnerable villages. However, on the basis of analysis conducted in the previous chapters, identifying villages which are at higher risk, suggest a need for more roads to be developed in Narendranagar block, for better accessibility of villages. Figure 6.12 shows the roads proposed by PWD and the villages which need to be provided road connectivity urgently, to reduce their vulnerability due to inaccessibility conditions. Since planning of road network in hills is a highly technical work requiring significant research, it has not been attempted in this research work.

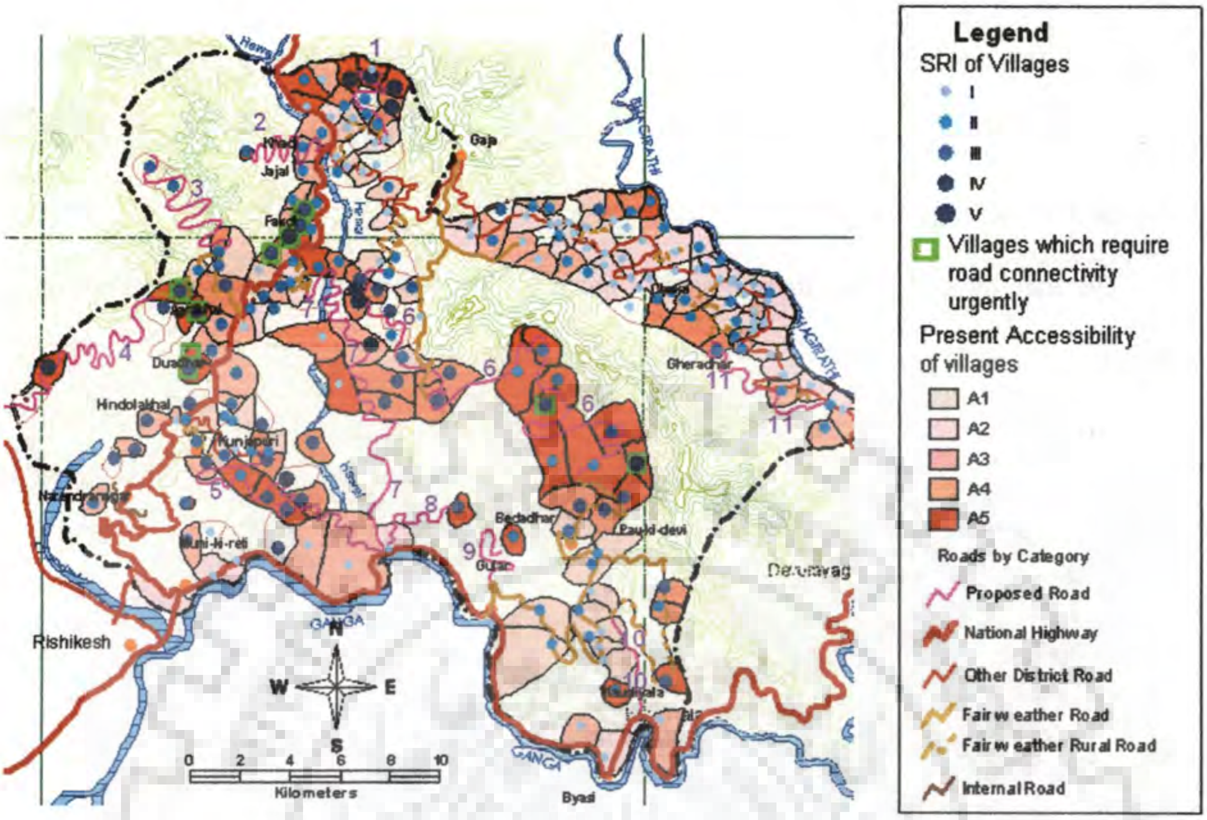


Figure 6.12: Roads proposed by PWD providing accessibility to villages and other vulnerable villages which need road connectivity urgently.

Hence, it is known that proposed roads by PWD would provide direct accessibility to **48** more villages with total population of 13831. However, the result of the research work carried out identifies 10 more villages viz. Malas, Fart, Diuli, Bhainsark, Kandarigaon, Bhairgad, Bhangala, Katkod, Naur and Odarkhet with total population of 2381, which require road connectivity up to the village due to their high SRIs.

Aerial Connectivity

The discussion about possible landslides in the landslide prone sub-regions of Narendranagar block which in the event of earthquake might block the roads and render the settlements inaccessible, emphasize the need to provide aerial connectivity. All the settlements identified as relief centers should have an open area for landing of helicopters during emergency except for Tapowan, Muni-ki-reti and Dhalwala which are at very close proximity to the city of Rishikesh and are not prone to landslides. At Narendranagar the helipad at hotel Ananda can be used and also the large open space at the Army Cantonment can be used for helicopter landing.

The locations of these are shown in Figure 6.13 and the co-ordinates are given in Table 6.1.

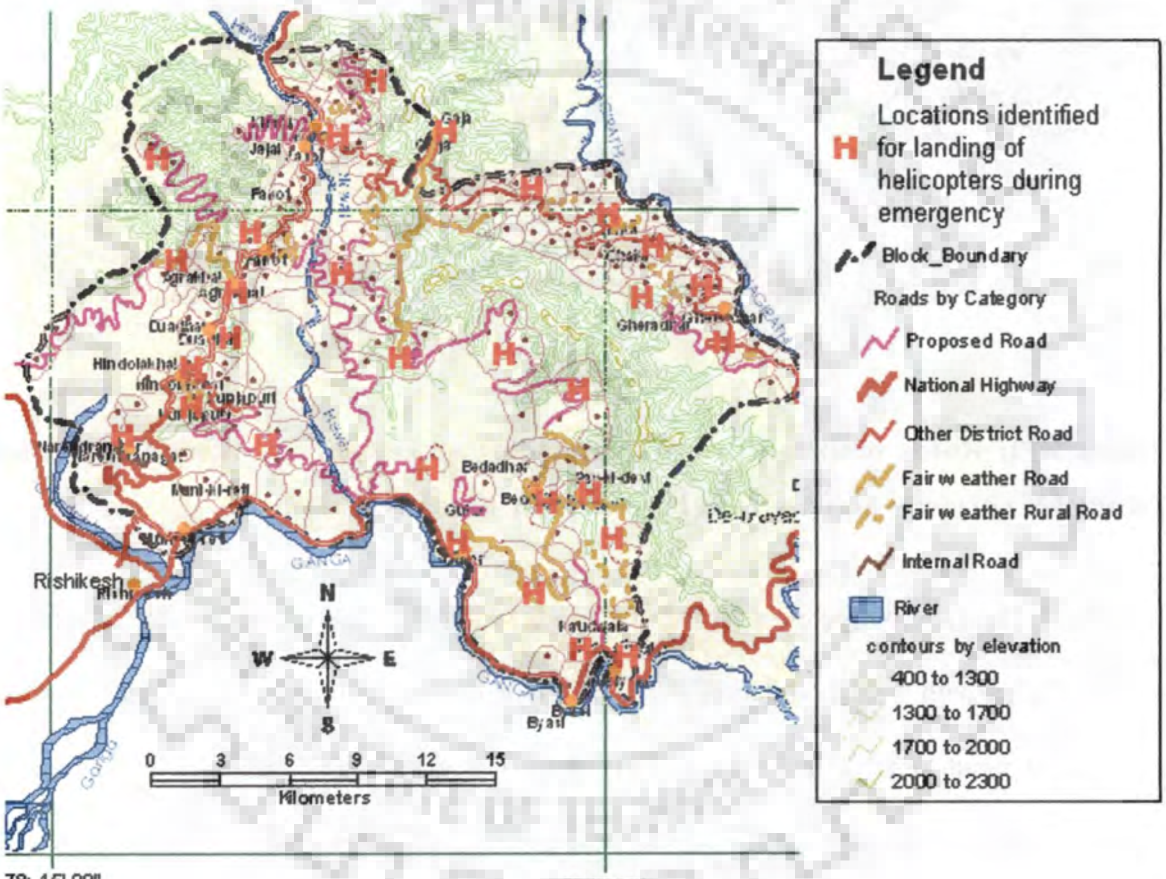


Figure 6.13: Locations identified for landing of Helicopters during emergency in Narendranagar block

Table 6.1: Helicopter landing locations during emergencies in Narendranagar block

S.No.	Relief Center	Latitudes (^{0}N)	Longitudes (^{0}E)
1	Gaja	30 :16 :46	78 :25 :44
2	Odada	30 :13 :29	78 :22 :57
3	Mathiyali	30 :11 :33	78 :24 :28
4	Gular	30 :07 :10	78 :26 :03
5	Loyal	30 :06 :00	78 :28 :07
6	Mindath	30 :07 :17	78 :30 :19
7	Byasi	30 :04 :43	78 :29 :20
8	Kaudiyala	30 :04 :29	78 :30 :37
9	Bedadhar	30 :08 :08	78 :28 :28
10	Pav-ki-devi	30 :08 :21	78 :29 :37
11	Bhangala	30 :11 :36	78 :27 :19
12	Banskatal	30 :10 :44	78 :29 :18
13	Chaka	30 :14 :49	78 :30 :07
14	Pokhri	30 :15 :28	78 :28 :04
15	Maroda	30 :11 :50	78 :33 :16
16	Ranakot	30 :12 :55	78 :31 :06
17	Saundi	30 :13 :11	78 :32 :40
18	Nauga	30 :14 :10	78 :31 :23
19	Agrakhal	30 :13 :07	78 :20 :02
20	Diuli	30 :13 :51	78 :18 :27
21	Kukhai Talli	30 :15 :57	78 :17 :37
22	Duadhar	30 :12 :00	78 :19 :53
23	Khadi	30 :16 :42	78 :22 :51
24	Fakot	30 :14 :27	78 :20 :25
25	Maun	30 :17 :58	78 :23 :49
26	Narendranagar	30 :09 :40	78 :17 :00
27	Hindolakhal	30 :11 :19	78 :18 :52
28	Kunjapuri	30 :10 :25	78 :18 :52
29	Neer	30 :09 :30	78 :20 :51
30	Timli	30 :08 :58	78 :25 :13

(Based on field survey findings)

6.4 PLANNING FOR PERFORMANCE OF CRITICAL ACTIVITIES

Emergency phase deals with management of various critical activities as mentioned in section 2.3. This section deals with planning of five most critical activities viz. preliminary damage assessment, search and rescue, provision of medical assistance, emergency relief distribution and provision of temporary shelters to the victims of earthquake, within Narendranagar block. The norms used for requirement of resources in villages under the following sections are based on discussions with various experts involved in practical disaster management (section 6.6). The detailed planning of activities includes measures to be taken prior to earthquakes at various organizational levels, checklists and action plans.

6.4.1 Preliminary Damage Assessment

Preliminary damage assessment is the most important activity which should start immediately and should be completed within 4 -5 hours after the earthquake. It gives a general picture of damage occurred in the settlements so that it is possible to mount a reasonable relief operation without any delay. The results of this activity determine the planning of all other activities. The criticality of this activity for its short completion time suggests the application of project management techniques for its planning. Critical Path Method (CPM) is found to be useful to know what sub tasks are of critical importance and hence needs more preparedness. This section provides preparedness measures to be taken for performance of this activity along with the checklist (Table 6.2) and planning of this activity using CPM.

Preparedness measures in Villages

1. Preliminary damage assessment should be the responsibility of the village head.
2. The earthquake resistant control room in the village should always have information about number of residential buildings, number and types of other private and public buildings, infrastructural facilities, micro level map showing locations of all houses, access routes, facilities, important phone numbers and demographic information of all households in the village like the name of family head, persons in each household.

Table 6.2: Checklists for preliminary damage assessment

Level	Responsibility	Requirements		
		Manpower	Equipment	Information
Village	Village Head	Assistants; Trained damage assessment personnel of required number	Control Room; Amateur Radio Set	Detailed maps; Demographic Information; Important Phone Numbers; Details of critical Infrastructure Facilities
Relief Center	Village Development Officer	Assistants; Trained damage assessment personnel of required number	Control Room; Amateur Radio Set	Detailed maps; Demographic Information; Important Phone Numbers; Details of critical Infrastructure Facilities
Monitoring center	Appointed Government Official	Assistants; Trained damage assessment personnel of required number	Control Room; Amateur Radio Set; Very High Frequency Radio; Internet; FAX	Detailed maps; Demographic Information; Important Phone Numbers; Details of critical Infrastructure Facilities
Block level disaster management centre	Block Development Officer	Assistants; Trained damage assessment personnel of required number	Control Room; Amateur Radio Set; SSB High Frequency Radio; Internet; FAX	Detailed maps; Demographic Information; Important Phone Numbers; Details of critical Infrastructure Facilities

3. The village head, responsible for performance of this activity has to be trained along with two other persons who would function as his substitutes whenever required, for quick and objective damage assessment and for operating the communication equipments.
4. The village head should be assisted by a number of trained persons for damage assessment from the village. The number of these trained persons for all villages and market towns are given in Column B of Annexure XI. These persons could be the village masons, teachers of primary / secondary schools or any other volunteers.
5. The damage assessment should be carried out with respect to a designed Damage and Needs Assessment Proforma as given in Annexure X. This Proforma should be in Hindi for comprehension of village people.

Preparedness measures in Relief Centers

1. A village development officer should be appointed as relief center head.
2. All the village level preparedness measures suggested above should also be adopted for villages or market towns identified as relief centers.

3. The relief center control room should always have a list of all dependent settlements, micro level location maps, routes, demographic information about number of households, total population etc. and infrastructure facilities available in all villages.
4. Suitable training should be provided to the village development officer and his 2 suitable substitutes. He should be assisted by a staff of at least 2 persons for emergency communications who are suitably trained for handling of communication equipment.

Preparedness measures in monitoring centers

1. A government official should be appointed as monitoring center head. The principals or senior teachers from the existing educational facilities could be possible monitoring center heads.
2. The appointed head and two selected substitutes should be given training for all tasks including communications.
3. All Village and relief center preparedness measures should be adopted in monitoring centers.

Preparedness measures in Block Level Disaster Management Centre (Narendranagar)

1. The block level disaster management centre should be headed by the Block Development Officer. He along with his two substitutes should be trained for actions during emergency situations.
2. The block control room should contain detailed information about all villages, Gram Panchayats and Kshetra Panchayats. The hotline numbers, maps, location of all important facilities, resources, list of highly vulnerable villages, landslide hazard zoning maps etc should always be kept ready in the control room.
3. Technical personnel from administrative offices should be trained to operate all kinds of communication equipment, internet, GIS etc. They should be always present in close vicinity so that at least ten of them can be made available within no time after earthquake.

Action Plan for Preliminary damage assessment

Action Plan for the preliminary damage assessment aims at performing this critical activity in minimum possible time. Any delay in this activity would delay all the other critical activities. Hence, Critical Path Method (CPM) technique is used for the action plan and identifying the critical sub activities (Figure 6.14). The whole procedure should be repeated after all the aftershocks to ensure that information about the damage in villages is supplied to the decision makers in time.

List of Sub-activities

Activities at Villages with SRI I, II and III

A. Getting general information about damage caused in village.

B. Passing the information to Relief Center control room.

Activities at Villages with SRI IV and V and all Market towns

C. Getting general information about damage caused in village / town.

D. Passing the information to relief center,

E. Passing the information to monitoring center

F. Passing the information to block control room.

Activities at Relief Centers

G. Collecting information from Villages

H. Analysis, compilation of damage data procured.

I. Passing the information to monitoring center

Activities at Monitoring center s

J. Collecting information from relief centers and villages with damage SRI IV and V and market towns

K. Compilation and analysis of information

L. Passing the damage information to block control room.

Activities at Block Control Room

M. Collecting information from Monitoring center s

N. Analysis and compilation of damage information

O. Passing the information to all departments and agencies identified for emergency management and the district control room.

Activities at District Control Room

P. Getting information about damage caused in all towns and villages in the district through the Block Headquarters / Tehsil Headquarters

Q. Passing the information to the state Disaster Management Authority.

R. Passing the information to various concerned departments for taking actions

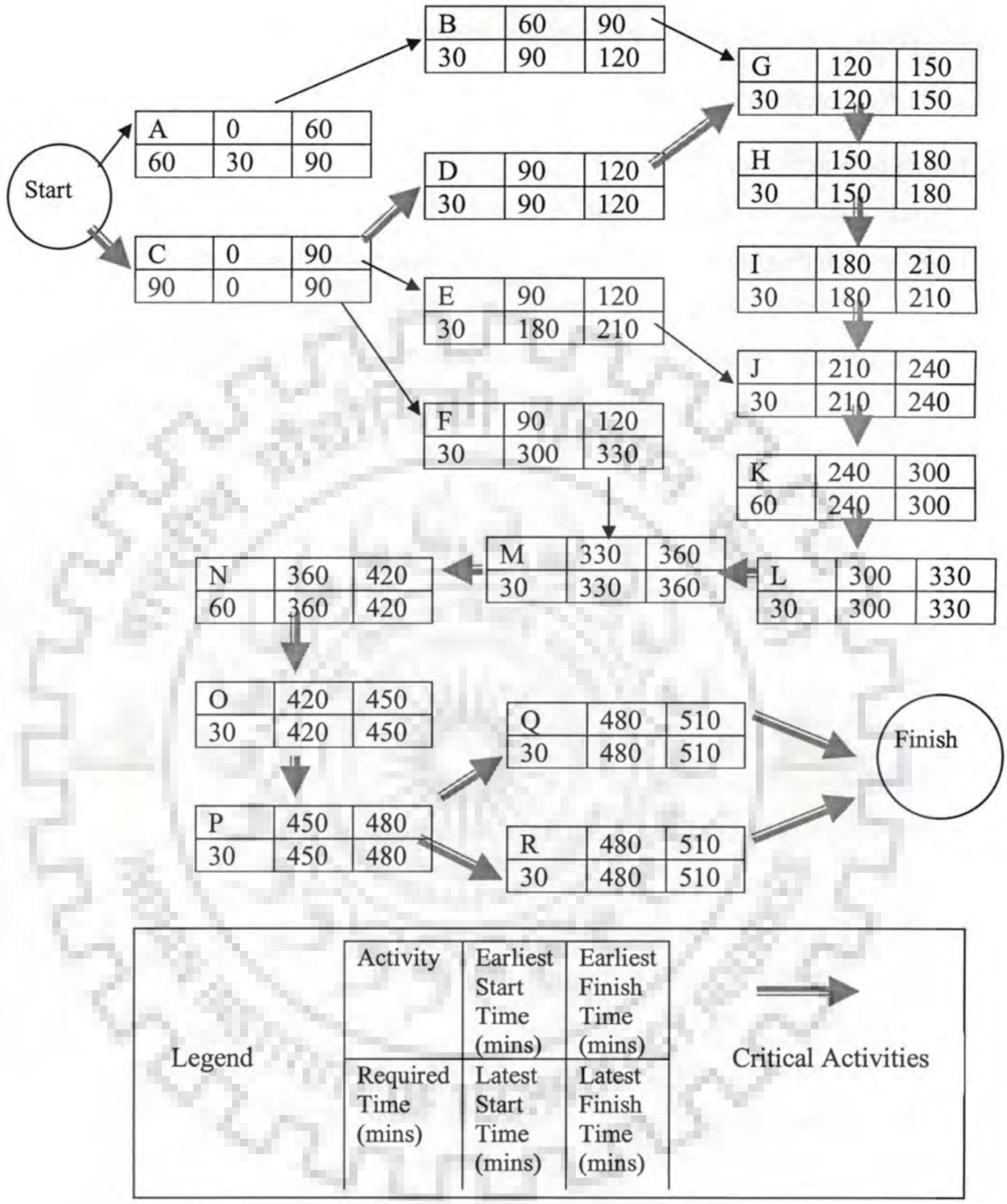


Figure 6.14: CPM network for 'preliminary damage assessment' in Narendranagar block.

Figure 6.14 shows that all activities except for A, B, E, and F are critical and need thorough preparedness. All the key persons for damage assessment should be made aware of these facts, their time limits and the implications of the delays.

6.4.2 Search and Rescue Operations

Search and Rescue is the life saving activity in which first 48 hours are most crucial for survival of trapped victims (Coburn and Spence, 2002). The isolated character of villages with the probability of landslides blocking the access routes, make the external help for search and rescue activities difficult and emphasize the need to strengthen community capacities for these operations. The construction technology prevalent in Narendranagar block is low rise masonry constructions. Hence, the search and rescue operations could be successfully carried out by local people if properly trained and equipped. The advanced rescue teams and equipment might be required only at important market towns viz. Narendranagar, Fakot, Tapowan, Muni-ki-reti, Dhalwala, Gaja and Gular. The preparedness measures for other settlements are given below.

Preparedness measures in villages

1. Search and rescue in settlements should be the responsibility of appointed rescue head. This appointed rescue head should be the village head or panchayat member or village development officer or other government officer or principal of primary school.
2. All villages should have manpower trained for rescue operations. At present there is a requirement of 5201 rescue persons in Narendranagar block. The numbers of trained persons in settlements are given in column C of Annexure XI. Equal number of persons should be trained as reserves. At least one or two of these trained persons should be masons from the village so that no time is wasted after an earthquake. Small teams should be formed with an appointed head. The teams should be allotted with number of houses and micro areas beforehand. Prior instructions should be given to these trained persons for acting immediately after any earthquake. Training should be given for carefully removing the surface debris, triage and first aid.
3. All villages should have appropriate number of rescue kits containing the domestic equipment like axe, sheave, hammer, saw, shovel, torch, rope, gloves etc. The number of rescue equipment kits which should be present in villages is determined from the number of heavily damaged buildings. Narendranagar block requires almost 1700 such kits. The settlement wise numbers are given in column D of Annexure XI. Apart from

these kits the settlements should also possess mechanical jack, cutters bolt, generator set, ladder extensions, lighting system, tarpauline etc.

4. All villages should have a number of canvas stretchers determined from the number of persons trapped and critically injured. The total number of stretchers in Narendranagar block would be 309. The need of individual settlements is given in column E of Annexure XI.
5. All villages should have body bags for the calculated numbers of dead persons. The total number of body bags calculated for Narendranagar is 1314 and the settlement wise number are given in Column F of Annexure XI.
6. The rescue equipment thus estimated should be procured locally from the village as far as possible and should be stored in earthquake resistant control rooms, so that it is easily available after earthquakes.

Preparedness measures at relief centers

1. Search and rescue activity should be coordinated by appointed rescue in charge at relief center.
2. All the preparedness measures suggested above for villages should be implemented for villages serving as relief centers also.
3. Relief center rescue in charge and his two substitutes should be trained to keep records of all rescue equipment and manpower at all villages within sub region.
4. Relief center head and his two substitutes should also be trained to monitor all rescue operations through control rooms, within their sub region and regulate the excess manpower and equipment resources within and outside the relief centers.

Preparedness measures at monitoring centers

1. Search and rescue operations should be monitored by appointed government official in the monitoring centers.
2. All the preparedness measures suggested in villages and relief centers should be adopted in settlements acting as monitoring center also.
3. Monitoring center rescue in charge should be trained for collecting information about the rescue operations within his sub region, from relief center heads after every 3 hours.
4. Monitoring center head should be trained to regulate the available resources within his sub region and contacting the block control room for any other needs.

Preparedness measures at Block Level

1. Sub-District Magistrate (SDM), who is also the Commander, Home Guards, Narendranagar Block, should be the officer for rescue operations in the block and should be suitably trained. Two alternative officers should also be trained to act in place if required.
2. All preparedness measures suggested above should be adopted for Narendranagar town also.
3. SDM should be able to communicate with all Monitoring centers and relief centers and should be able to monitor the local rescue activities.
4. SDM should be directly connected with external resource organizations for rescue operations in the block. He should have all the relevant information and resources to communicate the need of specialized rescue assistance in villages and market towns to various external rescue organizations and intimate about this to district magistrate.
5. The specialized manpower within the block like army, police, and home guards should be trained for rescue operations, locations and access to all villages of Narendranagar block.

Preparedness measures at District level

1. Police commissioner should be the officer in charge of rescue operations at district level and should be suitably trained for planning of emergency rescue operations. Two substitute officers should also be trained to act in his place if required.
2. Police commissioner should be well connected to block control rooms and external rescue organizations.

Action Plan for search and rescue operations

The important sub tasks of the search and rescue operations are given here. Table 6.3 gives the checklist and time durations proposed for the sub tasks.

Activities at Village level

A. All rescue teams should collect at control room
B. The rescue kits, stretchers and body bags allotted to team heads.
C. The village head reports to the relief center head about the start of rescue operations
D. The rescue team starts removing debris from the collapsed houses and taking out the injured and dead people.

E. The casualties are taken to medical camps

F. The village head informs the relief center head about any further requirement of resources or specialized teams in the villages.

G. The village head informs the relief center head about the progress of rescue operations after every three hours.

H. The rescue team heads return the rescue kits to the control rooms.

I. Passing the information about end of rescue operations.

Activities at Relief Centers

J. Collecting information from villages about start of rescue operations.

K. Passing the information to monitoring centers.

L. Receiving information about progress of rescue operations in villages and requirement of any additional resources or specialized teams in villages.

M. Passing the information to monitoring centers.

Activities at Monitoring centers

N. Collecting information about start of rescue operations in all villages.

O. Passing the information to block control room

P. Receiving information about progress of rescue operations in relief centers and requirement of any additional resources or specialized teams in villages.

Q. Passing the information to block control room.

Activities at Block level disaster management centre

R. Collecting information about start of rescue operations in all villages.

S. Collecting information about progress of rescue operations in all villages and requirement of specialized teams in villages

T. Instructing the specialized teams for reaching the villages in shortest possible time.

U. Passing the information about progress to District control room.

Activities at District Level

V. Monitoring the rescue operations in the district.

W. Making the advanced rescue teams and equipment available in the district wherever required.

X. Keeping the state control room informed.

Table 6.3: Action plan for search and rescue operations in Narendranagar block

Activity	Responsibility	Requirement			Start Time (min)	End Time (min)
		Manpower	Equipment / Material	Information		
A	Village Rescue In-charge	Trained rescue persons		Number of masons and rescue team members	10 min	30 min
B	Same as A	Same as A Volunteers	Rescue kits, stretchers, body bags	Village maps, demographic and buildings information	30 min	60 min
C	Same as A	Communication expert	Communication equipment	Important phone numbers, Knowledge to operate communication equipment	60 min	70 min
D	Rescue team heads	Same as A	Same as B	Same as B	60 min	2-3 days
E	Same as D	Volunteers	Stretchers, vehicles	Location of medical camps	60 min	2-3 days
F	Same as A	Same as C	Same as C	Same as C	60 min	2-3 days
G	Same as A	- do -	- do -	- do -	60 min	2-3 days
H	Same as D	Same as B	Same as B		Day 2	Day 3
I	Same as D	Same as C	Same as C	Same as C	Day 2	Day 3
J	Relief Center Rescue in charge	Same as C	Same as C	Same as C	60 min	75 min
K	Same as J	Same as C	Same as C	Same as C	75 min	90 min
L	Same as J	Same as C	Same as C	Same as C	60 min	Day 2-3
M	Same as J	Same as C	Same as C	Same as C	70 min	Day 2-3
N	Control center rescue in charge	Same as C	Same as C	Same as C	70 min	90 min
O	Same as N	Same as C	Same as C	Same as C	90 min	110 min
P	Same as N	Same as C	Same as C	Same as C	70 min	Day 2-3
Q	Same as N	Same as C	Same as C	Same as C	90 min	Day 2-3
R	Sub District Magistrate	Same as C	Same as C	Same as C	90 min	110 min
S	Same as R	Same as C	Same as C	Same as C	90 min	2-3 days
T	Same as R	Same as C	Same as C	Same as C	100 min	Day 2-3
U	Same as R	Same as C	Same as C	Same as C	100 min	Day 2-3
V	Police Commissioner	Same as C	Same as C	Same as C	60 min	Day 2-3
W	Same as V	Same as C	Same as C	Same as C	60 min	Day 2-3
X	Same as V	Same as C	Same as C	Same as C	60 min	Day 2-3

6.4.3 Providing Medical Assistance and Handling of Dead

The earthquake leaves many people killed and injured and at such times health care becomes the most critical service. This activity starts with setting up of medical camps in villages and hence needs careful planning to save precious time.

Preparedness measures at village and market town level

1. All the present health facilities with high earthquake vulnerability should be made earthquake resistant through appropriate retrofitting measures and reconstruction.
2. New health facilities should be developed for the villages Timli, Mindath, Maun, Loyal, Bedadhar, Nauga, Agrakhal, Hindolakhal, Kukhai and Byasi for their high estimated casualties and lack of medical facility (Figure 6.15). The type of new health facilities and the resources should be decided by health experts on the basis of feasibility studies. Bamboo structures should be erected for housing the new medical facility.
3. Sub centers of Mathiyali, Kaudiyala, Maroda, Duadhar and Neer should be upgraded to medical facility with doctor, and infrastructure required for setting up medical camps during emergencies should be provided (Figure 6.15).

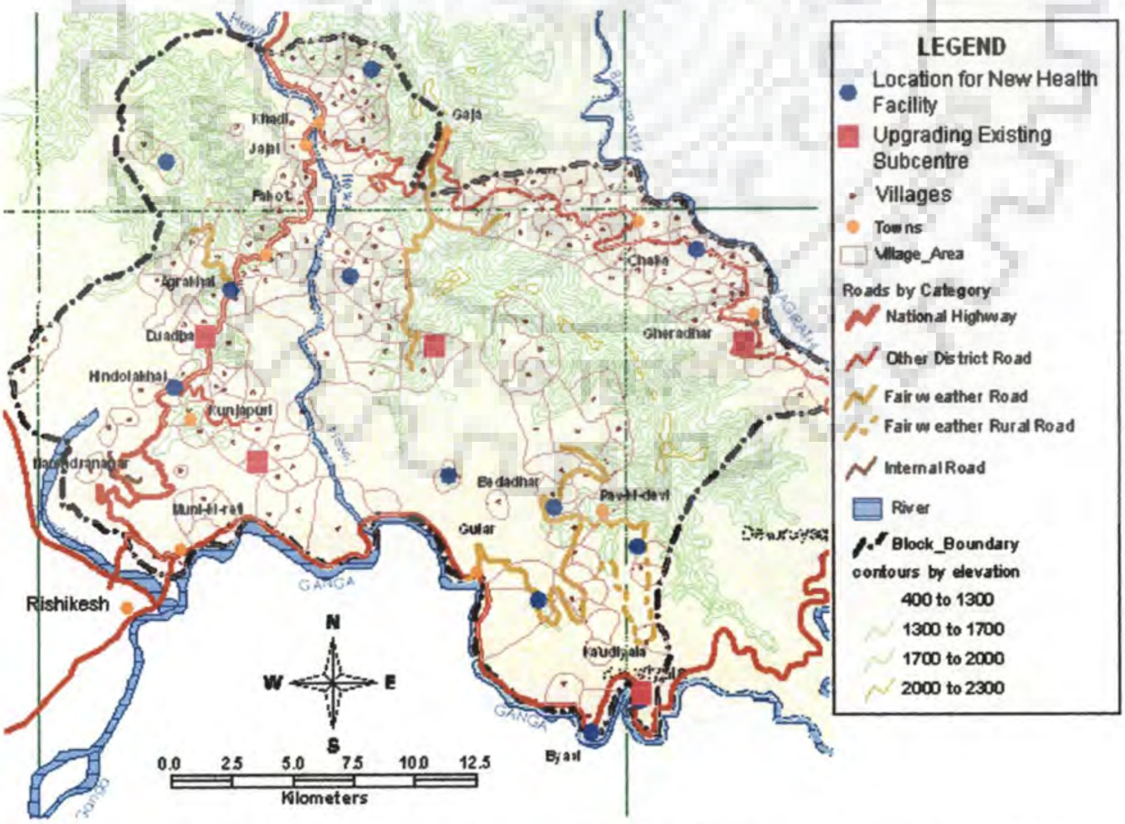


Figure 6.15: Locations for new health facilities and existing sub centers which need to be upgraded in Narendranagar Block.

4. Appropriate transportation facility should be available for transportation of victims to the nearest medical camps.
5. For the cremation / burial of dead victims in the villages, suitable sites should be identified in every village. Wood required for the cremation of dead victims should be available and / or the source should be identified beforehand. An official should be appointed as incharge for maintaining records during emergencies.

Preparedness measures at relief centers

1. Relief centers should be prepared to host medical camps in the existing health facility premises for the victims in their sub region.
2. In most relief centers the space offered by health facilities would be very less than required to deal with significantly high number of patients. In such cases the available open spaces or any public building like school or inter college building should be identified for setting up of medical camps.
3. The medical camps should be in close proximity with the control rooms so that the requirement about medicines, material, equipment or staff could be conveyed to monitoring centers and block control room. Also the information about critically injured victims who need to be taken to higher level medical facilities would be passed.
4. Volunteers required for setting up of medical camps should be identified and trained beforehand.
5. The number of doctors, nurses and other paramedic staff to be always present in relief centers should be calculated by health experts on the basis of casualties and the feasibility studies.
6. The emergency equipment, dressing material and some medicines should be always stored in medical camps. However, due to perishable nature of medicines, they should be kept in circulation and provisions for procuring them immediately during emergencies should be made.
7. Any requirement for this activity in terms of doctors and other manpower, equipment, medicines etc. should be immediately conveyed to monitoring centers through control rooms so that no crucial time wasted.

Preparedness measures at Monitoring centers

1. The relief centers identified as monitoring centers should possess higher level of equipment, doctors and material to deal with more critical patients.

Preparedness measures at block level

1. Suman Hospital Narendranagar should be empowered with all advanced medical facilities to setup a higher level medical camp for the block. A medical camp should be set up at the large open assembly space close to Suman hospital and opposite to market (Figure 6.16). The manpower and other resources from all the health facilities in Narendranagar should be available in medical camp.

Figure 6.16: Open assembly space in Narendranagar identified for medical camp

2. The medical officer in charge at Narendranagar should be connected directly with Dehradun, Rishikesh and Devprayag medical camps.
3. Preparedness measures in terms of ambulances / vehicles, drivers, fuel would ensure road transportation of the critically injured patients from Jajal, Agrakhal, and Gaja monitoring centers to Narendranagar medical camp; from Bedadhar, Tapowan and Gular monitoring centers to Rishikesh Medical camp; and from Chaka monitoring center to Devprayag town of Devprayag block.
4. In case of air transport, critically injured patients should be taken to Himalayan Medical College, Dehradun.

Measures at District level

Apart from providing medical assistance to New Tehri Township, the role of district level medical camps is to co-ordinate medical assistance activity in the district.

Action Plan

The following actions need to be taken in order to perform the activity of provision of medical assistance to victims in most efficient way. The checklists and time durations are given in Table 6.4.

Activities at Villages

A. The rescued and injured victims are brought on stretchers to health facility in village. For villages without any health facility the injured victims are taken to medical camps in relief centers.

B. For dead victims the bodies are covered in body bags, records are maintained and bodies are cremated immediately with assistance from the relatives of the dead.

Activities at Relief Centers

C. Setting up of medical camps under the supervision of doctors by trained volunteers.

D. Conveying the demand of medical needs in terms of material, medicines, equipment and manpower to the monitoring center and the block control room.

E. Providing medical assistance to the victims.

F. Sending critically injured victims to monitoring center medical camps.

G. Maintaining records.

H. Procuring cremation wood.

I. Cremation of Dead bodies.

Monitoring center

J. Setting up of medical camps under the supervision of doctors by trained volunteers.

K. Conveying the demand of medical needs in terms of material, medicines, equipment and manpower to the block control room.

L. Providing medical assistance to the victims.

M. Receiving and treating critically injured victims from the relief center medical camps.

N. Sending more critical patients to respective block level medical camps.

O. Air lifting of very critically injured patients to Dehradun.

Block level disaster management centre

P. Setting up of medical camps under the supervision of doctors by trained volunteers.

Q. Conveying the demand of medical needs in terms of material, medicines, equipment and manpower to important medical resources of state.

R. Providing medical assistance to the victims.

S. Receiving and treating critically injured victims from Agrakhal, Jajal, and Gaja monitoring centers.

T. Conveying demand and procuring emergency medical needs in terms of material, medicines, equipment and manpower from Dehradun.

District level

U. Keeping record of medical assistance activities going on in the district.

Table 6.4: Action plan for medical assistance and handling of dead in Narendranagar Block

Activity	Responsi-bility	Requirement			Start Time	End Time
		Manpower	Equipment / Material	Information		
A	Rescue team heads	Volunteers	Stretchers, vehicles	Location of medical camps	60 min	Day 2-3
B	Village Head	Volunteers	Body bags; cremation wood; Death certificates and forms for record.	Resources for cremation wood	Day 2	Day 4
C	Health Officer at Relief Center	Paramedical staff; volunteers	Space for medical camps; medical equipments; medicines, bandage and other material; Stretchers, Ambulances	Important telephone numbers of medical resources	30 min	180 min
D	-do-	Communication expert	Communication equipment; control room	Important phone numbers	60 min	Day 10
E	-do-	Medical equipment, medicines, other material	Doctors, nurses, paramedical staff	Knowledge of emergency medical services	60 min	Day 10
F	-do-	Volunteers	Ambulances, helicopters; Communication equipment;	Phone numbers	60 min	Day 10
G	-do-	Paramedical staff	Forms, stationary	Emergency procedures / formalities	60 min	Day 10
H	-do-	Volunteers	Cremation wood	Resources of cremation wood	60 min	Day 10
I	-do-	Volunteers	Cremation wood	Resources of cremation wood	60 min	Day 10
J	Health Officer at Monitoring Centre	Same as C	Same as C	Same as C	30 min	180 min
K	-do-	Same as D	Same as D	Same as D	60 min	Day 10
L	-do-	Same as E	Same as E	Same as E	60 min	Day 10
M	-do-	Same as F	Same as F	Same as F	60 min	Day 10
N	-do-	Same as F	Same as F	Same as F	60 min	Day 10
O	-do-	Same as F	Same as F	Same as F	60 min	Day 10
P	Block Medical officer	Same as C	Same as C	Same as C	30 min	180 min
Q	-do-	Same as D	Same as D	Same as D	60 min	Day 10
R	-do-	Same as E	Same as E	Same as E	60 min	Day 10
S	-do-	Same as D	Same as D	Same as D	60 min	Day 10
T	-do-	Same as D	Same as D	Same as D	60 min	Day 10

6.4.4 Emergency Relief Distribution

The victims of earthquakes need to be provided with relief in terms of food, drinking water, clothing, blankets etc. The preparedness measures, actions and networking for relief distribution are given here.

Preparedness measures at Village level

1. All government fair price ration shops should be made earthquake resistant by retrofitting or erecting new buildings.
2. New government ration shops should be provided at Ranakot, Maun, Sasman, Bairaigaon and Daur because of their high damage grade and absence of any government ration shop within 5 kms.
3. Open ground should be identified for community kitchens and requirements for the same should be identified, listed and procured. Womenfolk from the villages should be instructed for running the community kitchens in case of emergency situations.
4. Natural resources of drinking water should be protected to minimize the probability of blockage after earthquakes. Earthquake resistant water storage tanks should be constructed in all villages. In case of disruption of water supply, the demand of the drinking water should be made to relief centers. A stock of disinfectants for water supply should always be present in the emergency store.
5. Other relief material like blankets and clothing, should be kept ready in emergency stores in appropriate numbers. These numbers should be determined from the number of persons needing relief which are given in Annexure XI (column G and H).

Preparedness Measures at Relief Centers

1. All the village level preparedness measures mentioned above should be taken at relief centers also.
2. Relief centers would have a responsibility to convey the demand of relief in villages to monitoring centers, procure the relief material and distribute them to villages. Volunteers required for this purpose should be suitably trained villagers. The facilities like store, vehicles, drivers etc. should also be ready in relief centers.

Preparedness Measures at Monitoring centers

1. All the village level preparedness measures mentioned above should be taken.
2. Volunteers should be trained for setting up of relief camps.
3. Monitoring centers should be prepared to convey the demand of relief material in villages to Narendranagar (for Agrakhal, Jajal and Gaja monitoring center s), Rishikesh

(for Tapowan, Gular and Bedadhar monitoring center s) and Devprayag (for Chaka monitoring center).

4. Vehicles with fuel and drivers should always be ready at the monitoring centers to procure the relief and distribute it to the villages and relief centers.

Block level Relief Center (Narendranagar/ Rishikesh and Devprayag)

1. Emergency store should contain stocks of all relief material.
2. The relief head could be Commanding Officer of the Army Cantonment Narendranagar. He should be well connected to state resources for relief procurement.
3. The demand of relief in different monitoring centers should be procured and supplied to monitoring centers via vehicles. These vehicles should always be in good conditions, fuel and drivers should be ready for operations.

Preparedness Measures at District Level

1. District relief co-coordinator should be well connected to all block relief centers, monitoring centers and state relief centers to make arrangements for relief distribution wherever required.
2. Inventory of NGOs and CBOs working in the district should be made and making them capable for assisting for relief distribution during emergencies.

Action Plan

All the sub tasks for emergency relief are given here. Table 6.5 shows all the sub tasks for checklists and time durations.

Activities at Village level

A. Village Relief head asses relief needs on the basis of preliminary damage assessment and compares item wise existing stock of relief.
B. Further Demand or excess quantities are conveyed to the relief center.
C. Community kitchens are established for meeting the food demand.
D. Community Kitchens starts functioning.
E. Distribution of relief and maintenance of records.
F. Restoration of water resource.
G. Any requirement conveyed to Relief centers.

Table 6.5: Action plan for emergency relief

Activity	Responsi-bility	Requirement			Start Time	End Time
		Manpower	Equipment / Material	Information		
A	Village relief Head	Assistants	Emergency store, Relief stock	documentation of quantities relief stock;	180 min	240 mins
B	-do-	Communication expert	Communication equipment	Knowledge to operate communication equipment	240 min	270 min
C	Aanganbadi members	Womenfolk;	Cooking utensils; food material; water; fuel; space for kitchen	Number of persons requiring food	180 mins	300 mins
D	-do-	-do-	-do-	-do-	300 mins	Day 5
E	Village relief Head	Trained assistants, volunteers	Emergency store, Relief stock, record forms	Quantities to be distributed	270 mins	Day 2
F	-do-	Trained masons	Rescue equipment	Maps of supply lines, locations of natural resources	240 mins	Day 1
G	-do-	Same as B	Same as B	Same as B	240 mins	Day 5
H	Relief center Head	Same as E	Same as E	Same as E	300 mins	360 mins
I	Relief center Head	Same as E	Same as E	Same as E	360 mins	Day 3
J	- do-	Same as B	Same as B	Same as B	360 mins	Day 3
K	-do-	Trained assistants, volunteers, drivers	Vehicles,	locations for helicopter landing	360 mins	Day 3
L	Monitoring Center Relief Head	Same as B	Same as B	Same as B	360 mins	Day 3
M	-do-	Same as K	Same as K	Same as K	360 mins	Day 3
N	Block relief head	Same as B	Same as B	Same as B	360 mins	Day 3
O	-do-	Same as K	Same as K	Same as K	360 mins	Day 3
P	District relief head	Same as B	Same as B	Same as B	360 mins	Day 3
Q	-do-	Same as K	Same as K	Same as K	360 mins	Day 3

Relief Center

H. Establishment of relief camps in identified school building.
I. Distribution of relief and maintenance of records.
J. Conveying demands to monitoring center.
K. Receiving and distributing relief through helicopters or vehicles.

Monitoring Centers

L. Communicating with relief centers and block level disaster management centre for relief requirements.
M. Receiving the relief material and sending it to relief centers.

Block level relief camp

N. Communicating with monitoring centers, state resources, NGOs and other national and international agencies for relief requirements.
O. Receiving the relief material and sending it to monitoring centers.

District Level

P. Communicating with monitoring centers, state resources, NGOs and other national and international agencies for relief requirements.
Q. Receiving the relief material and sending it to monitoring centers.

6.4.5 Provision of Temporary shelters to the victims

As a result of building damage during earthquakes several people are rendered homeless. Provision of temporary shelters to such victims of earthquake is a crucial activity. It is important to provide temporary shelter to victims in their own village, hence this activity is essentially at settlement level.

Preparedness measures at settlement level

1. A senior person other than village head should be identified and appointed as in charge of temporary sheltering of population in an earthquake event.
2. All the school buildings in the villages should be made earthquake resistant by incorporating retrofitting measures or re-erecting them.
3. New earthquake resistant schools should be constructed at Bawani, Atali, Banali, Bhangala, Kharki, Manderigaon, Naur, Sweer and Thanyul, for their high population leading to more shelter less people and absence of adequate educational facilities. Nayee, Mindath, Sasman should be provided with an additional educational facility to the existing one.

4. The damage assessment persons from villages should also be trained for declaring the houses safe or unsafe, on the basis of damage caused.
5. In villages where capacity of school buildings is less than the estimated shelter less population, the shelter less population should be provided accommodation in the nearby villages within 3 kms from the village. For e.g. Bamankhola, Pokhri, Sera and Saundi can provide temporary accommodation to 10, 19, 44 and 6 persons from neighboring villages respectively.
6. In all other villages tents should be kept available for providing temporary shelters. Narendranagar block requires a large number of tents for temporary sheltering i.e. almost 3000 tents. The village wise numbers are given in Column I of Annexure XI
7. Open space for the erection of tents should also be identified. If possible these tents should be erected near the collapsed houses so that the occupants can check their belongings and can repair their houses easily.
8. Number of sleeping bags in villages as given in Column J Annexure XI should be always kept ready at the villages.
9. The residents from villages should be made aware about the probable places for their temporary shelters in the village or in the nearest village, so that they can reach the temporary shelter on their own and time is not wasted in instructing them about the evacuation centers.

Action Plan

The sub tasks provision of temporary shelters to the shelterless population is provided in this section. Table 6.6 provides action plan for the same.

Activities at Settlement Level

A. Number of persons to be provided temporary shelters are estimated on the basis of preliminary damage assessment.

B. Analysis of available temporary shelters in identified school buildings and available tents compared with required numbers.

C. Contacting the neighbouring villages for available accommodations and directing the shelterless people.

D. Allocation of temporary shelters and sleeping bags to the shelterless population.

E. Erection of tents at the identified places with the help from trained volunteers.

F. Any further demand is conveyed to relief centers.

Table 6.6: Action plan for provision of temporary shelters

Activity	Responsi-bility	Requirement			Start Time	End Time
		Manpower	Equipment / Material	Information		
A	Appointed person in-charge	Assistants	Emergency store, tents, sleeping bags	documentation of quantities of material ;	180 min	240 mins
B	Same as A	Trained assistants, volunteers	Emergency store, tents, sleeping bags	Norms for distribution	240 min	300 min
C	Same as A	Communication expert	Communication equipment	Knowledge to operate communication equipment	300 min	360 min
D	Same as A	Volunteers	Same as B, distribution space	Norms for distribution	330 mins	Day 1
E	Same as A	Volunteers, affected residents	Tents, erecting equipment,	Knowledge of tent erection	330 mins	Day 1
F	Village relief Head	Same as C	Same as C	Same as C	360 mins	Day 1

6.5 Detailed Preparedness Plans for Selected Settlements

Detailed preparedness plans are suggested here for three selected villages with different SRI and at different hierarchy level designed for emergency management in Narendranagar block. These three settlements are namely Kharsad (village), Odada (relief center) and Fakot (monitoring center) (Figure 6.17).

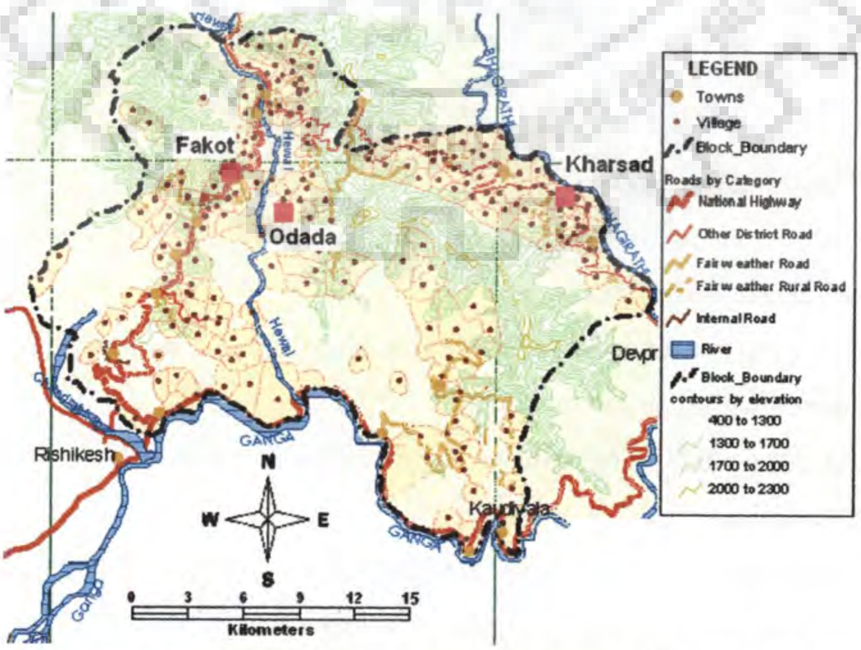


Figure 6.17: Locations of settlements selected for detailed preparedness plans

The existing resources in these 3 settlements are summarized in Table 6.7 and the earthquake induced expected losses and material requirement are given in Table 6.8.

Table 6.7: Available resources in 3 settlements selected for detailed plans

Resource	Village Kharsad	Relief Centre Odada	Monitoring Centre Fakot
Accessibility Category	A1	A4	A1
Health Facility	No	Homeopathy Hospital (Closed)	Primary Health Centre
Education facility	Primary School, Sec. School	Primary School, Secondary School, High School, Inter College	Primary School, Secondary School, High School, Inter College
Number of Govt. Fair Price Shops	2	1	2
Panchayat Office	No	No	Yes
Post Office	No	Yes	No
Bank	No	No	Yes
Telephone Connections	No	Yes	Yes
Electricity	Yes	Yes	Yes
Water Supply	Yes	Marginal	Yes
Aanganbadi Center	Yes	Yes	Yes
Members of Mahila Mangal Dal	9	9	9
Members of Nav Yuvak Mangal Dal	4	4	4
Number of Masons	4	6	10
Number of Drivers	2	4	5
Number of Soldiers	2	2	1

Table 6.8: Earthquake induced losses and emergency requirements in 3 selected villages for detailed planning.

Village Name		Kharsad	Odada	Fakot
Total Population		505	459	650
Number of Households		125	85	155
Buildings with damage grade G5		0	26	9
Buildings with damage grade G4		6	30	33
Buildings with damage grade G3		39	20	54
Buildings with damage grade G2		51	9	51
Buildings with damage grade G1		29	0	8
Dead or Un-savable Persons		1	13	6
Persons with Life threatening injuries		1	20	10
Persons with injuries requiring hospital treatment		1	20	10
Persons with light injuries		1	13	6
Shelter-less Population	Population of G3, G4 and G5 Buildings	180	409	403
	Population of G4 and G5 Buildings	23	300	176
SRI		I	V	II
Rescue Kits		2	18	18
Stretchers		0	4	4
Body bags		1	13	13
Tents		7	35	28
Sleeping bags		23	300	176
Vehicles		2	5	4
Community Kitchen (For Number of Persons)		23	300	176
Cremation Wood (For Number of Persons)		1	13	6
Blankets		23	300	176
Clothing (For Number of Persons)		23	300	176

6.5.1 Village Kharsad

Kharsad is a village with low vulnerability with SRI I. Kharsad falls under the Nauga relief center and Chaka monitoring center. The block level disaster management center during emergencies for Kharsad would be Devprayag town.

Preparedness Measures

1. Kharsad has no panchayat office so a room in primary school should be prepared to act as control room during emergencies. The school should be retrofitted to make it earthquake resistant. Two rooms should be reserved or erected for disaster management activities. One room should be made control room and panchayat office at peace time. It should have an amateur radio set installed for emergency operations. Emergency store should be made in the other room containing rescue kits and other rescue equipment. These two rooms should be supervised constantly by the village head.
2. Four masons from the village should form two rescue teams and trained suitably.
3. One more emergency store should also be present in the primary school containing the emergency relief material, tents and sleeping bags. This store should be supervised by the principal of primary school.
4. Four Nav Yuvak Mangal Dal members should be trained for transporting the 3 injured persons to the Chaka medical camp and then reporting the village head for assistance. The village head on receiving the instructions for relief center head may direct them to other nearby villages for assistance.
5. The two retired soldiers from the village should supervise the activity of transportation of critically injured persons to medical camps and then make themselves available for other affected villages.
6. The secondary school of Kharsad should also be retrofitted. This secondary school along with primary school should act as temporary shelters for shelter less people of the village. The principal of secondary school should look after the condition of buildings and availability of tents and should be trained for allocation of temporary shelters to the victims.
7. Nine members of Mahila Mangal Dals from village should run a community kitchen for 23 persons. The food material required should be procured from the government fair price shop present in the village. This ration shop should be retrofitted to make it earthquake resistant.

6.5.2 Relief Centre Odada

Odada is a highly vulnerable village with damage SRI V (very high risk) and identified to serve as relief center. The detailed primary survey report of Odada is given as Annexure VII. The information about villages under relief center Odada can be referred from

Annexure IX. The total number of persons needing relief in all dependent villages is 1152. Although these would be provided the basic relief in their respective villages, they might be directed to Odada for further needs. Measures should be taken by the relief center to avoid overlap of relief to the victims. The high earthquake damage potential in Odada requires various preparedness measures to be taken on the most urgent basis as suggested.

Preparedness Measures at Odada

1. It is of utmost importance to reduce the vulnerability of residential buildings, so that the intensity of earthquake in the village is reduced. The already discussed bamboo technology should be adopted for this purpose.
2. The katchha motorable road starting from Adwani (on Jajal Gaja Road) upto Berni should be improved and made pakka motorable road and extended upto Odada. One more road should be constructed from Gaja Gular road to reach Odada. This will improve the accessibility of dependent villages with Odada.
3. Location for helipad for emergency operations should be identified at Lat $30^0 13'29"$ Long 78^0 22'57"
4. The primary school, higher secondary school and the inter college should be made earthquake resistant.
5. There is no Panchayat Bhawan in Odada. Hence the control room should be established in room identified in primary School. Amateur radio sets should be installed in the control room. This control room should be headed by the village development officer and assisted by the village head. They should be trained for establishing contact with villages under Odada relief centers; Gaja Monitoring center and Narendranagar block disaster management center.
6. Three persons appointed for damage assessment should be suitably trained for working and reporting to the control room immediately after an earthquake.
7. An emergency store should be constructed with primary school, to store 18 rescue kits under the supervision of village head.
8. Six masons from Odada village should be trained for rescue operations who in turn should train 55 rescue persons divided in 19 teams. They should be told to immediately collect the rescue kits from the primary school store and start the work.
9. A new health facility with 10 beds, 2 doctors, 3 pharmacists, 5 nurses and other staff of 10 should be constructed on most urgent basis. In the event of earthquake this facility would have to serve 45 dead or unsavable persons, 68 persons with life

threatening injuries and 68 persons requiring hospital treatment. The existing homeopathy hospital, presently closed due to unavailability of doctor could be re-erected for this purpose with open space for setting field medical camp.

10. This health facility should be constructed on vehicular road, so that patients from other dependent villages could be easily transported and critically injured patients could be easily taken to Gaja.
11. The four Nav Yuvak Mangal Dal Members should be trained for assisting in setting up of medical camp.
12. The medical facility should also have an emergency store containing emergency medical needs. They should be looked after by the doctor in charge of the health facility.
13. The two retired army soldiers in the village should be trained suitably to administer the medical assistance in the medical camp.
14. The inter college of Odada should store the emergency relief items particularly blankets and clothing. The principal of inter college should be the in-charge of maintaining the stores and conducting the relief distribution activity during emergency situation. In his absence this activity should be conducted by senior teachers of the college. All of them should be suitably trained. The senior students of inter college should be trained for relief distribution and maintaining records.
15. The secondary school of the village should also be retrofitted. This secondary school along with primary school would serve as temporary shelter for shelter less people of the village. The schools together offer accommodation to almost 200 persons. Odada needs 35 tents for providing accommodation to shelter less people as well as people living in G3 (moderate damage) buildings which are recommended to be vacated because of probability of collapse during aftershocks. This need of tents would reduce when the residential buildings would be retrofitted.
16. The principal of secondary school should look after the condition of all school buildings and availability of tents and should be trained for allocation of temporary shelters to the victims.
17. The anganbadi member and helper from the village should co-ordinate the community kitchen activity. The nine Mahila Mangal Dal members of the village should be instructed to run a community kitchen with the assistance of womenfolk from the village.
18. A ration shop with earthquake resistant construction should be constructed in the village and food material for the community kitchen should be provided by this shop.

6.5.3 Monitoring Centre Fakot

Fakot is the administrative headquarter of Narendranagar block (Figure 6.4a, 6.18) and serves as an important market town for the neighboring villages because of availability of facilities like PHC, bank, schools and inter college, few commercial shops, block development office, flour mill, small restaurants etc.

Figure 6.18: Market town Fakot

Fakot which is an identified relief centre is also identified to bear the responsibility of monitoring center during emergencies. The preparedness measures required for this are given below:

Preparedness Measures at Fakot

1. In Fakot the existing residential buildings should be retrofitted with the bamboo technology to reduce the overall vulnerability of the town.
2. The accessibility of dependent villages under Fakot (Annexure IX) must be improved by development of new roads and strengthening of existing rural roads.
3. Location for helipad for emergency operations should be identified at Lat $30^{0}14'27''$ Long $78^{0}20'25''$
4. The primary school, higher secondary school and the inter college should be made earthquake resistant.
5. The control room should be established in the office of Block Development Officer. Communication equipment should be installed in the control room (Figure 6.10 a). This control room should be headed by the block development officer and assisted by the village development officers and the office staff. They should be trained for establishing contact with villages under Fakot relief center and Narendranagar (block level disaster management centre).
6. Six persons appointed for damage assessment should be suitably trained and told to carry out the damage assessment and report to the control room immediately.

7. An emergency store should be constructed with primary school, to store 14 rescue kits under the supervision of village development officer.
8. Ten masons from Fakot should be trained for rescue operations who in turn should train 42 rescue persons divided in 12 teams. They should immediately collect the rescue kits from the primary school store and start the rescue work.
9. The existing PHC should be upgraded to health facility with 10 beds, 2 doctors, 3 pharmacists, 5 nurses and other staff of 10 on most urgent basis. Since the building of PHC (Figure 4.15 a) shows moderate vulnerability it should also be retrofitted immediately. There is an unused open space near the health facility which should be left vacant for setting medical camps during emergencies (Figure 6.19).

Figure 6.19: Open spaces near PHC Fakot identified for medical camps

10. In the event of earthquake this facility would have to serve 38 dead or unsavable persons, 57 persons with life threatening injuries and 57 persons requiring hospital treatment from Fakot and 12 dependent villages.
11. The four Nav Yuvak Mangal Dal Members should be trained for assisting in setting up of medical camp.
12. The medical facility should also have an emergency store containing emergency medical needs. They should be looked after by the doctor in charge of the health facility.
13. The retired army soldier in Fakot should be trained suitably to administer the medical assistance in the medical camp.
14. The inter college of Fakot should store the emergency relief items particularly blankets and clothing (Figure 6.20). The principal of inter college should be the in-charge of maintaining the stores and conducting the relief distribution activity during emergency situation. In his absence this activity should be conducted by senior teachers of the

Figure 6.20: Government Inter College, Fakot

college. All of them should be suitably trained. The senior students of inter college should be trained for assisting in relief distribution and maintaining records.

15. The total number of persons needing relief from all dependent villages to Fakot relief camp is 848. Although these would be provided the basic relief in their respective villages, they might be directed to Fakot for further needs. Measures should be taken by the relief center to avoid overlap of relief to the victims.
16. The secondary school of the village should also be retrofitted (Figure 6.21). This secondary school along with primary school would serve as temporary shelter for shelter less people of the village. The schools together offer accommodation to almost 220 persons, which is sufficient for the occupants of residential buildings of G4 and G5 damage grade. However, if occupants of G3 buildings also have to be accommodated in temporary shelters then 15 tents would be required. This need of tents would reduce when the residential buildings would be retrofitted.

Figure 6.21: Secondary school, Fakot

17. The principal of secondary school should look after the condition of all school buildings and availability of tents and should be trained for allocation of temporary shelters to the victims.
18. The anganbadi member and helper from the village should be prepared to co-ordinate the community kitchen activity. The nine Mahila Mangal Dal members of the village along with the cooks of two restaurants should be instructed to run a community kitchen with the assistance of womenfolk from the village.

6.6 ADOPTED NORMS FOR ESTIMATION OF RESOURCES

The quantities of manpower and material resource requirements suggested for the preparedness of settlements in the previous sections are derived by developing norms based on discussions with various experts, administrative functionaries and many others who though at lower levels, are involved in the emergency operations and practical aspects of disaster management (Table 6.9). These adopted norms can also be used as planning norms in the formulation of earthquake preparedness plans for similar hilly settlements.

Table 6.9: Norms adopted and suggested for quantities

S. No.	Resource Type	Minimum Number	Suggested Average
1	Persons to be Trained for Damage Assessment	1	(Total estimated number of buildings with G3, G4 and G5 damage) / 30
2	Persons to be Trained for Search and Rescue	2	Total estimated number of G4 and G5 buildings.
3	Volunteers to be Trained for emergency operations	5	5% of Total Population
4	Number of Doctors*	1	(Inj 1/ 10) + (Inj 2/ 10) + (Inj 3/ 20) + (Inj 4/ 30)
5	Number of Nurses*	2	Number of Doctors X 2
6	Number of Paramedical Staff*	5	Number of Doctors X 5
7	Number of Beds*	4	(Inj 1 / 2) + (Inj 2) + (Inj 3 / 2)
8	Number of Rescue Kits	1	(Total estimated Number of G4 and G5 Buildings) / 3
9	Number of Stretchers	2	(Total estimated number of Inj 1 and Inj 2 persons) / 8
10	Number of Body Bags	2	Estimated Number of Inj 1 persons
11	Number of Blankets	5	Number of Occupants of buildings with G4 and G5 grade damage.
12	Number of Persons Requiring Clothing	-	Number of Occupants of buildings with G4 and G5 grade damage.
13	Number of Tents	2	(Total estimated number of Shelterless persons – estimated person space in educational buildings) / 10
14	Number of Sleeping Bags	5	Number of Occupants of buildings with G4 and G5 grade damage.

* The numbers indicate the emergency requirements in the existing and proposed health facilities

6.7 ASPECTS FOR EFFECTIVE IMPLEMENTATION OF PLAN

6.7.1 Phasing of Plans

The preparedness measures that have been outlined for all villages in general and 3 villages in detail, will involve expenditure of enormous funds and other resources including time. Since the aim of preparedness plan is to get ready before the next earthquake, all the preparedness measures have to be implemented immediately. All the proposed preparedness measures can not be implemented in short time and the resources required for implementing the plan may not be readily available. Hence, there is a need for phasing the plan over a reasonable period by prioritizing the preparedness measures. The most essential aspects like setting up of organizational structure and training of manpower should start immediately. The village level measures should be prioritized with preference given to villages with high SRIs and low resource potentials followed by the others.

6.7.2 Training of manpower

Training of manpower with respect to disaster preparedness should be provided under three elements which need to be considered viz. technical training, management training and education to general public (UNDRO, 1984). They are:

A. *Technical training*: Technical training should be provided so that people likely to be required to participate in emergency relief activities will be able to utilize enhanced or specialized skills to greater effect. Technical training programs must be arranged for all personnel related to damage assessment, rescue, health care, telecommunications, GIS etc. for disaster management.

B. *Management training*: Management training and education should be provided for all key officials, important persons, emergency managers and planners at different levels. Management training and education must be provided to all personnel identified for management of disasters for co-coordinating different activities within Narendranagar block. These are importantly the village heads, members of panchayat raj institutions, village development officers, block development officers, sub-district magistrate, district magistrate, tehsildar, school and college teachers etc. The roles and responsibilities of such key persons are identified and hence special training modules should be developed for them.

C. *Education for the general public*: Significant manpower required for post disaster activities can be obtained from general public. General public forms a significant percentage of manpower in the post disaster activities. The understanding, co-operation and participation of members of the public are therefore necessary if full value is to be obtained from the preparations which are made. Thus in the interaction between the disaster management authorities and the general public, the knowledge about actions to be taken during the emergency phase has to be imparted to the general public. The authorities must neither over – nor under – emphasize the seriousness of the potential or actual situation and must take care that materials they issue and whatever warnings and instructions they give are appropriate, accurate and clear.

The training thus provided in all the three categories must be refreshed periodically through various short refreshment courses, so that it is not forgotten.

6.7.3 Periodic Review and Revision of Plan

The disaster management plan is developed on the basis of vulnerability and resource potential which change on account of implementation of plan. Hence, there is a need for periodic review and revision of plans. The block level disaster management plan should be reviewed every year considering the increase in population and development of infrastructural facilities in the block, and revised if necessary. A record of disaster management activities should be maintained by the concerned officials including the village heads. Monitoring, reviewing and updating the disaster management plans and the development of new initiatives should be built on and monitored through key indicators like accessibility of settlements, number of retrofitted buildings, new infrastructural development and increased numbers of trained manpower.

6.7.4 Community participation

Disaster mitigation initiatives by government and institutions are often inadequate if enough attention is not paid to addressing community perceptions or priorities. In Narendranagar block it was found that the local communities are unaware of the formal disaster management interventions. The local officials and village heads find these interventions inappropriate, due to the lack of recognition of the community's vulnerabilities and capacities. The disaster management plan should encourage every individual family, organization, business and public service within a community affected by disaster to play some role in disaster management. As mentioned by GFDR (2005) over the last two decades there has been a growing realization that disaster management is most effective at the community level, where specific local needs, resources and capacities are met. It is at the local level that the physical, economic and social risks faced by the poor can be adequately assessed and managed. Hence, the disaster management plan suggested should ensure maximum possible community participation for all pre and post disaster activities. In Narendranagar block special projects for community participation need to be designed for vulnerability reduction. Anganbadi members and the school teachers should be used for reaching the villagers.

6.7.5 Role of Panchayat Raj Institutions (PRIs)

As mentioned by Satendra (2003) and Sharma (2002), the constitution recommends for an important role to the PRIs in respect of important subjects such as education, health, agriculture, housing, land reform, social and farm forestry, drinking water, poverty alleviation programmes, social welfare etc. which play very important and strategic role in the field of disaster management. Pande (2006d) emphasize on a participatory approach bases on consensus for local disaster management in Uttarakhand state.

Hence, the initiatives of PRIs need to be guided with consideration for earthquake vulnerability reduction. These subjects if dealt effectively at local level taking into consideration the local needs and conditions (physical and social both), may be very effective in reducing the vulnerability of the people and make the society resilient to the adverse impact of the natural hazards.

6.7.6 Role of Voluntary Sector

The voluntary sector including local NGOs, CBOs etc have the best access to the masses. These voluntary organizations having the necessary skills could effectively take the message of mitigation to the people in their respective constituency. In case of a disaster, such organizations have necessary skills and could rapidly bring in relief. A major shortcoming of these voluntary organizations observed during past earthquakes as mentioned by Desai (1999) has been the inability of NGOs to see importance of the issue of mitigation or the long term safety. Hence, the disaster management plan needs to give a greater emphasis to harness the strength of the NGOs in this work by roping them in.

6.8 GENERAL RECOMMENDATIONS

The concept of disaster preparedness is comparatively new in India than the other developed countries. Since past two decades India is increasingly alarmed by disasters, which have tended to be more destructive. The response to disasters in India was originally directed primarily to relief actions, but it is now increasingly realized that much greater emphasis has to be given to planning and prevention. This section recommends general policy recommendations for India as important steps for disaster mitigation.

6.8.1 Integration of disaster management measures into national development planning process

The measures suggested by Omachi and Huu (2003) where overview of natural disasters in the Asia and the Pacific is given, would prove to be important for disaster management activities in the country. From the experiences of many disasters experienced by the country during past two decades, it would be desirable to review the disaster management practices of India. The integration of disaster management measures into national development planning process would facilitate control over the future growth of potential disaster loss, and future mitigation of disaster damage to existing development. Although lots of initiatives are being taken in different fields of disaster management, India is yet to adopt an integrated approach for disaster management. The preferred disaster management system should integrate the following elements.

- The individual disaster management measures taken by different national level organizations, institutes and government departments.
- The roles and responsibilities of all stakeholders should be identified in the pre disaster phase and their capabilities should be strengthened for disaster mitigation activities.
- The disaster management plans and emergency plans should be developed with a decentralization approach and controlled and monitored centrally.
- The concepts of comprehensive land use planning should be based on considerations of physical vulnerability to the natural disasters, wherever possible.
- The disaster management system should be prepared having regard to social and economic costs and benefits to individuals, as well as the community at large.
- More research is required for development of affordable earthquake resistant building technology.

6.8.2 Formation of the national Disaster Medical System in India

Like America's medical readiness force (Stopford, 2005), India should also develop a Disaster Medical Response System. The system should deploy multiple components to many disaster sites to provide a variety of health and medical support services. The services should include definitive medical care, hospital staffing support, medications, mass fatality management, mass casualty decontamination, disease surveillance, patient's evacuation and animal care. The medical response team members should include nurses, physicians, paramedics, emergency medical technicians, veterinarians, funeral directors, psychologists and other professionals integral to health and medical response capabilities. The medical response teams should be trained and be available on short notice to provide emergency medical services at the disaster sites within and outside India.

6.8.3 Strengthening Institutional Framework for Disaster Mitigation

The most important need at the national level is to strengthen and develop capacity to undertake national disaster mitigation strategies. The existing seismic data acquisition networks in India should be updated and improved. Research in earthquake prediction should be given encouragement. Institutional arrangements should be established for the exchange of information among neighboring countries on all phases of disasters on a continuation basis. The disaster management process requires an ongoing commitment to the education and training of disaster managers by the various tiers of government and professional bodies. The exchange of information regarding difficulties, problems and solutions and the results of research is essential for improved disaster management. This can be fostered by the free flow of information at the local and international levels through formal agreement, workshops and conferences.

6.8.4 Incorporating Technological Advances in the Disaster Management System

The technological advances in the fields of GIS and Remote Sensing have ample application based utility in disaster situation (Tarafdar *et. al.* 2002). Exercises for identification of the type of data to be gathered, followed by its assimilation, generation and periodical updating are necessary. The fusion of these in the present system needs high attention and promotion in India. Remote sensing technologies have wide applications in identifying risks associated with earthquakes, such as those of potential landslides.

The organization and operational capabilities developed by World Meteorological Organization (WMO) to facilitate, monitor and coordinate world wide collection and exchange of information should be used as a model by India with consideration and organizational modification for disaster management.

The remote sensing, geographical information system and advanced telecommunications can be valuable tools for disaster managers. In India they are not commonly available to everyone pertaining to their fairly high costs. Research to assess the costs and benefits of using these technologies for disaster management in India should be carried out. Various organizational, institutional and political issues must be addressed. Various other issues which need to be addressed are data access, data exchange, data standards, and training and associated costs.

6.8.5 National Programme on Vulnerability Reduction

As observed in the case of Narendranagar block, enormous resources are required to deal with the emergency situations. Moreover we also lose precious lives and face the development lag caused by the disaster. Hence, vulnerability reduction activities for all kinds of disasters in all the sub regions of India should be most important course of action at present times. The projects for vulnerability reduction including formulation of earthquake mitigation plans for micro regions should be implemented urgently in India.

6.9 CONCLUSIONS

The expected earthquake losses in the tectonically active region of Narendranagar block emphasized the necessity to develop a comprehensive disaster management system that considers vulnerability reduction to minimize losses and strengthening resources for better disaster management. The disaster management plan proposed in this chapter suggests development of a new organizational structure for dealing with diverse aspects like vulnerability reduction and relief operations in a planned manner. It addresses various general preparedness measures for the block on the basis of observations made in chapter 4 and chapter 5 and definite preparedness measures with spatial references for performing selected five most critical emergency activities, with emphasis laid on strengthening community capacities. The preparedness measures and action plans suggested for different levels of organizational structure would facilitate understanding of disaster management planning by the authorities. The norms adopted and suggested for calculation of emergency relief needs could be used for any other regions with suitable modifications. The proposed preparedness plan for Narendranagar block includes detailed settlement level plans for 3 selected settlements which are at different hierarchical levels. The guidelines provided for implementation of disaster management plans should prove effective if implemented in other regions also. General recommendations made for disaster management are pertaining to tasks to be undertaken at national level in the field of earthquake disaster management.

CHAPTER 7

CONCLUSIONS AND SCOPE FOR FURTHER RESEARCH

7.1 INTRODUCTION

The preparedness measures suggested for Narendranagar block on the basis of literature survey, analysis of collected data for assessment of vulnerability and resource potential, earthquake scenario generation and estimate of likely damages should reduce the losses from future earthquake in the sub region and ensure a better and efficient emergency response, if implemented. The main conclusion of the entire research process is that settlements in Himalayas need more attention towards disaster preparedness in terms of vulnerability reduction and resource build up for emergency response after earthquakes. The significant conclusions drawn out of the research are given in this chapter. There are a few aspects of research which though significant in preparedness planning could not be covered in detail due to limitation of data and other resources. Hence, a scope for further research emerges for achieving the objective of earthquake disaster reduction in a comprehensive way.

7.2 INFERENCES DRAWN FROM LITERATURE REVIEW

1. The adverse effects of disasters are constantly increasing at global level, with developing countries being often worst affected. Asia bears a disproportionate burden of losses due to disasters with 83.77% of total disaster fatalities in years 2000- 2005. Within Asia earthquakes share almost 50% of total human and material losses.
2. India is prone to almost all kinds of natural disasters with earthquakes drawing attention due to their sudden impact and increasing frequency. Himalayan ranges are particularly vulnerable on account of the plate-tectonic forces.
3. The settlements of Himalayas having considerable populations are at increased risk due to their construction typologies, landslide hazard and poor infrastructure development. These situations also hamper the emergency response to earthquake disasters.

4. Significant research is being carried out in the field of risk assessment, vulnerability reduction, emergency management etc. many important initiatives are being taken at the national and global level by various national and international agencies.
5. Various models are proposed for disaster management by eminent researchers and leading agencies for e.g. Pressure and Release Model, Sustainable Livelihood Approach, Earthquake Disaster Risk Index, HAZUS, RADIUS etc. These models give understanding of disasters in methodical way and offer guidance for counter measures.
6. Earthquake disaster management is a complex, multidisciplinary and multidimensional task needing involvement of experts from many vocations. Sectoral and segregated efforts offer only partial solutions.
7. Out of five phases of earthquake disaster viz. pre-disaster phase, emergency phase, temporary shelter phase, reconstruction phase and rehabilitation phase, emergency phase is the most crucial requiring utmost preparedness because of the unpredictable nature of earthquakes and availability of very limited time.
8. Earthquake risk of settlements can be modeled by carrying out (i) vulnerability analysis, considering physical, social and economic aspects; (ii) loss estimation, using scenario studies, probabilistic loss analysis and potential loss studies; (iii) casualty estimation as consequent to building damage estimation.
9. Most important aspect of earthquake disaster reduction is ensuring earthquake resistant constructions within a region, because most fatalities due to earthquakes are caused by collapse of seismically unsafe buildings. Although guidelines for earthquake resistant constructions for both engineered and non-engineered constructions exist, the issues of the compliance should be addressed urgently.

10. Communication systems occupy the most important position in the emergency management. The advances in the field of information and communication technology in terms of internet, GIS, remote sensing and satellite based communication links need to be effectively utilized for dealing with earthquake emergencies.
11. Search and Rescue operations are most critical for saving lives of trapped victims and need precise planning and preparedness, so that no time gets wasted, which would result in loss of precious lives.
12. The survivors of earthquakes are required to be provided with medical assistance on urgent basis. Since, the medical systems of peace times are usually not capable of handling emergency situations of large magnitudes. An inventory of medical resources with other crucial aspects like setting up medical camp, administration etc. should be made. Very significant initiatives in this field are development of National Disaster Medical System (NDMS), International Medical Surgical Response Team – East (IMSuRT-E) and Deployable Rapid Assembly Shelter / Surgical Hospital by the United States Government.
13. Planning for relief operations is also important aspect of emergency management which requires more co-ordination between donor agencies, government agencies, NGOs, CBOs and the community. Needs assessment after earthquakes is important from the point of relief procurement and distribution.
14. In hilly areas earthquake often trigger the landslides which render the already isolated settlements more inaccessible. Various agencies carry out landslide hazard assessment and demarcate more landslide prone zones. These studies need to be combined with overall vulnerability studies for their critical importance during emergency phase.
15. The importance of community in all disaster management activities is widely accepted. However the involvement of community in planning for earthquake disaster and the

incorporation of community needs in the disaster management plans still remains a problem.

16. Voluntary organizations which are importantly NGOs and CBOs are identified to be of great importance in earthquake mitigation activities, on account of their links with government agencies, other national and international agencies and the community; flexibility in administrative procedures as compared to government organizations; and various technical and material resources. They can contribute in the critical areas of communications, coordination, manpower availability, professional / technical services and finances and materials.
17. Apart from these other specialized sectors with potential for invaluable contribution during disasters are the armed forces and media. Role of corporate sector is now being explored in the field of disaster management.
18. The review of literature reveals a research gap in terms of (i) inadequacy in guidelines for community involvement and practical disaster management; (ii) lack of standardized methodology or planning guidelines which could be used for disaster preparedness; (iii) need for a common seismic risk indicator for rural hilly settlements of India; (iv) neglect of highly vulnerable rural hilly settlements for disaster management; and (v) need for involvement of architects and planners in the field of earthquake disaster management.

7.3 METHODOLOGY FORMULATED

An analytical framework derived on the basis of literature review comprises of three types of analysis viz. (i) activity analysis – dealing with a sequential inventory of all activities of emergency phase, (ii) vulnerability analysis for physical and social factors – identifying and assessing the risks of various elements and (iii) analysis of resource potential in terms of infrastructure facilities, manpower, institutional setup and materials. Development of a hypothetical earthquake scenario and subsequent loss estimation would give a measure of expected losses in terms of buildings, infrastructure and human lives. Development of Seismic Risk Indicator and the related guidelines should be useful for comparing earthquake risk of all rural hilly settlements. The procedure formulated for developing preparedness plans and action plans, would result in vulnerability reduction and efficient emergency response respectively, when implemented.

7.4 CHARACTERISTICS OF SELECTED SUB-REGION

1. Selected Tehri-Garhwal district of Uttarakhand state has a total population of 580153 and is subdivided into five tehsils and nine development blocks for administrative purpose. Almost 94% district population is rural living in 1814 villages. The hilly terrain of district is not conducive for the formation of large settlements, hence almost 50% settlements of district have population less than 200 and almost 80% settlements have population below 500. The sex ratio of 1057 females per 1000 males shows the trend against national average of 933 females per 1000 males.
2. Tehri-Garhwal district is prone to various disasters like earthquakes, droughts, landslides, floods, excess rains and cloud bursts.
3. Narendranagar block of Tehri Garhwal district, chosen for detailed studies and proposals for its location on highest vulnerability microzone, highest population density in district, high landslide hazard and approachability, holds a total population of 103032 spread in 214 villages and 17 market towns.
4. Database for the research work, on Narendranagar block was established with - (i) secondary data; (ii) village information collected from village development officers

through circulated questionnaires; (iii) pilot survey data from the field; and (iv) detailed primary survey in sample villages – give a comprehensive picture of Narendranagar block while identifying data gaps in the secondary sources and discrepancies of secondary data with actual ground conditions.

5. Almost 67% of total area of Narendranagar block is covered by forests. Villages of Narendranagar are generally small and isolated, situated 0 to 8 kms from any kind of road. Altitude varies from 380 meters to 1800 meters and agriculture on terraced field is the main occupation. The houses within villages are either grouped together or scattered.
6. Village layout is often defined by the contours where houses are built in rows.
7. Villages host 87% of total block population, while the remaining 13 % lives in market towns. Block has 1012 females per 1000 males with total literacy level being 47.81%.
8. Almost 50% block population lives in 181 villages with population less than 500.
9. Existing construction typology is influenced by the road accessibility of the villages.
10. Residential buildings are small and simple structures with load bearing walls of stone, brick or concrete block masonry.
11. The chief walling material is stone followed by slates, bricks and earth, while chief roofing material is slate, followed by RCC, timber, thatch and mud. Composite constructions also exist where extensions in the original structures are made by using modern construction materials. RCC framed structures are mostly seen in market towns.
12. The performance of similar structures during past earthquakes in the region, particularly Uttarkashi earthquake of 1991 and Chamoli earthquake of 1999, shows that earth walls are the most vulnerable followed by stone masonry in mud mortar. Single storied stone masonry in cement mortar shows moderate vulnerability. Composite walls are often highly vulnerable due to lack of proper bonding between different constructions. Among roof

constructions slate roofs are highly vulnerable although they do not result in many casualties. RCC roofs show moderate to low vulnerability. All structures generally have stone or brick foundations.

13. The villages with better accessibility show use of modern constructions like RCC while the remote villages often show predominant use of locally available material.

7.5 OUTCOME OF VULNERABILITY AND RESOURCE POTENTIAL ANALYSIS

Assessment of vulnerability in physical and social context and amount of resource potential in terms of infrastructure, institutional setup, manpower and materials, highlights many significant aspects as discussed below:

1. Tectonic composition of Narendranagar block is characterized by Main Boundary Fault, which is manifest as several large tectonic elements viz. Tons Nayar Thrust, Garhwal Thrust and Krol Thrust. Southern part of Narendranagar block coincides with microzone of highest vulnerability. Almost 31% population of Narendranagar block from 79 villages and 7 market towns resides on this highly vulnerable zone.
2. Almost 28% population of Narendranagar block is more vulnerable because of its location in inaccessible settlements. 16% population is moderately accessible, while 56% has good accessibility and hence is less vulnerable.
3. Out of 20,861 residential buildings of Narendranagar block, 26% show high vulnerabilities, 40% show moderate vulnerability, while 34% show low vulnerability. High vulnerability houses are mostly located in the remote villages, while most of the low vulnerability houses are located in market towns and villages with very good accessibility.
4. A total of 17.59% population of Narendranagar block living in 65 villages and 2 market towns viz. Duadhar and Chaka is located on high and very high landslide hazard zones.

5. Landslide hazard zones also identify various stretches of existing roads vulnerable to landslides being triggered by earthquake.
6. A total of 11 villages and 6 market towns with total population of 10048, which is 9.75% of total block population, are prone to flash floods after earthquakes due to landslides resulting in formation of temporary dams on rivers.
7. It is proved that settlements located on higher altitudes suffer more damage and hence 14% population from 29 villages and 6 market towns is more vulnerable because of its location on high altitudes. 56.37% population from 161 villages and 7 market towns are moderately vulnerable, while 29.64% population from 24 villages and 4 market towns displays low vulnerability because of their low altitudes.
8. Forty six villages are socially vulnerable because of very low literacy level. 114 villages and 5 market towns are moderately vulnerable while 54 villages and 12 market towns are les vulnerable on account of their literacy levels.
9. Common people as well as local leaders from settlements of Narendranagar block are unaware of their earthquake vulnerability, actions to be taken in a disaster situation and government's initiatives for disaster reduction, which increase their vulnerability. The missing link of local disaster management effort also increases their vulnerability.
10. Health infrastructure in Narendranagar block is highly insufficient, particularly for handling emergency situations. Many health facilities have highly vulnerable buildings and inadequate resources. The distance of health facility for settlements vary from 0 to 21 kms.
11. Ninety nine villages of Narendranagar block do not have any educational facility and hence are vulnerable because of total lack of such important infrastructure.
12. Government fair price shops are present in 64 villages and 17 market towns, while the other villages do not have food resource which could be used during emergency period.

13. Only 76 villages have telephone connections which are at risk during earthquake. Other villages are vulnerable due to lack of telecommunication facility.
14. Institutional setup in Narendranagar block involves various government organizations while the presence of voluntary or private organizations in the region is minimal.
15. Army, police and home guards at Narendranagar form important trained manpower resource, while 59 anganbadi workers with 56 helpers can be used for various preparedness and response activities.
16. The 920 masons in Narendranagar block, if suitably trained, can play an important role in retrofitting of buildings and search and rescue operations during emergency.
17. Availability of material resources in Narendranagar block in terms of tents, rescue equipment, relief material, ambulances etc. are insufficient to deal with disasters.

7.6 SALIENT FINDINGS OF HYPOTHETICAL SCENARIO GENERATION AND LOSS ESTIMATION

A hypothetical earthquake scenario created within the Narendranagar block and the subsequent loss estimation demonstrates the enormity of risk the selected sub region is exposed to. Various significant findings are as given below:

1. A hypothetical epicenter located near Tapowan at $30^0$08'10" N and $78^0$20'30"E of magnitude 7.5, suggest that the maximum PGA experienced by the block would be 0.41g, which is higher than what is expected as per the seismic zoning map of India (0.25g).
2. The iso-acceleration contours of PGA 0.41g, 0.365 and 0.325, plotted for hypocentral distances of 20 kms, 25 kms and 30 kms, and elongated parallel to the trend of Main Boundary Fault, cover the entire Narendranagar block.

3. The computed PGAs translated into MSK intensities considering the effect of topography, suggest that all settlements of Narendranagar block would face intensity VIII to IX. Three intermediate intensities viz. VIII+, VIII++ and VIII+++, ensure the consideration for all computed PGAs.
4. The building damage computed on the basis of MSK scale reveals that almost 28% residential buildings from villages and 18% residential buildings from market towns, would suffer high damages and collapse. Almost 26% of total block population would be rendered homeless as a result of this.
5. Casualty assessment results in an expected number of 990 persons, which is 0.96% of total block population, to be dead or unsavable, 1484 (1.44%) persons with life threatening injuries needing immediate medical attention, 1484 (1.44%) persons with injury requiring hospital treatment and 990 (0.96%) persons with light injuries.
6. The assessment of landslides expected to be triggered by earthquake suggest that 85 settlements with a total population of 27462 (26.65% of total block population) would be rendered completely inaccessible.
7. SRI developed for the scenario identifies 12 very high risk villages viz. Maun, Kodarna, Kudi, Bhairgad, Khatiyad, Kakhoor, Khakar, Malas, Odada, Talai, Matiyala and Lamoli.
8. The computed casualties determined the enormous shortcomings of the existing health facilities in terms of doctors, number of beds and other staff.
9. The very less number of temporary shelters available from the school buildings as compared to the shelterless victims of earthquake emphasize the preparedness needs.
10. The identified shortcomings of the existing distribution system of Narendranagar block which is determined by the administrative hierarchy underline the need of a new organizational structure considering the diversity and complexity of disaster management aspects.

7.7 PROPOSITIONS OUT OF RESEARCH

As per the stated objectives, the undertaken research evolves a preparedness plan for Narendranagar block including proposal of several developmental measures to be carried out for vulnerability reduction and emergency response in the sub regional block. The useful inferences of the exercise of preparedness plan are given below:

1. The new organizational structure proposed for Narendranagar block for disaster management considers critical aspects like accessibility, presence and adequacy of infrastructural facilities, availability of other resources and distance of dependent villages. This proposed structure with the hierarchy of an apex authority at the district headquarter, disaster management centre at block headquarter, 8 monitoring centers and 34 relief centers for 214 villages and 17 market towns, should function efficiently for disasters.
2. Since a most important aspect of earthquake disaster preparedness is vulnerability reduction of existing settlements and structures, a retrofitting plan and vulnerability reduction plan is proposed with highest priority to buildings of critical importance and which host assembly of large number of persons, followed by lifelines and residential buildings. Since, the challenge for ensuring earthquake resistant constructions in rural areas is lack of a regulatory authority, some general measures suggested for improving the housing stock should be helpful. The recent innovations made in the traditional bamboo construction technology are found to be the most appropriate for this purpose.
3. Guidelines provided for establishment of control rooms, immediately after an earthquake, in block headquarter, monitoring centers, relief centers, all villages and market towns and their related preparedness measures, should ensure efficient and effective management of emergency phase pertaining to preliminary damage assessment and relief.

4. The vulnerability of Himalayan settlements to a great extent is due to their inaccessibility and infrastructural inadequacy. Measures suggested for improving this aspect should reduce the vulnerability. Locations identified to be left vacant for landing of helicopters during emergency situation ensures emergency assistance to all settlements.
5. Planning for critical activities viz. damage assessment, search and rescue, relief distribution, medical assistance and temporary sheltering, is proposed at all hierarchical levels of the organizational structure. The preparedness measures and action plan suggested in detail would ensure vulnerability reduction, capacity building and efficient emergency response if implemented. The resource requirement computed for each settlement facilitates easy reference for implementing the measures.
6. The settlement level planning demonstrated through three selected settlements of Narendranagar block at different hierarchical levels and different SRI, provide a sample for undertaking similar measures for other settlements also.
7. The guidelines provided in terms of training of manpower, revision of plans, community participation, role of 'Panchayat Raj Institutions' and voluntary organizations should ensure effective implementation of developed plans.
8. Broad recommendations made for integrating disaster management measures into national development planning process, formation of National Disaster Medical System in India, strengthening institutional framework and incorporating technological advances are all aimed at reducing the vulnerability of country to natural disasters in general.

7.8 SCOPE FOR FURTHER RESEARCH

1. The study needs to be extended to other earthquake prone regions also by using sophisticated models and software to minimize the errors.
2. It was realized that a lot of time taken for settlement level earthquake research is spent in procuring field data in difficult Himalayan terrain. Hence, funded projects should be undertaken for documentation of earthquake prone Himalayan settlements with respect to location, accessibility, available resources and facilities, conditions of buildings etc. and the data should be made easily available for research purpose.
3. There is a need for integrated studies for seismically active region combining the studies carried out by experts of various vocations like geologists, structural engineers, architects, planners, policy makers, administrators, which is missing at present. The inputs should also be taken from community through local leaders.
4. The research work should be extended with financial analysis for estimated damage, replacement costs and preparedness measures. The economical feasibility studies hence produced would give important criteria for decision making.
5. The objective of earthquake disaster management could be approached through diverse fields like management science and transportation engineering. The applications of various theories and practices of these fields, in disaster management need to be explored.
6. The technological advances in remote sensing / satellite images should be used more extensively for research, owing to its increasing applications in the field of disaster management.
7. Research should be carried out for incorporating disaster management aspects in setting up of e-governance, which is already under consideration.

7.9 CONCLUSIONS

The research work presented in this thesis aims at earthquake disaster reduction and emergency management in Narendranagar block situated within highly vulnerable Himalayan ranges. The suggested plan strategy is to make the predominantly rural community self sufficient. The measures suggested should reduce the vulnerability of the selected region and ensure a speedy emergency response if implemented. The results of the underlying studies could be used in the preparedness planning for other Himalayan regions also and the evolved planning methodology and analytical techniques have much wider applications in the realm of preparedness planning of earthquake disaster management.

GLOSSARY OF TERMS

Glossary of Local Terms

1. Anganbadi: is an organization, which is run by local village women. It functions under Child Development Project Officer at the block level and District Programme Officer at district level and the records are maintained by the block development office. Anganbadi centers are present in many villages with minimum one member and one helper. There is one supervisor appointed for every 25 centers. All workers attend a meeting in block headquarter once in a month (usually third Friday of month). Work areas of Aanganbadi members are mainly to provide supplementary nutrition to kids; pre-school education (children of age 3-6 years); immunization (all vaccinations); health check up; nutrition and health education to children below 6 years, adolescent girls and females between ages 11 to 45; basic medication and referral services (CDPO, 2005).
2. Gram Panchayat: is unit of local self government consisting of a group of villages clustered together for the administrative and judiciary purposes.
3. Katchha: refers to temporary, sub standard and feeble constructions.
4. Kshetra Panchayat: is unit of higher level local self government consisting of a cluster of gram panchayats and forms an administrative sub division.
5. Mahila Mangal Dal: refers to women welfare centers in the villages. The members are local womenfolk of villages who are active for empowerment through social developmental activities like literacy, health, nutrition, sanitation and household industry.
6. Nav Yuvak Mangal Dal: refer to youth welfare centers in the villages aiming at empowerment of youth through training and facilitation for self employment.
7. Pucca: refers to well built, good quality durable constructions.
8. Tehsil: is the administrative sub division of district. For e.g. tehri-Garhwal district has 5 tehsils.
9. Tehsildars: the officer in-charge of tehsil is called as tehsildar
10. Patwaris: are persons at village level who look after land records and revenue collection from villages
11. Nagar Palika: refers to municipalities of towns.

Glossary of Technical Terms

1. Acceleration: The change from one speed, or velocity, to another is called acceleration. During an earthquake when the ground is shaking, it experiences acceleration. The peak acceleration is the largest acceleration recorded by a particular station during an earthquake. (USGS, 2007 a)
2. Aftershocks: Aftershocks are earthquakes that follow the largest shock of an earthquake sequence. They are smaller than the mainshock and within 1-2 fault lengths distance from the mainshock

fault. Aftershocks can continue over a period of weeks, months, or years. In general, the larger the mainshock, the larger and more numerous the aftershocks, and the longer they will continue. (USGS, 2007 a)

3. Capacity: A combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster. Capacity may include physical, institutional, social or economic means as well as skilled personal or collective attributes such as leadership and management. (United Nations, 2004)
4. Coping capacity: The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. This involves managing resources, both in normal times as well as during crises or adverse conditions. (United Nations, 2004)
5. Disaster: A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk. (United Nations, 2004)
6. Disaster risk management: The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid or to limit adverse effects of hazards.
7. Disaster risk reduction: The conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid or to limit the adverse impacts of hazards, within the broad context of sustainable development. (United Nations, 2004)
8. Earthquake: Earthquake is a term used to describe both sudden slip on a fault, and the resulting ground shaking and radiated seismic energy caused by the slip, or by volcanic or magmatic activity, or other sudden stress changes in the earth. (USGS, 2007 a)
9. Earthquake hazard: Earthquake hazard is anything associated with an earthquake that may affect the normal activities of people. This includes surface faulting, ground shaking, landslides, liquefaction, tectonic deformation, tsunamis, and seiches. (USGS, 2007 a)
10. Earthquake risk: Earthquake risk is the probable building damage, and number of people that are expected to be hurt or killed if a likely earthquake on a particular fault occurs. Earthquake risk and earthquake hazard are occasionally incorrectly used interchangeably. (USGS, 2007 a)
11. Epicenter: The epicenter is the point on the earth's surface vertically above the hypocenter (or focus), point in the crust where a seismic rupture begins. (USGS, 2007 a)

12. Fault: A fault is a fracture along which the blocks of crust on either side have moved relative to one another parallel to the fracture. (USGS, 2007 a)
13. Foreshocks: Foreshocks are relatively smaller earthquakes that precede the largest earthquake in a series, which is termed the mainshock. Not all mainshocks have foreshocks. (USGS, 2007 a)
14. Frequency: The frequency is the number of times something happens in a certain period of time, such as the ground shaking up and down or back and forth during an earthquake. (USGS, 2007 a)
15. g: g is the acceleration of gravity 9.8 (m/s^2). When there is an earthquake, the forces caused by the shaking can be measured as a percentage of gravity, or percent g. (USGS, 2007 a)
16. Hazard: A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technologicalhazards). (United Nations, 2004)
17. Hypocenter: The hypocenter (focus) is the point within the earth where an earthquake rupture starts. The epicenter is the point directly above it at the surface of the Earth. (USGS, 2007 a)
18. Intensity: The intensity is a number (written as a Roman numeral) describing the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures. (USGS, 2007 a)
19. Isoseismal: An isoseismal (line) is a contour or line on a map bounding points of equal intensity for a particular earthquake. (USGS, 2007 a)
20. Landslide: A landslide is a movement of surface material down a slope. (USGS, 2007 a)
21. Lifelines: Lifelines are structures that are important or critical for a community to function, such as roadways, pipelines, powerlines, sewers, communications, and port facilities. (USGS, 2007 a)
22. Magnitude: The magnitude is a number that characterizes the relative size of an earthquake. Magnitude is based on measurement of the maximum motion recorded by a seismograph. (USGS, 2007 a)
23. Microzonation: Microzonation is the identification of separate individual areas having different potentials for hazardous earthquake effects. (USGS, 2007 a)
24. Mitigation: Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards. (United Nations, 2004)
25. Plate Tectonics: Plate Tectonics is the theory supported by a wide range of evidence that considers the earth's crust and upper mantle to be composed of several large, thin, relatively rigid plates that move relative to one another. Slip on faults that define the plate boundaries commonly results in earthquakes.(USGS, 2007 a)

26. Preparedness: Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations. (United Nations, 2004)
27. Prevention: Activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological and biological disasters. (United Nations, 2004)
28. Resilience / resilient: The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures. (United Nations, 2004)
29. Richter scale: The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. On the Richter Scale, earthquake magnitude is expressed in whole numbers and decimal fractions. (USGS, 2007 a)
30. Risk: The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Conventionally risk is expressed by the notation: Risk = Hazards x Vulnerability. (United Nations, 2004)
31. Risk assessment/analysis: A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. (United Nations, 2004)
32. Seismicity: Seismicity refers to the geographic and historical distribution of earthquakes(USGS, 2007 a)
33. Seismology: Seismology is the study of earthquakes and the structure of the earth, by both naturally and artificially generated seismic waves. (USGS, 2007 a)
34. Strong motion: Strong motion is ground motion of sufficient amplitude and duration to be potentially damaging to a building or other structure. (USGS, 2007 a)
35. Tectonic: Tectonic refers to rock-deforming processes and resulting structures that occur over large sections of the lithosphere. (USGS, 2007 a)
36. Tectonic plates: The tectonic plates are the large, thin, relatively rigid plates that move relative to one another on the outer surface of the Earth. (USGS, 2007 a)
37. Vulnerability: The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. (United Nations, 2004)

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ANNEXURE I

INTERNATIONAL AGENCIES / ORGANIZATIONS WITH ACTIVE ROLES IN DISASTER REDUCTION

International Federation of Red Cross and Red Crescent Societies

The International Federation of Red Cross and Red Crescent Societies is humanitarian organization with a mission *to improve the lives of vulnerable people by mobilizing the power of humanity*. Founded in 1919, the International Federation comprises 185 members Red Cross and Red Crescent societies, a Secretariat in Geneva and more than 60 delegations strategically located to support activities around the world (IFRC, 2007).

FEMA

The Federal Emergency Management Agency (FEMA) is the independent Federal agency responsible for leading America's efforts to prepare for, prevent, respond to, and recover from disasters. The primary mission of the Federal Emergency Management Agency is *to reduce the loss of life and property and protect the Nation from all hazards, including natural disasters, acts of terrorism, and other man-made disasters, by leading and supporting the Nation in a risk-based, comprehensive emergency management system of preparedness, protection, response, recovery, and mitigation.* (FEMA, 2007)

American Red Cross

The Red Cross provides expert instructions and develops tools and services to help Americans prepare for any emergency. As part of coalition of 185 Red Cross and Red Crescent Societies around the world, the American Red Cross provides assistance in response to appeals from other national societies. The American Red Cross also leads projects globally in areas where its expertise meets a specific need and objective. (American Red Cross, 2006).

Relief Web

ReliefWeb is an on-line gateway to information (documents and maps) on humanitarian emergencies and disasters, designed specifically to assist the international humanitarian community in effective delivery of emergency assistance, it provides timely, reliable and relevant information as events unfold, while emphasizing the coverage of "forgotten emergencies" at the same time. ReliefWeb maintains three offices in three different time zones (New York, Geneva, and Kobe) to update the web site around the clock. (Reliefweb, 2007)

USAID

As part of USAID's Bureau for Democracy, Conflict, and Humanitarian Assistance (DCHA), OFDA (Office of U.S. Foreign Disaster Assistance) provides humanitarian assistance to save lives, alleviate human suffering, and reduce the social and economic impact of humanitarian emergencies worldwide. OFDA responds to all types of natural disasters, including earthquakes, volcanic eruptions, cyclones, floods, droughts, fires, pest infestations, and disease outbreaks and also civil conflict, acts of terrorism, or industrial accidents. OFDA funds mitigation activities to reduce the impact of recurrent natural hazards and provides training to build local capacity for disaster management and response (USAID, 2007).

Asian Disaster Reduction Center (ADRC)

The ADRC was established in Kobe, Japan, to facilitate exchange of disaster reduction experts from each country and concerned bodies, accumulate and provide disaster reduction information, and carry out research into multinational disaster reduction co-operation as the focus of this initiative.

Asian Disaster Preparedness Center (ADPC)

Established in January 1986, ADPC is recognized as an important focal point in Asia and the Pacific for promoting disaster awareness and developing local capabilities to foster institutionalized disaster management, and technical mitigation policies.

The Asia Pacific Disaster Management Centre, Manila, Philippines, is a non-governmental agency actively involved in disaster management programmes in Southeast Asia.

The UN System

The United Nations co-ordinates international co-operation in the field of disaster management and mitigation, through the organizations under its aegis.

UNDRO (Office of the United Nations Disaster Relief Coordinator): UNDRO is the focal point for disaster management in the UN system. Established in 1971 to mobilize and co-ordinate international emergency relief to areas struck by disaster, it is also charged with promoting disaster preparedness in nations and regions at risk. The major focus of its activities in mitigation is to promote the study of risks and their reduction as well as information dissemination to promote disaster management and planning.

UNDP (United Nations Development Programme): UNDP promotes the incorporation of disaster mitigation in development planning, and funds technical assistance for all aspects of disaster management. Assistance is also provided in the planning and implementation of post-disaster rehabilitation and reconstruction and incorporation of risk reduction techniques in the affected areas.

FAO (Food and Agriculture Organization): FAO provides technical advice in reducing vulnerability and helps in the rehabilitation of agriculture, livestock, fisheries and local food production.

WFP (World Food Programme): WFP provides targeted food aid for humanitarian relief and supports rehabilitation, reconstruction and risk reducing development programmes.

WHO (World Health Organization): WHO provides advice and assistance in all respects of preventive and curative health care including the preparedness of health services for rapid disaster response.

UNHCR (United Nations High Commission for Refugees): UNHCR provides protection to refugees and seeks durable solutions to their problems along with necessary assistance in the country of asylum.

UNESCO (United Nations Educational, Scientific and Cultural Organization): UNESCO is involved in the assessment and mitigation of risks from natural hazards and contributes to the study of hazards of geological and hydro-meteorological origins. UNESCO undertakes a natural hazard sub-programme in the science sector of its activities within most of its work on disaster mitigation is carried out.

UNCHS (Habitat) United Nations Center for Human Settlements: This organization has the responsibility of promoting human settlements development through execution of technical cooperation projects with focus on disaster mitigation in human settlement design and construction. It is also in the forefront of promoting the incorporation of natural disaster mitigation concepts in urban planning and management.

UNICEF (United Nations International Children's Emergency Fund): UNICEF assists in child health and nutrition especially in disaster – prone and disaster affected countries.

ANNEXURE II
DISASTER MANAGEMENT SETUP IN INDIA

The information provided in this section is compiled from Pasrija (2002), UNDP (2005) and NCDM (2001 b)

1. Basic Responsibility
In the federal set up of India, the basic responsibility for undertaking rescue, relief and rehabilitation measures in the event of natural disasters is that of the State Government concerned. The role of the Central Government is supportive, in terms of physical and financial resources and complementary measures in sectors such as transport, warning and inter-state movement of food grains.

2. Disaster Management: Role at Central Level
Nodal Ministry: Ministry of Home Affairs
Other line Ministries:/Departments/Organizations: India Meteorological Department, Central Water Commission, Ministry of Home Affairs, Ministry of Defense, Ministry of Finance, Ministry of Rural Development, Ministry of Urban Development, Department of Communications, Ministry of Health, Ministry of Water Resources, Ministry of Petroleum, Department of Agriculture & Cooperation. Ministry of Power, Department of Civil Supplies, Ministry of Railways, Ministry of Information and Broadcasting, Planning Commission, Cabinet Secretariat, Department of Surface Transport, Ministry of Social Justice, Department of Women and Child Development, Ministry of Environment and Forest, Department of Food. Each Ministry/Department/Organization has their sectoral. Action Plan as Emergency Support System. The institutional mechanism at the National Level is as under:
Cabinet Committee/Task Force: The Union Cabinet may set up a Cabinet Committee/Task Force / Group of Ministers for effective coordination and implementation of relief measures in the wake of a natural disaster. Such Committees/Task Force/Group of Ministers had been set up in the wake of Super Cyclone of Orissa in 1999, Earthquake of Gujarat 2001, severe floods in 2000 and drought in 2002.
National Crises Management Committee (NCMC): Cabinet Secretary, which is the highest executive officer, heads the NCMC. Secretaries of all the concerned Ministries /Departments as well as organizations are the members of the Committee. The NCMC gives direction to the Crisis Management Group as deemed necessary.
Crisis Management Group (CMG): The Central Relief Commissioner in the Ministry of Home Affairs is the Chairman of the CMG, consisting of senior officers (called as nodal officers) from various concerned Ministries. The CMG's functions are to review
Every year contingency plans formulated by various Ministries / Departments / Organizations in their respective sectors, measures required for dealing with a natural disaster, coordinate the activities of the Central Ministries and the State Governments in relation to disaster preparedness and relief and to obtain information from the nodal officers on measures relating to above.
Control Room (Emergency Operation Room): An Emergency Operations Center (Control Room) exists in the nodal Ministry of Home Affairs, which functions round the clock, to assist the Central Relief Commissioner in the discharge of his duties. During crisis period, providing additional manpower and equipment, as per the need, strengthens it. The Central Relief Commissioner receives information relating to forecast / warning of the natural calamity from the director general, India Meteorological Department (IMD) or from the Central Water Commission on a continuing basis. He may whenever required, also disseminate the information to different Central Government Ministries / Departments and the State Governments for appropriate follow – up action.

The response of Central Government to a natural disaster depends on:

- The gravity of the calamity;
- The scale of the relief operation necessary, and
- The requirement of central assistance for augmenting the financial resources at the disposal of the state government.

The operational aspects of Central Governments are as:

I. Forecasting and operation of warning systems.
II. Maintenance of uninterrupted communications.
III. Wide publicity to warnings of impending calamity, disaster preparedness and relief measures through TV, AIR and news papers.
IV. Transport with particular reference to evacuation and movement of essential commodities and petroleum products.
V. Ensuring availability of essential commodities at reasonable prices particularly the commodities through the Public Distribution System.
VI. Ensuring availability of medicines, vaccines and drugs.
VII. Preservation and restoration of physical communication links.
VIII. Investments in infrastructure.
IX. Mobilization of financial resources.
X. Flood / inflow forecasts from the Central Water Commission.
XI. Relief, rehabilitation and restoration through military aid to civil authorities.
XII. Contingency plans for crops, cattle preservation, nutrition and health measures.
XIII. Technical and technological inputs for provision of drinking water.
XIV. Technical assistance in the water budgeting and water management for various uses.
XV. Coordination for the activities of the state agencies and voluntary organizations.

3. Disaster Management: Role at State Level

At the State level, a State Crisis Management Committee has been set under the Chairmanship of the Chief Secretary, who is the highest executive functionary in the State. The Committee is required to take into consideration the instructions and guidance received, from time to time, from the Government of India and formulates action plans dealing with the different natural disasters. An officer of the level of Secretary in the State Government is designated as Relief Commissioner, which is the nodal officer in the State and is the coordinator of all activities/programs for disaster management.

4. Disaster Management: Role at District Level

District level is the key level for disaster management related activities. District Collector, the highest administrator in the district, is the focal point for preparation of the district level plans and for directing, supervising and monitoring relief measures for the natural disasters. A District Level Co-ordination and Relief Committee is constituted and is headed by the Collector as Chairman with participation of all other related government and non governmental agencies and departments in addition to the elected representatives

Contingency Action Plan (CAP)

A National Contingency Action Plan (CAP) for dealing with contingencies arising in the wake of natural disasters has been formulated by the Government of India and it had been periodically updated. It facilitates the launching of relief operations without delay. The CAP identifies the initiatives required to be taken by various Central Ministries/Departments in the wake of natural calamities, sets down the procedure and determines the focal points in the administrative machinery

State Relief Manuals

Each State Government has relief manuals/codes which identifies that role of each officer in the State for managing the natural disasters. These are reviewed and updated periodically based on the experience of managing the disasters and the need of the State.

5. Financial Arrangements

The Scheme and arrangements for financing the relief expenditure in the wake of natural calamities are governed by the recommendations of Finance Commissions appointed by Government of India after every five years.

The present scheme, in operation for the period 2000-2005, is based on the recommendations of Eleventh Finance Commission. As per the Scheme, each State has been allocated a certain annual corpus called Calamity Relief Fund (CRF), administered by a State Level Committee, headed by the Chief Secretary of the State Government.

The corpus is built by annual contributions of the Union Government and the State Governments concerned in the ratio of 3:1. The share of the Union Government is released in two equal installments irrespective of the fact that there is any calamity or not.

At present, the aggregate accretion in the States' CRF for a period of five years from 2000-2005 amounts to Rs 110,075.90 million against an amount of Rs 63042.0 million for the period 1995-2000.

The Scheme also provides for extending additional assistance to the States, over and above the provisions of CRF, in the event of a natural calamity of severe nature, after following the established procedure. This provision exists in the form of National Calamity Contingency Fund (NCCF) with an initial corpus of Rs. 5000.00 million (for 2000-2005) with the Union Government to supplement the financial resources needed for relief operations. This fund is required to be recouped by levy of a special surcharge on the Central taxes for a limited period.

6. Legislative Support to the Disaster Management

There is no mention of disaster management as a subject/item in any of the three lists (Central, State and concurrent) under the Schedule 7 of the Constitution of India. Keeping in view the importance of field of disaster management, the issue of inclusion of this subject appropriately is under active consideration of the Government of India. The National Committee on Disaster Management, set up in February 2001 under the Chairmanship of Prime Minister, is considering the matter.

7. Un Assisted Projects

(i) UNDP Project on Strengthening the disaster management capacity (1997-2001)

-imparted specialized training/increased skills and capabilities of the officers working in this area from Government of India, State Governments, National Institute of Disaster Management, State Faculties on NDM through training programs/study tours, provided basic equipment, making available manual and guidelines for training centers and contributed in creating awareness about the importance of and the need of preparedness and mitigation measures.

(ii) UNDP Project on Natural Disaster Risk Management Programs (2002-2007)

-being implemented in 125 the most multi-hazard prone districts of 12 States- with focus on district and community level activities.

8. Disaster Related Standardization–

Preparation of Codes and guidelines through Bureau of Indian Standards, Building Material & Technology Promotion Council and Structural Engineering Research Center for the use of concerned organizations and individuals for constructing disaster resistant building/houses.

9. Plan Scheme for Disaster Management

To improve disaster management strategy and to enhance our capability to mitigate the impact of disasters in the country in the long-run, A Central Sector Scheme on Natural Disaster Management Programs (NDMP) is being implemented from December 1993. The main objective of the program is to enhance the national capability for disaster reduction, preparedness and mitigation. The program is also expected to enhance the level of awareness of the community about disasters they are likely to face and prepare them adequately to face the crisis situation. The components of the program include human resource development, research and consultancy services, documentation of major events, operation of Centers for Disaster Management at the National and State Levels, public education and community participation, international cooperation.

10. Strengthening Forecasting and Warning Systems

India Meteorological Department, Central Water Commission are continuously making efforts for strengthening forecasting and warning of various disasters, keeping in view the experiences of previous disasters and technological development taking place in and outside the country.

11. Campaign for Public Education and Community Involvement

Government is taking all steps to undertake more extensively activities relating to educating the people, particularly students, and motivating them to involve in various programs of the Government- assistance of non-governmental organizations and other private organizations are being taken.

12. Networking of Various Institutions

There are large number of organizations working in one or the other areas of disaster management including preparedness and mitigation. Efforts are being made to network them, so that the benefit of their work can be taken and also to avoid duplication of activities.

13. Involvement of Non –Governmental Organizations

NGOs are required to play a vital role in the management disasters to supplement the efforts of the Government, keeping in view of vastness of the country. Efforts have been initiated to involve them more effectively.

14. International Cooperation

1. Policy for acceptance of External assistance

The present policy of the Government of India to attract relief is, not to issue any formal appeal on behalf of the Government, either directly or through any other agency. However, relief donated on a voluntary basis will be accepted and acknowledged as a sign of international solidarity. In case of assistance coming in cash, it should be sent to the Prime Minister's National Relief Fund and if it is in kind, it should preferably routed through the Indian National Red Cross.

2. Cooperation with various Countries and International Institutes

Country is making all efforts to have cooperation with the various countries and international institutions in the filed of disaster preparedness and mitigation, keeping in view the policy for acceptance of external assistance.

- Bilateral agreements with some countries like Switzerland, Russia, for emergency response are under consideration.
- Membership of the Asian Disaster Reduction Centre, Kobe, Japan
- Representation in the Board of Trustees and Consultative Committee of the Asian Disaster Preparedness Centre (ADPC), Bangkok .
- Member of United Nations Disaster Assessment and Coordination (UNDAC) system of United Nations Office of the Humanitarian Affairs (UNOCHA).
- A proposal to set up regional office of UNOCHA in New Delhi is under consideration of the Government of India.

ANNEXURE III

INFORMATION COLLECTION FOR POST-DISASTER ASSESSMENT

(UNDRO, 1984)

Priority Areas for Information Collection	Nature of the Assessment Techniques	Major Dimensions	Assessment of Needs
Extent of impact on geographical area	- Existing thematic maps - Aerial photography - Ground-level photography • Windshield surveys • Team observation - Ground level reconnaissance - Surveys - Interpersonal Communication • Key informants • Telephone • Radio	- Political divisions - Land use associations - Topographical characteristics - Population information (density, characteristics) - Main economic activities - Urban / rural - Geological Characteristics - Hydrological information - Transportation - Climatic conditions	
Demographic data	- Existent baseline information - Census data - Thematic maps - Aerial photography - Ground-level reconnaissance • Surveys Population and demographics • Team observation - Interpersonal communication • Radio • Telephone • Key informants	- Population size - Density - Distribution - Economic characteristics - Cultural characteristics - Ethnic characteristics	
Casualties deaths and injuries	- Census data, country profiles - Ground – level reconnaissance • Surveys • Interpersonal communication • Key informants • Radio • Telephone	- Causes of death - Types of injuries - Causes of injuries - Distribution of sex/ age of injured - Location of population	- Accessibility - Rescue needs - Types of treatments required - Severity of trauma - Communicable diseases
Health	- Health Ministry - Census data - Country profiles - Maps of medical resources - Aerial photography - Surveys • Team observation • Key informants • Radio • Telephone - Epidemiological surveillance system	- Hospitals - Health centers (regional dispensaries) - Medical doctors, nurses - Para medicals - Medical supplies - Power plants - Types of equipment - Types of supplies - Threats of epidemics - Water supply	- Number of medical facilities required - Types of facilities, resources, kinds of medical specializations, surgery, epidemiology, traumatology, etc. - Emergency transport - Medical supplies

Priority Areas for Information Collection	Nature of the Assessment Techniques	Major Dimensions	Assessment of Needs
Housing	- Census data - Country profiles - Aerial photography - Ground-level reconnaissance - Surveys • Thematic maps • Team observation • Windshield surveys • Interpersonal communication	- Types of buildings - High rise, low-rise, single family, multi family - Materials: construction, foundations - Construction techniques - Density of buildings - Size of houses - Location - Division according to social strata - Land ownership - Extent of damage: totally destroyed/seriously damaged, minor damage - Recuperable materials - Relationships, casualties/ architectural elements	- Alternative shelter (public buildings, hotels, schools, etc.) - Available/ extended family - Location of refugees(individually and by authorities) - Relationship between shelter needs / climate - Priority areas for reconstruction (e.g. housing vis-à-vis productive activities) - Number of housing units needed - Cooking facilities - Areas of limited suitability for residential development
Transportation system	- Census data - Thematic maps - Aerial photography - Ground level photography • Surveys • Team observation • Key informants	- Roads, major arterial - Bridges and overpasses - Railroads - Mass transit - Harbour - Ground displacement - Landslides - Cracking - Traffic bottlenecks	- Essential transport systems - Access to all affected areas - Access to the country - Vehicle resources (buses, trucks) - Fuel supplies - Specialized vehicles (refrigerated vans, ambulances)
Communications Systems	- Census data - Ground – level reconnaissance - Surveys - Interpersonal communications	- Telephone - Telegraph - Radio - Television - Newspapers - Magazines	- Re-establishment of internal communication - Communication with remote and isolated areas - International communication
Liquid and Gas Conveyance	- Census data - Thematic maps - Ground-level reconnaissance - Surveys - Aerial photography - Laboratory analysis of water contamination	- Potable water and waste water treatment facilities - Pipelines and conducts - Gas - Electricity - Dams and reservoirs - Potential future risks (fire) - Power plants	- Water demand - Possibilities of contamination of water - Sources of uncontaminated water - Alternate routes to convey water - Sources of power - Major repair equipment - Laboratory facilities - Potential sewerage system

Priority Areas for Information Collection	Nature of the Assessment Techniques	Major Dimensions	Assessment of Needs
Nutrition and Food System	- Census data - Thematic maps - Ground – level reconnaissance • Surveys • Interpersonal communication • Team observation	- Food availability/ supplies/ reserves - Nutrition and food patterns - Organization of market - Grocery warehouses - Grocery wholesalers - Types of agricultural production - Climatic conditions / agricultural products - Power plants	- Food available - Agricultural production cycles - Food distribution system - Food patterns - Shortage facilities (existent and predicted) - Special food needs (children basis)
Public buildings and other types of buildings	- Census data - Thematic maps - Aerial photography - Ground-level photography - Low-level reconnaissance • Surveys • Observation • Key informant	- Schools, universities - Government buildings - Theaters - Banks - Museums - Stadiums - Office buildings - Hotels - Extent of damages: total, serious, minor	- Reconstruction needs - Priorities
Industry	- Census data - Thematic maps - Aerial photography - Ground-level photography - Low level reconnaissance • Surveys • Observation • Key informant	- Type of industry (heavy industry; light industry) - Size/ scale of facilities - Production - Extent of damage in terms of production - Percentage of country's industrial production	- Reconstruction rehabilitation needs - Priorities
Commerce	- Census data - Thematic maps - Aerial photography - Ground-level photography - Ground – level reconnaissance • Team observation • Key informants • Windshield survey	- Wholesale / retail - Location / extent of damage (total, serious, minor)	- Rehabilitation, reconstruction needs - Priorities

ANNEXURE IV

POPULATIONS IN SETTLEMENTS OF NARENDRANAGAR BLOCK

S.No	Kshetra Panchayat	Gram Panchayat	Village	Total Pop	Household Number	Male Pop	Female Pop	SC Pop	ST Pop
1	Khanana	Khanana	Khanana	720	167	301	419	55	0
2	Khanana	Niger	Niger	346	83	143	203	14	0
3	Khanana	Niger	Maroda	108	19	47	61	0	0
4	Khanana	Niger	Sera	61	9	39	22	0	0
5	Khanana	Niger	Dhouldhar	53	11	21	32	0	0
6	Khanana	Bhadni	Bhadni	411	86	180	231	44	0
7	Pali	Pali	Pali	441	101	188	253	56	0
8	Pali	Pali	Shrikot	304	75	127	177	13	0
9	Pali	Gadil	Gadil	174	37	81	93	56	0
10	Pali	Gadil	Thapliyalgaon	141	26	70	71	20	0
11	Pali	Gadil	Baksari	135	26	59	76	26	0
12	Pali	Gadil	Mayangaon	124	24	58	66	0	0
13	Pali	Gadil	Gudangaon	37	6	20	17	0	0
14	Ranakot	Ranakot	Ranakot	953	183	429	524	102	0
15	Ranakot	Nauga	Nauga	307	67	128	179	8	0
16	Kharsad	Kharsad	Kharsad	505	125	203	302	99	0
17	Kharsad	Kharsad	Sakanyani	165	36	69	96	111	0
18	Kharsad	Digwali	Digwali	152	27	69	83	46	0
19	Kharsad	Digwali	Jamri	120	23	49	71	0	0
20	Kharsad	Koti	Koti	280	55	124	156	0	0
21	Kharsad	Bhatgaon	Bhatgaon	313	55	133	180	37	0
22	Kharsad	Bhatgaon	Jimangaon	72	16	34	38	0	0
23	Kharsad	Bhatgaon	Saund	178	41	77	101	0	0
24	Ukhel	Ukhel	Ukhel	244	57	101	143	18	0
25	Ukhel	Ukhel	Soni Ukhel	164	34	65	99	45	0
26	Ukhel	Ukhel	Paweth	112	23	43	69	18	0
27	Ukhel	Laser	Laser	199	36	89	110	0	0
28	Ukhel	Laser	Ghorsad	191	41	89	102	0	0
29	Ukhel	Bhutli	Bhutli	144	30	71	73	25	0
30	Ukhel	Bhutli	Nail	125	22	47	78	0	0
31	Ukhel	Bhutli	Saundi	64	11	39	25	16	0
32	Guriyali	Guriyali	Guriyali	192	41	93	99	9	0
33	Guriyali	Guriyali	Guriyali Chhoti	84	22	37	47	17	0
34	Guriyali	Guriyali	Palkot	222	53	104	118	26	0
35	Guriyali	Soundadi	Soundadi	208	50	99	109	2	0
36	Guriyali	Soundadi	Mansari	72	12	32	40	48	0
37	Guriyali	Kensur	Kensur	280	69	117	163	21	0
38	Lava	Lava	Lava	1013	228	450	563	93	0
39	Lava	Gumalgaon	Gumalgaon	232	50	110	122	0	0
40	Jakoli	Jakholi	Jakholi	640	133	299	341	236	0
41	Jakoli	Jakholi	Khola	74	15	33	41	0	0
42	Jakoli	Sain	Sain	261	51	125	136	78	0
43	Jakoli	Sain	Pendars	214	45	101	113	54	0
44	Jakoli	Sain	Adali	109	22	54	55	0	0
45	Jakoli	Kirada	Kirada	325	71	153	172	136	0
46	Bairola	Bairola	Bairola	767	179	351	416	18	0
47	Bairola	Payalgaon	Payalgaon	199	44	76	123	9	0
48	Bairola	Payalgaon	Kot	332	72	129	203	0	0
49	Bairola	Payalgaon	Kandarigaon Bairola	94	23	46	48	21	0
50	Bairola	Aamsarigaon	Aamsarigaon	348	74	168	180	98	0

S.No	Kshetra Panchayat	Gram Panchayat	Village	Total Pop	Household Number	Male Pop	Female Pop	SC Pop	ST Pop
51	Bairola	Aamsarigaon	Maidhar	191	46	83	108	87	
52	Mangaon	Mangaon	Mangaon	249	50	115	134	0	
53	Mangaon	Mangaon	Fafrangaon	98	21	40	58	56	
54	Mangaon	Mangaon	Medwa	78	16	38	40	7	
55	Mangaon	Mangaon	Sautiyalgaon	146	28	66	80	0	
56	Mangaon	Mangaon	Bamankhola Pokhri	28	6	12	16	0	
57	Mangaon	Mangaon	Mangaon	122	37	68	54	7	
58	Mangaon	Mangaon	Palogi	146	28	69	77	1	
59	Mangaon	Bamangaon	Bamangaon	852	169	437	415	58	
60	Mangaon	Bamangaon	Matola	8	1	5	3	0	
61	Mangaon	Thanyul	Thanyul	335	71	142	193	0	
62	Jaykot	Jaykot	Jaykot	650	126	296	354	240	
63	Jaykot	Dandeli	Dandeli	336	59	165	171	187	
64	Jaykot	Dandeli	Aandarfigaon	160	32	81	79	0	
65	Jaykot	Falsari	Falsari	426	74	193	233	13	
66	Jaykot	Dawra	Dawra	174	33	79	95	0	
67	Jaykot	Dawra	Bhatoli	106	22	40	66	0	
68	Mathiyali	Mathiyali	Mathiyali	1055	164	497	558	52	
69	Mathiyali	Majiyadi	Majiyadi	625	89	280	345	28	
70	Odada	Odada	Odada	459	85	218	241	26	
71	Odada	Odada	Pokhri Odada	67	12	36	31	6	
72	Odada	Pasar	Pasar	136	29	62	74	0	
73	Odada	Pasar	Vandan	50	8	21	29	0	
74	Odada	Pasar	Pungaddu	36	7	21	15	0	
75	Odada	Pasar	Talai	151	26	75	76	0	
76	Odada	Pasar	Dhaigala	42	5	26	16	0	
77	Odada	Pasar	Kandchak	0	0	0	0	0	
78	Odada	Tamiyar	Tamiyar	128	22	65	63	0	
79	Odada	Tamiyar	Banali Malli	94	18	41	53	0	
80	Odada	Tamiyar	Banali Talli	104	22	42	62	0	
81	Odada	Tamiyar	Lamoli	95	31	45	50	0	
82	Berni	Berni	Berni Badi	281	61	137	144	0	
83	Berni	Berni	Berni Chhoti	177	34	96	81	35	
84	Berni	Berni	Aamsari	46	11	23	23	0	
85	Berni	Adwani	Adwani	331	61	164	167	40	
86	Berni	Adwani	Gangsarigaon	130	26	62	68		
87	Berni	Raundeli	Raundeli	348	80	155	193	75	
88	Berni	Raundeli	Hadisera	166	32	80	86	21	
89	Rampur	Rampur	Rampur	346	82	164	182	25	
90	Rampur	Rampur	Bhandargaon	316	80	167	149	30	
91	Rampur	Koti	Koti	378	64	172	206	0	
92	Rampur	Pali Kakadsari	Pali Kakadsari Nala	208	45	95	113	0	
93	Rampur	Pali Kakadsari	Kanchanpur	120	23	51	69	0	
94	Rampur	Kafolgaon	Kafolgaon	159	29	61	98	19	
95	Rampur	Kafolgaon	Chidiyali Talli	65	14	36	29	0	
96	Rampur	Kafolgaon	Chidiyali Malli	172	33	77	95	6	
97	Khakar	Khakar	Khakar	216	43	98	118	44	
98	Khakar	Khakar	Sunarkot	237	52	102	135	4	
99	Khakar	Khakar	Tipli	274	52	123	151	45	

S.No	Kshetra Panchayat	Gram Panchayat	Village	Total Pop	Household Number	Male Pop	Female Pop	SC Pop	ST Pop
100	Khakar	Khakar	Kaud	27	7	16	11	0	0
101	Khakar	Than	Than	311	58	145	166	80	0
102	Khakar	Than	Bidon	241	45	111	130	56	0
103	Maun	Maun	Maun	680	132	306	374	0	0
104	Maun	Maun	Khatiyad	237	48	107	130	129	0
105	Maun	Maun	Salamkhet	12	2	4	8	0	0
106	Maun	Kudi	Kudi	454	96	197	257	0	0
107	Maun	Atali Malli	Atali Malli	123	24	48	75	0	0
108	Maun	Atali Malli	Atali Talli	146	30	62	84	0	0
109	Sweer	Sweer	Sweer	441	95	208	233	7	0
110	Sweer	Gaindi	Gaindi	262	46	126	136	52	0
111	Sweer	Gaindi	Dadua	124	27	48	76	0	0
112	Sweer	Aampata	Aampata	340	79	153	187	22	0
113	Pipleth	Pipleth	Pipleth	572	121	253	319	102	0
114	Pipleth	Chaumpa	Chaumpa	225	61	118	107	8	0
115	Pipleth	Chaumpa	Kumali	325	58	168	157	42	0
116	Pipleth	Udkhanda	Udkhanda	113	29	47	66	6	0
117	Bhaintan	Bhaintan	Bhaintan	555	137	292	263	26	0
118	Bhaintan	Bhaintan	Katkod	156	26	84	72	0	0
119	Bhaintan	Bhaintan	Jangleth	112	17	53	59	0	0
120	Bhaintan	Bhaintan	Pata	111	21	57	54	0	0
121	Bhaintan	Naur	Naur	332	57	166	166	0	0
122	Bhaintan	Naur	Basuee	263	50	124	139	53	0
123	Bhaintan	Naur	Malas	78	14	35	43	0	0
124	Bhaintan	Tachhla	Tachhla	140	26	64	76	0	0
125	Bhaintan	Tachhla	Odarkhet	110	19	61	49	19	0
126	Bhaintan	Tachhla	Bemar	67	11	33	34	0	0
127	Bhaintan	Tachhla	Bhaind	54	9	26	28	0	0
128	Bhaintan	Tachhla	Barathali	62	11	32	30	0	0
129	Aagar	Aagar	Agar	697	144	366	331	37	0
130	Aagar	Aagar	Semlikatal	23	7	9	14	0	0
131	Aagar	Bhaingarki	Bhingarki	237	41	127	110	0	0
132	Aagar	Bhaingarki	Chilogi	170	32	75	95	0	0
133	Aagar	Kasmoli	Kasmoli	350	64	156	194	5	0
134	Aagar	Kasmoli	Chaldgaon	157	36	88	69	0	0
135	Kodarna	Kodarna	Kodarna	571	96	287	284	53	0
136	Kodarna	Kodarna	Kol	152	25	71	81	0	0
137	Kodarna	Diuli	Diuli	381	63	168	213	22	0
138	Kodarna	Diuli	Kharki	277	46	115	162	10	0
139	Kodarna	Kakhil	Kakhil	249	38	110	139	56	0
140	Syud	Syud	Syud	359	61	201	158	9	0
141	Syud	Syud	Gwad	166	26	81	85	24	0
142	Syud	Fart	Fart	308	57	131	177	24	0
143	Syud	Saldogi	Saldogi	370	73	189	181	7	0
144	Syud	Saldogi	Badeda Malla	76	15	36	40	0	0
145	Syud	Kukhai	Kukhai Malli	91	14	36	55	17	0
146	Syud	Kukhai	Kukhai Talli	265	51	118	147	265	0
147	Banali	Banali	Banali	282	65	140	142	0	0
148	Banali	Banali	Bhatoli	94	15	45	49	0	0
149	Banali	Banali	Khedagad	243	42	124	119	0	0
150	Banali	Banali	Sarswad	91	16	35	56	0	0

S.No	Kshetra Panchayat	Gram Panchayat	Village	Total Pop	Household Number	Male Pop	Female Pop	SC Pop	ST Pop
151	Banali	Pildi	Pildi	512	82	231	281	0	
152	Banali	Chamolgaon	Chamolgaon	193	48	76	117	10	
153	Banali	Chamolgaon	Adali	109	22	42	67	12	
154	Banali	Chamolgaon	Dangoo	82	20	33	49	22	
155	Soni	Soni	Soni KP	429	72	195	234	0	
156	Soni	Soni	Dagar	303	45	147	156	10	
157	Soni	Bahinsark	Bhainsark	266	40	123	143	0	
158	Soni	Bahinsark	Kandarigaon Soni	179	28	88	91	0	
159	Soni	Daur	Daur	626	102	312	314	41	
160	Soni	Daur	Bagar	74	14	28	46	0	
161	Soni	Aoni	Aoni	349	62	177	172	105	
162	Soni	Aoni	Talai	217	41	106	111	8	
163	Dhalwala	Dhalwala	Dhalwala	11444	2525	6407	5037	154	1
164	Tapovan	Tapovan	Tapowan	2320	525	1235	1085	141	
165	Badeda	Badeda	Badeda Talla	265	45	126	139	33	
166	Badeda	Badeda	Pater	47	6	25	22		
167	Badeda	Badeda	Badkot	129	21	56	73	0	
168	Badeda	Badeda	Chhatendi	47	6	22	25	0	
169	Badeda	Badeda	Ghugtani Talli	217	33	115	102	0	
170	Badeda	Badeda	Ghugtani Malli	144	26	66	78	38	
171	Badeda	Badeda	Pathau	130	21	55	75	0	
172	Badeda	Badeda	Jamri Katal	68	12	32	36		
173	Badeda	Bingarki	Bhingarki	224	42	101	123	36	
174	Badeda	Bingarki	Pateshri	72	17	35	37	0	
175	Badeda	Bingarki	Ars	165	32	76	89	63	
176	Badeda	Bingarki	Kakhoor	219	38	93	126	64	
177	Bawani*	Bawani	Bawani	852	135	415	437	273	
178	Bawani*	Bawani	Matiyala	130	21	66	64	0	
179	Bawani*	Kyarki	Kyarki	200	30	111	89	0	
180	Bawani*	Kyarki	Kuee	173	33	79	94	0	
181	Bawani*	Neer	Neer	479	89	251	228	31	
182	Bawani*	Neer	Dharkot	106	18	45	61	0	
183	Timli	Timli	Timli	1566	229	757	809	190	
184	Timli	Timli	Shivpuri	222	43	149	73	0	
185	Lodsi	Lodsi	Lodsi	670	105	323	347	211	
186	Lodsi	Loyal	Loyal	764	128	367	397	142	
187	Lodsi	Mundala	Mundala	402	76	199	203	0	
188	Lodsi	Mundala	Nasogi	209	43	102	107	25	
189	Nayee	Nayee	Nayee	963	165	450	513	56	
190	Nayee	Nayee	Maanghera	153	27	78	75	48	
191	Nayee	Bugala	Bugala	252	54	114	138	19	
192	Nayee	Bugala	Manderigaon	411	82	205	206	19	
193	Nayee	Bugala	Chaundli	45	10	20	25	0	
194	Mindath	Mindath	Mindath	1235	221	617	618	0	
195	Mindath	Purvala	Purvala	287	50	135	152	0	
196	Badir	Badir	Badir	159	27	83	76	0	
197	Badir	Badir	Gangsali	609	102	319	290	14	
198	Badir	Sasman	Sasman	704	126	349	355	25	
199	Badir	Atali	Atali	412	73	207	205	4	
200	Badir	Atali	Simtali	233	49	112	121	7	

S.No	Kshetra Panchayat	Gram Panchayat	Village	Total Pop	Household Number	Male Pop	Female Pop	SC Pop	ST Pop
201	Badir	Atali	Kodiyala	81	15	46	35	3	0
202	Bairaigaon	Bairaigaon	Bairaigaon	723	110	328	395	93	0
203	Bairaigaon	Chameli	Chameli	635	125	301	334	15	1
204	Bairaigaon	Silkani	Sailkani	400	64	186	214	0	0
205	Bairaigaon	Silkani	Pajaigaon	340	57	151	189	111	0
206	Banskatal	Banskatal	Banskatal	622	111	257	365	15	0
207	Banskatal	Banskatal	Bhairgad	253	37	118	135	0	0
208	Banskatal	Ghigud	Ghigud	681	113	308	373	87	0
209	Kakhoor	Kakhoor	Kakhoor	294	54	136	158	23	0
210	Kakhoor	Kakhoor	Tipri	204	45	91	113	41	0
211	Kakhoor	Bhangala	Bhangala	318	58	138	180	13	0
212	Kakhoor	Kyara	Kyara	616	90	276	340	10	0
213	Kakhoor	Jamola	Jamola	352	72	172	180	0	0
214	Kakhoor	Kotar	Kotar	369	62	175	194	8	0
Total			214 Villages	72362	14222	35081	37281	6138	12

	Market Towns		Kunjapuri	415	98	201	214	21	0
			Pav-ki-devi	521	103	253	268	15	0
			Gheradhar	565	121	274	291	32	2
			Fakot	650	155	315	335	14	0
			Bedadhar	695	125	337	358	20	0
			Jajal	745	159	361	384	5	1
			Duadhar	755	**162**	366	389	25	0
			Hindolakhal	815	180	395	420	36	0
			Khadi	819	175	397	422	8	3
			Agrakhal	850	170	412	438	15	0
			Byasi	1026	253	497	529	45	6
			Chaka	1590	305	771	819	10	2
			Kaudiyala	1925	504	933	992	55	8
			Gular	2865	675	1389	1476	105	12
			Gaja	3250	620	1576	1674	130	16
			Narendranagar	5304	1264	3425	1879	365	25
			Muni-ki-reti	7880	1570	4215	3665	212	36
Total			17 Market Towns	30670	6639	16117	14553	1113	111

ANNEXURE V

Village Information Hindi Questionnaire By Village Development Officer for Village Diuli

ग्राम स्तरीय सूचना संग्रह हेतु प्रपत्र

उत्तरांचल शासन

टिहरी गढ़वाल

भाग-1 सामान्य सूचनायें

1.1 गांव का नाम : दिउली

1.2 ग्राम सभा का नाम: दिउली गांव से दूरी: 0 Km

1.3 ग्राम पंचायत का नाम: दिउली गांव से दूरी: 0 Km

1.4 न्याय पंचायत का नाम: कनाताल गांव से दूरी: ~~0 Km~~ 16 Km

1.5 पटवारी क्षेत्र का नाम: दिउली गांव से दूरी: 0 Km

1.6 विकास खण्ड से दूरी: 17 Km

1.7 ग्राम प्रधान का नाम: श्रीमति शैला जोशी शिक्षा: बी०ए० पुरूष/महिला ✓ दूरभाष: ✗

1.8 ग्राम पंचायत सदस्यों का विवरण:

	कुल	स्त्री	पुरूष	अनुजाति/जनजाति	विकलांग
गांव से	381	191	190	22	5
ग्राम पंचायत से	658	332	326	2	10

भाग-2 भौगोलिक सूचनायें:

2.1 भौगोलिक स्थिति:

1. गांव की ऊँचाई: घाटी में ----✗--- मध्य ----✓---- अधिक ऊँचाई पर --✗----
2. पर्वत श्रृंखला पर गांव की स्थिति (दिशा)
   पूर्व---✗---, पश्चिम---✓----, उत्तर ---✗----दक्षिण----✗----
3. जलवायु
   वर्षा: अधिक----✗---, औसत -✗-----, कम---✓-----
   वायु प्रवाह दिशा: पूर्व से---✗ पश्चिम से--✗ उत्तर से-✗ दक्षिण से-✓
   वायु प्रवाह तीव्रता:अधिक ✗--- औसत --✓----- कम---✗---

2.2 क्षेत्रफल

कृषि योग्य जमीन	सिंचित जमीन	चारागाह	वन	फल उद्यान	अन्य	कुल
61.00	7.70	56.00	103.50	3.00		178.50

2.3 मुख्य पैदावार एवं बागान उत्पादन

	फस्ल के प्रकार	कुल	उत्पादन	फसल बीमा वाल कुल क्षेत्र
अनाज	गेहूँ —	10 ह	10 ह	—
	धान —	18 ह	18 ह	—
	मडुआ —	12 ह	12 ह	—
	झंगोरा —	13 ह	13 ह	—
फल				

2.4 जलस्रोत

प्रकार	नाम/संख्या	गांव से दूरी	गांव की जलस्रोत से ऊँचाई
नदी	—	— 16 Km	500 मी.
नहर गूल	6	1.5 Km	—
झरना	1	1.5 Km	—
जलधार	4	1.5 Km	—
तालाब	—	—	—
नलकूप	—	—	—

नदी पर बाढ़ के लिये खतरे के निशान की उपस्थिति: ~~है~~ / नहीं है

तटबन्धों का विवरण

संख्या	नाम	प्रकार	लंबाई
—	—	—	—

भाग-3 जनसांख्यिकी सूचनायें

3.1 गांव के परिवारों का विवरण:

	सामान्य	अनु जाति	अनु जनजाति	अन्य पिछड़ा वर्ग	कुल
कुल परिवार	~~78~~ 73	5	—	—	78
गरीबी रेखा से नीचे के परिवार	30	5	—	—	35

3.2 जनसंख्या का वर्गीकरण

आयु वर्ग (वर्षो में)	सामान्य		अनुजाति		अनु जनजाति		अन्य पिछड़ा वर्ग		विकलांग		कुल	
	पुरूष	महिला	पुरूष	महिला	पुरूष	महिला	पुरूष	महिला	पुरूष	महिला	पुरूष	महिला
6 से कम	26	29	2	2	—	—	—	—	—	—	28	31
6 से 15 तक	90	89	5	4	—	—	—	—			95	93
15 से 60 तक	58	55	2	3	—	—	—	—	4	1	60	58
60 से ज्यादा	27	07	2	2	—	—	—	—	—	—	29	09

3.3 वार्षिक आय के आधर पर परिवार का वितरण:

वार्षिक आय	परिवार संख्या
12,000 से कम	35
12,000 से 24,000	30
24,000 से 48,000	8
48,000 से ज्यादा	5
कुल परिवार	78

3.4 गांव में साक्षरता प्रतिशत पुरूष ------25 %-- प्रतिशत
महिला -------8 %, प्रतिशत

3.5 जीविकोपार्जन का ब्यौरा

	पुरूष	महिला
मुख्य कर्मकार	10	5
सीमांतक कर्मकार	60	10
काम नहीं करने वाले	10	5
कुल	80	20

मुख्य कर्मकारों का विवरण:

कृषक	खेतिहर मजदूर	परिवारिक उद्योग	लघु उद्योग /कुटीर उद्योग	अन्य (नौकरी)	कुल
78	—	5	2	2	87

उद्योग (लघु उद्योग / कुटीर उद्योग)

उद्योग का नाम	उद्योग का प्रकार	कार्यर मजदूरों की संख्या	लागत	उत्पादन	बीमा है /नहीं
आटा चक्की	लघु	2	80,000	—	नही

गांव में रोजगार के प्रमुख स्रोत: ---------कृषि / मजदूरी---------

3.6 पशुधन जनसंख्या विवरण (संख्या)
गाय --40-- बैल ---100--- भेड़ ---5----- खच्चर ----6------
भैंस --108-- बकरी---61---- मुर्गी ---5----- अन्य ---6--------

दैनिक दुग्ध उत्पादन --400----- लीटर

3.7 गांव में उपलब्ध प्रमुख संसाधन --------Nil-----------
3.8 भूमि वितरण सारांश (परिवारों की संख्या)

बड़े किसान (30 नाली से ज्यादा जमीन)	सीमान्त किसान (15-30 नाली जमीन)	छोटे किसान (0-15 नाली जमीन)	बटाईदार	भूमिहीन	कुल परिवार
24 कृषक	27 कृषक	25	—	2	78

भाग 4 : अवस्थापना सुविधायें

4.1 गांव के लिये पहुँच मार्ग (किमी)

प्रकार	पगडंडी	पक्का पैदल मार्ग	कच्चा मोटर मार्ग	पक्का मोटर मार्ग
लम्बाई	1 Km	—	12 Km	—

4.2 पेयजल आपूर्ति

	गांव से दूरी
सरकारी नल	0 Km
हैण्ड पंप	—
अन्य	स्रोत

पेयजल आपूर्ति - पर्याप्त ----X----, अपर्याप्त ---✓---------

4.3 विद्युतीकरण है --आंशिक है, नहीं है-----------------
औसत आपूर्ति समय प्रतिदिन ---आंशिक------- घंटे

4.4 जनसंचार का माध्यम:

प्रकार	रेडियो	टीवी.	टेलिफोन	समाचार पत्र	मोबाईल फोन
संख्या	हाँ	हाँ	—	—	1

4.5 यातायात के साधन: खच्चर -✓--- पैदल -✓---- दुपहिया वाहन -X-- मोटर -1---अन्य--X

4.6 गांव में आयात निर्यात
मुख्य निर्मित वस्तुयें / सामग्री : ------X------------------------------------
मुख्य निर्यातित वस्तुयें / सामग्री : ---अदरक-----------------------------------
मुख्य आयातित वस्तुयें / सामग्री : ---आटा, चावल एवं खाद्य सामग्री---
4.7 पशुचारा उपलब्धता: पर्याप्त -----X-----------, अपर्याप्त --✓---------------
4.8 ऊर्जा के मुख्य स्रोत : ----------लकड़ी----------------------------
(खाना बनाना, प्रकाश एवं आग जलाने के स्रोत)
बायोगैस प्लांट : संख्या ------7--- सात (कार्य नहीं करते)
सौर ऊर्जा से चलने वाले उपकरण -------Nil-----------------------------

4.9 घरों की स्थिति

अच्छे मजबूत घर	आधे कच्चे	कच्चे घर	कुल घर
40	20	18	78

4.10 गांव में सामाजिक कल्याण संस्थानों का विवरण
(गैर सरकारी संस्थान / स्वयंसेवी संस्थान / सामाजिक संगठन / महिला मंगल दल / युवा कल्याण केन्द्र आदि)

संस्था का नाम	कार्यक्षेत्र	लोगों की संख्या	अन्य संसाधन	पता / दूरभाष
महिला मंगलदल	दिखली	10	—	—

4.11 गांव की मुख्य समस्यायें

1. मोटर मार्ग का आभाव
2. तन्दोल, कुड, मैंडी वाढला आदि तोको मे बिजली का आभाव
3. जुनियर हाईस्कूल न होना

4.12 गांव की अत्यंत आवश्यक जरूरतें

1. तन्दोल कुड मैंडी वाढला बिजली,
2. उक्त तन्दोल कुड मैंडी वाढला मे मोटरमार्ग
3. जूनियर हाई स्कूल

4.13 गांव में सुविधाओं की नजदीकी

	सुविधा		नाम	जगह	ईमारत की स्थिति (पक्की / कच्ची)	गांव से दूरी (किमी0)
शैक्षिणिक सुविधायें	प्राथमिक विद्यालय	कमरों की संख्या 2	रा0प्रा0वि0 दिखली	तन्दोल	पक्की	0 Km
	माध्यमिक विद्यालय	—	—	—	—	5 Km
	महाविद्यालय	—	—	—	—	35 Km
	इन्टरमीडिएट	—	—	—	—	05 Km
	उच्च शिक्षा	—	—	—	—	35 Km
	साक्षरता केन्द्र	—	—	—	—	—
स्वास्थ्य सुविधायें	प्राथमिक स्वास्थ्य केन्द्र	बिस्तरों की संख्या				
	अस्पताल	—	—	—	—	27 Km
	दवाखाना	—	—	—	—	27 Km
	यूनानी चिकित्सालय	—	—	—	—	35 Km
	आयुर्वेदिक अस्पताल	—	रा0 आ0औ0 दिखली	दिखली	[illegible]	0 Km
	होम्योपैथिक अस्पताल	—	—	—	—	17 Km
	परिवार कल्याण केन्द्र	—	—	कमार	—	18 Km
	आंगन बाड़ी	—	दिखली	दिखली	नहीं	0 Km
	पशु चिकित्सा केन्द्र	—	—	कमार	—	18 Km
	डाक घर	—	दिखली	दिखली	—	0 Km
	पुलिस चौकी/ थाना	—	—	[illegible]	—	12 Km
	धर्मशाला	लोगों की क्षमता				
	मन्दिर	—	[illegible]	[illegible]	[illegible]	3 Km
	पंचायत भवन	—	—	—	—	—

4.13 गांव में सुविधाओं की नजदीकी

	सुविधा		नाम	जगह	ईमारत की स्थिति (पक्की / कच्ची)	गांव से दूरी (किमी0)
खाद्य सुविधायें	कोल्ड स्टोर	—	—	[illegible]	[illegible]	35 Km
	सब्जी मण्डी	—	—	[illegible]	—	35 Km
	बीज केन्द्र	—	—	[illegible]	—	17 Km
	सरकारी अनाज मण्डी	—	—	[illegible]	—	35 Km
	खाद्य गोदाम	—	—	[illegible]	—	35 Km
	राशन की दुकान	—	[illegible]	[illegible]	—	0 Km
	निकटतम बाजार / हार्ट	—	—	[illegible]	—	12 Km
	बस स्टॉप	—	—	[illegible]	—	12 Km
	सार्वजनिक फोन सुविधा	—	—	[illegible]	—	12 Km
	विद्युत सब स्टेशन	—	—	[illegible]	—	27 Km
	बैंक	—	—	[illegible]	—	17 Km
	घराट	—	[illegible]	[illegible]	—	0 Km

भाग-5 आपदा जोखिम प्रबंधन सूचनायें

5.1 घटित होने वाली आपदायें

प्रकार	प्रभाव		प्रभावित सुविधायं	बारंबारता	सरकारी स्तर पर तैयाी है/ नही	अन्य संस्थाओं द्वारा तैयारी है /नही	ग्राम समुदाय द्वारा तैयारी हैं /नही
	गंभीर	सौम्य					
भूकम्प	✓		हां	नहीं	है,	है.	है,
भूस्खलन	✓		नहीं	—	—	—	—
बाढ़	—	✓	—	—	—	—	—
बादल फटना	—	✓	—	—	—	—	—
सूखा	नहीं	—	—	—	—	—	—
अन्य		—		—		—	—

गांव में भूस्खलन की संभावना : है ✓ ----------- नही है -----------
(अगर गांव के ऊपर कोई पहाड़ है) ✓
शासन की प्रतिक्रिया संबंधी जानकारी: है--------- नहीं है -------------

5.2 गांव में संसाधनों की उपलब्धता

संसाधन	विवरण	संख्या	मालिक का नाम / पता / दूरभाष
यातायात	ट्रेकर	—	
	ट्रैक्टर	—	
	नाव	—	
	चार पहिया वाहन	—	
	दुपहिया वाहन	—	
जमा करने के लिए बड़े बर्तन	पानी की टंकी	—	
	टेंकर	—	
	जेरी कैन	—	
	बड़े बर्तन	100	
कटाई / सफाई के उपकरण	कुदाल	150	
	फावड़ा	50	
	रस्सी	50	
	आरी	10	
	सबला	100	
अन्य संसाधन	जनरेटर सेट	—	
	पेट्रोमैक्स	10	
	पम्प सेट	—	
	टेन्ट सेट	—	
	टेन्ट हाऊस	—	
	गैस लाईट	—	
	सौर ऊर्जा	01	श्री [illegible]

5.3 मानव संसाधन

प्रकार	पुलिस	डाक्टर	स्वास्थकर्मी	सेनानी	स्वयंसेवी	मिस्त्री	ड्राइवर	अन्य
संख्या	01	—	—	01	10	2	3	—

5.4 व्यवसायिओं का ब्यौरा

व्यवसायी	संपर्क व्यक्ति / पता	दूरभाष	टिप्पणी
भवन निर्माण सामग्री	—	—	—
सब्जी	5	—	—
दवा	—	—	—
टेन्ट एवं तारपोलिन	1	—	—
चूड़ा / चावल	—	—	—
लकड़ी	10	—	—
बिजली के सामान	—	—	—
भोजनालय	—	—	—
कृषि उपकरण	60	—	—

ANNEXURE VI
VILLAGE SURVEY QUESTIONNAIRE

1. Name of Village: ………...............
2. Name of Gram Sabha: …………………Distance from Village:……
3. Name of Nyay-Panchayat: …………………Distance from Village:…….
4. Name of Block: …………………Distance from Village:…….
5. Name of Gram Pradhan:…………………Education:……….Male / Female, Phone Number:…………………
6. Members of Gram Panchayat in Village:

	Total	Females	Males	SC / ST	Handicapped
From Village					
From Gram Sabha					

7. Height of Village: Altitude:…………………
8. Description of Village Families:

	General	SC	ST	OBC	Total
Total					
BPL					

9. Population Distribution – Age Distribution

Age	Handicapped		Total	
	F	M	F	M
Below 15				
15 – 60				
Above 60				

10. Income Structure

Annual Income	Below 12,000	12000 - 24000	24000 - 48000	Above 48000	Total Families
Families					

11. Literacy Percentage: Males:……….. Females:……………
12. Occupation Structure:

Occupation		Males	Females
Main Workers	Farmers		
	Farm Workers		
	Family Business		
	Small Scale Industry		
	Service / Others		
Marginal Workers			
Non Workers			
Total Workers			

13. Cattle Population
Cows:………………Bulls:…………………Sheep:……………Mules:………
Buffalos:……………Goats:………………..Chickens:…………Others:……..
14. Accessibility:

Distance of Village from Bus Way	Approach Road			
	Pucca Motor Road	Katchha Motor Road	Pucca Foot way	Kutchha Footway

15. Water Supply:

Govt Taps	Hand Pumps	Natural Resource	Others

16. Electricity: Number of Hours:……………………..
17. Communication:

Types	Radio	TV	Telephone	News paper	Mobile Phones
Number					

18. Condition of Houses:

Pucca	Semi Pucca	Katchha	Total

19. Construction Material

Materials of wall	Materials of Roof					
	Thatch	Slate and Stone	CGI	RCC	Others	Total
Thatch						
Earth						
Timber						
Brick						
Stone						
Others						
Total						

20. Presence of Organizations in Village
(NGOs, CBOs, Social Organizations, Women Welfare Centers, Youth Welfare Centers, others)

Name of Organization	Area of Work	No of members	Resources	Phone Number

21. Number of members of such organizations in Village:
Males:………..Females:………
22. Major problems and Needs of Village
    a) …………………………
    b) …………………………..
    c) …………………………..
23. Past Experiences of Natural Disasters

Type of Disaster	Effect		Affected Facilities	Repeat Period	Gov. Preparedness (Yes / No)	Preparedness of other organizations	Comm-unity Preparedness
	High	Low					
Earthquakes							
Landslides							
Floods							
Droughts							
Cloud Burst							
Others							

24. Possibility of Landslides:……………….(Presence of mountain rocks over village)

25. Awareness about actions to be taken after earthquake:…………………………….

26. Availability of Material resources in village

Type of Resource	Description	Number
Transportation	Tractor	
	Trekkers / Jeeps	
	Cars	
	Two Wheelers	
	Boats	
For Food Supply	Water Tanks	
	Tanker	
	Jerry Cans	
	Big Utensils	
	Mass Cooking Facility	
Construction Equipment	Kudal	
	Fawda	
	Ropes	
	Aaris	
	Sabla	
Others	Generator Set	
	Petromax	
	Pump Set	
	Tents	
	Gas Light	
	Solar Energy Equipments	

27. Manpower Availability

Type	Police	Doctors	Health Persons	Soldiers	Volunteers	Masons	Drivers	Others
No.								

28. Availability of Infrastructure Facilities of the Village

Educational Facility

Facility		No. of Rooms	Name of Village	Condition of Building	Distance from Village
Educational Facility	Primary School				
	Secondary School				
	High School				
	Inter School				
	Higher Education				
	Literacy Centers				

Health Facility

Facility		No. of Beds	Village Name	Condition of Building	Distance from Village
Health Facility	Primary Health Cent.				
	Hospitals				
	Unani Hospital				
	Ayurvedic Hospital				
	Homeopathic Hosp				
	Family Welfare Cent.				
	Veterinary Hosp				
	Medicine Shop				
	Others				

Food Facility

Facility		Capacity	Village Name	Condition of Building	Distance from Village
Food Facilities	Food Go-downs				
	Govt ration Shops				
	Anaj Mandi				
	Sabji Mandi				
	Restaurants / Dhabas				
	Cold Store				
	Seeds Kendra				

Other Facility

Facility		Imp Aspects	Name of Village	Condition of Building	Distance from Village
Others	Post Office				
	Police Station				
	Dharamshala	Beds			
	Temples				
	Panchayat Bhavan				
	Market				
	Bus Stop				
	Public Telephone				
	Electric Sub Station				
	Bank				

Presence of Developable land ……………………………………………

29. Businessmen in Village

Businessmen	Name / Address / Phone	Resources available
Construction		
Vegetables		
Grains		
Medicines		
Tents and Tarpaulin		
Agricultural equipment		
Wood		
Restaurants		

ANNEXURE VII
ODADA - VILLAGE SURVEY REPORT

General Information

1. Geographical Location:
   Village Odada is located on Latitude 3o^{0}12'45"N and Longitude 78^{0}22'45"E. The highest point of Odada is at an elevation of 1380 m from mean sea level and the lowest point is at 1200 m. Odada occupies top of a ridge with majority of houses facing East. Odada is spread over a length of approximately 1800 meters with the geographical area of approximately 4 sq.kms. including the agricultural fields (Figure 1; 2).

2. Administrative Location
   Odada is part of Gram Panchayat Odada and Kshetra Panchayat Odada of Narendranagar block. Neighbouring villages to Odada are viz. Lamoli and Raundeli on the northern side, Pokhri and Talai on the north southern side and River Hemwal on the Eastern side.

3. Land use
   Table 1: Approximate Landuse of Village Odada

Agricultural Land	Grazing Fields	Forest	Fruit & Gardens	Housing	Total
50%	18%	13%	12%	7%	100%

4. Climatic Conditions
   The climate of Odada is Moderate. The winters are severe in the village while the temperatures in summers varies from 20 to 30 ^{0}C. Rainfall is moderate in the area.

5. Cropping Pattern
   Villagers of Odada are mostly farmers and farm workers. The village is devoid of any advanced agricultural and irrigation facilities. The traditional methodology of farming is adopted here. The main crops in the village are wheat, rice, pulses, ginger and vegetables.

Demographic Conditions

6. Total Population
   Village has total 85 households with population of 459. Total 52% males and 14% females are literate.

7. Population Distribution
   There are 4 handicapped females in the village (1 blind, 2 lame, 1 paralyzed) within age group of 25 to 60. There is no mentally handicapped person in the village. Approximate numbers of age wise distribution of population is given in Table 2.

Table 2: Age wise population of Village Odada

	Population		Total
Age	Male	Female	
Below 15	74	56	130
15 to 60	100	140	240
Above 60	44	45	89
Total	218	241	459

8. Caste Structure

The population of Odada are mostly Rawat and Negi caste people which fall in general category. There are 26 schedule cast people from 4 families in the village.

9. Income Distribution

Table 3: Distribution of population based on income

Annual Income	Number of Households
Less than 12000	47
12000 to 24000	20
24000 to 48000	11
More than 48000	7
Total	85

10. Occupational Structure

Farming and cultivation are the main occupations of villagers. There are total 20 big farmers having land more than (30 nali) 19 medium farmers having land between 15 to 30 nali and 49 small farmers with land less than 15 nali. One person runs a government ration shop in the village, six persons are masons. 9 persons are in job outside the village.

11. Cattle Population

All families in the village have cattle. Mules in the village are used for transportation of goods to and from the neighboring villages.

Table 4: Cattle population of the Odada

Type	Cows	Bulls	Sheep	Mules	Buffalos	Goats	Chickens
Number	10	40	15	6	60	100	50

Physical Infrastructure

12. Housing Stalk - Construction Technology

The chief building material found to be used in Odada is stone. Stone is used in construction of all walls and roofs of older houses. New houses are constructed of combination of stone and cement. In these houses walls are constructed of stone and roofs are RCC slabs. Few houses have thatch roofs over the stone walls (Figure 3). These houses usually belong to poor families. Table 5 below shows the number of houses with different construction material in Odada.

Table 5: Number of houses with different construction material in Odada.

Material for wall	Material for Roofs					Total
	Thatch	Slate and Stone	CGI	RCC	Others	
Stone	8	36	0	5	0	49
Brick	0	22	0	14	0	36
Total	8	58	0	19	0	85

13. Electricity

Electricity has reached the village but many families have not taken the connections yet. They are using solar batteries provided by the government for energy. There are total 30 batteries in the village.

Figure1: Topography of Village Odada (Source: Survey of India, 1967a)

Figure 2: View of Village Odada

Figure 3: Housing Stalk in Odada

Figure 4: Natural Stream near Odada

Figure 5: Shop for Household needs in Odada

Figure 6: Inter College in Odada

Figure 7: Irrigation in Odada through Canals

Figure 8: Open space near Odada

Figure 9: Landslide on access to Odada

14. Water Supply
    Village has government tap water supply in the village. The water supply is adequate. In addition to this village is close to minor river Hemwal. The discharge of the river is adequate in all seasons. There are also natural water streams flowing near the village (Figure 4).

15. Water tanks
    Village has a water tank which is operational and in good condition.

16. Telecommunication
    Village has six telephone connections and no mobile phones. Odada also has a Public telephone booth.

17. Public Communication
    Village has almost 15 radio sets and 5 TV sets operating on solar batteries. They can be used for public communication for spreading awareness about the disasters.

18. Food Facility
    Odada has a government fair price shop and 5 other shops for household needs (Figure 5).

19. Health Facility
    Odada has a Homeopathic hospital, but the lack of doctor in which forces people to go to Gaja which is 14 kms away to avail, medical facility.

20. Education Facility:
    Odada has education facility from primary schooling till inter college. For further studies the students have to go to Narendranagar, Chamba or Rishikesh (Figure 6).

21. Irrigation Facility
    Irrigation is through small canals made from natural streams (Figure 7). The discharge is adequate.

22. Mode of Transport
    The village can be reached by foot or through mules from a katchha motorable road which is 3 km away from the village. This katchha motorable road leads to Adwani after a distance of 10 kms.

23. Police
    There is no police station in the village. The nearest facility is a revenue police chauki at Gaja which is 14 kms from the village. Odada has a Gram Prahri who informs the patwari at Gaja about the any incidence happening in the Odada Gram Panchayat.

24. Fire Brigade
    There is no fire brigade facility in the region.

25. Post Office
    Odada has a Post office.

26. Bus stop
    Nearest bus stop is at Gaja, 14 kms from village.

27. Bank
Nearest bank is at Gaja, 14 kms away from village.

28. Army
Army cantonment is at Narendranagar which is almost 52 kms from the village.

Social Infrastructure

29. NGOs / CBOs or other voluntary organizations
Odada has 9 members of Mahila Mangal Dal and 4 members of Nav Yuvak Mangal Dals.

30. Adult Literacy Centers
There are no adult literacy centers in the entire region.

31. Temporary Shelter
Primary school, secondary school and inter college at Odada can be used fortemporary shelter during emergencies. The building of secondary school and inter college at Odada is a new building with 12 rooms in good condition.

32. Panchayat Office
There is no panchayat office in Odada.

33. Temple / any open ground for relief camps.
Village has a temple with open and fairly flat ground near the access road (Figure 8). This place can be used as gathering place and setting up of relief camps or medical camps in case of emergencies.

Manpower availability

34. Table 6 below shows the availability of key persons in village that can be helpful during the emergency situation.

Table 6: availability of key persons on Odada

Type	Police	Doctors	Health Persons	Soldiers	Masons	Drivers
No.	1 (posted at Devprayag)	-	-	2(on Posting) 2 (Retd)	6	4

Six masons in the village can be trained for carrying out rescue operations in the village. If required they can also be helpful to clear road in case of landslides. Four drivers can be helpful for carrying out the relief operations in the region.

Community Preparedness for Disasters

35. Past experiences
Village has experienced low to moderate losses during past earthquake events. Village is not prone to landslides and hence there are no cases of destructions due to landslides in the past.

36. Effect of disasters on public and houses
    Till now village was not affected by disasters.

37. Public Awareness
    Public is not aware about vulnerability of village for any kind of disasters. Public is not aware of actions to be taken in case of any emergency situation caused due to earthquakes. They are also not aware about what kind of assistance they can get from government in such situations and whom to approach for that.

38. Facilities that can be affected during disasters
    Earthquakes can trigger landslides which can block the access road to village. Village can become inaccessible due to this. This can severely hamper the relief and rescue activities in the region.

39. Most frequent and destructive disasters
    Blockage of approach roads due to heavy rains (Figure 9).

40. Awareness about govt actions / measures
    No awareness.

41. Role of voluntary organizations (Before / during and after disaster)
    Anganbadi worker and helper can be key people for spreading awareness in the village.

42. Preparedness at Govt level, NGO level, CBO level and the community level:
    No preparedness.

43. Loss estimation and insurance
    There is no mechanism of loss estimation in Odada and people have not taken any insurance policies.

ANNEXURE VIII

Estimated Building damage and Human Casualties in Narendranagar Block

Name of Village	Number of Buildings with Damage Grades					Buildings To be Vacated	ShelterLess Population	Inj 1	Inj 2	Inj 3	Inj 4	SRI
	G5	G4	G3	G2	G1							
Aampata	0	4	24	32	18	4	17	1	1	1	1	I
Aamsari	1	2	4	3	1	3	13	0	0	1	1	I
Aamsarigaon	6	22	29	15	2	28	132	5	5	7	7	II
Aandarfigaon	1	8	13	8	1	9	46	2	2	2	2	II
Adali Banali	0	3	8	8	4	3	14	0	0	1	1	I
Adali Jakholi	0	4	9	6	2	4	22	1	1	1	1	I
Adwani	1	9	22	21	7	10	56	2	2	3	3	I
Agar	4	30	62	42	6	35	167	6	6	8	8	II
Aoni	7	24	23	7	1	32	178	7	7	10	10	III
Ars	2	10	13	6	1	12	62	2	2	3	3	II
Atali	0	15	30	21	7	15	82	2	2	4	4	I
Atali Malli	1	7	10	5	1	8	42	1	1	2	2	II
Atali Talli	2	9	12	6	1	10	50	2	2	3	3	II
Badeda Malla	0	3	6	4	1	3	15	0	0	1	1	I
Badeda Talla	6	16	16	7	0	22	129	5	5	7	7	III
Badir	0	8	9	6	3	8	48	1	1	2	2	II
Badkot	3	9	7	2	0	12	74	3	3	4	4	IV
Bagar	0	2	5	5	2	2	9	0	0	0	0	I
Bairaigaon	14	40	39	18	0	54	352	13	13	20	20	III
Bairola	2	18	59	72	29	20	84	3	3	4	4	I
Baksari	0	1	8	11	6	1	7	0	0	0	0	I
Bamangaon	2	17	56	68	27	19	94	3	3	5	5	I
Bamankhola	1	2	2	1	0	3	14	1	1	1	1	III
Banali	8	25	24	7	1	33	144	5	5	8	8	III
Banali Malli	0	2	7	6	3	2	12	0	0	1	1	I
Banali Talli	3	9	7	2	0	13	59	2	2	3	3	IV
Banskatal	13	38	36	18	7	51	286	11	11	16	16	III
Barathali	0	3	4	3	1	3	19	1	1	1	1	II
Basuee	4	15	20	10	2	19	100	4	4	5	5	II
Bawani	0	27	56	39	13	27	170	5	5	8	8	I
Bemar	1	3	4	2	0	4	25	1	1	1	1	II
Berni Badi	3	14	23	17	5	17	77	3	3	4	4	II
Berni Chhoti	2	8	13	9	3	9	49	2	2	3	3	II
Bhadni	3	22	36	22	3	25	119	4	4	6	6	II
Bhaind	1	4	3	1	0	5	28	1	1	2	2	III
Bhainsark	6	17	13	4	0	23	152	6	6	9	9	IV
Bhaintan	4	29	59	40	5	33	133	4	4	7	7	II
Bhairgad	11	13	9	4	0	24	164	7	7	11	11	V
Bhandargaon	2	14	30	26	8	16	63	2	2	3	3	I
Bhangala	10	24	14	8	1	35	191	7	7	11	11	IV
Bhatgaon	3	17	23	13	0	20	113	4	4	6	6	II
Bhatoli	1	6	9	6	1	6	31	1	1	2	2	II
Bhatoli	2	6	6	2	0	8	48	2	2	3	3	III
Bhingarki A	5	16	15	5	0	21	121	4	4	7	7	III
Bhingarki B	6	18	13	4	0	24	128	5	5	7	7	IV
Bhutli	1	8	13	8	1	9	42	1	1	2	2	II
Bidon	0	5	15	18	7	5	27	1	1	1	1	I
Bugala	0	7	20	19	9	7	32	1	1	1	1	I
Chaldgaon	5	13	13	6	0	18	77	3	3	4	4	III
Chameli	0	38	44	30	14	38	191	6	6	9	9	II
Chamolgaon	7	20	15	5	0	27	110	4	4	6	6	IV
Chaumpa	5	18	24	12	2	23	86	3	3	5	5	II
Chaundli	0	1	4	4	2	1	6	0	0	0	0	I
Chhatendi	1	2	2	1	0	3	24	1	1	1	1	III
Chidiyali M	0	2	10	14	8	2	9	0	0	0	0	I
Chidiyali T	1	4	6	3	0	5	23	1	1	1	1	II
Chilogi	4	12	12	4	0	16	87	3	3	5	5	III
Dadua	1	5	10	9	3	5	25	1	1	1	1	I
Dagar	7	19	14	5	0	26	173	7	7	10	10	IV
Dandeli	2	15	25	15	2	17	97	3	3	5	5	II
Dangoo	4	8	5	3	0	12	49	2	2	3	3	IV
Daur	15	43	33	10	1	58	357	14	14	20	20	IV
Dawra	3	10	13	7	1	13	66	2	2	4	4	II

Name of Village	Number of Buildings with Damage Grades G5	G4	G3	G2	G1	Buildings To Be Vacated	ShelterLess Population	Inj 1	Inj 2	Inj 3	Inj 4	SRI
Dhaigala	0	2	2	1	1	2	13	0	0	1	1	I
Dhalwala	0	126	783	1035	581	126	572	17	17	26	26	I
Dharkot	0	5	6	4	2	5	32	1	1	1	1	II
Dhouldhar	1	3	5	3	0	4	19	1	1	1	1	II
Digwali	0	5	11	8	3	5	30	1	1	1	1	I
Diuli	11	26	15	9	1	38	229	9	9	13	13	IV
Fafrangaon	0	5	9	5	2	5	25	1	1	1	1	II
Falsari	1	11	27	26	9	13	72	2	2	4	4	I
Fart	10	24	14	8	1	34	185	7	7	11	11	IV
Gadil	1	9	16	9	1	11	50	2	2	3	3	II
Gaindi	4	14	18	9	1	17	100	4	4	5	5	II
Gangsali	0	13	37	36	17	13	76	2	2	3	3	I
Gangsarigaon	4	11	8	3	0	15	74	3	3	4	4	IV
Ghigud	20	47	27	16	2	68	409	16	16	24	24	IV
Ghorsad	0	8	17	12	4	8	38	1	1	2	2	I
Ghugtani M	0	5	11	8	2	5	29	1	1	1	1	I
Ghugtani T	0	2	10	14	8	2	11	0	0	0	0	I
Gudangaon	0	1	2	2	1	1	4	0	0	0	0	I
Gumalgaon	1	5	17	20	8	6	26	1	1	1	1	I
Guriyali Badi	0	2	13	17	9	2	10	0	0	0	0	I
Guriyali C	0	4	9	6	2	4	17	1	1	1	1	I
Gwad	3	10	10	3	0	13	85	3	3	5	5	III
Hadisera	0	8	13	8	3	8	42	1	1	2	2	II
Jakholi	0	7	41	55	31	7	32	1	1	1	1	I
Jamola	9	24	23	12	4	33	162	6	6	9	9	III
Jamri	0	2	8	9	4	3	13	0	0	1	1	I
Jamri Katal	2	5	3	1	0	7	42	2	2	2	2	IV
Jangleth	2	7	6	2	0	9	57	2	2	3	3	III
Jaykot	0	6	39	52	29	6	33	1	1	1	1	I
Jimangaon	0	1	5	7	4	1	4	0	0	0	0	I
Kafolgaon	1	4	10	10	3	5	27	1	1	1	1	I
Kakhil	3	11	15	8	1	14	93	3	3	5	5	II
Kakhoor B	11	13	9	4	0	25	142	6	6	9	9	V
Kakhoor KP	0	16	19	13	6	16	88	3	3	4	4	II
Kandarigaon S	4	12	9	3	0	16	102	4	4	6	6	IV
Kandarigaon B	0	2	8	9	4	3	10	0	0	1	1	I
Kandchak	0	0	0	0	0	0	0	0	0	0	0	I
Kasmoli	8	23	22	10	0	31	171	6	6	10	10	III
Katkod	5	11	8	2	0	16	96	4	4	6	6	IV
Kaud	0	2	3	2	0	2	8	0	0	0	0	I
Kensur	0	3	21	28	16	3	14	0	0	1	1	I
Khakar	13	15	10	5	0	28	140	6	6	9	9	V
Khanana	7	42	70	42	7	48	209	7	7	11	11	II
Kharki	8	19	11	6	1	28	166	6	6	10	10	IV
Kharsad	0	6	39	51	29	6	25	1	1	1	1	I
Khatiyad	14	17	12	5	0	31	154	7	7	10	10	V
Khedagad	3	13	17	8	1	16	91	3	3	5	5	II
Khola	1	4	6	3	1	5	25	1	1	1	1	II
Kirada	1	7	23	28	11	8	36	1	1	2	2	I
Kodarna	29	34	23	11	0	62	371	16	16	24	24	V
Kodiyala	0	1	5	6	3	1	4	0	0	0	0	I
Kol	0	8	9	6	3	8	46	1	1	2	2	II
Kot	1	7	24	29	12	8	37	1	1	2	2	I
Kotar	7	21	20	10	4	29	170	6	6	10	10	III
Koti Kharsad	1	6	18	22	9	6	31	1	1	2	2	I
Koti Rampur	2	11	24	21	6	13	76	3	3	4	4	I
Kudi	29	34	23	11	0	62	295	13	13	19	19	V
Kuee	6	14	8	5	1	20	104	4	4	6	6	IV
Kukhai Malli	2	5	4	2	1	6	42	2	2	2	2	III
Kukhai Talli	6	17	16	8	3	23	122	5	5	7	7	III
Kumali	2	15	24	15	2	17	94	3	3	5	5	II
Kyara	0	27	32	22	10	27	185	6	6	8	8	II

Name of	Number of Buildings with Damage Grades					Buildings To	ShelterLess	Inj 1	Inj 2	Inj 3	Inj 4	SRI
Village	G5	G4	G3	G2	G1	Be Vacated	Population					
Kyarki	0	6	12	9	3	6	40	1	1	2	2	I
Lamoli	9	11	7	3	0	20	62	3	3	4	4	V
Laser	0	4	12	14	6	4	22	1	1	1	1	I
Lava	2	23	75	91	36	25	111	4	4	5	5	I
Lodsi	8	32	42	21	3	39	251	9	9	14	14	II
Loyal	10	38	51	26	3	48	287	10	10	15	15	II
Maanghera	2	8	11	5	1	10	57	2	2	3	3	II
Maidhar	2	14	19	11	0	17	69	2	2	4	4	II
Majiyadi	13	37	28	9	1	51	356	14	14	20	20	IV
Malas	4	5	3	2	0	9	51	2	2	3	3	V
Manderigaon	6	25	33	16	2	31	154	6	6	8	8	II
Mangaon	1	9	19	16	5	10	50	2	2	3	3	I
Mansari	0	3	5	3	0	3	21	1	1	1	1	II
Maroda	0	2	6	8	3	2	12	0	0	1	1	I
Mathiyali	25	69	52	16	2	93	601	23	23	34	34	IV
Matiyala	5	9	5	2	0	14	85	4	4	5	5	IV
Matola	0	0	0	0	0	0	3	0	0	0	0	I
Maun	40	46	32	15	0	86	442	19	19	29	29	V
Mayangaon	0	1	7	10	6	1	6	0	0	0	0	I
Medwa	0	4	6	4	1	4	20	1	1	1	1	II
Mindath	33	93	71	22	2	126	704	27	27	40	40	IV
Mundala	6	23	30	15	2	29	151	5	5	8	8	II
Nail	1	6	9	6	1	6	36	1	1	2	2	II
Nala Kan	0	2	8	9	4	3	13	0	0	1	1	I
Nasogi	0	5	16	15	7	5	26	1	1	1	1	I
Nauga	1	7	22	27	11	7	34	1	1	2	2	I
Naur	11	24	17	5	0	35	204	8	8	12	12	IV
Nayee	12	50	66	33	4	62	361	13	13	20	20	II
Neer	16	37	21	12	2	53	287	11	11	17	17	IV
Niger	1	8	27	33	13	9	38	1	1	2	2	I
Odada	26	30	20	9	0	55	298	13	13	20	20	V
Odarkhet	4	8	6	2	0	12	68	3	3	4	4	IV
Pajaigaon	9	24	18	6	1	32	194	7	7	11	11	IV
Pali	4	25	42	25	4	29	128	4	4	7	7	II
Pali Kakadsri	1	8	17	15	5	9	42	1	1	2	2	I
Palkot	1	5	17	21	8	6	24	1	1	1	1	I
Palogi	0	3	9	11	4	3	16	1	1	1	1	I
Pasar	4	11	10	5	0	14	66	2	2	4	4	III
Pata	1	4	9	6	1	5	27	1	1	1	1	II
Pater	1	2	2	1	0	3	23	1	1	1	1	III
Pateshri	1	5	7	3	0	6	27	1	1	1	1	II
Pathau	3	8	8	2	0	11	66	2	2	4	4	III
Paweth	0	6	9	6	2	6	28	1	1	1	1	II
Payalgaon	0	4	15	18	7	5	22	1	1	1	1	I
Pendars	0	14	16	11	5	14	64	2	2	3	3	II
Pildi	10	32	30	9	1	42	261	10	10	15	15	III
Pipleth	10	36	47	24	4	46	217	8	8	12	12	II
Pokhri Mangn	0	4	12	15	6	4	13	0	0	1	1	I
Pokhri Odada	1	4	5	2	0	5	25	1	1	1	1	II
Pungaddu	1	3	2	1	0	4	22	1	1	1	1	IV
Purvala	0	13	20	13	4	13	72	2	2	3	3	II
Rampur	2	14	31	27	8	16	69	2	2	4	4	I
Ranakot	9	57	75	42	0	66	343	12	12	18	18	II
Raundeli	12	34	26	8	1	46	198	8	8	11	11	IV
Sailkani	10	27	20	6	1	36	228	9	9	13	13	IV
Sain	0	13	21	13	4	13	65	2	2	3	3	II
Sakanyani	2	11	15	8	0	13	59	2	2	3	3	II
Salamkhet	0	1	1	0	0	1	5	0	0	0	0	I
Saldogi	11	31	23	7	1	42	211	8	8	12	12	IV
Sarswad	1	5	6	3	0	6	34	1	1	2	2	II
Sasman	23	53	30	18	3	76	422	16	16	25	25	IV
Saund	2	10	17	10	2	12	52	2	2	3	3	II
Saundi	0	1	4	4	2	1	7	0	0	0	0	I

Name of Village	Number of Buildings with Damage Grades					Buildings To Be Vacated	ShelterLess Population	Inj 1	Inj 2	Inj 3	Inj 4	SRI
	G5	G4	G3	G2	G1							
Sautiyalgaon	0	4	10	10	5	4	18	1	1	1	1	I
Semlikatal	0	1	3	2	1	1	5	0	0	0	0	I
Sera	0	1	3	4	1	1	7	0	0	0	0	I
Shivpuri	0	2	13	18	10	2	11	0	0	0	0	I
Shrikot	8	25	28	13	2	32	131	5	5	7	7	III
Simtali	0	2	15	20	11	2	12	0	0	1	1	I
Soni KP	11	30	23	7	1	41	245	9	9	14	14	IV
Soni Ukhel	0	3	11	14	5	4	18	1	1	1	1	I
Soundadi	1	8	18	18	6	9	35	1	1	2	2	I
Sunarkot	3	15	21	11	2	18	81	3	3	4	4	II
Sweer	5	28	39	20	4	32	150	5	5	8	8	II
Syud	7	24	23	7	1	31	183	7	7	10	10	III
Tachhla	2	8	10	5	1	10	53	2	2	3	3	II
Talai Odada	8	9	6	3	0	17	98	4	4	6	6	V
Talai Soni	8	17	12	4	0	25	133	5	5	8	8	IV
Tamiyar	3	8	8	4	0	11	62	2	2	4	4	III
Tapowan	0	26	163	215	121	26	116	3	3	5	5	I
Than	3	19	21	10	5	22	118	4	4	6	6	II
Thanyul	0	14	29	21	7	14	67	2	2	3	3	I
Thapliyalgaon	1	8	11	5	1	9	48	2	2	2	2	II
Timli	41	96	55	32	5	137	940	37	37	55	55	IV
Tipli	1	5	17	21	8	6	30	1	1	1	1	I
Tipri	0	14	16	11	5	14	61	2	2	3	3	II
Udkhanda	3	10	9	5	2	13	52	2	2	3	3	III
Ukhel	1	6	19	23	9	6	27	1	1	1	1	I
Vandan	1	3	2	1	0	5	30	1	1	2	2	IV
Total 214 Villages	894	3124	4802	3907	1490	4023	46154	801	801	1201	1201	

Name of Market Town	Number of Buildings with damage Grades					Buildings To be Vacated	ShelterLess Population	Inj 1	Inj 2	Inj 3	Inj 4	SRI
	G5	G4	G3	G2	G1							
Agrakhal	10	36	60	56	9	46	230	8	8	13	13	II
Bedadhar	8	26	44	41	6	34	188	7	7	10	10	II
Byasi	0	25	65	99	65	25	103	3	3	5	5	I
Chaka	6	40	85	113	61	46	239	8	8	12	12	I
Duadhar	10	34	57	53	8	44	204	7	7	11	11	II
Fakot	9	33	54	51	8	42	176	6	6	10	10	II
Gaja	25	99	192	211	93	124	650	23	23	35	35	II
Gheradhar	7	25	42	40	6	33	153	6	6	8	8	II
Gular	0	68	172	263	172	68	287	9	9	13	13	I
Hindolakhal	11	38	63	59	9	49	220	8	8	12	12	II
Jajal	6	25	49	54	24	32	149	5	5	8	8	II
Kaudiyala	0	50	129	197	129	50	193	6	6	9	9	I
Khadi	7	28	54	60	26	35	164	6	6	9	9	II
Kunjapuri	6	21	34	32	5	26	112	4	4	6	6	II
Muni-ki-reti	0	157	400	612	400	157	788	24	24	35	35	I
Narendranagar	76	265	442	417	63	341	1432	53	53	79	79	II
Pav-ki-devi	6	22	36	34	5	28	141	5	5	8	8	II
Market Towns 17	187	992	1979	2393	1089	1179	5425	189	189	283	283	
TOTAL BLOCK	**1081**	**4116**	**6781**	**6300**	**2579**	**5202**	**51579**	**990**	**990**	**1484**	**1484**	

ANNEXURE IX

Proposed Organizational Structure for Narendranagar Block

Control Centre	Relief Centre	Name of Villages	Pop Total	Accessibility Category	Inj 1	Inj 2	Inj 3	Inj 4
Gaja	Gaja	Gaja	3250	A1	23	35	35	23
		Adwani	331	A1	2	3	3	2
		Total	**3581**		**25**	**38**	**38**	**25**
	Odada	Odada	459	A4	13	20	20	13
		Banali Talli	104	A4	2	3	3	2
		Lamoli	95	A4	3	4	4	3
		Pokhri Odada	67	A2	1	1	1	1
		Banali Malli	94	A2	0	1	1	0
		Talai Odada	151	A4	4	6	6	4
		Tamiyar	128	A2	2	4	4	2
		Dhaigala	42	A5	0	1	1	0
		Kandchak	0	A5	0	0	0	0
		Pasar	136	A2	2	4	4	2
		Berni Badi	281	A2	3	4	4	3
		Berni Chhoti	177	A2	2	3	3	2
		Aamsari	46	A2	0	1	1	0
		Gangsarigaon	130	A4	3	4	4	3
		Raundeli	348	A4	8	11	11	8
		Hadisera	166	A4	1	2	2	1
		Total	**2424**		**45**	**68**	**68**	**45**
	Mathiyali	Mathiyali	1055	A4	23	34	34	23
		Majiyadi	625	A4	14	20	20	14
		Vandan	50	A5	1	2	2	1
		Pungaddu	36	A5	1	1	1	1
		Total	**1766**		**38**	**57**	**57**	**38**
Gular	Gular	Gular	2865	A1	9	13	13	9
		Total	**2865**		**9**	**13**	**13**	**9**
	Loyal	Lodsi	670	A2	9	14	14	9
		Loyal	764	A2	10	15	15	10
		Mundala	402	A2	5	8	8	5
		Nasogi	209	A2	1	1	1	1
		Gangsali	609	A2	2	3	3	2
		Chaundli	45	A2	0	0	0	0
		Manderigaon	411	A2	6	8	8	6
		Bugala	252	A2	1	1	1	1
		Total	**3362**		**35**	**52**	**52**	**35**
	Mindath	Mindath	1235	A4	27	40	40	27
		Purvala	287	A4	2	3	3	2
	Byasi	Byasi	1026	A1	3	5	5	3
		Total	**1026**		**3**	**5**	**5**	**3**
	Kaudiyala	Kaudiyala	5304	A1	6	9	9	6
		Sasman	704	A5	16	25	25	16
		Badir	159	A5	1	2	2	1
		Atali	412	A3	2	4	4	2
		Simtali	233	A1	0	1	1	0
		Total	**6812**		**27**	**40**	**40**	**27**

Control Centre	Relief Centre	Name of Villages	Pop Total	Accessibility Category	Inj 1	Inj 2	Inj 3	Inj 4
Bedadhar	Bedadhar	Bedadhar	695	A2	7	10	10	7
		Sailkani	400	A4	9	13	13	9
		Bairaigaon	723	A2	13	20	20	13
		Chameli	635	A5	6	9	9	6
		Pajaigaon	340	A4	7	11	11	7
		Total	2793		42	63	63	42
	Pav-ki-devi	Pav-ki-devi	521	A2	5	8	8	5
		Nayee	963	A2	13	20	20	13
		Maanghera	153	A2	2	3	3	2
		Total	1637		20	30	30	20
	Bhangala	Bhangala	318	A5	7	11	11	7
		Kyara	616	A5	6	8	8	6
		Jamola	352	A5	6	9	9	6
		Kotar	369	A5	6	10	10	6
		Kakhoor KP	294	A5	3	4	4	3
		Total	1949		28	42	42	28
	Banskatal	Banskatal	622	A5	11	16	16	11
		Bhairgad	253	A5	7	11	11	7
		Ghigud	681	A5	16	24	24	16
		Tipri	204	A5	2	3	3	2
		Total	1760		36	54	54	36
Agrakhal	Agrakhal	Agrakhal	850	A1	8	13	13	8
		Agar	697	A1	6	8	8	6
		Bhaind	54	A3	1	2	2	1
		Chilogi	170	A3	3	5	5	3
		Bhingarki Aagar	237	A3	4	7	7	4
		Semlikatal	23	A3	0	0	0	0
		Fart	308	A5	7	11	11	7
		Syud	359	A3	7	10	10	7
		Saldogi	370	A4	8	12	12	8
		Total	3068		45	67	67	45
	Diuli	Diuli	381	A5	9	13	13	9
		Kharki	277	A5	6	10	10	6
		Kakhil	249	A2	3	5	5	3
		Kasmoli	350	A2	6	10	10	6
		Chaldgaon	157	A2	3	4	4	3
		Total	1414		28	42	42	28
	Kukhai Talli	Kukhai Talli	265	A5	5	7	7	5
		Kukhai Malli	91	A5	2	2	2	2
		Total	356		7	9	9	7
	Duadhar	Duadhar	755	A1	7	11	11	7
		Bhainsark	266	A4	6	9	9	6
		Kandarigaon	179	A1	0	1	1	0
		Soni Ukhel	429	A1	1	1	1	1
		Gwad	166	A3	3	5	5	3
		Banali	282	A3	5	8	8	5
		Sarswad	91	A2	1	2	2	1
		Bhatoli	94	A3	2	3	3	2
		Pildi	512	A3	10	15	15	10
		Bhingarki Badeda	224	A4	5	7	7	5
		Total	2998		40	60	60	40

Control Centre	Relief Centre	Name of Villages	Pop Total	Accessibility Category	Inj 1	Inj 2	Inj 3	Inj 4
Chaka	Chaka	Chaka	1590	A1	8	12	12	8
		Paweth	112	A4	1	1	1	1
		Soundadi	208	A1	1	2	2	1
		Kensur	280	A1	0	1	1	0
		Guriyali Badi	192	A1	0	0	0	0
		Palkot	222	A1	1	1	1	1
		Guriyali Chhoti	84	A3	1	1	1	1
		Medwa	78	A4	1	1	1	1
		Jakholi	640	A1	1	1	1	1
		Kirada	325	A1	1	2	2	1
		Adali Banali	109	A2	0	1	1	0
		Khola	74	A4	1	1	1	1
		Sain	261	A4	2	3	3	2
		Gumalgaon	232	A1	1	1	1	1
		Lava	1013	A1	4	5	5	4
		Bairola	767	A1	3	4	4	3
		Total	6187		25	38	38	25
	Pokhri	Pokhri Mangaon	122	A1	0	1	1	0
		Palogi	146	A1	1	1	1	1
		Bamangaon	852	A1	3	5	5	3
		Bamankhola	28	A2	1	1	1	1
		Mangaon	249	A2	2	3	3	2
		Sautiyalgaon	146	A2	1	1	1	1
		Fafrangaon	98	A4	1	1	1	1
		Matola	8	A3	0	0	0	0
		Thanyul	335	A3	2	3	3	2
		Kot	332	A1	1	2	2	1
		Kandarigaon	94	A4	4	6	6	4
		Maidhar	191	A1	2	4	4	2
		Payalgaon	199	A1	1	1	1	1
		Aamsarigaon	348	A3	5	7	7	5
		Pendars	214	A5	2	3	3	2
		Dandeli	336	A3	3	5	5	3
		Falsari	426	A1	2	4	4	2
		Jaykot	650	A1	1	1	1	1
		Aandarfigaon	160	A3	2	2	2	2
		Bhatoli	106	A3	1	2	2	1
		Dawra	174	A3	2	4	4	2
		Total	5214		36	54	54	36
	Maroda	Maroda	108	A1	0	1	1	0
		Niger	346	A1	1	2	2	1
		Khanana	720	A3	7	11	11	7
		Dhouldhar	53	A1	1	1	1	1
		Sera	61	A1	0	0	0	0
		Bhadni	411	A3	4	6	6	4
		Total	1699		14	21	21	14
	Ranakot	Ranakot	953	A1	12	18	18	12
		Shrikot	304	A4	5	7	7	5
		Gadil	174	A3	2	3	3	2
		Thapliyalgaon	141	A4	2	2	2	2
		Total	1572		20	30	30	20

Control Centre	Relief Centre	Name of Villages	Pop Total	Accessibility Category	Inj 1	Inj 2	Inj 3	Inj 4
Chaka	Saundi	Saundi	64	A1	0	0	0	0
		Pali	441	A3	4	7	7	4
		Mayangaon	124	A1	0	0	0	0
		Jamri	120	A1	0	1	1	0
		Gheradhar	565	A2	6	8	8	6
		Baksari	135	A1	0	0	0	0
		Digwali	152	A3	1	1	1	1
		Gudangaon	37	A1	0	0	0	0
		Sakanyani	165	A1	2	3	3	2
		Total	1803		14	21	21	14
	Nauga	Nauga	307	A1	1	2	2	1
		Bhutli	144	A3	1	2	2	1
		Ghorsad	191	A3	1	2	2	1
		Laser	199	A1	1	1	1	1
		Nail	125	A3	1	2	2	1
		Soni KP	164	A4	9	14	14	9
		Ukhel	244	A1	1	1	1	1
		Koti Kharsad	280	A1	1	2	2	1
		Mansari		A3	1	1	1	1
		Kharsad	505	A1	1	1	1	1
		Bhatgaon	313	A1	4	6	6	4
		Jimangaon	72	A1	0	0	0	0
		Saund	178	A3	2	3	3	2
		Total	2722		24	36	36	24
Tapowan	Tapowan	Tapowan	2320	A1	3	5	5	3
		Shivpuri	222	A1	0	0	0	0
		Ghugtani Talli	217	A1	0	0	0	0
		Ghugtani Malli	144	A3	1	1	1	1
		Jamri Katal	68	A3	2	2	2	2
		Kyarki	200	A3	1	2	2	1
		Bawani	852	A3	5	8	8	5
		Total	4023		13	19	19	13
	Neer	Neer	479	A5	11	17	17	11
		Dharkot	106	A5	1	1	1	1
		Dangoo	82	A5	2	3	3	2
		Kuee	173	A5	4	6	6	4
		Matiyala	130	A4	4	5	5	4
		Kakhoor Badeda	219	A5	6	9	9	6
		Total	1189		28	42	42	28
	Muni-ki-reti	Muni-ki-reti	7880	A1	24	35	35	24
		Total	7880		24	35	35	24
	Dhalwala	Dhalwala	11444	A1	17	26	26	17
		Total	11444		17	26	26	17
	Timli	Timli	1566	A5	37	55	55	37
		Total	1566		37	55	55	37
Bhopar (Dehradun District)	Kodarna	Kodarna	571	A5	16	24	24	16
		Kol	152	A5	1	2	2	1
		Total	723		17	26	26	17

Control Centre	Relief Centre	Name of Villages	Pop Total	Accessibility Category	Inj 1	Inj 2	Inj 3	Inj 4
Fakot	Fakot	Fakot	650	A1	6	10	10	6
		Bhaintan	555	A1	4	7	7	4
		Pata	111	A1	1	1	1	1
		Jangleth	112	A3	2	3	3	2
		Katkod	156	A3	4	6	6	4
		Odarkhet	110	A3	3	4	4	3
		Tachhla	140	A3	2	3	3	2
		Malas	78	A5	2	3	3	2
		Barathali	62	A5	1	1	1	1
		Bemar	67	A3	1	1	1	1
		Basuee	263	A3	4	5	5	4
		Naur	332	A3	8	12	12	8
		Badeda Malla	76	A3	0	1	1	0
		Total	2712		38	57	57	38
	Khadi	Jajal	745	A1	5	8	8	5
		Khadi	819	A1	6	9	9	6
		Aampata	340	A1	1	1	1	1
		Gaindi	262	A3	4	5	5	4
		Dadua	124	A2	1	1	1	1
		Sweer	441	A4	5	8	8	5
		Chidiyali Malli	172	A1	0	0	0	0
		Bhandargaon	316	A2	2	3	3	2
		Chidiyali Talli	65	A1	1	1	1	1
		Kafolgaon	159	A1	1	1	1	1
		Pali Kakadsari	208	A2	1	2	2	1
		Rampur	346	A2	2	4	4	2
		Koti Rampur	378	A2	3	4	4	3
		Nala Kanchanpur	120	A1	0	1	1	0
		Bidon	241	A1	1	1	1	1
		Kaud	27	A3	0	0	0	0
		Tipli	274	A1	1	1	1	1
		Sunarkot	237	A4	3	4	4	3
		Than	311	A5	4	6	6	4
		Kumali	325	A3	3	5	5	3
		Chaumpa	225	A3	3	5	5	3
		Pipleth	572	A3	8	12	12	8
		Udkhanda	113	A5	2	3	3	2
		Total	6820		57	86	86	57
	Maun	Salamkhet	12	A5	0	0	0	0
		Atali Talli	146	A4	2	3	3	2
		Atali Malli	123	A4	1	2	2	1
		Khatiyad	237	A5	7	10	10	7
		Kudi	454	A5	13	19	19	13
		Maun	680	A5	19	29	29	19
		Khakar	216	A5	6	9	9	6
		Total	1868		49	73	73	49

Control Centre	Relief Centre	Name of Villages	Pop Total	Accessibility Category	Inj 1	Inj 2	Inj 3	Inj 4
Narendranagar	Narendranagar	Narendranagar	5304	A1	53	79	79	53
		Daur	626	A4	14	20	20	14
		Talai Soni	217	A3	5	8	8	5
		Aoni	349	A3	7	10	10	7
		Pathau		A3	2	4	4	2
		Chhatendi		A3	1	1	1	1
		Total	6496		81	122	122	81
	Hindolakhal	Hindolakhal	815	A1	8	12	12	8
		Bagar	74	A2	0	0	0	0
		Dagar	303	A4	7	10	10	7
		Ars	165	A2	2	3	3	2
		Badeda Talla	265	A2	5	7	7	5
		Pater	47	A2	1	1	1	1
		Pateshri	72	A2	1	1	1	1
		Badkot	129	A4	3	4	4	3
		Adali Jakholi	109	A3	1	1	1	1
		Khedagad	243	A2	3	5	5	3
		Chamolgaon	193	A4	4	6	6	4
		Total	2415		35	52	52	35
	Kunjapuri	Kunjapuri	415	A2	4	6	6	4
		Total	415		4	6	6	4

Inj 1 – Dead or Unsavable
Inj 2 – Life threatening cases requiring immediate medical attention
Inj 3 – Injury requiring hospital treatment
Inj 4 – Light injury not requiring hospital treatment

ANNEXURE X

PROFORMA FOR ASSESSMENT OF DAMAGE AFTER EARTHQUAKES

HOUSEHOLD DAMAGE ASSESSMENT

Building damage assessment (Put✓)

1. Use of Building
   Public: ______, Private: ______
2. Type of structure and construction material
   Structure A: ________, Structure B: _________, Structure C: _________
3. Damage Grade
   Grade 1: ____, Grade 2: ____, Grade 3: ___, Grade 4: ____, Grade 5: ____
4. Weather the building is suitable for habitation or not
   Yes: ____, No: ______.
5. Food is available with the household: Yes:_________, No: ________

Casualty Assessment (Write Number)

1. Trapped persons: __________
2. Dead or unsavable: __________
3. Life threatening Injuries __________
4. Injuries requiring hospital treatment __________
5. Light injuries not necessitating hospital treatment __________
6. Homeless __________
7. Affected children up to 5 years age __________
8. Orphans __________
9. Traumatized Population __________

VILLAGE DAMAGE AND NEEDS ASSESSMENT

Food and Nutrition

1. Food is available at the market: Yes:________, No: ________
2. Food is available with government agencies: Yes:________, No: ________
3. Storage facilities at the affected sites: Adequate: _______, Inadequate: ________
4. Availability of cooking utensils at household level: Adequate: _____, Inadequate: ____
5. Community kitchen for number of persons: ________
6. Availability of energy for cooking: Adequate: ____, Inadequate: ____
7. Other important requirements: ____
8. Other important information about local coping mechanisms: ____________________

Health

1. Infrastructure damage: Low: _______, Moderate: _________, High: ________
2. Facilities available for emergencies: ___________________________
3. Condition of equipments: ____________________________________
4. Staff affected: ____
5. Availability of medicine / drugs: Adequate: ________, Inadequate: ___________
6. Supply of stock: Adequate: _________, Inadequate: ___________
7. Vaccination / Immunization: ______________________________
8. Major health problems: __________________________________
9. Other specific health problems needing immediate attention: ____________________
10. Number of deaths after earthquake: ____________________
11. Main causes of death: ______________________________

Water Supply and Sanitation

1. Type of water supply system in village: ______________
2. Water treatment facilities: __________________________
3. Damage to supply system: Yes: _______, No: __________
4. Supply of disinfectants: ____________________________
5. Cleaning of water body: Required: _________, Not Required: ____________
6. Availability and use of toilets: Adequate: _________, Inadequate: _____________

Temporary shelters

1. Damage to public building identified for temporary shelter
   Grade 1: ____, Grade 2: ____, Grade 3: ____, Grade 4: ____, Grade 5: ____
2. Availability of temporary shelters: Adequate: ________, Inadequate: ____________
3. Requirement of temporary shelters for persons: _______________

Critical Infrastructure

1. Road Network: Disrupted: ________, Not Disrupted: ________
2. Transportation Facilities: Available: ___, Not Available: ___, Requirement: ______
3. Telecommunications networking status: Disrupted: ______, Not Disrupted: ______
4. Electricity: Disrupted: ________, Not Disrupted: ________
5. Government buildings: ____
6. Damage to industries: ____

Response:

	Type of Assistance		
	Government	NGOs	CBOs
Local			
National			
International			

Local Coping Mechanisms: ____

Priority Needs:

1. Clothing
   Children: __________No.,
   Adult Male: ________No
   Female: ______No.
   Winter Clothing: _______ No.
2. Blankets: _________ No.

3. Food Item: Quantities / Specifications
   Type of food:
   Baby Food: _______________Kg
   Specialized Food:
   Wheat Flour ________kg
   Rice: ________kg
   Sugar: ________kg
   Oil: ________li

Others: _______kg, ________kg, _______kg

4. Water

   Portable water: _______ li

   Chlorine powder and disinfect: _________gm

5. Others:

   ____

   ____

Table: Preliminary Damage Assessment Performa

Type	Description	Number of buildings	Expected Number of trapped persons	Expected Number of Casualties			
				I1	I2	I3	I4
G1	Total collapse of buildings						
G2	Gaps in walls; parts of buildings may collapse; separate parts of the building lose their cohesion; inner walls and filled – in walls of the frame collapse						
G3	Large and deep cracks in walls, fall of chimneys						
G4	Small cracks in walls; fall of fairly large pieces of plaster; pan tiles slip off; cracks in chimneys; parts of chimneys fall down.						
G5	Fine cracks in plaster; fall of small pieces of plaster						
Total							

I1- Dead or Unsavable,

I2- Life threatening injuries,

I3- Injuries requiring hospital treatment,

I4- Light injuries not requiring hospital treatment

ANNEXURE XI

Emergency Resource Needs

Name	Persons to be Trained for Damage Assessment	Number of Rescue Persons	Number of Rescue Kits	Number of Strechers	Number of Body Bags	Number of Blankets	Clothing Requirement (Persons)	Number of Tents	Number of Sleeping Bags (Persons)
Aampata	2	4	1	2	3	16	16	2	16
Aamsari	1	3	1	2	2	12	12	3	12
Aamsarigaon	2	28	9	3	5	120	120	22	120
Aandarfigaon	2	9	3	2	3	42	42	11	42
Adali Banali	1	3	1	2	2	13	13	5	13
Adali Jakholi	1	4	1	2	3	20	20	7	20
Adwani	1	10	3	3	3	52	52	10	52
Agar	3	35	12	3	6	153	153	41	153
Aoni	2	32	11	2	7	161	161	22	161
Ars	2	12	4	3	2	56	56	9	56
Atali	1	15	5	3	2	76	76	25	76
Atali Malli	2	8	3	2	2	38	38	6	38
Atali Talli	2	10	3	3	3	45	45	7	45
Badeda Malla	1	3	1	2	2	14	14	5	14
Badeda Talla	1	22	7	3	5	117	117	14	117
Badir	2	8	3	2	2	44	44	3	44
Badkot	2	12	4	3	3	67	67	11	67
Bagar	1	2	1	2	2	9	9	4	9
Bairaigaon	3	54	18	4	23	319	319	50	319
Bairola	3	20	7	3	3	77	77	30	77
Baksari	1	2	1	2	2	6	6	5	6
Bamangaon	2	19	6	3	3	86	86	33	86
Bamankhola	1	3	1	2	3	12	12	0	12
Banali	2	33	11	3	5	130	130	23	130
Banali Malli	1	2	1	2	2	11	11	4	11
Banali Talli	2	13	4	3	2	54	54	5	54
Banskatal	3	51	17	3	23	259	259	39	259
Barathali	1	3	1	2	3	17	17	4	17
Basuee	1	19	6	2	4	91	91	19	91
Bawani	3	27	9	3	5	158	158	51	158
Bemar	1	4	1	2	3	23	23	2	23
Berni Badi	1	17	6	3	3	70	70	6	70
Berni Chhoti	2	9	3	3	3	44	44	8	44
Bhadni	2	25	8	2	4	109	109	17	109
Bhaind	1	5	2	2	2	25	25	4	25
Bhainsark	1	23	8	3	6	137	137	19	137
Bhaintan	3	33	11	2	4	122	122	33	122
Bhairgad	1	24	8	2	7	146	146	18	146
Bhandargaon	2	16	5	3	2	58	58	18	58
Bhangala	2	35	12	2	7	172	172	25	172
Bhatgaon	1	20	7	2	4	103	103	19	103
Bhatoli	2	6	2	2	2	28	28	4	28
Bhatoli	1	8	3	3	3	43	43	8	43
Bhingarki Aagar	1	21	7	2	4	110	110	17	110
Bhingarki Badec	1	24	8	3	5	116	116	19	116
Bhutli	2	9	3	2	2	38	38	10	38
Bidon	2	5	2	2	3	24	24	10	24
Bugala	2	7	2	2	3	29	29	9	29
Chaldgaon	1	18	6	3	3	69	69	12	69
Chameli	3	38	13	3	6	176	176	33	176
Chamolgaon	1	27	9	2	4	100	100	10	100
Chaumpa	2	23	8	3	3	78	78	9	78
Chaundli	1	2	1	2	2	5	5	2	5
Chhatendi	1	3	1	2	3	22	22	4	22
Chidiyali Malli	1	2	1	2	2	8	8	6	8
Chidiyali Talli	1	5	2	2	3	21	21	5	21
Chilogi	2	16	5	2	3	79	79	14	79
Dadua	2	5	2	2	3	23	23	7	23
Dagar	1	26	9	2	7	156	156	22	156
Dandeli	1	17	6	2	3	89	89	20	89
Dangoo	2	12	4	3	3	44	44	6	44
Daur	3	58	19	4	24	323	323	45	323
Dawra	2	13	4	3	2	60	60	13	60
Dhaigala	1	2	1	2	2	12	12	3	12
Dhalwala	30	126	42	5	27	529	529	389	529
Dharkot	1	5	2	2	3	29	29	7	29

Name	Persons Trained for Damage Assessment	Number of Rescue Persons	Number of Rescue Kits	Number of Strechers	Number of Body Bags	Number of Blankets	Clothing Requirement	Number of Tents	Number of Sleeping Bags
Dhouldhar	1	4	1	2	3	17	17	4	17
Digwali	2	5	2	2	3	28	28	6	28
Diuli	2	38	13	3	9	206	206	27	206
Fafrangaon	1	5	2	2	3	23	23	6	23
Falsari	1	13	4	3	2	66	66	15	66
Fart	2	34	11	2	7	167	167	21	167
Gadil	2	11	4	3	3	46	46	9	46
Gaindi	1	17	6	2	4	91	91	19	91
Gangsali	2	13	4	3	2	70	70	26	70
Gangsarigaon	2	15	5	3	3	67	67	8	67
Ghigud	3	68	23	5	26	369	369	46	369
Ghorsad	2	8	3	2	2	35	35	11	35
Ghugtani Malli	2	5	2	2	3	27	27	9	27
Ghugtani Talli	1	2	1	2	2	10	10	8	10
Gudangaon	1	2	1	2	2	5	4	2	5
Gumalgaon	2	6	2	2	3	23	23	10	23
Guriyali Badi	1	2	1	2	2	9	9	7	9
Guriyali Chhoti	1	4	1	2	3	16	16	5	16
Gwad	2	13	4	3	3	77	77	11	77
Hadisera	2	8	3	2	2	38	38	7	38
Jakholi	2	7	2	2	3	30	30	20	30
Jamola	2	33	11	3	6	147	147	23	147
Jamri	1	3	1	2	2	12	12	2	12
Jamri Katal	1	7	2	3	3	38	38	6	38
Jangleth	1	9	3	3	2	52	52	9	52
Jaykot	2	6	2	2	3	30	30	20	30
Jimangaon	1	2	1	2	2	5	3	3	5
Kafolgaon	2	5	2	2	3	25	25	8	25
Kakhil	2	14	5	2	3	85	85	18	85
Kakhoor Badeda	1	25	8	3	6	127	127	15	127
Kakhoor KP	1	16	5	3	3	82	82	18	82
Kandarigaon Sc	2	16	5	2	4	92	92	15	92
Kandarigaon Ba	1	3	1	2	2	9	9	4	9
Kandchak	1	2	1	2	2	5	0	2	5
Kasmoli	2	31	10	2	6	155	155	25	155
Katkod	2	16	5	2	4	86	86	10	86
Kaud	1	2	1	2	2	7	7	2	7
Kensur	2	3	1	2	2	13	13	7	13
Khakar	1	28	9	3	6	125	125	6	125
Khanana	4	48	16	2	7	191	191	42	191
Kharki	1	28	9	2	6	150	150	22	150
Kharsad	2	6	2	2	3	23	23	7	23
Khatiyad	1	31	10	2	7	137	137	19	137
Khedagad	1	16	5	2	3	83	83	18	83
Khola	1	5	2	2	3	23	23	5	23
Kirada	1	8	3	2	2	33	33	11	33
Kodarna	3	62	21	5	26	330	330	40	330
Kodiyala	1	2	1	2	2	5	4	3	5
Kol	2	8	3	2	2	42	42	6	42
Kot	1	8	3	2	2	34	34	7	34
Kotar	2	29	10	2	6	154	154	24	154
Koti Kharsad	2	6	2	2	2	28	28	12	28
Koti Rampur	1	13	4	3	3	69	69	18	69
Kudi	3	62	21	4	23	263	263	34	263
Kuee	2	20	7	2	4	94	94	14	94
Kukhai Malli	1	6	2	2	3	38	38	7	38
Kukhai Talli	1	23	8	2	5	110	110	12	110
Kumali	1	17	6	2	3	86	86	19	86
Kyara	2	27	9	3	6	171	171	31	171
Kyarki	2	6	2	2	2	37	37	9	37
Lamoli	2	20	7	3	3	55	55	8	55
Laser	2	4	1	2	3	20	20	5	20
Lava	3	25	8	2	4	102	102	36	102
Lodsi	3	39	13	3	9	229	229	46	229
Loyal	3	48	16	3	10	261	261	49	261
Maanghera	2	10	3	3	2	52	52	11	52

Name	Persons Trained for Damage Assessment	Number of Rescue Persons	Number of Rescue Kits	Number of Strechers	Number of Body Bags	Number of Blankets	Clothing Requirement	Number of Tents	Number of Sleeping Bags
Maidhar	1	17	6	3	2	63	63	11	63
Majiyadi	3	51	17	4	24	323	323	45	323
Malas	1	9	3	3	2	45	45	3	45
Manderigaon	2	31	10	3	6	140	140	30	140
Mangaon	2	10	3	3	3	46	46	14	46
Mansari	1	3	1	2	3	19	19	5	19
Maroda	1	2	1	2	2	11	11	5	11
Mathiyali	5	93	31	7	23	544	544	81	544
Matiyala	2	14	5	2	4	76	76	11	76
Matola	1	2	1	2	2	5	3	2	5
Maun	4	86	29	6	29	394	394	48	394
Mayangaon	1	2	1	2	2	6	6	2	6
Medwa	1	4	1	2	3	18	18	5	18
Mindath	7	126	42	8	27	637	637	100	637
Mundala	2	29	10	3	5	137	137	27	137
Nail	2	6	2	2	2	33	33	5	33
Nala Kanchanpu	1	3	1	2	2	12	12	5	12
Nasogi	2	5	2	2	3	24	24	3	24
Nauga	2	7	2	2	2	31	31	10	31
Naur	2	35	12	3	8	184	184	28	184
Nayee	4	62	21	4	23	329	329	68	329
Neer	2	53	18	4	22	259	259	30	259
Niger	1	9	3	2	2	35	35	8	35
Odada	3	55	18	4	23	266	266	30	266
Odarkhet	2	12	4	3	3	61	61	5	61
Pajaigaon	2	32	11	2	7	175	175	21	175
Pali	2	29	10	2	4	117	117	27	117
Pali Kakadsari	2	9	3	2	2	38	38	8	38
Palkot	2	6	2	2	3	22	22	2	22
Palogi	1	3	1	2	3	15	15	4	15
Pasar	2	14	5	3	2	60	60	8	60
Pata	1	5	2	2	3	24	24	7	24
Pater	1	3	1	2	3	21	21	4	21
Pateshri	1	6	2	2	3	25	25	5	25
Pathau	2	11	4	3	2	60	60	8	60
Paweth	2	6	2	2	3	26	26	7	26
Payalgaon	2	5	2	2	3	20	20	9	20
Pendars	2	14	5	3	3	59	59	6	59
Pildi	2	42	14	3	10	237	237	39	237
Pipleth	3	46	15	2	8	198	198	39	198
Pokhri Mangaor	2	4	1	2	2	12	12	2	12
Pokhri Odada	1	5	2	2	3	23	23	5	23
Pungaddu	1	4	1	2	3	19	19	3	19
Purvala	1	13	4	3	2	66	66	7	66
Rampur	2	16	5	3	2	63	63	16	63
Ranakot	5	66	22	4	23	314	314	63	314
Raundeli	2	46	15	2	8	180	180	26	180
Sailkani	2	36	12	3	9	206	206	30	206
Sain	1	13	4	3	3	60	60	17	60
Sakanyani	2	13	4	3	2	54	54	12	54
Salamkhet	1	2	1	2	2	5	4	2	5
Saldogi	2	42	14	2	8	191	191	28	191
Sarswad	1	6	2	2	2	31	31	7	31
Sasman	4	76	25	5	26	381	381	52	381
Saund	2	12	4	3	3	47	47	12	47
Saundi	1	2	1	2	2	6	6	2	6
Sautiyalgaon	1	4	1	2	3	17	17	3	17
Semlikatal	1	2	1	2	2	5	4	2	5
Sera	1	2	1	2	2	6	6	2	6
Shivpuri	2	2	1	2	2	10	10	4	10
Shrikot	2	32	11	3	5	119	119	20	119
Simtali	2	2	1	2	2	11	11	4	11
Soni KP	2	41	14	3	9	221	221	33	221
Soni Ukhel	1	4	1	2	3	17	17	4	17
Soundadi	2	9	3	2	2	32	32	11	32
Sunarkot	1	18	6	3	3	74	74	17	74

Name	Persons Trained for Damage Assessment	Number of Rescue Persons	Number of Rescue Kits	Number of Strechers	Number of Body Bags	Number of Blankets	Clothing Requirement	Number of Tents	Number of Sleeping Bags
Sweer	2	32	11	3	5	137	137	32	137
Syud	2	31	10	2	7	166	166	27	166
Tachhla	2	10	3	3	3	48	48	10	48
Talai Odada	2	17	6	2	4	87	87	12	87
Talai Soni	1	25	8	3	5	120	120	18	120
Tamiyar	2	11	4	3	2	57	57	7	57
Tapowan	6	26	9	2	3	107	107	79	107
Than	1	22	7	2	4	108	108	19	108
Thanyul	1	14	5	3	2	62	62	20	62
Thapliyalgaon	2	9	3	3	3	44	44	10	44
Timli	6	137	46	22	37	848	848	115	848
Tipli	2	6	2	2	3	28	28	12	28
Tipri	2	14	5	3	3	57	57	13	57
Udkhanda	2	13	4	3	3	47	47	5	47
Ukhel	2	6	2	2	3	25	25	11	25
Vandan	1	5	2	2	2	27	27	4	27
Market Towns									
Agrakhal	3	46	15	3	8	82	82	39	82
Bedadhar	19	34	11	2	7	175	175	26	175
Byasi	4	25	8	3	3	780	780	31	780
Chaka	3	46	15	3	8	266	266	51	266
Duadhar	4	44	15	2	7	220	220	31	220
Fakot	6	42	14	2	6	634	634	20	634
Gaja	3	124	41	7	23	91	91	139	91
Gheradhar	2	33	11	3	6	150	150	20	150
Gular	4	68	23	3	9	1411	1411	87	1411
Hindolakhal	3	49	16	3	8	184	184	41	184
Jajal	12	32	11	3	5	216	216	18	216
Kaudiyala	3	50	17	3	6	161	161	61	161
Khadi	3	35	12	3	6	205	205	25	205
Kunjapuri	2	26	9	2	4	142	142	4	142
Muni-ki-reti	3	157	52	7	24	129	129	234	129
Narendranagar	8	341	114	26	53	9	9	266	9
Pav-ki-devi	26	28	9	3	5	99	99	15	99
Total	**921**	**5215**	**1742**	**660**	**1314**	**24724**	**24711**	**4965**	**24724**

ANNEXURE XII

PUBLICATIONS OUT OF RESEARCH WORK

Journal Papers

1) Gupta, I., Shankar, R. and Sinvhal, A (*in press*) "Earthquake Vulnerability Assessment of House Constructions in the Himalayas", Journal of Design and Built Environment.
2) Gupta, I., Sinvhal, A. and Shankar, R. (2006) "Himalayan Population at Earthquake Risk: Strategies for Preparedness", Disaster Prevention and Management, Vol.15 No.4, 2006, pp. 608 - 620
3) Shankar, R. and Gupta, I., (2005) "An Analytical Framework for Earthquake Preparedness Plan: Activity, Vulnerability and Resource Potential Assessment", Spatio-economic Development Record, Vol 12 No 1, pp. 30 – 38

Conference Papers

1. Gupta, I., and Shankar, R., "Earthquake Risk Assessment of Population in Narendranagar Block of Uttaranchal State due to Construction Technology", World Conference on Disaster Reduction, Mumbai, India, November 16-18, 2005.
2. Gupta, I., and Shankar, R., "Assessment of Health Facilities in Narendranagar Block of Uttaranchal State and Strategies for Emergency Management", World Conference on Disaster Reduction, Mumbai, India, November 16-18, 2005.
3. Gupta, I., Sinvhal, A. and Shankar, R., "Assessment of Earthquake Vulnerability in Narendranagar Block of Tehri Garhwal District", Symposium of Seismic Hazard Assessment and Microzonation, Department of Earthquake Engineering, Indian Institute of Technology Roorkee, Roorkee India, Sept 2005. (Paper Presentation)
4. Gupta, I., and Shankar, R., "Activity Planning For Earthquake Emergency Management", Prithvi: Global Meet, Trivendrum, India, 2005.