DISASTER MITIGATION: SUSTAINABLE APPROACHES FOR HIMALAYAN REGION

POST DISASTER RESETTLEMENT - THE SUSTAINABLE WAY

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INCREASING TREND OF NATURAL DISASTERS

The image shows a line graph depicting the number of events per year from 1900 to 2000. The graph includes data on all disasters, with a significant increase in the late 20th century. The specific disasters included are drought, earthquake, extreme temperatures, famine, flood, insect infestation, slides, volcanic eruption, wave/surge, wild fires, and wind storms. The source of the data is the EM-DAT International Disaster Database Center.
### Loss events worldwide 2014

#### 10 deadliest events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Affected area</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-15.9.2014</td>
<td>Floods</td>
<td>India, Pakistan</td>
<td>665</td>
</tr>
<tr>
<td>3.8.2014</td>
<td>Earthquake</td>
<td>China</td>
<td>617</td>
</tr>
<tr>
<td>9-16.8.2014</td>
<td>Floods, landslides</td>
<td>Nepal</td>
<td>229</td>
</tr>
<tr>
<td>11-22.7.2014</td>
<td>Typhoon Rammasun (Glenda)</td>
<td>China, Philippines, Vietnam</td>
<td>195</td>
</tr>
<tr>
<td>April - May 2014</td>
<td>Floods, flash floods</td>
<td>Afghanistan</td>
<td>175</td>
</tr>
<tr>
<td>2.8.2014</td>
<td>Landslide</td>
<td>Nepal</td>
<td>156</td>
</tr>
<tr>
<td>October 2014</td>
<td>Floods</td>
<td>Democratic Republic of Congo</td>
<td>154</td>
</tr>
<tr>
<td>30.7.2014</td>
<td>Landslide</td>
<td>India</td>
<td>151</td>
</tr>
<tr>
<td>August - September 2014</td>
<td>Floods</td>
<td>India</td>
<td>151</td>
</tr>
<tr>
<td>December 2014</td>
<td>Cold wave</td>
<td>India</td>
<td>145</td>
</tr>
</tbody>
</table>

Source: Munich Re, NatCatSERVICE, 2015

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As at: January 2015
Mountains

Mountains form one of the most important bio-geographical resource zones of the world.

Mountains cover 24 per cent of the earth’s continental surfaces and 52 per cent of Asia.

They directly support 22 per cent of the world’s people who live within mountain regions. A further 40 per cent live adjacent or very close to mountain areas and are benefited from mountain resources in more than one ways.

Over half the global population depends on mountain environments for a wide range of goods and services including for water, food, hydro-electricity, timber, biodiversity maintenance and mineral resources.
The Himalayan Region

- 17% of global Mountain Area
- Area: 4.3 million sq km (Approx.)
- Himalaya, youngest and the highest mountain range
- Most populated mountain systems in the world
World’s fastest uplift rate 10 mm/a (at Nanga Parwat)
The Himalayan Region

Eight Countries
- AFGHANISTAN
- BANGLADESH
- BHUTAN
- CHINA
- INDIA
- MYANMAR
- NEPAL
- PAKISTAN

Nine large Asian river systems
- The Indus
- Ganges
- Brahmaputra
- Irrawaddy
- Salween
- Mekong
- Tarim
- Yangtse
- Yellow River

1.5 Billion People depend on Himalaya for Water, Food and Energy
THE HIMALAYAN ECOSYSTEM

- COMPLEX and FRAGILE
- SENSITIVE TO CLIMATE CHANGE
- PERSISTENT POVERTY
- RICH IN NATURAL RESOURCES
- BIOLOGICAL DIVERSITY
- SOCIO-CULTURAL & ETHNIC DIVERSITY
- PREDOMINANT SOURCE OF FRESH WATER
Challenges for Sustaining Himalayan Ecosystem

- Population Growth
- Persistent Poverty
- Natural Resource Degradation
- Climate Change is increasing the frequency of disasters.
- Melting Glaciers
- Geology is ridden with numerous fault lines
- Increasing Disaster Risks: vulnerable to natural disasters such as cloudbursts, landslides, flash floods, glacial lake outbursts and earthquakes.
FACTORS RESPONSIBLE FOR INCREASING THE VULNERABILITY OF HIMALAYAN COMMUNITIES

**PHYSICAL ISOLATION**
- The Himalayan communities are vulnerable due to physical isolation, the scattered settlement patterns, and the harsh climatic conditions.

**DEVELOPMENT OF INFRASTRUCTURE**
- 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.

**DIFFICULT AVAILABILITY OF LAND**
- The difficult availability of land area often compels for building any house or roads on vulnerable locations.

**LACK OF EARTHQUAKE RESISTANT BUILDING TECHNOLOGIES**
- The remotely located communities totally lack access to earthquake resistant building technologies and construction materials.

**POOR COMMUNICATION TECHNOLOGY**
- Because of the poor communication technology, the communities remain cut-off from the rest of the world.
Kedarnath floods

- June 2013
- Death Toll: 6000 (Approx)
Srinagar floods

- Sept 2014
- Death Toll : 600 (Approx)
Earthquakes

Earthquake events of magnitude more than 3
Nepal Earthquake

- 25th April 2015
- Death Toll: 8000 (Approx)
Landslides

Avalanche
Disaster Management Cycle

(NDMA 2016)
PLANNING PROCESS FOR DISASTER MANAGEMENT IN AN HIMALAYAN MICRO-REGION

Vulnerability Analysis
- Physical Vulnerability
- Social Vulnerability
- Economic Vulnerability
- Environmental Vulnerability

Resource Potential Analysis
- Infrastructure
- Manpower
- Institutional setup
- Material Supplies

Diagram:
- Secondary Data
- Primary Data from Field Studies
- Planning Data Base
- Generating Hypothetical Disaster Scenario
- Environmental Analysis
- Vulnerability Analysis
- Resource Potential Analysis
- EVOLVING LOCALIZED REGIONAL PLANNING NORMS
- Loss Estimation
  - Infrastructure and Livelihood
  - Human Casualty
- Plan Formulation
  - Vulnerability Reduction Plan
  - Preparedness Plan
  - Action Plan
  - Feedback / Review / Revisions
- Implementation
Study Area Profile

Uttaranchal State

Narendranagar Block

Tehri Garhwal District

India
Administrative Sub-division: Narendranagar Block

- 40 Kshetra Panchayats
- 103 Gram Panchayats
- 213 Villages
- 17 Market towns.
17 market Towns
Settlement Pattern

Organic village form following contours and physiographic features

Aerial view of village Kharsad of Narendranagar block

Aerial view of village Malas of Narendranagar block
House Form

Single Storied Houses

Double Storied Houses

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: Detail at M

A: Front elevation of a typical double storied house, B: Cross section of a typical double storied house, C: Ground floor plan of a typical double storied house, D: First floor plan of a typical double storied house
### Walling Material

<table>
<thead>
<tr>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth walls</td>
</tr>
<tr>
<td>Stone in mud (single story / double storied)</td>
</tr>
<tr>
<td>Stone in cement (single story / double storied)</td>
</tr>
<tr>
<td>Brick / Concrete block</td>
</tr>
<tr>
<td>Composite (Stone and Brick)</td>
</tr>
<tr>
<td>Composite (timber and stone)</td>
</tr>
</tbody>
</table>

### Roofing Material

<table>
<thead>
<tr>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate</td>
</tr>
<tr>
<td>RCC</td>
</tr>
<tr>
<td>Others (thatch, timber, CGI)</td>
</tr>
<tr>
<td>Composite</td>
</tr>
</tbody>
</table>
Random rubble stone masonry in Narendranagar block

Clay Brick and Concrete Block Masonry Walls

(a) Brick walls without RC frame in Gaja

(b) Brick wall with RC frame in Tapowan

(c) Brick construction on stilts near Byasi

Random rubble stone masonry with mud plaster

Random rubble stone masonry with cement plaster
Factors discussed for all types of Roofs,

- Positive Aspects or Strengths;
- Common Defects Observed;
- Performance during past earthquakes.
Composite Constructions
PERFORMANCE IN PREVIOUS EARTHQUAKES

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

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

Damage to random rubble stone masonry during Chamoli Earthquake

Damage to random rubble stone masonry at Anjar during Gujarat Earthquake 2001

(a) Damaged unreinforced brick masonry wall in Muzaffarabad

(b) Little damaged concrete block masonry wall during Chamoli Earthquake

Source: Jain et al. (1999)
Other Factors affecting Vulnerability

- Improper stilt construction on the slopes
- Dangerous locations
- Absence of proper joints in composite constructions breaking the integrity of structure
- Construction of upper story on weak lower stories
## Landslide Vulnerability

### Villages

<table>
<thead>
<tr>
<th>Number</th>
<th>Population</th>
<th>No. of Market Towns</th>
<th>Number</th>
<th>Population</th>
<th>Total Pop</th>
<th>% Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>15787</td>
<td>2</td>
<td>2</td>
<td>2345</td>
<td>18132</td>
<td>17.59%</td>
</tr>
</tbody>
</table>

Landslide prone settlements of Narendranagar block.
Number of road stretches under different landslide hazard zones

<table>
<thead>
<tr>
<th>Landslide Hazard Zone</th>
<th>National / State Highways</th>
<th>Other District Roads</th>
<th>Fair Weather Roads</th>
<th>Rural roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Low</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>High</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Very High</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Landslides after Rains in Study Area

View at A

View at B
Landslides after Rains

View at C

View at D

View at E
Vulnerability due to River Proximity

Settlements of prone to flash floods due to landslides after earthquakes

<table>
<thead>
<tr>
<th>Villages</th>
<th>No. of Market Towns</th>
<th>Total Pop</th>
<th>% Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Population</td>
<td>Number</td>
<td>Population</td>
</tr>
<tr>
<td>11</td>
<td>2103</td>
<td>6</td>
<td>7945</td>
</tr>
</tbody>
</table>
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 indicates 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.

A hypothetical epicenter is considered near Tapowan at 300 08'10"N and 780 20'30"E. 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 hypocentral distances, to cover the entire Narendranagar block.
The peak accelerations expected in seismic zone IV, on which Narendranagar block lies are 0.25 cm/sec².

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.

<table>
<thead>
<tr>
<th>Hypo-central distance (km)</th>
<th>Peak accelerations (cm / sec²)</th>
<th>Area (Sq. Km)</th>
<th>Length of Axis (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mag 7.0</td>
<td>Mag 7.5</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.309</td>
<td>0.410</td>
<td>1257</td>
</tr>
<tr>
<td>25</td>
<td>0.269</td>
<td>0.365</td>
<td>1964</td>
</tr>
<tr>
<td>30</td>
<td>0.249</td>
<td>0.325</td>
<td>2828</td>
</tr>
</tbody>
</table>
Earthquake

Methodology followed to determine Intensity of an Earthquake

Methodology adopted to estimate the destruction caused by earthquake
Intensities of Villages
<table>
<thead>
<tr>
<th>Range (%)</th>
<th>Number of villages</th>
<th>Names of Market towns</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 10</td>
<td>16</td>
<td>Byasi, Kaudiyala, Muni-ki-reti, Gular</td>
</tr>
<tr>
<td>10 to 20</td>
<td>54</td>
<td>Jajal, Khadi, Gaja, Chaka</td>
</tr>
<tr>
<td>20 to 30</td>
<td>35</td>
<td>Narendranagar, Duadhar, Agrakhal, Fakot, Hindolakhal, Gheradhar, Bedadhar, Pav-ki-devi, Kunjapuri</td>
</tr>
<tr>
<td>30 to 40</td>
<td>35</td>
<td>Nil</td>
</tr>
<tr>
<td>40 to 50</td>
<td>15</td>
<td>Nil</td>
</tr>
<tr>
<td>50 to 60</td>
<td>41</td>
<td>Nil</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>17</td>
<td>Nil</td>
</tr>
</tbody>
</table>

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

LEGEND
Percentage of severely Damaged Buildings to Total Buildings of the Settlements (%)
- 0 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 75

Roads by Category
- National Highway
- Other District Road
- Fair weather Road
- Fair weather Rural Road
- Internal Road

Block_Boundary
- contours by elevation
  - 400 to 1300
  - 1300 to 1700
  - 1700 to 2000
  - 2000 to 2300

Kilometers
Total 8824 village houses and 14,554 market town houses would need to be vacated rendering population of 46,154 (63% of total village population) and 14,554 (47% of total market town population) would be rendered homeless.
## Casualty Assessment

<table>
<thead>
<tr>
<th>Injuries</th>
<th>Village</th>
<th></th>
<th></th>
<th></th>
<th>Market Towns</th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dead or unsavable</td>
<td>801</td>
<td>1.1</td>
<td>189</td>
<td>0.6</td>
<td>990</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life threatening injuries needing immediate medical attention</td>
<td>1201</td>
<td>1.6</td>
<td>283</td>
<td>0.9</td>
<td>1484</td>
<td>1.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injury requiring hospital treatment</td>
<td>1201</td>
<td>1.6</td>
<td>283</td>
<td>0.9</td>
<td>1484</td>
<td>1.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light injury not requiring hospital treatment</td>
<td>801</td>
<td>1.1</td>
<td>189</td>
<td>0.6</td>
<td>990</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As results of these landslides total 85 settlements with a total population of 27462 (26.65%) would be rendered completely inaccessible
Seismic Risk Indicator (SRI) is determined from the number of people dead per 100,000 population at settlement level.

<table>
<thead>
<tr>
<th>SRI</th>
<th>Description</th>
<th>Number of Villages</th>
<th>Number of Market Towns</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Very Low Risk</td>
<td>76</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>Low Risk</td>
<td>65</td>
<td>12</td>
</tr>
<tr>
<td>III</td>
<td>Moderate Risk</td>
<td>27</td>
<td>-</td>
</tr>
<tr>
<td>IV</td>
<td>High Risk</td>
<td>34</td>
<td>-</td>
</tr>
<tr>
<td>V</td>
<td>Very High Risk</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>214</td>
<td>17</td>
</tr>
</tbody>
</table>
POST DISASTER RESTTLEMENT

Short-Term Imperatives
***EMERGENCY ACTIVITIES***

- **Preliminary damage assessment**
  - Rescue of trapped persons and recovery of dead bodies
  - Organizing manpower for relief operations
  - Supply of food and water
  - Restoration of transport routes
  - Protection from atmospheric conditions
  - Provision of medical assistance to the injured
- **Interim damage assessment**
  - Disposal of dead bodies
  - Provision of temporary shelters for the victims
  - Preventive steps against chain reaction
  - Restoration of services like: water supply, telecommunication and electric supply
- **Detailed damage assessment**
  - Restoration of drainage system

**MOST URGENT ACTIVITIES**

**URGENT ACTIVITIES**

**LESS URGENT ACTIVITIES**
POST DISASTER RESTTLEMENT

Medium-Term Imperatives
PHYSICAL REHABILITATION
- Restoring Infrastructure
  - Rebuilding roads, schools, health centres etc.
  - Replanning of roads on fragile terrains
  - Green roads
  - Ecological considerations for new buildings

ECONOMIC REHABILITATION
- Restoring Livelihoods
  - Sustainable options to evolve pattern of livelihoods
  - Should not impinge upon fragile resource base
  - Skill based production
  - Relocation of population wherever necessary

SOCIAL REHABILITATION
- Rehabilitation of Affected Community
  - Restoring psychological and social balance
  - Appropriate institutional and medico-psychological interventions
  - Role of Non-government organizations
  - Role of local PRIs
POST DISASTER RESTTLEMENT

Long-Term Imperatives
Long–Term imperatives

Mountain Specific Development Perspective to deal with:

- Inaccessibility
- Diversity of micro eco systems
- Fragility of terrain, disaster proneness
- Environmental sensitivity
- Balancing Economic and Environmental Needs
Sustainable Economic Development

• Decentralized planning. Development of a region-specific model for sustainable development.
• Explicit recognition of constraints and worth of the mountain areas in the promotion of economic activities.
• Selection of activities on the criteria of maximum economic benefit to local population and minimum short and long term damage to ecology and environment.
• Assessment of carrying capacity of locations/areas for promoting activities (e.g. tourism) and settlement (towns/cities) and enforcement of suitable regulations to ensure sustainability.
• Assessments of the technologies used in infrastructure and other construction activities. Discouragement of the use of environment-damaging and encouragement that of environment-friendly technologies.
• Environment impact of the entire pattern of activities needs to be assessed with a view to ensuring sustainability of the overall development pattern at the micro, meso and macro, regional level.
Thank You