Hazard Vulnerability Analysis of Himalayan Village Cluster

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Abstract: The natural hazards make the Himalayan region and its communities vulnerable with an impact on ecological, social, behavioral and economic structure. The Hazard Vulnerability Analysis (HVA) is one of the tools to address and to minimize vulnerabilities and hazards risk. For the last 3 decades advancements in the fields of Geographic Information System (GIS) and Remote Sensing (RS) have greatly facilitated the operation of risk assessment. The objectives were to assess the vulnerability and maps to understand the coping mechanism of Lah-Jhekla, Chachna and Dapha villages of district Pithoragarh, Uttarakhand. The primary and secondary data was collected by using structured/ semi-structured questionnaire, Participatory Rural Appraisal (PRA) and from district line departments and NGOs respectively. The agriculture (approximately 90%) in the villages is mostly rain fed. The area is being experienced by climate induced hazards. The HVA revealed the very high vulnerability of villages. On the basis of relative threat percentage of particular hazard the vulnerability to landslide was assessed about 66%, earthquake 65%, cloud bursts 43% and heavy rainfall 21% having a direct impact on livelihood options with a limited support from various agencies. To cope up with the various risks there is a need of habitat selection for emergency operation sites, livelihood options, relief and rescue training along with micro level disaster mitigation and management plan for sustaining the life in the region.

Index Terms **- Hazard Vulnerability Analysis, Natural hazards, Risk, Vulnerability, RS and GIS**

I. INTRODUCTION

In Himalaya not only the habitats but communities have also become more vulnerable. The landslide on 7 August 2009 near Kuty village of Pithoragarh district in Uttarakhand buried two villages (Lah and Jhekhla) and took 38 lives. The landslide, triggered by cloud burst resulted in massive debris flow along a stream channel. The site is still in danger reflects the presence of cracks on sloppy debris. The lack of Political will and wishes, ignorance by administration towards policies, funding, preparedness, implementation and rules and regulations; making communities more vulnerable. The disaster causes indirect loss to production, employment and livelihood [1] and also emotional stress, trauma; destroy homes and business leads to economic and financial hardships. According to [2] even construction sites contain several supporting facilities may be exposed to several hazards The losses to life and properties can be, minimize using appropriate tools and adopting suitable measures such as Hazard Vulnerability Analysis (HVA) which contribute largely in mitigation of risk and its impact. The HVA aims at building safe societies through prevention, mitigation and preparedness towards disasters. Besides that for the last 3 decades advancements in the fields of geographic information system (GIS) and remote sensing (RS) have greatly facilitated the operation of risk assessment [3]

The vulnerability, generally considered as a function of exposure to a stressor, effect and recovery potential or adaptive capacity [4] which is not easily reduced to a single metric and is not easily quantify [5]. There are kinds of vulnerabilities such as physical, social and economic related to infrastructure, society and economy respectively and many questions to be answered on this. Vulnerability analysis enables detailed understanding of the nature of disaster impacts and resilience vulnerability of the people, structure, geography, etc. It includes the baseline information, situational analysis and also proposed alternative mitigation plan essential to mitigate the risks which is helpful to provide a strong base for risks mitigation and impact reduction at the micro level.

A hazard vulnerability assessment (HVA) systematically evaluates the damage that could be caused by a potential disaster, the severity of the impact, and the available medical resources during a disaster to reduce population vulnerability and increase the capacity to cope with disasters [6]. The Socio-Ecological Systems (SES) implies that "human action and social structures are integral to nature and hence any distinction between social and natural systems is arbitrary" [5]. It has become accepted wisdom within social sciences that the lack of social capital (e.g., individual levels of social trust, participation in networks and family support) is a significant determinant of vulnerability to health hazards and risks [7, 8]. The ecological or ecosystem vulnerability analysis is also needed because it directly associated with human well being and should be described at species, population, communities and ecosystem level [9].

The vulnerability analysis can be done using qualitative approach to vulnerability indicators by considering the multiple characteristics of humans (age, wealth, health, education level etc.), institutions and/ or societies (Collins et al., 2009). The basis for risk reduction measures is an assessment of the hazards, elements at risk, and their vulnerability of these to the hazard types, resulting in a risk assessment [10]. An innovative meta-analysis and ''meta-knowledge'' exercise on urban vulnerability to Temperature-related hazards also been studied by [11]. A number of studies on vulnerability analysis have been performed by various previous researchers [12; 13; 14; 15; 16; 17; 18 and 19]. Many workers have also analyzed hazard risk using RS and GIS [20; 21 and 22]. The purpose of HVA is to address vulnerabilities, mitigate the hazards and prepare toward response and

recovery from hazardous events. The main objective was to prepare a data base of the village and assesses the vulnerability level along with gaps finding.

II. STUDY AREA

The study area lies between 30^0 01'17.46" N Lat. to 80^0 08' 58. 75" E Lang, consisting of three villages; Lah-Jhekla, Chachna and Dapha fall in seismic zone IV. Geologically, belongs to Tejam group of rocks, Munsiyari Thrust (Main Central Thrust) mainly comprising dolomite and argillaceous limestone; degraded by intense fracturing and shearing and subjected to severe erosion [23]. The area is blessed with variety of flora and fauna. The climate varied from subtropical to cold temperate.

III. METHODOLOGY

Data was collected through primary and secondary sources; using Participatory Rural Appraisal (PRA), informal interviews and focus group discussion with community, direct observation including household survey and interaction with key informants. The Secondary data was collected from various Government departments and non-government agencies like; the qualitative and quantitative information's were used for vulnerability assessment. The various software's like; Arc GIS (Version 9 and10), Erdas Imagine (version 9.3 & 10) and Microsoft excel software were used for database creation and analysis. Hazards those have an impact on facilities were considered like; probability, response, human impact, and property. Each of these categories was based on a point system, ranging from 0 to 3. For each hazard, a point estimated from 0 (NA) to 3 (high) for each of the four categories. Collected data was organized, tabulated and analyzed to understand, represent and assess the vulnerability and resources of the village. The Fig.1 describes the schematics of methodology used in this study.

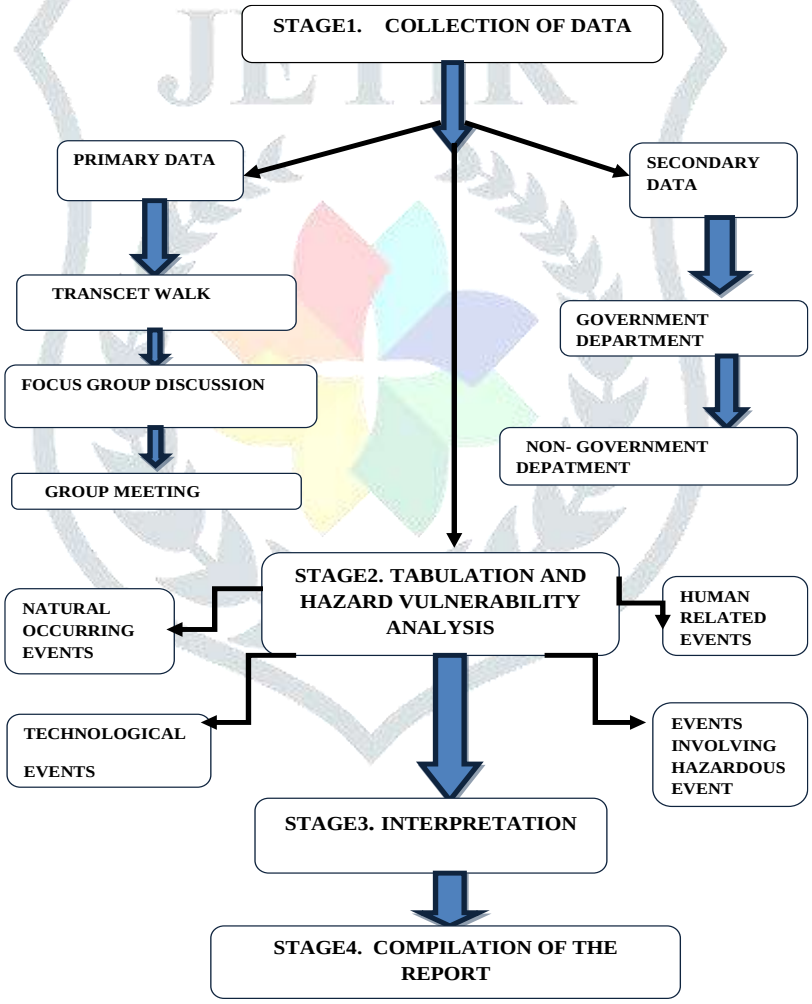

Fig. 1 Flow chart of schematics of methodology used in current study.

IV. RESULTS AND DISCUSSION

4.1 Socio-economic and Demographic status of Dapha

A total of 78 households (310 male and female) of Dapha gram sabha were assessed including various aspect such as demography, educational status and livelihood etc. The family size was observed about 4-5 individuals in each. The women

were involved in various household and agricultural activities while males were involved in outdoor employment activities. It was also found that some individuals migrated toward cities for employment.

4.2 Educational status

The village is facilitated by Junior High School and two Aganbadis. For higher education it is observed that students move to other part of district and state. Though the literacy rate was approximately 65%, where in both male and female literacy rate is increasing.

4.3 Livelihood

The households of Dapha were involved in various livelihood activities (Fig.2) wherein agriculture was major practice. The average land holding was about 4-5 nali (50 Nali= 1 hectare). 90% of the area was rain fed and mainly crops like; millet (Pennisetum glaucum), barley (Hordeum vulgare L.) and Rajma (Phaseolus vulgaris) along with potato (Solanum tuberosum) cultivated in the village.

Fig. 2 Livelihood engagements in studied villages

In spite of that the major problems in agriculture are irrigation, suitability of land, changing pattern of land use, lack of techniques and man-animal conflicts. 24 male and 5 females were in government sector, out of them 7 individuals were migrated for jobs. The land of the villages was distributed in settlement, agricultural land, van panchayats and water bodies as depicted in Fig. 3 and landuse/cover has been given in Fig. 4.

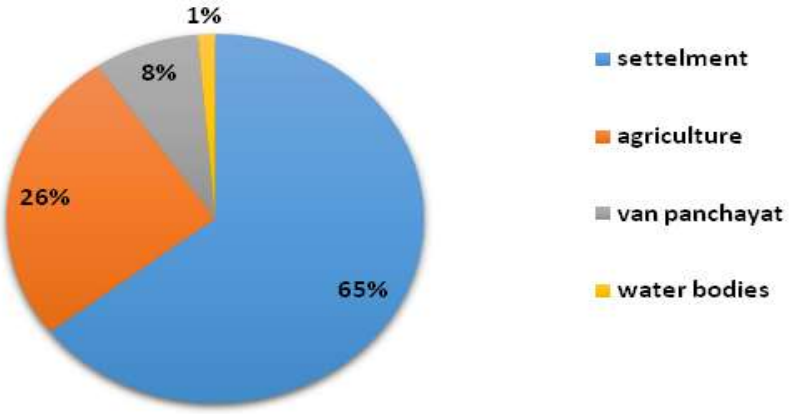

Fig. 3 Land use distribution (%) of study areas

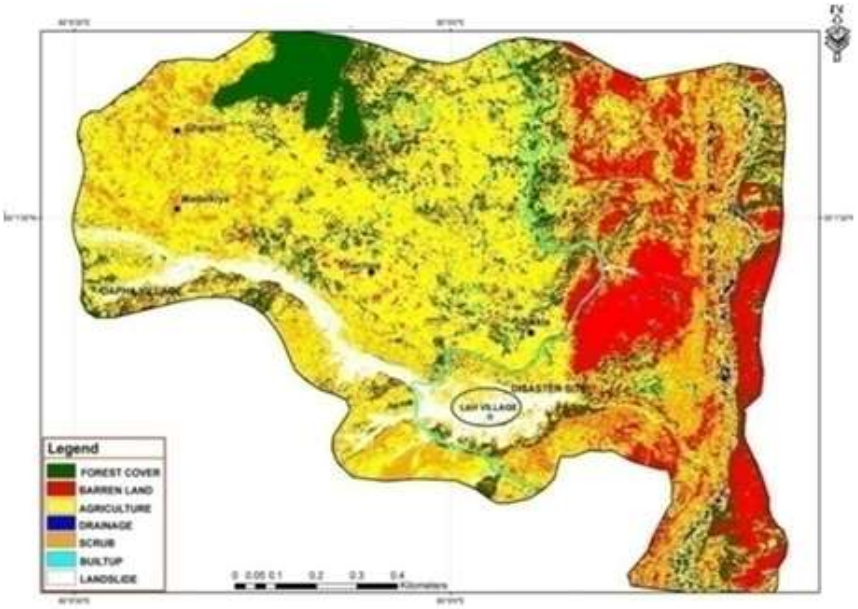

Fig. 4 Landuse/cover map of study area

3.2.4 Health hazards and risk

The individuals were also affected with various diseases in the village such as cold, typhoid, tuberculosis, malaria, diarrhea, respiratory disease, etc. The maximum numbers of people were affected with cold cough which was followed by various respiratory diseases. The disease like diarrhea, typhoid and headache also show a high percentage among the community (Fig.5).

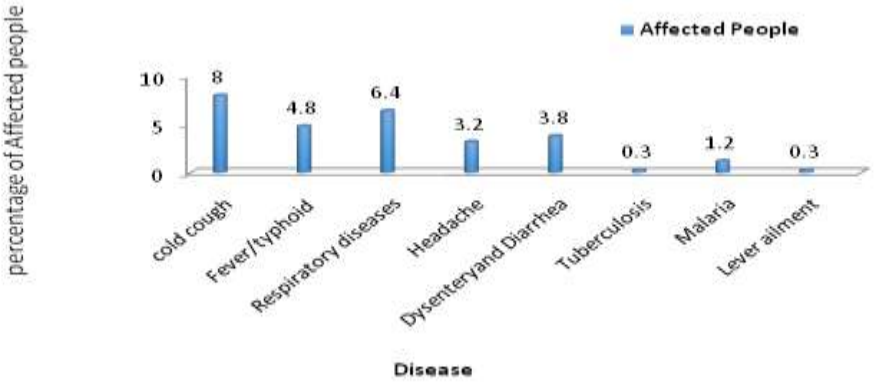

Fig. 5 People affected with various diseases

3.2.5 Basic Infrastructure and administrative support

More than 50% of the infrastructure such as road, water facility, electricity, houses, and safety equipment were damaged during the cloud burst in 7 august 2009 and still require adequate support by administrative bodies. In total vulnerable population children population contribute about 62% which was followed by old aged, widows and physically challenged respectively. A qualitative vulnerability assessment was done by giving weightage to the geography, demography, infrastructure and resources.

3.2.6 Vulnerability to Natural Hazard

Hazard Vulnerability Analysis (Vulnerability Assessment Using Quantitative Information) The maximum risk was assessed for landslide (66%) followed by earthquake (65%), cloud burst (43%) and heavy rainfall respectively. The overall impact due to natural disasters was assessed maximum for physical loss to property and human death. The landslide possesses maximum severity and risk which was followed by earthquake and cloud burst respectively as depicted in Table no. 1.

Table 1 Vulnerability to natural hazard

Event	Probability	Severity =(Magnitude-Mitigation)						Risk
		Human impact	Property impact	Business impact	Preparedness	Internal resources	External resources	
	Likelihood to occurrence	Possibility of death or injury	Physical losses and damage	Interruption of services	Preplanning	Time, effectiveness, Resources	Community, mutual aid staff and supplies	Relative threat
Score	0= NA 1=L 2= Mod 3=H	0= NA 1=L 2=Mod 3=H	0=NA 1=L 2=Mod 3=H	0=NA 1=L 2=Mod 3=H	O=NA 1= H 2=Mod 3= L	0-NA 1=H 2=Mod 3=L	0=NA 1=H 2= Mod 3= L	0-100%
Earth quake	2(0.66)	2(0.66)	2(0.66)	2(0.66)	1(0.33)	2(0.66)	0(0.00)	65%
Landslide	1(0.33)	3(1.00)	3(1.00)	2(0.66)	2(0.66)	0(0.00)	0(0.00)	66%
Cloud burst	2(0.66)	3(1.00)	2(0.66)	0(0.00)	3(1.00)	0(0.00)	0(0.00)	43%
Heavy rainfall	1(0.33)	2(0.66)	2(0.66)	0.(00)	2(0.66)	0(0.00)	0(0.00)	21%
Average score	1.5	2.5	2.25	1.00	2.00	0.5	0.00	48%

Legend: L=Low, Mod= Moderate, H=High, Avg.= Average

3.2.7. Vulnerability to Technical Hazards

The HVA analysis shows that probability of occurrence of various events was maximum for communication failure followed by electricity failure, fuel shortage and food supply failure while risk was maximum for fuel shortage. The severity was maximum for sewage failure events followed by fuel shortage and other events. The vulnerability towards technological events was also observed. Out of these the risk of fuel shortage followed by food supply failure was noticed as depicted in Table 2.

Table 2 Vulnerability to technical hazards

Event	Probability	Severity =(Magnitude- Mitigation)						Risk
		Human impact	Property impact	Business impact	Prepared ness	Internal resources	External resources	
Event	Likelihood this will occur	Possibility of death or injury	Physical losses and damages	Interruption of services	Preplanning	Time, effectiveness, resources	Community , mutual aid staff, supplies	Relative threat
Score	0= NA 1= L 2=Mod 3= H	0=NA 1=L 2=Mod 3= H	0= NA 1= L 2=Mod 3= H	0=Na 1= L 2=Mod 3= H	0= NA 1= H 2= Mod 3= L	0=NA 1= H 2=Mod 3= L	0=NA 1= H 2=Mod 3= L	0-100%
Electrical failure	1(0.5)	1(0.5)	1(0.5)	1(0.5)	1(0.5)	0	1(0.5)	25%
Fuel shortage	1(0.5)	0	0	3(1.5)	0	0	0	75%
Sewerage failure	0	0	0	0	3(1.5)	0	3(1.5)	3%
Water failure	0	0	0	0	1(0.5)	0	1(0.5)	1%
Communication information failure	3(1.5)	2(0.66)	0	0	1 (0.5)	0	0	24%
Food Supply failure	1(0.5)	2(0.66)	1(0.5)	0	1(0.5)	0	0	33%
Average score	1.00	0.83	0.33	0.66	1.16	0.00	0.83	26%

Legend: L=Low, Mod= Moderate, H=High, Avg.= Average

3.2.8 Manual Hazards

Under this hazard the maximum risk was assessed for mass casualty incidents while labor action has slightly less risk then mass casualty incidents. Mass casualty also exhibits maximum probability and severity while labor action less as shown in Table 3.

Table 3: Showing Human related events by using HVA tool

Event	Probability	Severity = magnitude -mitigation						Risk
		Human impact	Property impact	Business impact	Prepared ness	Internal resource	External resource	
	Likelihood this will be occur	Possibility death injury	Physical losses damages	Interruption service	Preplanning	Time effectiveness/ resources	Community mutual aid staff supplies	Relative threat
Score	0=NA 1= L 2= Mod 3=H	0= NA 1=L 2=Mod 3=H	0= NA 1= L 2=Mod 3= H	0=NA 1= L 2= Mod 3= H	0= NA 1=H 2= Mod 3=L	0= NA 1= H 2= Mod 3= L	0= NA 1= H 2= Mod 3= L	0-100%
Mass casualty incident infection	2(0.66)	2(0.66)	2(0.66)	2(0.66)	2(0.66)	0(0.0)	0(0.0)	87%
Labour actions	1(0.5)	1(0.5)	0(0.5)	2(0.66)	0	0	0	83%
Average score	1.5	1.00	1.00	0.5	3.00	3.00	3.00	85%

Legend: L=Low, Mod= Moderate, H=High, Avg.= Average

3.2.9 Risk of Various Hazards

In Dapha gram panchayat the risk from hazardous material also assumes to occur and observed their impact even if their probability is less than 1. The maximum risk was assessed for human related events among the all hazardous event which is followed by natural events, technological events and risk caused by hazardous material respectively. Hazards either natural or man-made pose a constant threat to the people and property. Along with the physical and environmental factors, social and economic conditions exacerbate the vulnerability of people in Himalayan region to different types of disaster as depicted in Fig. 6.

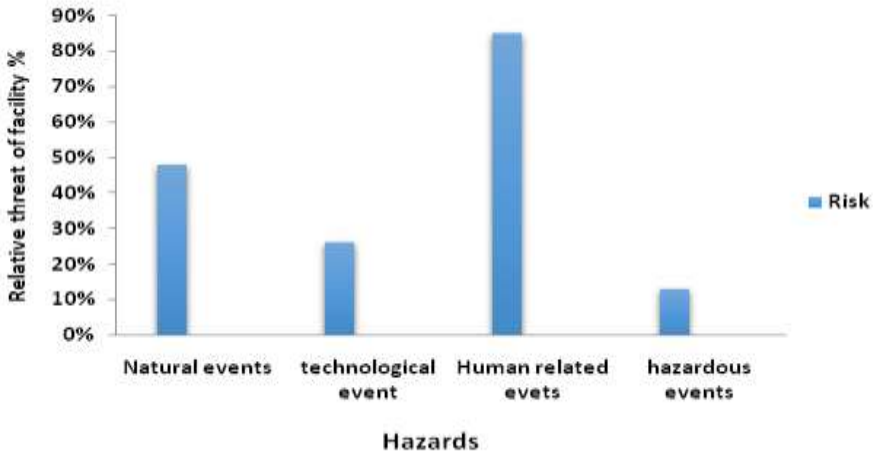

Fig. 6 Various hazards and risk

V. RECOMMENDATIONS AND CONCLUSION

The area is highly prone to natural hazards and accessibility of governmental facilities is hard which also increases the vulnerability. The communities are unaware and lack of attitude reflected towards the mitigation strategies Promotions of micro financial institutions and rural banking for creating livelihood and crop insurance will be helpful to cope up with unforeseen incidents. The disasters are intimately linked with sustainable development and HVA mutually supporting the goals. Unless sustainable development practices are not adopted, risks from disasters will continue leads to increase in vulnerability and the sustainable development cannot be achieved unless risks are managed. Southern Maine Regional Resource Centre for Public Health Emergency Preparedness (SMRRC) interviewed staff members at eight hospitals in Maine to document current HVA processes and develop recommendations for improvement [24]. New technological intervention can also be introduced like [25] said that no clear connection has been established between vulnerability and the actual consequences resulting from a nature hazard event, geographic information system-based vulnerability modeling is evaluated, and the association between modeled-

produced expressions and the aftermath impact of a natural hazard event on the human landscape is examined. There is a need to mitigate and prevent various risk associated with disaster by participatory approach involving the community in health, food supply, transport, communication sector in pre disaster planning and preparedness.

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