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MULTI-DISASTER RISK AND VULNERABILITY IN WESTERN HIMALAYAN STATE OF HIMACHAL PRADESH

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Abstract

Natural disasters occur when natural forces come into contact with a vulnerable population/situation. It is not possible to eliminate hazards though their impacts may be minimized by anticipating the risk and vulnerability and ensuring preparedness. This requires an understanding of physical as well as human vulnerability. An amalgamation of these two shall portray disaster zones. This concept forms the basis for assessing and analysing multi-disaster risk and associated human vulnerability in Himachal Pradesh, a Himalayan state that is physically vulnerable to several disasters. The cool temperate zone of the area is susceptible to hydro-meteorological and geo-physical disasters. The human vulnerability is very high in certain pockets of high population potential; the valley of the river Beas is amongst the most vulnerable zones. The mechanism behind these disaster events is predominantly natural; however, the triggering agent and conditions that lead to destruction are created by humans. The encroachments upon unsuitable landscapes for several developmental activities have increased the vulnerability of people residing in these areas and infrastructure developed over it. The management efforts must attempt to identify and map these aspects of disasters at a sufficiently large scale to visualise how and why a landscape becomes hazardous and people become vulnerable.

Introduction

The earth and its environment is continuously being shaped by natural processes of geological, geomorphic and climatic origin. When such processes threaten human life and its support system, they become natural hazards. Natural disasters occur when these natural forces come into contact with the vulnerable people/situations adversely impacting upon human lives, property, infrastructure and environment. It is evidently not possible to eliminate hazards. However, their impacts may be minimized if we know what and who is the most vulnerable. Vulnerability refers to the potential for loss, a measure of system's capacity to cope with disasters (Bogard, 1989; Mitchell, 1989; Blaikie et al. 1994; McCarthy et al. 2001; Adger 2006; Birkmann, 2006) and can be viewed as 'vulnerability in terms of hazard exposure' i.e. human occupancy of hazardous areas; 'vulnerability in terms of societal response' i.e. capacity for coping and recovery from hazards and 'vulnerability in terms of space' i.e. amalgamation of hazard exposure and social response within a geographic space (Cutter, 1996 and 2003). It is a situation of susceptibility resulting from physical, social, economic and environmental factors, which determine odds and dimensions of damage of a hazard (United Nations, 2004) that has the capability to threaten the very existence of human lives, livelihoods, infrastructure, properties, natural resources and economy (Barnett et al. 2008) of a region, area or place.

To understand the vulnerability and to reduce the social and economic impacts of disasters it is very important to understand (a) physical vulnerability: identifying the degree to which an area is prone to disasters; (b) human vulnerability: determination of vulnerable population in the area i.e. assessment of absolute population, marginal population, deprived sections and segments of the society occupying the hazardous places. An amalgamation of these two very important elements of vulnerability shall portray disaster regions which represent the probable disaster spaces. This notion forms the basis for assessing and analysing multi-disaster risk and associated human vulnerability in the state of Himachal Pradesh, India.

Study Area

Himachal Pradesh is a hilly and mountainous state located between 30º22' to 33º15' N latitude and 75º4' to 79º E longitude. The altitude that increases from west to east and south to north ranges from 450-7000 meters above mean sea level. The state is a part of Himalayan system of mountains having three distinct physiographical zones, namely the Siwaliks, Lesser (Middle) Himalayas and Greater Himalayas running parallel to each other in the northwest-southeast direction. The state is prone to natural disasters due to its special geographical situation. The presence of seismic active zones; occurrence of more than 250 earthquakes of magnitude above 4.0 on the Richter Scale; 20 meteorological droughts between 1875-2000; deadly avalanches of 1978, 1979, 1988, 1991 and 1995; regular occurrence of landslides and flash floods and 108 devastating cloudbursts between 1971-2009 (Planning Commission, 2005; Chandel and Brar 2010a) are few examples that reveal the deadly play of natural forces leading to disasters in Himachal Pradesh. These facts have propelled thinking in the direction of assessing and mapping the degree of risk and vulnerability of natural disasters in the state.

Data and Methodology

The work is based on chronological data on disasters compiled from gazetteers, catalogues, government reports and the newspaper 'The Tribune' for the period 1971-2009; however, analysis of earthquake (1800-2009) and drought (1901-2005) takes into account data for longer time intervals. The different types of natural disasters are analysed in relation to the risk they pose followed by the composite risk profile defining the multi-disaster prone areas. To assess the physical vulnerability, the disaster incidence scores (DIS) are calculated (Fig. 1) which indicate the ratio between the frequency of a particular disaster class in a district and total frequency of that disaster class in the state. For each disaster class, districts are given a value from 12-1 in decreasing order of disaster occurrences. Then the disaster rank score (DRS) is calculated (Fig. 1) for each district by dividing the rank of the district by the maximum rank value i.e. 12. The average of DIS and DRS was then determined to calculate the disaster risk score (DRkS). The DRkS values (Fig. 1) are computed for each district for 6 types of disasters i.e. earthquake, landslides, avalanches, flood, cloudburst and drought. The total disaster risk score (TDRkS) is computed which is the average of sum of the disaster risk score (DRkS) (Fig. 1). The value of

DISASTER RISK SCORE CALCULATION

$$DIS = \frac{df}{sf} \qquad DRS = \frac{dr}{tr}$$

$$DRkS = \left[\frac{DIS+DRS}{2}\right]$$

$$TDRkS = \left[\frac{DRkS_1 + DRkS_2 + \cdots + DRkS_n}{N}\right]$$

Where
N= Number of disaster types/ classes
df = Frequency of disaster in district
sf = Total frequency of disaster in state
dr = District rank in disaster occurrence
tr = Total ranks given to all districts
DIS= Disaster Incidence Score
DRS= Disaster Rank Score
DRkS= Disaster Risk Score
TDRkS= Total Disaster Risk Score

Source: Method devised by researchers

Fig. 1

this score ranges from 0-1. A value closer to 0 denotes least disaster risk while 1 represents maximum disaster risk. To make the analysis more comprehensive, the different disasters are combined into two sub-groups on the basis of major controlling factors. These sub-groups are geo-physical (earthquake, landslide and avalanche) and hydro-meteorological (flood, cloudburst and drought) disasters.

To understand the dimensions of human vulnerability, an analysis of population distribution was carried out with the help of population potential analysis. The potential values were plotted as point locations at tahsil and sub-tahsil headquarters to draw population potential isopleths (lines joining places of equal population potential) using 'natural neighbour' interpolation technique, also known as Sibson or 'area-stealing' interpolation. This method finds the closest subset of input samples to a query point and applies weights to them based on proportionate areas in order to interpolate a value (Sibson, 1981; Theobald, 2007). The population potential as a basis for determining the vulnerability has an edge over other methods for showing population concentration as it negates uninhabited areas by considering cities or urban centers as focal points of concentration (Chandel and Brar, 2010b) as well as it also wipes out the same weight given to uninhabited areas as in the case of choropleth method. Finally, the high population potential zones are combined with physically vulnerable spaces in the state which define the densely populated areas most likely to be affected during the event of disaster.

DISASTER VULNERABILITY IN HIMACHAL PRADESH

Disaster Risk Zones

The state of Himachal Pradesh is prone to disasters of geo-physical and hydro-meteorological nature. These are location specific or seasonal phenomena associated with the tectonic or meteorological character of the state. The districts of Chamba, Kullu and Kinnaur score high risk values for maximum number of disaster types. The risk of earthquake, avalanche, flood and cloudburst is high in Chamba. Kinnaur has high risk for earthquake, avalanche, cloudburst and landslides while flood risk is moderately high. In Kullu risk is high for flood, cloudburst and avalanches while drought risk is moderately high (Table 1).

Lahaul-Spiti has maximum risk of earthquakes, avalanche and drought while earthquake, landslide and flood pose high risk in Mandi district. In Shimla district landslide and cloudburst pose maximum risk while risk from earthquake and flood is moderately high. Kangra and Solan districts have maximum risk

Table 1
HIMACHAL PRADESH: DISASTER RISK ZONES

	District	DISASTER-WISE RISK SCORE (DRkS)						Process-wise Disaster Risk Score		TOTAL DISASTER RISK SCORE (TDRkS)
		Geo-Physical Disasters			Hydro-Meteorological Disasters					
		Earthquake*	Landslide	Avalanche	Flood	Cloudburst	Drought**	Geo-Physical	Hydro Meteorological	
1	Chamba	0.669	0.380	0.424	0.427	0.546	0.151	0.491	0.375	0.433
2	Kullu	0.267	0.235	0.478	0.579	0.611	0.378	0.327	0.523	0.425
3	Kinnaur	0.501	0.484	0.641	0.358	0.426	0.103	0.542	0.296	0.419
4	Lahaul & Spiti	0.548	0.137	0.707	0.049	0.282	0.481	0.464	0.271	0.367
5	Shimla	0.377	0.614	0.000	0.399	0.486	0.240	0.330	0.382	0.348
6	Mandi	0.422	0.429	0.000	0.479	0.329	0.378	0.284	0.395	0.339
7	Kangra	0.327	0.281	0.000	0.533	0.375	0.240	0.203	0.383	0.293
8	Sirmaur	0.216	0.326	0.000	0.235	0.215	0.529	0.181	0.326	0.253
9	Solan	0.170	0.533	0.000	0.148	0.215	0.240	0.235	0.201	0.218
10	Bilaspur	0.084	0.188	0.000	0.105	0.134	0.577	0.091	0.272	0.182
11	Una	0.043	0.050	0.000	0.285	0.000	0.378	0.031	0.221	0.126
12	Hamirpur	0.127	0.093	0.000	0.192	0.088	0.054	0.073	0.111	0.092

Disaster Risk Scale

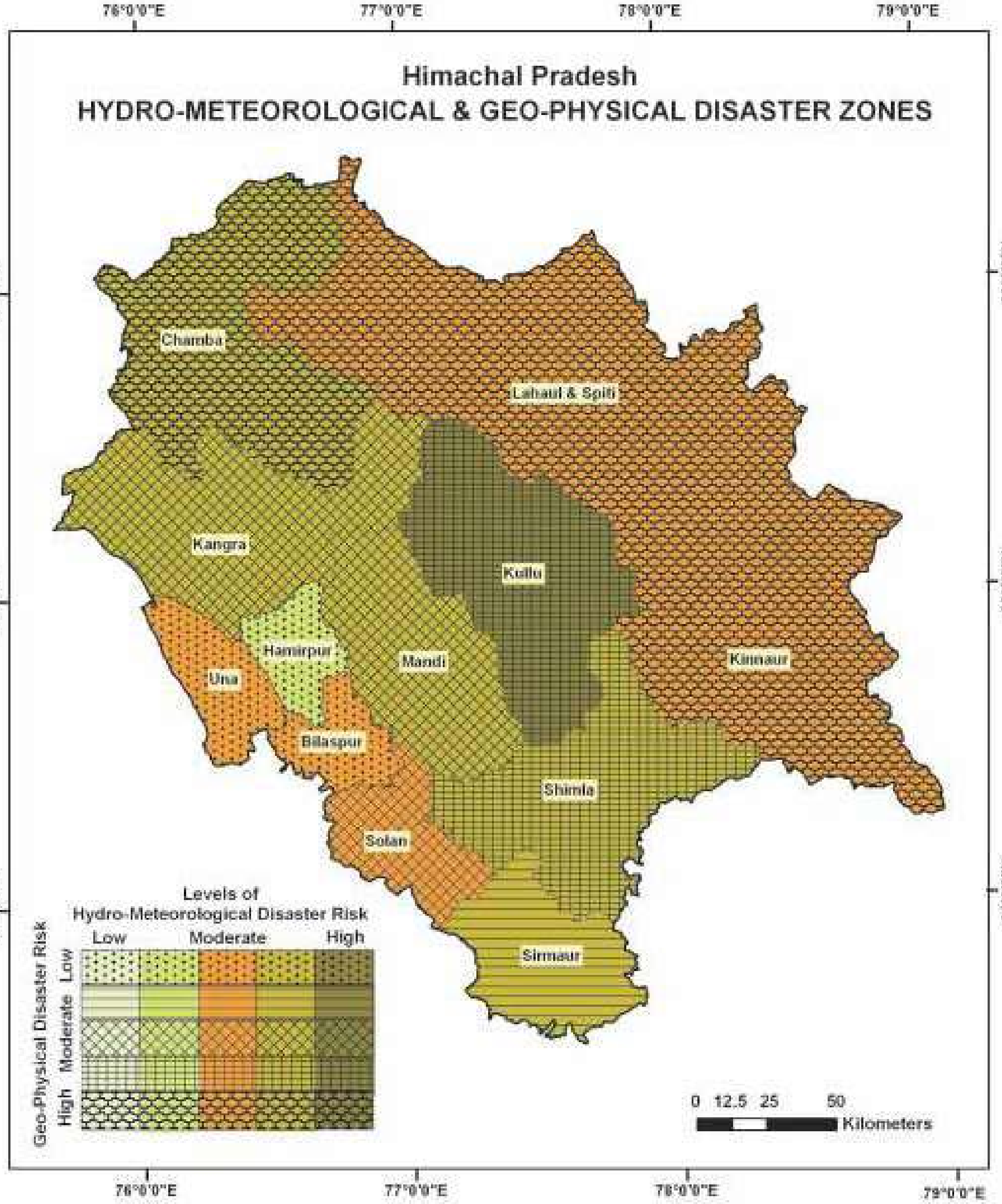
No Risk	Low	Low to Mod.	Moderate	Mod. to High	High
0	0.1	0.2	0.3	0.4	

Source: Compiled and calculated by the researchers from the data on disaster occurrence collected from 'The Tribune' (1971-2009); earthquake catalogue from India Meteorological Department (1800-2009); rainfall data from India Meteorological Department (1901-2005).
* Data period for earthquakes ranges from 1800-2009; ** Data period for drought ranges from 1901-2005; for other types of disasters (Landslide, Avalanche, Flood and Cloudburst) data period ranges from 1971-2009.

from flood and landslide, respectively while drought poses maximum risk in Sirmaur and Bilaspur (Table 1). There are four districts: Chamba, Kullu, Lahaul-Spiti and Kinnaur where all six types of disasters occur.

The districts located on north and northeastern parts having very high relief are most vulnerable to geo-physical disasters. These are Lahaul-Spiti, Kinnaur and Chamba which belong to cold dry to cold temperate regions (Map 1). This risk is moderately high in adjoining cool temperate areas of Kullu and Shimla districts. The hydro-meteorological disasters pose maximum risk in cool-temperate areas (Map 1). Kullu is the leading district in this respect while Chamba, Shimla, Mandi, Kangra and Sirmaur districts have moderately high risk to such disasters (Map 1).

From the analysis of total disaster risk (Table 1 and Map 2), it is evident that middle Himalayan areas of Chamba, Kullu and Kinnaur are the most susceptible in terms of physical vulnerability. Lahaul-Spiti, Shimla and Mandi have moderately high risk of disasters while remaining districts fall in moderate to low risk class. The temperate climate areas (Map 2) are more vulnerable to all types of disasters as compared to the other parts which are either highly vulnerable to a single disaster or only few types of disasters. The geo-physical alterations coupled with the sensitivity of these fragile environments to climatic variations make this zone more vulnerable than others. These areas represent the zones of high

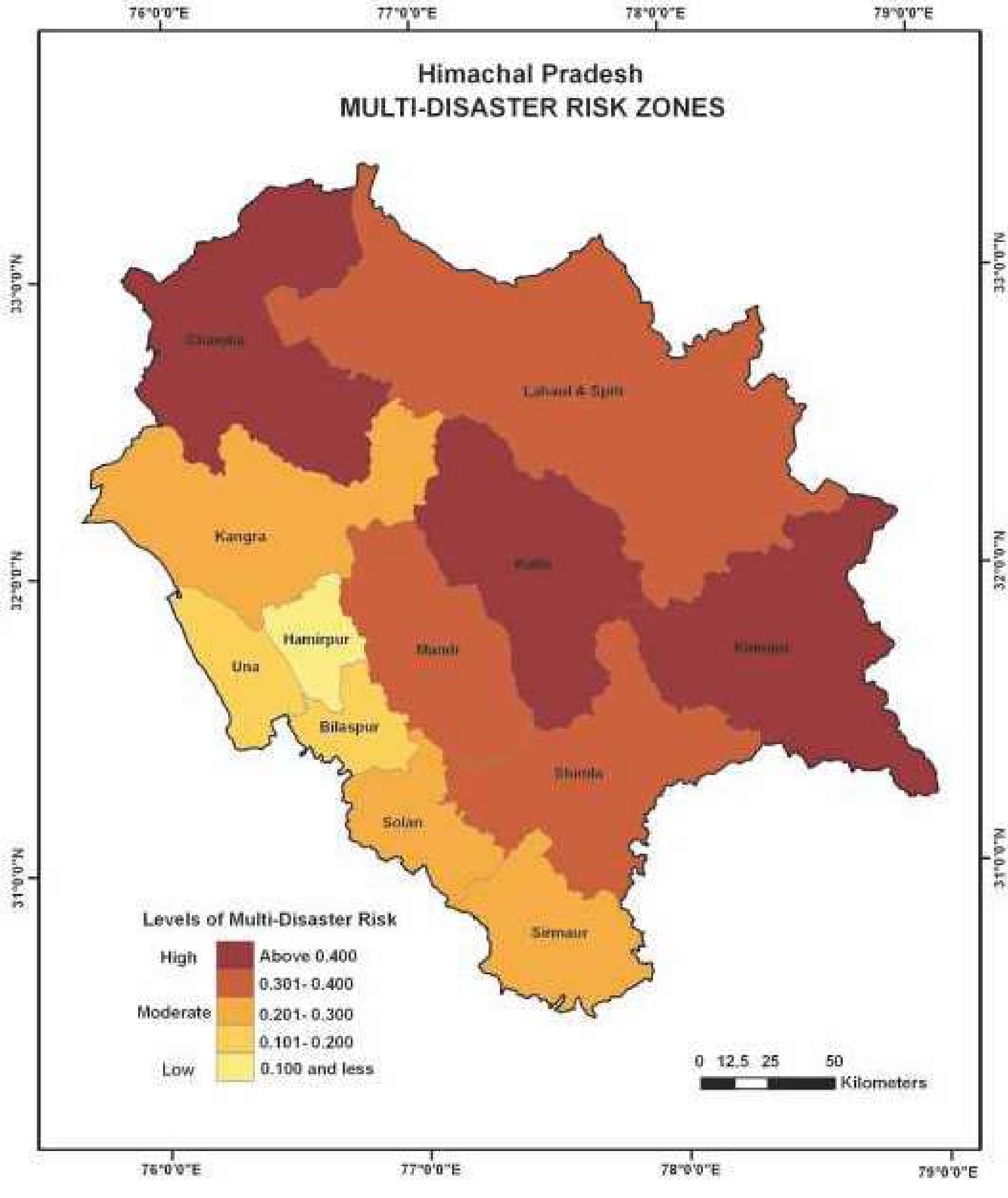


Map 1

mountains, steep slopes, and active tectonic activities. Climatic extremes are also more prominent in this zone which is an indication of change in the normal climatic regime.

Population Concentration and Vulnerable Zones

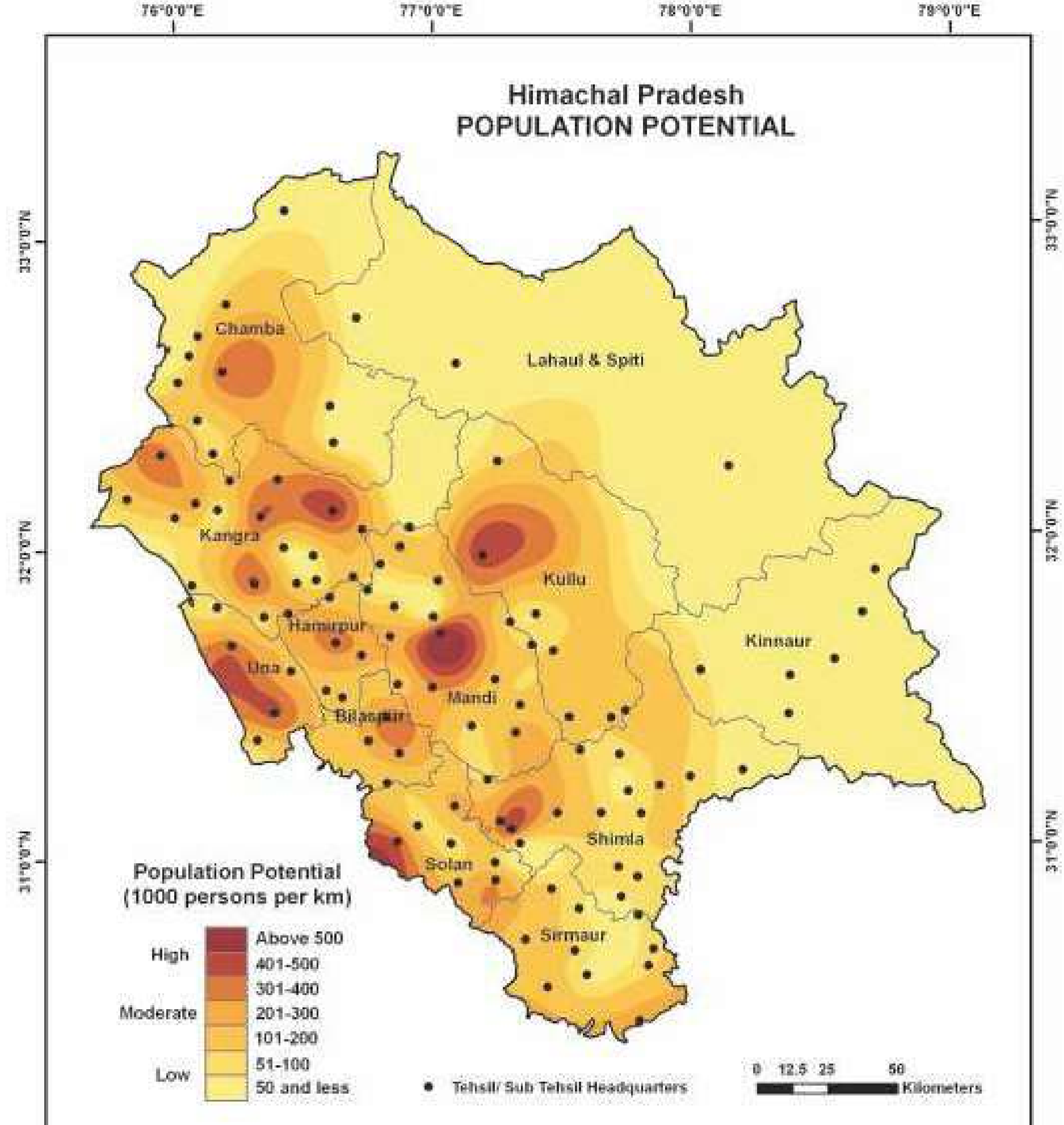
The population and its concentration is a major point of concern when addressing possible effects of disastrous activities (Kolars 1982). Such information can provide the basis for emergency decisions and acts as input for



Map 2

management plans for disasters in advance. A simpler yet effective way to understand possible threat from natural disasters to population is the 'population potential' which defines the number of persons within a given distance from a point. Population potential is an indicator of population pressure on a centre or a node. The high values denote higher concentration of population and vice-versa.

In this analysis, the population potential



Map 3

is calculated by taking into consideration the population of 109 tahsils and sub-tahsils of the state. The analysis of population potential shows that 80 (73.40%) tahsils and sub-tahsils have low to moderately low potential while 22 (20.18%) have moderate to moderately high potential and only 7 (6.42%) fall in high to very high population potential zones. This implies that population in the state is not only highly concentrated but also confined around a few locations. The very low potential areas are mainly confined to the cold desert and tribal regions of Himachal Pradesh consisting of Lahul-Spiti and Kinnaur districts and adjoining parts of Chamba, Kullu, Shimla and Sirmaur (Map 3). These are physically handicapped locations where terrain is mountainous and climate is harsh. Though the urban development and growth is low and economic activities are under-developed, yet there has been a remarkable development in the fields of horticulture and hydropower generation since the last 10-15 years which has initiated the process of infrastructural development in these areas.

The high population potential zones follow the major transport routes and include the corridors running through Kullu-Mandi-Sundernagar-Bilaspur, Palampur-Dharamsala-Kangra-Dehra, Solan-Nalagarh, Chamba-Dalhousie, Hamirpur and its surroundings, Una and its surroundings, Shimla and its surroundings, and Nurpur and its surroundings (Map 3). These are more developed parts of the state where apart from agriculture, development of other services including administrative, educational, tourism and industry is much more developed compared to the other parts of the state.

Vulnerable Population and Multi-Disaster Risk Zones

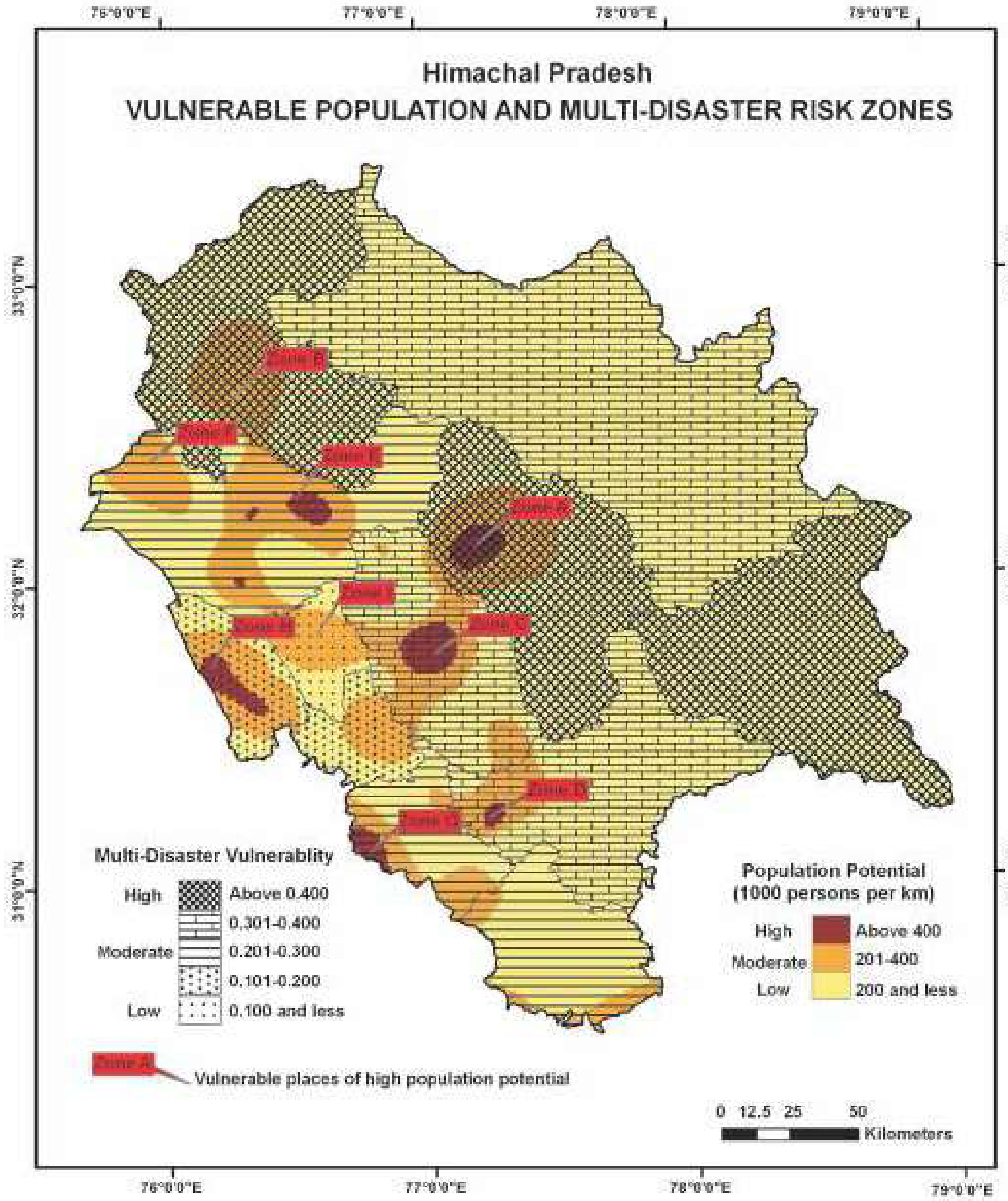
The amalgamation of disaster risk zones and population potential highlights the vulnerable areas (Table 2 and Map 4) which may be the possible locations of maximum impact in the event of a highly damaging disaster.

The leading amongst all major disaster sensitive zones (Table 2 and Map 4) is the valley of river Beas in Kullu district (Zone A) which is prone to almost every disaster that has struck the state. The area is highly sensitive to flood or flash flood and cloudburst along with the occurrence of landslide and drought incidences. As far as earthquake occurrence is concerned, though the area has not witnessed any major event after 1906, it falls in a very high seismic zone and is considered to be a part of seismic gap which makes it even more hazardous. This part of the state has been experiencing high concentration of settlements along the course of river Beas while in the interior parts of the area a lot of construction activity is taking place for developing hydro-power. This has added to the vulnerability of people and place to natural disasters. The same is true for Chamba and its surrounding areas

Table 2
Himachal Pradesh: Vulnerable Population and Multi-Disaster Prone Areas

Zone	Zone/ Area Description	Disaster Vulnerability	Population Potential
A	Kullu: Valley of river Beas	High	High-Moderate
B	Chamba and surroundings	High	Moderate
C	Mandi-Sundernagar-Bilaspur	Moderately high	High-Moderate
D	Shimla town and surroundings	Moderately high	High-Moderate
E	Palampur-Dharamsala-Kangra-Dehra	Moderate	High-Moderate
F	Nurpur and surroundings	Moderate	Moderate
G	Nalagarh and surroundings	Moderate	High-Moderate
H	Una: Valley of river Swan	Moderately Low	High-Moderate
I	Hamirpur and surroundings	Low	Moderate

Source: The Tribune (1971-2009); Census of India, Primary Census Abstract, Himachal Pradesh, 2001



Map 4

(Zone B) which unlike Kullu is highly sensitive to regular seismic activities. As far as population is concerned the area has moderate potential but its complex topography makes it highly prone to disasters like flood, cloudburst, earthquake and landslide.

Mandi-Sundernagar-Bilaspur (Zone C) and Shimla and its surroundings (Zone D) are next in line for disaster risk. In these areas, moderately high disaster vulnerability coincides with high to moderate population potential (Table 2 and Map 4). The former

(Zone C) is prone to flood, landslide or drought while latter (Zone D) is vulnerable to landslide and seismic activities.

The Palampur-Dharamsala-Kangra-Dehra corridor (Zone E) has moderate vulnerability to multi-disasters but the population potential ranges from high to moderate. This zone is particularly prone to cloudbursts, flash floods and landslides. Also the high population potential area coincides with very high seismic risk zone of which the 1905 and 1986 earthquakes are an example. Nurpur and its surrounding area (Zone F) is vulnerable to flood and landslide activities. Another such area of high to moderate population potential is Nalagarh (Zone G) that has moderate disaster vulnerability mainly to flood and drought. The high population potential is the result of its being the only industrially developed area of the state which has a large influx of migrant population. Una (Zone H) has moderately low vulnerability but high to moderate population potential (Table 2 and Map 4). The area is particularly prone to monsoonal floods and drought incidences. The least sensitive among all is Hamirpur and its surroundings (Zone I) which have moderate population potential and low disaster vulnerability.

Conclusion

Disaster risk zones have been identified within the state of Himachal Pradesh by blending the physical and human vulnerability zones. It emerges that different parts of the state are physically vulnerable to different disasters. The northern and northeastern districts are more susceptible to geo-physical disasters owing to their complex geology, geomorphology and altitudinal factors. The cool temperate middle part of the state is more susceptible to hydro-meteorological disasters. The zone bordering the plains of Punjab is found to be only mildly susceptible to disasters of any kind. Kullu district, comprising the valley of river Beas, is the most vulnerable zone in the state with high disaster vulnerability and high to moderate population potential.

It is true that the mechanism behind such events is predominantly natural; however, the triggering agent and conditions that lead to destruction are created by humans. These events have been in existence since times immemorial but their presence and impacts are more visible at present. This clearly emerges in the study area. The human vulnerability in these geologically young, unstable steep slopes and fragile environments has increased due to anthropogenic activity. The encroachment upon unsuitable landscapes for these activities have increased the vulnerability of people residing in these areas and of infrastructure developed over it. The promotion of infrastructure for tourism, hydro-power generation and allied activities, expansion of urban settlements and initiation of industrial development have been extensive, even reckless, in the last 15 years (Chandel and Brar, 2010b). Such ventures have attracted a huge influx of population from within and outside the state. Construction activity and expansion has been hasty and uncontrolled largely ignoring the hazards posed by natural phenomena.

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