Disasters are inseparable from human kind, their occurrence inevitable. The occurrence of disasters is not a recent phenomenon. These have shaped the course of human civilization since the very beginning. The recent and consistent rise in natural disasters and their impacts are well recognized all over the world. This geographical enquiry on natural disasters was focused on the construction of disaster profile, identification and delineation of critical areas of concern for natural disasters, and the aspects of disaster management in Himachal Pradesh, a hilly state situated in northwestern Himalayas of India. Physiographically and climatically diverse, 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 aim of this research work was to examine the problem of natural disasters in their historical, spatio-temporal manifestation and to identify critical disaster prone areas. 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. The state level analysis involved the construction of an overall disaster scenario and its impacts. 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; identification of cause-and-effect relationships between events and their manifestations; and provided a base for detailed hazard modeling and vulnerability assessment at micro level. At the micro level the analysis centered on multi-hazard zonation and identification of risk and vulnerability associated with various kinds of disasters in Kullu district. In addition, information gathered through field observations, questionnaires and interviews with local people and
authorities formed the basis for understanding and evaluating the aspects of disaster mitigation and preparedness.

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 and satellite imageries 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.

This study was conducted under certain constraints and limitations. There is a lack of data availability on disaster occurrence since no such data is recorded and published on a regular basis. Whatever information was available it was either patchy or inconclusive. A major drawback was the lack of location specific data in the spatial and temporal context. These limitations made the analysis of all kinds of disasters difficult particularly in a similar framework. The non-availability of Survey of India (SOI) topographical maps of various scales made analysis and mapping challenging. The fact that over 60 per cent of the study area falls in a restricted zone defined by Survey of India and Ministry of Defence only added to the problem. Alternate sources and methods of data compilation, mapping and analysis were resorted to, such as, topographical sheets published by US Army Map Service (Series 502); ASTER and SRTM data. The work could have been more comprehensive if some more time had been available for field work. However, it was not possible in the time bound schedule of research work.

The analysis of natural disasters, their historical manifestations, spatio-temporal patterns, and critical zones, assessment of disaster management, planning, policies and measures presents a very revealing picture of disaster occurrence in Himachal Pradesh. The entire research work concludes with the following findings and suggestions:

- 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 geophysical and hydro-meteorological.

- The geo-physical disasters that occur in the state include earthquakes, landslides and snow avalanches. The state owes its seismically active status to the fact that it is situated in the zone of continental-continental collision of the Indian and Eurasian plates. The state falls in the most seismically active northwestern Himalayas and seismic activity here is associated with active faults and folds. The entire state falls in high to very high seismic risk zone. In the last 200 years, the state experienced over 550 earthquakes out of which 33 were damaging events involving loss of life and property. Over two-thirds of these earthquakes were concentrated in Chamba, Lahaul & Spiti and Kinnaur districts. 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 and bordering areas of Kullu district. The Kullu area has been identified as a seismic gap that is experiencing a period of quiescence where no seismic activity has taken place for a considerable period of time.

- Landslides are spatially the most widespread among all natural disasters in Himachal Pradesh with over 90 per cent of the total geographical area of the state being prone to landslide risk. Certain historical sites of major landslide occurrence have also been identified. The annual distribution of landslide events during the last four decades shows a rising trend, particularly since early 1990s. Landslide 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. Landslide occurrence in Himachal Pradesh is particularly persistent along a few major highway stretches. The landslides in these areas are the outcome of the combined effect of highly jointed, fractured structures and slope cutting for road construction and widening. The resultant unconsolidated material is very susceptible to landslides especially during monsoons when the surface material is saturated with moisture. The trend also shows that the number of people killed by landslides in the state has been on the rise. Among the 12 districts, Kullu and Shimla are the most affected, accounting for half of the total deaths by landslides.

- The occurrence of snow avalanches in Himachal Pradesh is considerably less disastrous and has restricted spatial, seasonal and temporal extent. The overall frequency of avalanches shows an insignificant rise in last four decades. 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. Although their occurrence is limited over time and space, they have the potential to cause havoc especially because the areas most vulnerable to avalanches are also the locations where large scale developmental activities are being undertaken.

- 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. The intense monsoon rainfall concentrated in three months is the major cause of floods and cloudbursts while its failure causes drought. These disasters have an established history of causing catastrophes and this is a matter of even graver concern as the economic development in the state is dependent on hydro power, tourism and horticulture which are directly influenced by climatic variations.

- Floods in Himachal Pradesh are sudden in character, occurring with little or no warning and are mostly a local phenomenon. The past patterns of occurrence of this event have been episodic but since 1990s their frequency has been consistently high. Kullu, Kangra, Mandi and Chamba
are the most affected districts. The major floods occur along the Satluj, the Beas, the Ravi and the Swan rivers. The occurrence of over 90 per cent of the total floods is restricted to the monsoon period. Floods in the state are an outcome of intense monsoonal rainfall and their disastrous manifestations are intensified through anthropogenic activities. Even though they have not shown a significant increase in occurrence, their damage profile has taken a dramatic upswing.

- Cloudburst occurrence in the state 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 in cloudburst occurrence over time and it is decidedly more prominent after 1990s. The occurrence is limited to the three monsoon months between July-September. 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 vulnerability to cloudburst incidents in terms of human casualties, disruption of infrastructure and facilities has also been on the rise.

- The occurrence of drought is a recurrent phenomenon in Himachal Pradesh and was particularly persistent in the first two decades of the 20th century and during 1960s. These tended to be particularly severe in pre-monsoon and winter period. The maximum number of drought events occurred in Lahaul & Spiti, Kinnaur and Una districts. Drought situations were episodic during 1970s and were most severe in 1980s. There were noticeable variations in drought occurrence in different climatic zones. The temperate zone had less incidence of drought than hot humid zone and the cold desert zone. The drought occurrence is severe in cold desert and hot-humid areas during the pre-monsoons and winter season. The cold desert areas, Sirmaur and bordering Shimla districts, are affected by frequent droughts even during the monsoons.

- 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 centre 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 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. These include Lahaul & Spiti, Kinnaur, Chamba, Kullu and Shimla districts. The hydro-meteorological disasters pose maximum risk in cool-temperate zones of Kullu, Chamba, Shimla, Mandi, Kangra and Sirmaur districts. 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 state is developing at the greatest pace ever witnessed and these parts are at the forefront in this respect. The development of infrastructure, expansion of settlements, development of hydro-power and horticulture activities is leading to encroachment upon natural landscapes. This has increased the vulnerability of people residing in these areas and the infrastructure developed over here. The emergence of increasingly vulnerable spaces at the interface of high population concentration and zones of intense economic activity could spell doom in the event of a disaster.

- The micro level analysis of disasters in Kullu district shows that the district has a history of extreme and damaging events such as floods, landslides, cloudbursts, occasional droughts and snow avalanches. 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. Such changes in climate are also validated by other studies (Singh & Roy, 2002; Bhutiyani et al. 2007) conducted in this area as well as other parts of western Himalayas. High probability of severe drought in pre-monsoon and drought conditions in winter and monsoon seasons draw attention to key issues of water availability in the area. Moreover, in context of such changes, the occurrence of extreme events like cloudburst and drought with increased intensity are expected. This possibly will have serious implications on major economic activities such as horticulture, tourism and hydro-power generation. However, such findings and results are restricted by the limited availability of climatic data and therefore further investigations of long term climatic records at micro scale are warranted.

- The hazardousness of Kullu district is the result of its physical and climatic conditions and such events will continue to pose a risk. On the other hand, disaster risk and vulnerability of people and infrastructure 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 area has managed to retain fairly good quality, healthy forests and so far has withstood the widespread exploitation of forest cover. Not much change in landuse was noted till independence. However, in the post 1970 era Kullu district emerged as one of the fastest developing parts of the state. This development stemmed from the emergence of horticulture, tourism and hydro-power generation ventures. These developments led to large scale change in the landuse/land cover. 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 development processes, 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. The risk and vulnerability to disaster has therefore increased in response to human activities relating to population concentration and growth of infrastructure facilities. In conjunction with the changes in physical environment, the human vulnerability has undoubtedly increased due to misuse and mismanagement of land and resources.

The field-work conducted in Kullu district for the appraisal of disaster preparedness and mitigation at individual and management levels highlighted several significant issues and gaps in disaster management practices. The people are aware of the nature of disasters that their area suffers from and the risks involved. The change in local climate emerged as a well noticed phenomenon: rise in temperature; declining snowfall and variable rainfall were observed by the local people. Drying up of natural sources of water and change in horticulture practices were related with deforestation and climate change. Linking changes in local climate with disasters, people feel that such events were strongly associated with climate. At the same time, they did not appear to possess adequate awareness to handle critical situations: knowledge of emergency warnings and standard procedures of evacuation during any emergency and structural controls to avoid/mitigate disasters were non existent. The level of sensitization to disaster mitigation practices is lacking. It needs to be inculcated through effective preparation and knowledge dissemination.

There exists ample research work focusing on disasters and related themes in the area. These can be of great significance in devising appropriate solutions to disaster occurrence but such inputs need to be blended in with the current disaster management plan. The disaster management plan for Kullu district lacks in terms of focus on
preparedness and mitigation. There are no attempts at hazard zonation, identifying vulnerable population and infrastructure and incorporating the local context. Any meaningful disaster management plan must consider these points.

- The evaluation of disaster management plan suggests a re-defining of management approach from a holistic view. Consideration must be given to the local contexts through wide-ranging technical and scientific interventions. Active community participation, awareness, knowledge sharing, skill development and participative governance for a resilient society are the other key factors in this respect. Establishment of a very competent authority at district level that takes all above factors into count is very essential. The decision making process and management practices need to be cultivated through awareness, cooperation and support among various sections or stakeholders.

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 situation is complex and needs to be understood in terms of linkages between both the natural and human world. The study area is rich in biotic and climatic resources and this has sustained a huge population base and led to prosperity in the area. Destruction of the harmony of the natural environment in response to development is clearly evident. This can be surmised from the fact that all kinds of disasters have increased in terms of frequency and their impacts on life and property are definitely rising.

Disasters are an inherent part of Himachal Pradesh and they have become rampant in the recent past due to the pulse of development that has accelerated in the state. During the past three decades the ventures of tourism and hydro-power generation have opened new vistas for economic growth in the state. The development of these ventures will definitely result in massive changes in land cover. Increasing impacts of extreme disaster events are evident and they pose a threat to such ventures; changing climatic conditions are only making matters worse as there are evidences of climate change
(Bhutiyani et al. 2007; Chandel & Brar, 2010a) and declining water discharge of Beas and Satluj rivers (Bhutiyani et al. 2008 & 2010). The development and policy frameworks of the state need to be reviewed, conceived and addressed in terms of their sustainability on a long term basis in line with sound environmental conservation considerations. The general outlook towards economic development in the state is that it has so far ignored the issues of environmental conservation. The linkages amongst disasters, climate change, environment and the development process need to be envisioned in the broad frame of sustainability.

FUTURE RESEARCH PROSPECTS AND AGENDA

The present research work was aimed at understanding the disaster scenario in Himachal Pradesh. The approach adopted included a historical reconstruction of disasters and identification of risk zones. The purpose was evaluating mitigation and preparedness measures to minimize the impacts of natural disasters. Several questions emerged in the course of this work, which call for further investigation. 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 following agenda for future research:

- **Landscape Analysis for Hazardscape Studies**: The preparedness and mitigation of disasters is subject to a knowledge of natural processes that bring about change in the landscape. Such processes may act as a hazard/source of danger. Therefore, understanding these natural processes, defining their hazardousness and the changes that these have and are likely to bring about in the landscape would be an important task for investigation. This would serve as a building block for assessing risk and vulnerability and developing adequate landuse and structural regulations. In this light, the researcher intends to expand the work done for this thesis to define the hazard potentials and come out
with hazardscape maps and models based upon extensive field studies and use of earth observation technologies.

- **Disaster Scenario in Changing Climates:** Climate change and disasters are closely linked. Disasters are increasingly being recognized both as a reason for and a response to climate change. Such climatic changes are clearly visible in the area under study and are likely to threaten the population not only by elevating disasters both in number and scale but also initiating unexpected changes that may alter the resistance of populations to cope with hazardous situations. The scenario may add yet another stress to society by inducing rapid environmental degradation, shortage of water and food resources and destruction of or compromised livelihoods. Hence it will be a challenging task to mutually deal with climate change scenario and natural disasters. Defining the parameters and direction of change in climate, resultant disaster scenario, recording of changes that have already been initiated in response to such changes and their implications need to be understood within a broader framework based upon local studies. It would be of immense value to link disasters, climate change, adaptive response of society, issues of development and resultant environmental conflicts for mainstreaming these issues in development policy and in framing sustainable disaster risk management regulations.

- **Dimensions of Human Vulnerability:** Technological appreciation of physical mechanisms of disaster scenario is an integral part of disaster management. However the purpose of safer society cannot be achieved without considering the human elements associated with these events. Natural hazards by themselves do not cause disasters, they manifest only when it is in combination with a vulnerable and ill-prepared population. Therefore, it is vital to acknowledge the factors that influence disaster preparedness and response. The appreciation of local values with regard to the agenda of disaster management would be an important dimension. Simultaneously it is important to recognize how different segments of population and society perceive and respond to disasters. This would be a meaningful task in the direction of
understanding ground realities for realizing disaster management in the area.

A vulnerability framework for a disaster resilient society must incorporate the three facets of:

i. the natural hazard scenario in its local context,
ii. the disastrous manifestations of such hazards, and
iii. what is the level of resilience exhibited by the society in the face of such disasters

Assessing human-environment links at micro scale mappable units will be a step in this direction. This research agenda forms an integral part of the wider reality of increasingly degraded, blemished and vulnerable spaces that humans have created. Disaster management needs to be a part of a larger context and it must operate within the totality of the system. Complex reality needs to be comprehended for disaster management to be effective. The success of this will rely on identifying and working on multifaceted linkages between humankind and natural systems. 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.