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NATURAL DISASTERS IN HIMACHAL PRADESH: A MICRO LEVEL GEOGRAPHICAL ANALYSIS USING REMOTE SENSING AND GIS

Doctoral Dissertation Abstract (2011)

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Disasters are inseparable from human kind, their occurrence inevitable. The rise and fall of great civilizations of the past has had direct or indirect links with the failure of the delicate relationship between nature and human kind. Disasters have always raised issues pertaining to human-environment relationships; they now occupy centre stage with worldwide debate over increasing impact of disasters particularly in the light of climate change. There has been a marked rise in natural disaster events during the last century; the closing decade particularly has borne witness to the growing impact of devastating disasters. Natural hazards have been recurrent phenomena of the Indian landscape due to its unique geo-climatic conditions. With natural disasters becoming a part of our life, it is imperative to be aware of them and, more pertinently, be prepared for them.

Considering the significant role that geographers can play in understanding disaster mechanism and their inter linkages with environment-human interface, the present work attempted to analyse natural disasters and their management with specific emphasis on pre-disaster mitigation and preparedness on which current disaster management agendas are focused. The work is of contemporary and futuristic relevance in understanding human-

environment relationships in the context of increasing impacts of disasters. By addressing natural disasters as an expression of physical process in association with human-environment interaction, disaster studies have the capacity to dilute boundaries between physical and human geography; this study is a step in that direction.

This study is an attempt to understand natural disasters through an analysis of their past behaviour and spatial manifestation in Himachal Pradesh, a hilly state situated in northwestern Himalayas of India. This state is prone to a number of geo-physical and hydro-meteorological disasters which cause colossal loss of human life and property every year. It was the recognition of this fact that stimulated an analysis of the patterns and trends of natural disaster occurrence, their impact on humans, hazard zonation and an evaluation of the prevalent practices of disaster management. The study was informed by an understanding of the dynamics of human-environment interface within the region and the manner in which these influenced the occurrence and impact of natural disasters.

The research exercise was conducted at two scales. Historical reconstruction, spatio-temporal analysis, impacts on humankind and identification of critical zones prone to various

disasters: earthquake, landslide, avalanche, flood, cloudburst and drought formed the focus at the state level. This led to the recognition of the seriousness of natural disasters in the state and provided a base for detailed hazard modeling and vulnerability assessment at micro level. At the micro level the analysis centered on RS and GIS application in multi-hazard zonation and identification of risk and vulnerability associated with various kinds of disasters in Kullu district.

The sources for data on disaster occurrence consisted of ancient Indian literature, gazetteers, books, government reports, published research work, information and datasets compiled from catalogues and inventories prepared by various organizations. Information was also derived from topographical sheets (1:50,000; 1:250,000) and satellite imageries (IRS, LANDSAT, ASTER) and various thematic maps of various scales and resolutions. Remote Sensing, GIS and spatial statistical techniques were extensively applied for the analysis and mapping. Field work formed a very important part of this exercise.

Major Findings

Although the occurrence of natural disasters in this part of the country is historically acknowledged, very little is written about them, especially for the study area. The documentation of natural disasters prior to 1800 A.D. is almost negligible and the available information is patchy. However, there are references in ancient Indian literature substantiated by modern scientific data indicating the presence of seismic activities in the area. Information available after 1800 A.D. establishes the vulnerability of the state to numerous natural disasters such as earthquakes, landslides, avalanches, floods, cloudbursts and droughts. The disasters to

which Himachal Pradesh is prone, fall in two main categories, namely geo-physical and hydro-meteorological.

- The geo-physical disasters that occur in the state include earthquakes, landslides and snow avalanches. The state falls in the most seismically active northwestern Himalayas and seismic activity here is associated with active faults and folds. The earthquakes in Himachal are concentrated in three major zones: the northwestern zone comprising of Chamba, northwestern Lahaul & Spiti and northern Kangra districts; the eastern zone consisting of Kinnaur and southeastern Spiti and the central zone comprising of Mandi district. Landslides affect over 90 per cent of the total geographical area of the state. Landslides during the last four decades show a rising trend, particularly since early 1990s. Such activity is most prominent in four districts, namely, Shimla, Solan, Kinnaur and Mandi. The intense and torrential rains are apparently the principal cause of slope failure as over 75 per cent of landslide events occurred during the monsoon season. The occurrence of snow avalanches in Himachal Pradesh has restricted spatial, seasonal and temporal extent. These events are confined to the Greater Himalayan region and parts of middle Himalayas including the areas of Kinnaur, Lahaul & Spiti, Chamba and Kullu districts.
- An analysis of the geo-physical disasters in the state clearly demonstrates the role of complex physiographic, geo-tectonic and climatic settings in occurrence of these disasters. However the role played by anthropogenic activities in inducing and aggravating such phenomena and increasing vulnerability is no less significant. The areas of high seismic concentration and slope failure correspond

with the rapidly developing centres of tourism and hydro-power generation. The instability of hill slopes is attributed to alteration of natural slopes for the construction of communication and transport services. This is particularly true for Kinnaur, Chamba, Shimla, Kullu and Lahaul & Spiti districts where large scale road construction and widening activities are progressing at a fast pace to facilitate hydro-power projects, transportation facilities, horticulture activities and tourism.

- The hydro-meteorological disasters that strike Himachal Pradesh include flood, cloudburst and drought. These are largely governed by climatic conditions that act as a triggering mechanism inducing floods, cloudbursts and drought in the state. Floods in Himachal Pradesh are sudden in character, the past patterns of occurrence have been episodic but since 1990s their frequency has been consistently high. Kullu, Kangra, Mandi and Chamba are the most affected districts. Cloudburst occurrence shows a highly concentrated pattern in time and space primarily concentrated in the districts of Kullu, Chamba, Shimla and Kinnaur. The trends show a consistent rise and it is decidedly more prominent after 1990s. Recent trends reveal an increase during the pre-monsoon and post monsoon periods and emergence of cloudburst events in the cold deserts of the Greater Himalayas due to fluctuating and erratic rainfall. The occurrence of drought is a recurrent phenomenon in Himachal Pradesh. The maximum number of drought events occurred in Lahaul & Spiti, Kinnaur and Una districts. There were noticeable variations in drought occurrence in different climatic zones. The drought occurrence is severe in cold desert and hot-humid areas during the pre-monsoons and winter season.
- The hydro-meteorological disasters in the state reveal that their frequency and impact on people is rising. The expansion of seasonality of disaster occurrence is quite evident from their higher frequency in pre and post monsoon seasons. There are evidences which suggest that rainfall patterns have become more erratic and this has impacted upon the disaster occurrence. The overall rainfall trends indicate that the cold desert area has become wetter while cool and wet temperate regions are becoming dry as rainfall regime is either below normal or decreasing. As a result, extreme events like flash floods, cloudbursts and drought are not only increasing but also making a mark in areas where these were not occurring earlier. The situation has become more complex as hazardous landscapes have been colonized by increasing population and have been given over to developmental activities. The expansion of corridor settlements in the valley of River Beas and large scale landscape alterations for road construction and hydro-power generation in Satluj, Beas and Ravi river valleys are situations waiting for disasters to happen.
- There are spatial variations in physical vulnerability to geo-physical and hydro-meteorological disasters. The districts located in north and northeastern parts having very high relief are the most vulnerable to geo-physical disasters while hydro-meteorological disasters pose maximum risk in cool-temperate zones. The overall results reveal that Kullu, Chamba and Kinnaur districts are highly vulnerable to both disaster sub-groups. Lahaul & Spiti, Shimla, Mandi, Kangra, Sirmaur and Solan districts are moderately vulnerable while

Bilaspur, Una and Hamirpur districts have low physical vulnerability to natural disasters. There are certain areas/zones which are more vulnerable to disasters due to higher population concentration and high disaster risk. Leading among these is Beas valley of Kullu district which is prone to almost every disaster. The other areas include Mandi-Sundernagar-Bilaspur stretch; Palampur-Dharamsala-Kangra-Dehra corridor; towns of Shimla, Chamba, Nurpur, Nalagarh, Una, Hamirpur and their surroundings.

- The micro level analysis of disasters in Kullu district shows that the hazardousness to natural events is rooted in its physical and climatic character that offers a very conducive environment to different kinds of natural hazards. Situated in high to very high seismic risk zone with diverse geomorphic character of young mountains and a variety of climatic conditions, this area has a natural tendency for hazardous processes like seismicity, flash floods, cloudbursts and slope failure. The extreme natural events that pose a hazard in Kullu district are related with erratic and variable climatic events resulting in increase in meteorological disasters such as flood, cloudbursts and drought with a definite upswing in terms of spatial, temporal and seasonal occurrence of cloudbursts. The rise in temperature and rainfall fluctuations with rise in wet and dry spells is noticeable. The rainfall and temperature patterns have changed in the area during the last century showing a slight increase in rainfall, while rise in the temperature regime is more clearly visible with mean maximum temperatures increasing substantially. The visible effects of these are a decrease in area under permanent snow cover. Moreover, in context of such changes, the occurrence of

extreme events like cloudburst and drought with increased intensity are expected.

- Disaster risk and vulnerability of people and infrastructure in Kullu district is a result of human activities of abusive nature. The increasing damages by disasters are a result of landuse intensification and ensuing pressure on land and resources. The most notable impacts include intensification of land already under utilization and further expansion of horticulture, settlements and infrastructure over marginal/vulnerable spaces which have increased the threat from natural disasters. In addition to these, other visible negative impacts of such changes are decreasing man-land ratio, an indicator of pressure on land; declining density of forest cover and encroachments over natural landscape. In response to these processes of development, the area has also experienced rapid growth of population. The area is not only densely populated but is also experiencing large scale expansion of corridor settlement mainly along the valley region in the district. This can be visualised in terms of the fact that population in the district increased by 98.35 per cent while the revenue area increased by just 10.55 per cent once again, indicating a high degree of intensification of landuse. In conjunction with the changes in physical environment, the human vulnerability has undoubtedly increased due to misuse and mismanagement of land and resources.

An appraisal of space-time analysis of disaster events reveals an alarming situation: changing climatic regime, excessive alteration in landuse/land cover and increasing vulnerability is evident. A complex picture emerges of vulnerability in the state where natural vulnerability is inherent and humans have exacerbated it. The linkages amongst disasters, climate change, environment and the

development process therefore need to be envisioned in the broad frame of sustainability. The complex interface between human-environment-disaster has emerged as a vital theme that calls for both an exhaustive and in depth investigation geared towards mitigating the impact of disasters and reducing vulnerability. That apart, this research work specifically outlines the agenda for future research that incorporate the three facets: the

natural hazard scenario in its local context; the disastrous manifestations of hazards, and level of societal resilience. Assessing human-environment links at micro scale mappable units will be a step in this direction. Moreover, such themes offer geographers the possibility to not only expand beyond their traditional domain but also to delve deep into the existent themes and bridge their divided inheritance to become a holistic discipline of knowledge.