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Assessing Impact of Geophysical Hydro-Meteorological Hazards Based on Perception Approach, Kinnaur Region, Himachal Pradesh

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***Abstract* - Disaster has been a continuous problem in the history of mankind and its effects have also been devastating. India's geo-climatic conditions as well as its high degree of socio-economic vulnerability, makes it one of the most disaster-prone country in the world. Landslides are the most costly geo-hazard in the world, and they're often the cause or the result of other hazards and disasters such as tsunamis, earthquakes, forest fires, and volcanic eruptions. It leads to an extreme disruption in the functioning of a society, causing widespread human, material and environmental loss and it exceeds the ability of the affected society to cope with its own resources. Kinnaur district of Himachal Pradesh has a hilly and mountainous topography which has a limited scope for human settlement and other human activity. The most common types of disaster in the region are earthquake and landslide. Apart from this, other kinds of disaster are also faced by the people of the region such as heavy rainfall, snowfall, deforestation, floods, soil erosion etc. The present study aims at analyze the landslide vulnerability and mitigation strategies and also the role of administration and community in their preparedness. The study is based on both primary as well as secondary data. Quantitative method was used to assess the landslide induced vulnerability and risk assessment in the study area. By using science and technology, community based management makes it possible to reduce the impact of disasters like earthquake and landslide in the study area.**
***Keywords:* Disaster, Landslide Vulnerability, Geo-Hazards, Risk Assessment, Community Based Management**

I. INTRODUCTION

Vulnerability analysis is an important part of the hazard assessment, which is confronted with complexity, uncertainty factors and other characteristics. India is a vastly stretched country with the population of around 1.3 billion and also has a lot of physio-geographical diversity, with features ranging from mountains to coastal areas and islands. India's geo-climatic conditions as well as its high degree of socio-economic vulnerability, makes it one of the most disaster-prone countries in the world. A disaster is an extreme disruption in the normal functioning of a society and causes widespread human, material and environmental loss that exceeds the ability of the affected society to cope with its own resources. As one can observe that the Himalayan belt is prone to various hazards both natural and man-made. Major hazards are earthquakes, landslides, snow storms, flash floods and snow avalanches. Himachal Pradesh is a part of the great Himalayas. It has wide valleys imposing Snow Mountains, limpid lakes, rivers and gushing streams. The entire region of Himachal Pradesh is hilly with the altitude ranging from 350 meters to 7000 meters above the mean sea level. Geographically, Himachal Pradesh can be divided into three distinct regions, the Shivalik or Lower Himalayas, Middle Himalaya or Inner Himalaya and Greater Himalaya or the alpine zone. Himachal Pradesh is prone to both man-made and natural disasters and comes under earthquake and landslide hazard Zone IV and V. So, there is need to assess the physical and socio-economic vulnerability to mitigate the impact of disaster.

Disaster has been a continuous problem in the history of mankind and its effects have also been devastating. The study of disaster has become an important and applied discipline in present days. A collaborative study of physical dimensions along with the human element is a must to identify the overall vulnerability of an area. Thus, the current study has been undertaken for understanding the physical set up along with socio-cultural vulnerability due to landslide using different indices of socio-cultural indicators in a spatial and temporal framework in Kinnaur region of Himachal Pradesh. It is situated in the middle Himalaya which is young folded mountain with steep slopes and rough terrain. Human activity, such as road construction and dam construction, has increased in recent decades due to huge potentiality of hydroelectricity, leading to enormous deforestation, which has made the area even more vulnerable to landslide.

Thus there is a need to assess the elements such as community, infrastructure, housing, social sector, livelihood sector, environment etc. It has been observed that due to natural conditions, like immature geology and high rainfall, the landslide hazards in Kinnaur have been a cause of great concern for the safety of life and property since the earliest times (MHHPC, 1958; ABAD, 1981). However, these natural conditions in combination with easy accessibility, rapid growth of population and urban development have tremendously increased the likelihood and frequency as well as the adverse effects of landslides in the last three decades (Niederer and Schaffner, 1988; Niederer *et al.*, 1989; Khan, 1992 and 1994). This has seriously endangered people and their property, infrastructure and livelihood amenities in the study area.

II. STUDY AREA

The Kinnaur district is one of the 12 administrative district of Himachal Pradesh give the special status of tribal district as schedule 5 area under the constitution of India. Kinnaur is located between 77°45' and 79°00'35" East longitudes and between 31°05'50" and 32°05'15" north altitudes. Its surrounded by the Tibet and Uttaranchal in the east, Shimla district in south-west, Kullu and Lahaul-Spiti district in the north-west and situated in the northeast corner of Himachal Pradesh. It is about 235 kms from Shimla is a tremendously beautiful district having the three high mountains ranges i.e. Zanskar, Greater Himalayas and Dhauladhar, enclosing valleys of Sutlej, Spiti, Baspa and their tributaries. The kinnaur has mountainous topography, ranging in altitude fron 1600m to 6816. The slopes are covered with thick wood, orchards, fields and picturesque hamlets. The much religious Shivlinga lies at the peak of Kinner Kailash mountain. The beautiful district was opened for the outsiders in 1989. The old Hindustan-Tibet road passes through the Kinnaur valley along the bank of river Sutlej and finally enters Tibet at Shipki La Pass.

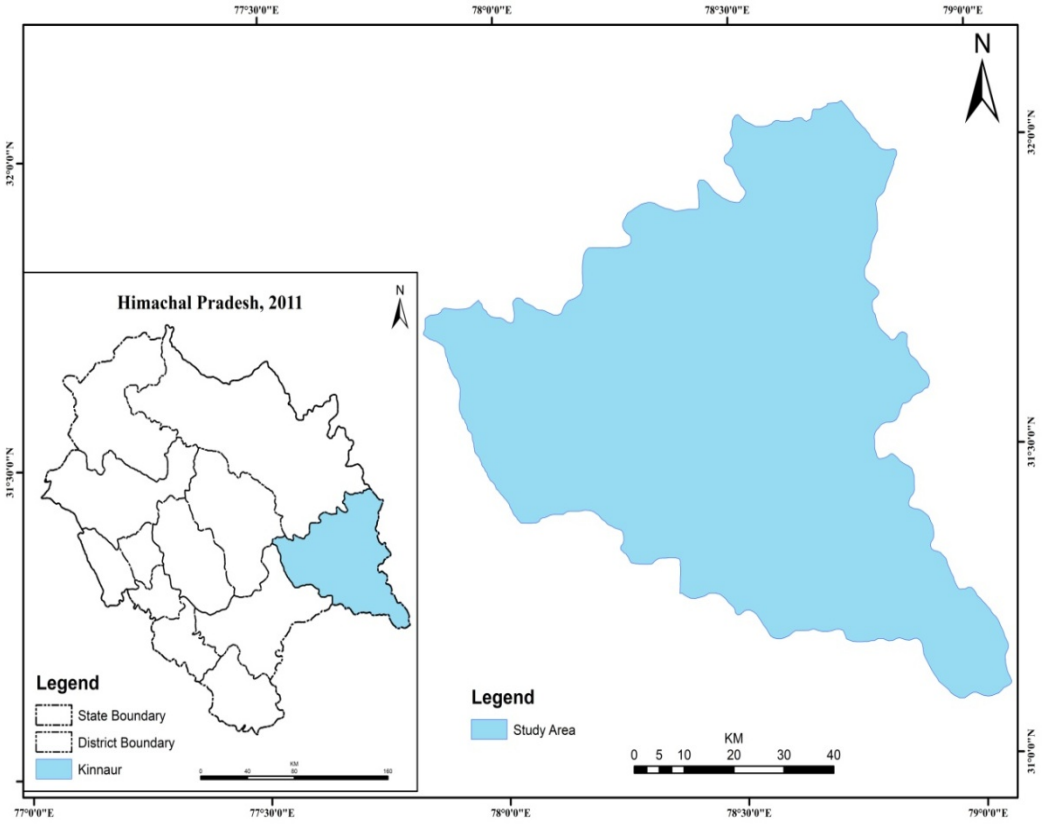

Fig.1 Location Map of Study Area Kinnaur, Himachal Pradesh

As per the previous recorded history, the district has been hit by more than 12 times by earthquakes having magnitude of 4.0 and above. The 4.0 and its surrounding magnitude earthquake are not much hazards in geological stable regions but the study area have rugged topography and deep and narrow valleys and steep slopes in young folded mountain which make it more vulnerable for such disaster like landslide, earthquake, rock fall etc.

III. OBJECTIVES OF THE STUDY

1. To access the geophysical hydro-meteorological hazard sin the study area.
2. To analyze the socio-economic impact of landslide in the study area.

IV. DATABASE AND RESEARCH METHODOLOGY

For the study purpose both primary and secondary data are used. The primary and secondary data have been collected to cover every aspect of the study. The Primary data have been collected through structured questionnaire prepared by the author. A group discussion and interview method has been used for collection the data. The people above aged forty were interviewed. The other information published by different sources, such as census of India, state disaster management Authorities (SDMA), district disaster management authorities (DDMA) has also been collected and employed in the study. For the purpose of analyses, percentage method has been used. The map has been prepared with the help of Arc GIS 10.3 software.

V. RESULTS AND DISCUSSION

Kinnaur is a mountainous district having rugged topography and deep and narrow valleys and steep slopes which makes it very prone to different types of slope failure namely Landsliding, Slumping/Creeping, Rock fall, Shooting Stones, etc. The unique Geo Climatic conditions of the District make it vulnerable to various kinds of natural hazards/disasters which have been compounded by increasing human interventions with the nature. There is need to identify and delineate the Hazard Risk zones of the District (areas vulnerable to various hazards) which will provide the necessary information to work on micro-level. The disasters, which generally occur in this district and its various areas prone/vulnerable to various kinds of disasters, are as under.

TABLE I HAZRDS RISK ZONES IN KINNAUR

Hazard Type	Name of Sub-Division & Hazard Vulnerability		
	Kalpa	**Pooh**	**Nichar**
Earthquakes	Moderate	Very High	Moderate
Floods	High	Very High	High
Landslides	High	High	High
Forest Fires	High	Low	High
Road Accidents	Moderate	Moderate	Moderate
Avalanches	Moderate	High	Low
Cloud Bursts	Low	NA	Moderate
Wind Storms	Moderate	High	Moderate
Drought	Moderate	High	Moderate

Source: State Disaster Management Plan

Landslides are the downslide movement of soil, debris or rocks, resulting from natural cause, vibrations, overburden of rock material, removal of lateral supports, and change in the water content of rock or soil bodies, blocked drainages etc.

This problem has been compounded by the increasing anthropogenic activities. The main cause of slope failure/landslide etc. is steep and fragile slopes, loose soil, fissured/fractured rock strata, some tectonic activity, heavy rainfall, toe erosion by running water and human intervention with the natural settings like various unplanned construction activity, deforestation, faulty land use planning, use of explosives in construction, practicing unscientific mining, quarrying, tunneling methods, unscientific dumping on the valleys etc. The shooting stone, which is very common in many parts of District Kinnaur is caused, among others, by the animal movements and winds. Landslide is a huge catastrophe in the hilly and sloppy area. It directly or indirectly affects the human and the developmental activities of an area. It also affects the flora and fauna and many of the time responsible for flash floods. The study area is hilly in nature and mostly affected by the landslide.

TABLE II OCCUPATION OF RESPONDENTS

Occupation of Respondents	No. of Respondents	Percentage (%)
Primary (agriculture, hoticulture, lovestock raising)	44	51.76
Secondary	10	11.76
Tertiary	31	36.47
Total	85	100

Source: Primary Data

TABLE III EXPERIENCE OF LANDSLIDE INCIDENCE

Have you Seen any Landslide	No. of Respondents	Percentage (%)
Yes	75	88.24
No	10	11.76
Total	85	100

Source: Primary Data

VI. CAUSES OF LANDSLIDE

The geological nature of kinnaur is very steep and hilly. Mostly people believed that natural phenomena's are performing major character for land sliding in the study area as much human being are. There are many reasons for the landslide in the Kinnaur District of Himachal Pradesh. The major landslide cause has been examined with reference to mining and blasting, rainfall and snowfall etc. and it can be analyse that rainfall and snowfall have been the play the major role, with 43% followed by mining and blasting (32%). The study area has much potentiality of hydroelectricity power plants and many of the hydropower plants are under construction following these blasting activities. However, road construction, deforestation and slope failure have relatively lower contribution towards landslips, with only a quarter of landslides being caused due to these reasons.

TABLE IV CAUSES OF LANDSLIDE

S. No.	Causes of Landslide	No. of Respondents	Percentage (%)
1	Mining & Blasting	27	31.76
2	Rainfall/snowfall	37	43.53
3	Road construction	11	12.94
4	Slope Failure	1	1.18
5	Deforestation	9	10.59
	Total	85	100

Source: Primary Data

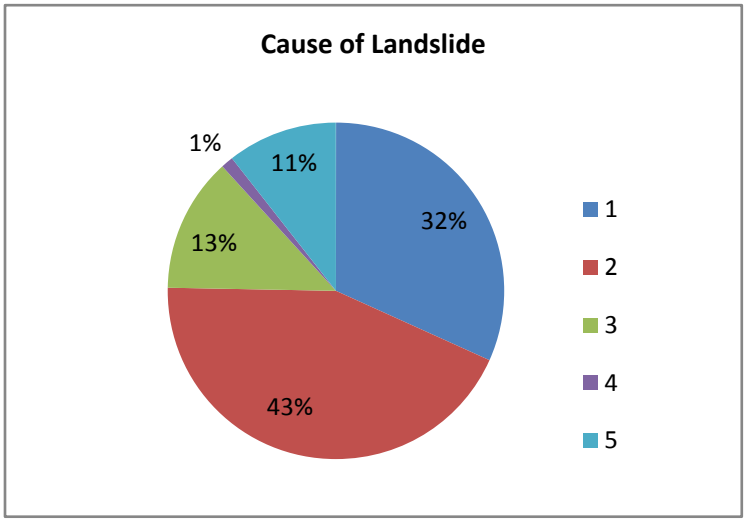

Fig. 2 Cause of landslide

A. Seasonally Frequency of Landslide

Table V shows the seasonal frequency of landslides in study area. The study area mainly come under three seasons namely, pre monsoon, monsoon and post monsoon. The seasonal frequency of Landslide in the study area, about 78% people feels that mostly landslide comes in the Monsoon seasons due to heavy rainfall, floods in major rivers and *nalas* about 13% peoples feel that landslide comes in pre Monsoon season while about 9% peoples of the study area believed that landslide comes in the season of Post Monsoon. The respondent also include that monsoon is not a main reasons for landslide but human activities such as mining, blasting, constructions of Road, hydroelectric project are mainly responsible for landslides in the study area.

TABLE V SEASONAL FREQUENCY OF LANDSLIDES

Frequency of Landslide	No. of Respondents	Percentage (%)
Pre Monsoon	11	12.95
Monsoon	66	77.65
Post Monsoon	8	9.40
Total	85	100

Source: Primary Data

B. Annually Frequency of Landslide

Landslide is a sudden fall of rocks, debris, mud flow etc. may not a single time problem in hilly area but the study area faces numerous instances in a one particular year. According to the people perception in the study area, around 87 % of the people believed that landslide occurs less than 5 times annually, followed by about 7 % people believed that landslide occur about 5 to 10 times every year. And about, 5 % people have no idea about the annual frequency of landslide. The frequency and intensity of landslide vary between one area to the another. The areas where human interventions are higher the frequency of landslide is higher and vice versa.

TABLE VI ANNUAL FREQUENCY OF LANDSLIDE

Landslide Frequency	No. of Respondents	Percentage (%)
Below 5	74	87.06
5-10	6	7.05
Above 10	1	1.18
Don't know	4	4.71
Total	85	100

Source: Primary Data

C. Loss of Human Life and Property

The topography of the study area enhances the devastation caused by cloudbursts, as the water flowing down the steep slopes brings debris, boulders and uprooted trees with great velocity damaging any structure which comes in the way leading to a significant loss of life, property and natural habitat. The shooting stone, which is very common in many parts of District Kinnaur is caused, among others, by the animal movements and winds. The landslides have caused loss of life and infrastructure in the past. About 45% of the people of the study area believed that they do not experience any loss after or during landslide while 55% were affected by the landslide. So, this type of variation in the opinion of the people of the study area is based on their settlement. Because, those people who have their settlement far from the prone area of landslide they have no any impact but those people who have their settlement near or under the prone area of landslide they have to face many categories of problems. The entire respondent in the study area believed that if the landslide happened in any area it directly or indirectly affect the human being. Many people believe that the major problems occur after the landslide which affects their life.

TABLE VII LOSS OF HUMAN LIFE AND PROPERTIES

Loss of Human Life & Properties	No. of Respondents	Percentage
Yes	47	55.29
No	38	44.71
Total	85	100

Source: Primary Data

TABLE IX PROVISION OF WARNING

Warning System	No. of Respondents	Percentage (%)
Yes	11	12.94
No	71	83.53
Don't know	3	3.53
No response	0	0.00
Total	85	100

Source: Primary Data

TABLE X PROVISION OF COMPENSATION

Provision of Compensation	No. of Respondents	Percentage (%)
Yes	69	81.18
No	12	14.12
Don't know	2	2.35
No response	2	2.35
Total	85	100

Source: Primary Data

VII. RESPONSE FORCE

The onset of an emergency creates the need for time sensitive actions to save life and property, reduce hardships and suffering, and restore essential life support and community systems, to mitigate further damage or loss and provide the foundation for subsequent recovery. Effective response planning requires realistic identification of likely response functions, assignment of specific tasks to individual response agencies.

This survey was conducted to knowing about the awareness among people about the role of administration and the disaster mitigating agencies. The agencies which work towards disaster mitigation in the study area are Indo-Tibbetan-Border-police (ITBP), District-Disaster-Management-Authority (DDMA), State-Disaster-Management-Authority (SDMA), National-Disaster-Response-Force (NDRF), Panchayat etc. and non-government agencies and self help groups like RSS, NSS. There were many institutions and agencies that has been working there but many people were aware and many were not.

About 85 % of the respondents were aware about the disaster mitigation agencies as they must have seen them responding during the times of disaster. while the 9% of surveyed population were unknown about the mitigating disaster agencies and said no one comes up to help during disaster for help and 6% respondents reported that they had no idea about these agencies either they work or not.

TABLE XI RELIEF MEASURE AGENCIES

Agencies for Relief Measures	No. of Respondents	Percentage (%)
Government	83	97.65
Non-government	2	2.35
Local people	0	0.00
Total	85	100

Source: Primary Data

VIII. RESCUE MEASURES AND MITIGATION

Mitigation refers to measures aimed at reducing the risk, impact or effects of a disaster or threatening disaster situation, whereas, preparedness refers to the measures undertaken to ensure the readiness and ability of a society to forecast and take precautionary measures in advance of imminent threat, and respond and cope with the effects of a disaster by organizing and delivering timely and effective rescue, relief and other post-disaster assistance. After any disaster, main activity is search and rescue. By effectively performing this activity loss due to disasters can be minimized. In the study area Landslide occurs because of the natural and manmade reason landslide is the basic problems because of the hilly and steep slope. According to the primary survey perceive that is very less contribution of local people (2%) for the relief and rescue operations in landslide. But, there is very big contribution of Indian Air Force, Indian Army and ITBP (54%) for contributing the operations and providing relief to the affected people by landslide. There is very less contribution of the district based authorities and local authorities to mitigate the problems of landslide in the study area, as we can the data in the given diagram.

TABLE XII RESCUE/ MITIGATION AGENCIES

Rescue/ Mitigation Agencies	No. of Respondents	Percentage (%)
ITBP/Army/Air force	46	54.12
Local people	2	2.35
Both ()	30	35.29
Don’t know	8	9.41
Total	85	100

Source: Primary Data

Disaster Response is the second phase of disaster management cycle. The post disaster phase of Disaster Management looks into Relief, rehabilitation, reconstruction and recovery. It consists of number of elements such as warning, search and rescue, providing immediate assistance, assessing damage, continuing assistance and immediate restoration or construction of infrastructure. In the study area different agencies are establish by government, to assessing the damage provide relief measures to affected peoples. While other non-governmental and local communities based agencies are also working efficiently on relief measures. They provide reliefs including medical, food, shelter, clothes and also compensation, to the affected peoples in case of any type of calamities. The main responsibility of relief in case of any emergency or casuality situation was government.

TABLE XIII TYPE OF RELIEF MEASURES

Type of Relief Measures	No. of Respondents	Percentage (%)
Medical Aid	36	42.35
Food and water	36	42.35
Shelter & Cloths	8	9.41
Sanitation Facilities	5	5.88
Total	85	100

Source: Primary Data

IX. INSTITUTIONAL SETUP AND PRECAUTIONARY MEASURES

For Prevention and mitigation of effects of disasters and for undertaking a holistic, coordinated and prompt response to any disaster situation it has been decided by the government to enact a law on disaster management to provide for requisite institutional mechanism for drawing up and monitoring the implementation of disaster management plans and ensuring measures by various wings of government. Other than that it has been observed in Kinnaur district of Himachal Pradesh, the institutions that play a vital role in the region are- District Disaster Management Authority (DDMA), National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Indo-Tibetan Border Police (I.T.B.P) and Police department of the region. Precautionary measures are very important in the disaster prone areas as these measures helps to lower the damage done during the time of disaster.

TABLE XIV PRECAUTIONARY MEASURES

Precautionary Measures	No. of Respondents	Percentage (%)
Retaining wall	38	44.71
Rock bolt	22	25.88
Afforestation	31	36.47
Others	1	1.18
Total	85	100

Source: Primary Data

In the study area when we asked about the precautionary measures taken by the people 42% said that they built retaining wall, 24% said that they use rock bolt technique to lower the damage of the disaster and 34% said they do Afforestation as trees helps them to lower the chances of the damage.

X. CONCLUSION AND SUGGESTION

Landslides are the most costly geo-hazard in the world, and they're often the cause or the result of other hazards and disasters such as tsunamis, earthquakes, forest fires, and volcanic eruptions. It leads to an extreme disruption in the functioning of a society, causing widespread human, material and environmental loss and it exceeds the ability of the affected society to cope with its own resources. Vulnerability analysis is an important part of the hazard assessment, which is confronted with complexity, uncertainty factors and other characteristics. A collaborative study of physical dimensions along with the human element is a must to identify the overall vulnerability of an area. Landslide is an anthropo-geomorphic process responsible for evolution of landscape and mutation of landuse in the mountainous terrain. It is not only the way of transformation of slope but also the redefining the existing pattern of land utilization. Kinnaur district of Himachal Pradesh has a hilly, sloppy and mountainous topography. The unique geo-climatic conditions of the study area make it vulnerable to various kinds of natural hazard. The major causes of such natural hazards are increasing anthropogenic activities, such as road construction, dam construction, deforestation, faulty agricultural practices, use of explosive for construction, dumping at the river valley site etc. These activities have increased in recent times may increase the frequency of landslide, which directly or indirectly affect the human population to identify and mapping the major landslide prone area for advance preparedness, Limiting the construction activities and minimizing the stress over land surface through scientific technology, to Increase forest area and controlled over grazing in sloppy area, spread awareness among people towards the cause, vulnerable area and provide training to both individual and community levels, and Perform mock drill regarding evacuation during landslides in the highly vulnerable areas to minimise loss of life.

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