CITIZEN-BASED DRR MODEL TO REDUCE DISASTER TOLL IN HIMALAYAS

IMPLEMENTING AGENCY:
PRAGYA

CONTENTS

1. INTRODUCTION

1.1. Background to the study

The remoteness of the Himalayas hampers reach of infrastructure/services and calls for innovations in delivery. Pragya's recent initiative aims to design a Citizen-based-Disaster Risk Reduction (DRR) system in Indian Himalayas. It seeks to overcome the information gap in the region by developing a process of recording and transmission of climatic and geologic information through trained local youth. The intervention would facilitate: development of a Himalaya-specific, easy-to-use early warning system for top 5 hazards in the region, development of a post-disaster damage and need assessment system managed by the community for quick and efficient information gathering and communicating to relief suppliers, thus facilitating timely relief.

1.1.1. Need for risk reduction systems

The high altitude belt of the Himalayan region is amongst the most hazardous places, periodically ravaged by a range of natural disasters, meteorological and geological. Climate change impacts are highest at these high altitudes, increasing the frequency of disasters, and introducing newer disasters (cloudbursts, Glacier Lake Outburst Floods - GLOFs). Studies on four Himalayan Rivers show increased number of 'high magnitude' flood events over the last 3 decades (*ICIMOD 2007)*. The disasters, increasing in scale & frequency, are affecting the local Himalayan communities (>65% of 210mn people in the Himalayas face frequent natural hazards), causing immense destruction of life & property (*IPCC, 2007, ICIMOD, 2006*, *2007)*. In 2005, flash floods in Kinnaur district damaged 9,848 hectares agricultural land, along with the crops and horticulture produce. In the Leh cloudburst event of 2010, 1,410 hectares of productive land were affected. The high altitude region also displays very low capacity to cope with to disasters, with no reduction in the death toll year upon year, while trends in livelihoods related disaster losses are on an upward curve. These indicate the critical need to determine trends and conditions that mark arrival of such natural hazards with high incidence and damage potential, and set up methods for prediction and early warning. It is also important to identify vulnerable zones and groups, towards minimising the impacts.

The area's remoteness and difficult geographic terrain has contributed to lack of climate and geologic data and lack of understanding of the trends/patterns. Limited work has been done in terms of assessing the vulnerability of inhabitant communities. The region is also characterised by poor infrastructure with limited all-weather roads and telephone/radio connectivity. Isolated communities are often miles away from hospitals and the district centres from where relief activities are directed, and are wholly cut-off in bad weather. They frequently suffer localised extreme events and corresponding damages. Further, the high altitude regions are on the periphery of the nation. Given the lack of research, and information & communication systems, relief services are rarely in time or adequate; existing transportation & communication too tend to snap during disasters, leaving the most remote and vulnerable out of reach. Hence, the need for creating a DRR system that is custom-made to the unique conditions of the Himalayas.

1.1.2. Target beneficiaries

Communities inhabiting the high altitude (>2500m) Himalayas, constitute the beneficiaries of the innovation. These comprise households of small farmers and pastoralists living in a scatter of small villages dispersed over a vast, inhospitable terrain, characterised by poverty, low HDI, extreme vulnerability to climate risks and low coping capacity. They lack awareness, capacity and access to welfare & infrastructure. Absence of preparedness measures and support contributes to a sense of helplessness in the face of increasing frequency of disasters. The target groups for the project also include CSOs serving the area, government departments/agencies in target provinces and at the national level, as well as policymakers & scientists dealing with disaster mitigation.

1.1.3. Previous work

In 2006-07, a Pragya study on environmental threat in Himalayan cold deserts, and its adaptation capacity, revealed the increasing vulnerability of the region and the need for interventions which would build adaptive capacity and mitigate environmental threats. Grassroot workshops on drought management in Himalayan districts (2008-09) and an international conference on Environmental Threats in the Himalayas (Delhi,2009) by Pragya, elicited stakeholder needs, constraints & suggestions. A research study in Ladakh Himalayas, followed by experiences with relief & rehab work to address flashfloods in Ladakh (2010), validated these.

1.2. Project Aims

Overall objective: The overall objective of the project is to reduce the vulnerability of disadvantaged & poor communities inhabiting the Himalayas to risks from natural hazards exacerbated by climate change, and mitigate the impacts of these hazards on their lives, property and livelihoods.

Specific objective: The project seeks to develop DRR methods & tools uniquely suited to Himalayan conditions towards reduction and mitigation of disaster risk on the ground and to aid in decision & policymaking. Towards this, the project aims to create a citizen-based DRR system comprising:
(a) a Himalaya-adapted, indicator-based early warning system for the top 5 hazards in the region;
(b) a post-disaster damage & need assessment system for decentralized, post-disaster generation of information and its relay to relief suppliers.
The systems are aimed to be anchored with local youth, thereby addressing the unique constraints of the Himalayas, and would enable mitigation through timely evacuation/protection and relief, and continual evidence generation on micro-level climate/ecosystem changes would aid decisions on adaptation/ mitigation. The process of shaping the innovation and its dissemination involve state/ non-state agencies & communities, generate their buy-in, and orient communities & youth.

1.3. Framework for the Model

In the table below are the specific innovations that are the focus of this project in the context of all the necessary components of a comprehensive DRR system for the Himalayan belt. The DRR components that each of the two proposed innovations would contribute to have been indicated.

Category	Components of a DRR system	Proposed innovations
(a) Pre-disaster (proactive)	Risk assessment including Vulnerability Mapping and Hazard Analysis as well as Risk Quantification	--
	Early warning systems and community preparedness	• a citizen science program for real-time information on local environment (and community preparedness) with a focus on weather (and climate) and hydrological/ mass movement trends • an indicator-based early warning system suitable for the target area (focus on top 5 hazards)
	A range of risk reduction/mitigation measures, including suitable protection of especially vulnerable areas/communities	*Not addressed under this project*
	Disaster risk cover in the form of insurance	--
(b) Post-disaster (reactive)	Emergency Response & Relief including first alert/information	--
	Evacuation, protection and assistance/relief during/after disaster	• a decentralised system for post-disaster damage & need assessment and communicating the information to relief suppliers
	A range of recovery-targeted measures (including psychosocial support, rehabilitation &	--

	reconstruction of livelihoods and infrastructure)	

Both the innovations are aimed at addressing a key characteristic of the Himalayan region vis a vis effective DRR in the area: that of its remoteness which hinders timely assessment & communication before and after disasters. The systems would enable the same to be carried out by/rest with the grassroots community themselves, with linkages created to facilitate that.

1.4. Way forward

The project-created 'DRR for the Himalayas' will be made available widely, and the necessary awareness & initial commitment developed in the stakeholders. Government, communities and NGOs will be liaised with for piloting the innovation, which would help ground-truthing, subsequent government endorsement and community uptake.

2. METHODOLOGY

We kick-started our endeavour in the domain of DRR through community preparedness, by facilitating the design of a decentralised system for early warning and post-disaster damage & need assessment and communication, adapted to the Himalayan socio-ecology and infrastructural gaps.

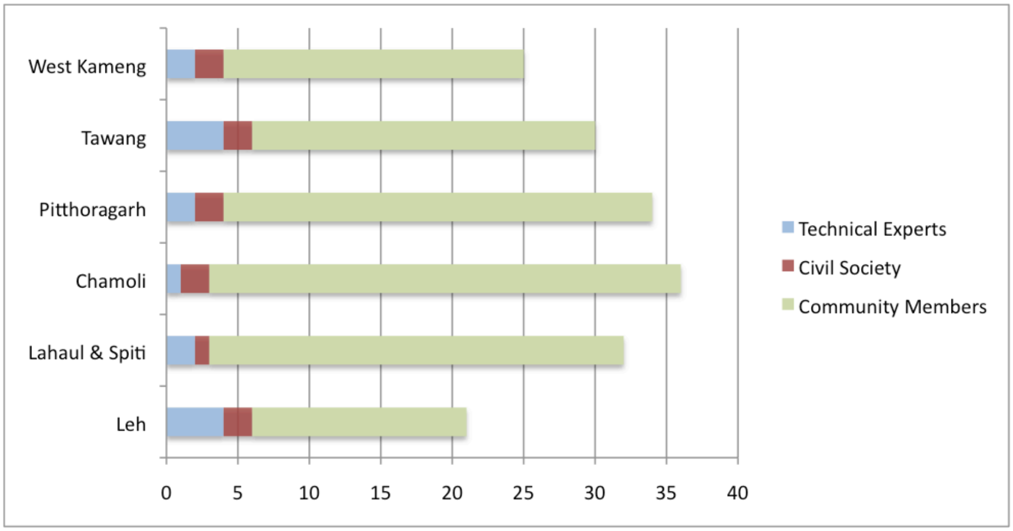
The process included the following:

2.1. Consultations at grassroots:

Consultations were carried out with stakeholders in each of the Himalayan districts that the project is being carried out in, in order to elicit feedback from the grassroots on key hazards for the region and associated needs and early warning indicators. The day-long, multi-stakeholder consultations conducted in the districts, were also designed to draw out hazard indicators that were available in traditional/local knowledge systems/customs/rituals, for each of the natural hazards deliberated on.

Given below is a brief account of the consultations conducted:

Zone	District	Period	Number of participants	Details of participants
Western Himalayas	Leh	October 2012	**Total: 21** 16 Male; 5 Female	Officials from LAHDC, DRDA, Dept. of Horticulture, SKUAST university, NGOs, village heads and community members
	Lahaul & Spiti	October 2012	**Total: 32**; 11 Male; 21 Female	Representatives from CSIR IHBT Centre for High Altitude Biology and Department of Agriculture and community members including village heads and women SHG members
Central Himalayas	Chamoli	October 2012	**Total: 36;** 25 Male; 11 Female	Representatives from local NGOs, scientist from Herbal Research Development Institute, journalists and community members
	Pitthoragarh	February 2013	**Total: 34;** 9 Male; 25 Female	Officials from Sub-District Magistrate office, Agricultural department, local NGOs and community members
Eastern Himalayas	Tawang	January 2013	**Total: 30;** 22 Male; 8 Female	Representatives from Forest Dept, KVK Scientist, Officer from Horticulture department, Specialist from local Health department, Village heads, local NGOs and community members
	West Kameng	February 2013	**Total: 25;** 16 Male; 9 Female	Officials from Agriculture Dept, village heads, Officer/Scientist from horticulture department, local NGOs and community members



Brief overview of participants for district consultations

Grassroots consultations

2.1.1. Hazard Prioritisation process:

Structured discussion formats were designed for the consultations and were aimed at helping to identify the top 5 hazards for each of the target eco-zones, based on frequency of occurrence, impact or extent of damage, and degree of vulnerability. Reference tables were drawn out for each to enable rating the hazards on the specific parameters.

Thus, reference tables for frequency of occurrence were drawn out, distinguished for rapid and slow onset disasters.

for Slow Onset Disasters (Drought, Desertification):

Rating	Frequency/Probability
1 Rare	Once in 15 years or more
2 Moderate	Once in 10 years
3 Frequent	Once in 5 years
4 High	Biannual

for Rapid Onset Disasters (Floods, Avalanche, Earthquake etc):

Rating	Frequency/Probability
1 Rare	Once in 5 years or more

2 Moderate	Every 2-3 years
3 Frequent	Annual
4 High	Several times a year

To map the perceptions regarding the extent of damage caused by each type of event, reference tables were drawn out to capture the event intensity and associated extent of losses caused by it. For example, given below is the refence table for GLOF related magnitudes of destruction.

Rating	Impacts
1 Low	Blockage of roads Disruption in communication Inundation of lands that are currently not in productive use
2 Moderate	Partial damage of road infrastructure Accumulation of debris on agricultural lands/ damage due to excessive erosion Disruption of daily activities Temporary water logging
3 High	Occasional cases of loss of lives, death of livestock. Damage of road & communication infrastructure Damage to houses/animal shelters, property loss Inundation of agricultural lands Epidemics
4 Very High	High number of deaths, severe epidemic Acute food and water crisis. Poor drinking water quality. Complete dependence on relief measures for survival. Homelessness. Region remains cut-off for a long time High number of death of livestock. Large-scale out-migration in search of shelter and alternate livelihood. Massive economic and emotional stress Damming of rivers, chances of flashfloods Difficulty is adapting to post-disaster stress

Feedback was also obtained regarding the vulnerability of the community in the target areas to the specific type of disaster event, and the rating scale used for the purpose was as follows:

Rating	Vulnerability Factors
1 Low	A proper Early-warning system is in place for the disaster Traditional knowledge systems exist Community has adequate capacity to deal with the disaster Community has a high level of awareness on the disaster
2 Moderate	An average early warning system is in place for the disaster Some traditional knowledge exists for the disater Community has moderate capacity to deal with the disaster Community has some awareness on the disaster
3 High	A poor early warning system is in place for the disaster Very little traditional knowledge exist Community has very little capacity to deal with the disaster Community has very little awareness on the disaster
4 Very High	No early warning system is in place for the disaster Community has no capacity at all to deal with the disaster Community has absolutely no awareness on the disaster

2.1.2. Determining TK on Hazard Indicators:

The grassroots consultations also sought to identify indications from physical surroundings or movements/behaviours of living beings that are connected to weather conditions, which can help predict the hydro-meteorological disasters such as floods, cloud burst, avalanche etc. The consultations tried to document such signs - observed and proven true in several occasions over the years in the target areas. Indicators identified related to: direction of wind/ cloud movement, movement or occurrence of insects, animals, birds etc, changes in flowering / fruiting / ripening of fruits / shedding of leaves or changes in phenology of plants, colour of sky, shape of cloud, water level of particular water body, colour of water, etc. Elderly citizens were engaged in the discussions to draw on their traditional knowledge/beliefs and long-term observations.

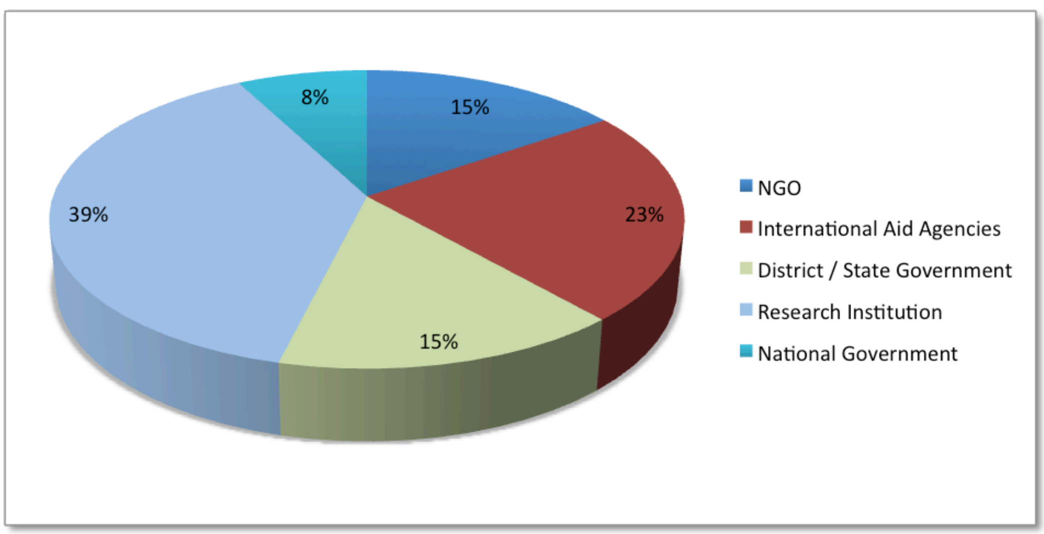
Reliability ratings were assigned by community members based on their experiences on how many times a prediction might come true based on the particular sign/observation. The indicators were rated on a scale to 1 (low probability) to 5 (high probability) to indicate how likely is the prediction to come true out of 5 occassions.

2.2. Consultations with sector experts:

Apart from the grassroots consultations in districts, the data collection process involved interviews with key stakeholders (Himalaya-experts, NGOs, CBOs, district authorities, international stakeholders) in the target districts and at the national level. Specific questionnaires were designed to elicit inputs on the potential indicators for various natural disasters, that would enable continual surveillance and timely warning, from the respondents. Telephonic interactions and face-to-face meetings were arranged for the consultations.

Meetings were also held with national DRR authorities in the districts and states and at the national level, including with the Disaster Mitigation & Management Centre - Uttarakhand, District Commissioner - Leh, Jammu & Kashmir, Natural Resources Data Management System - Ministry of Science & Technology, District Rural Development Agency, Agriculture, Horticulture, Disaster Management Cell, Block Development Office, Revenue Department. These meetings and interactions helped to draw out the suggestions from these expert stakeholders on the following: the process for surveillance along with the relevant scales & indicators for early warning, as well as the process for recording & relay of environmental, hazard and disaster information.

Inputs were also sought from the above DRR authorities, as well as NGOs with a mandate for DRR as well as Relief Aid Agencies with significant experience in this sector (such as Sphere India - National Coalition of Humanitarian Agencies in India, ACTED, SEEDS, UNICEF, CEE Himalaya, Rural Development & Youth - RDY, WWF, Ladakh Ecological Development Group - LEDeG, Ladakh Ecology and Health Organisation - LEHO, Leh Nutrition Project - LNP, All India Disaster Mitigation Institute - AIDMI), on the kind of information required during/post disaster, for effective relief measures.



Brief overview of sectoral experts consulted

Discussions were held with regional research institutions as well as meteorological and hydrological and geologic research institutions (IIT Roorkee, Dept of Water Resource Development & Management - IIT Roorkee, Geo-Hazard Risk Management Division - National Institute of Disaster Management, Institute of Industrial Science - University of Tokyo, Geosciences and Geohazards Dept - Indian Institute of Remote Sensing and

Global Forum for Disaster Reduction, National Institute of Disaster Management, Sher-E-Kashmir University of Agricultural Sciences & Technology, Defense Institute of High Altitude Research, Department of Geography - Kumaun University) to elicit information on the institutional capacity. This helped determine the nature of information available within the particular institution, that could be leveraged for the purpose of effective DRR in the target region. The discussions sought to establish the local institutional capacity for weather monitoring & forecasting, including locations & adequacy of available local & regional weather monitoring stations, and their capacity, infrastructural and human, for forecasting temperature & precipitation and extreme events. The discussions also helped identify the information gaps, and thereby the key areas for which information would need to be collected via the proposed citizen science program, towards creating an adequate information system that could aid DRR decisions.

2.3. Learnings from flood relief operations:

A multi-day cloudburst that caused devastating floods in the Indian Himalayan states of Uttarakhand and Himachal Pradesh in June 2013 and two of the project districts were among the worst affected. While working to address one of the worst humanitarian crisis of the decade in the Himalayas, the research team continued to interact with relevant stakeholders in the district including NGOs, CSOs working for relief and response, emergency coordinators from UN Disaster Management Teams, representatives of District Disaster Management Authority (DDMA) and nodal officers for external aid, representatives of media, coordinators of Sphere India district networks. These provided precious understanding of post-disaster convergence behaviour and relief chain (for 1st, 2nd and 3rd responders), and their effectiveness and first-hand knowledge of the coordinating mechanisms in place and their effectiveness/drawbacks. Discussion/correspondence was held with: representatives of first responders/rescuers: Indo-Tibetan Border Police force (ITBP), local police; local NGOs/CBOs: e.g. AAGAAS Foundation, Himadri Jan Kalyan Sansthan, Sri Bhuvneshwari Mahila Ashram, Janadesh; second responders including private entities/corporates: e.g. GMR Group, British Petroleum; those involved in reconstruction phase: e.g. General Reserve Engineering Force (GREF - a civil wing of Indian Army); stakeholder coordination agencies: e.g. United Nations Disaster Management Team - UNDMT - Rudraprayag, UNDMT - Chamoli and others.

The discussions focused on role and effectiveness of various agencies, the bottlenecks, factors that influence decision making and responsiveness, beneficiary prioritisation and indices of measurement of effectiveness, capacity of various agencies and suitable roles for each, preparedness of local communities and relief agencies, relief efforts with a focus on long-term development objectives. They also revolved around modes of data collection for assessment of on-ground situation, reliability of various sources, community involvement and use of technology. These provided significant inputs for the model.

2.4. Secondary research:

To supplement the information from the grassroots consultations regarding the frequency of disaster events and their impacts, studies and data on environmental threats in the target region were examined for trends in frequency and scale of impact, for slow onset as well as rapid onset disasters, both atmospheric hazards and hydrological/mass movement ones; there was a special focus on floods and droughts.

The research extracted and used both statistical data as well as media reports to supplement the verification process of the hazards prioritised in each target district. Data in DRR portals, crowd sourcing databases, government websites, data portals of inter-agency collaboration agencies, were explored for the same.

The secondary research also examined all research conducted on the natural hazards prioritised, in order to identify markers and parameters that could be adopted for the model, as well as the threshold levels and tools that could be used for measurement and communication. Further, inputs on good practices and critical success factors were also gathered through the process. These studies were guided by the inputs received from the consultations carried out with technical experts, and the relevant sources shared by them.

2.5. Designing the model

The data collected through consultations and secondary research have been analysed to develop simplified systems for recording & analysis of data on climate and hydrologic/mass movement. Essential parameters for data recording have been drawn out along with recommendations for the measurement process/instruments, scale & frequency of monitoring of various indicators, methods for relay of data, and analysis as well as procedures & methods for issuing warnings etc. These parameters and processes are envisaged to be a part of a citizen science (CS) program to be anchored with trained local youth, for ongoing information creation that could enable risk-reduction & preparedness. A Relief Information System (RIS) has been designed for collecting data on damage & need assessment during/after a disaster, and communicating it to relief agencies, towards enabling the desired relief.

3. Data Analysis

3.1. Hazard Prioritisation

The grassroots consultations along with the secondary research helped prioritise the natural disasters in each target district, based on frequency and impact.

Given below is a summary of such prioritisation:

i. Leh district (Western Himalayas)

	Frequency	Impact	Vulnerability	Top 5 Hazards
Drought	Moderate	Moderate	Moderate	1. Flood/Cloudburst 2. Earthquake 3. Avalanche 4. GLOF 5. Drought
Desertification	Low	Moderate	Moderate	
Landslide	Very High	Low	Low	
Avalanche	Moderate	Moderate	High	
Earthquake	Very High	Low	Very High	
Flood/Cloud burst	Moderate	Very High	Very High	
GLOF	Low	Moderate	Very High	

The top 5 hazards identified for Leh district are: Flood/Cloudburst, Earthquake, Avalanche, GLOF and Drought.

The consultations and literature review indicate a high frequency (several times a year) of landslides and tremors; it must be noted that earthquakes of high intensity were rarely recorded, and hence the impact of earthquakes is rated as low/negligible. Impact of landslides is also found to be low; since most habitations are sited with due consideration of slide-proneness, landslides typically occur in remote stretches, with effects primarily on the road infrastructure. Droughts, avalanches and floods/cloudbursts are perceived to be of moderate frequency (once in every 2-3 years; for slow onset disasters once in 10 years). Impact of floods and cloudbursts is rated to be the highest; the memory of recent 2010 flashflood event and associated losses still fresh in the minds of the community members, could have influenced the ratings.

ii. Lahaul & Spiti district (Western Himalayas)

	Frequency	Impact	Vulnerability	Top 5 Hazards
Drought	Moderate	Moderate	Low	1. Flood/Cloudburst 2. Avalanche 3. Earthquake 4. GLOF 5. Landslide
Desertification	Low	Moderate	Low	
Landslide	Very High	Low	Moderate	
Avalanche	Moderate	Moderate	Very High	
Earthquake	Very High	Low	High	
Flood/Cloud burst	Moderate	Very High	Moderate	
GLOF	Low	Moderate	Very High	

For Lahaul & Spiti district, the top 5 hazards are: Flood/Cloudburst, Avalanche, Earthquake, GLOF and Landslide.

Frequency of desertification and GLOF is found to be low. Although the frequency of occurrence of landslides and earthquakes is reported to be high, the damage caused by them is perceived to be considerably lower; since habitations are sited in slide-free zones, landslides do not affect the habitations, and earthquake intensity is quite low, in that they are usually no more than slight tremors. However, the community perceives higher vulnerability to earthquakes were they to occur, since, unlike other disasters, they feel ill-equipped to deal with earthquakes. The highest scale of impact is attributed to floods and cloudbursts, with particularly high vulnerability of the community to avalanches and GLOFs due to the quick onset of these events and the lack of community preparedness.

iii. Chamoli district (Central Himalayas)

	Frequency	Impact	Vulnerability	Top 5 Hazards
Drought	High	Moderate	Moderate	1. Landslide 2. Flood/Cloudburst 3. Earthquake 4. Avalanche 5. Drought
Desertification	Low	Low	Low	
Landslide	Very High	High	Very High	
Avalanche	Moderate	High	High	
Earthquake	Very High	Moderate	Very High	
Flood/Cloud burst	Very High	High	High	
GLOF	Low	Very High	Moderate	

In Chamoli district, the top 5 hazards identified are: Landslides, Floods & Cloudbursts, Earthquakes, Avalanches, and Droughts.

Landslides and floods/cloudbursts are reported to have very high frequency of occurrence and high impacts as well. Earthquakes, including tremors, although of high frequency, have only moderate impact. GLOFs on the other hand have a low occurrence rate, but are assessed to cause very high damage. Vulnerability level of the inhabitants is perceived to be very high with respect to the combination of landslides and earthquakes (the latter often leads to the former); vulnerability level to avalanches and floods/cloudbursts is felt to be mildly lower. The occurrence and effects of desertification is perceived to be negligible.

iv. Pithoragarh district (Central Himalayas)

	Frequency	Impact	Vulnerability	Top 5 Hazards
Drought	Moderate	Moderate	Low	1. Flood/Cloudburst 2. Earthquake 3. Landslide 4. Drought 5. Avalanche
Desertification	Low	Moderate	Low	
Landslide	Low	Low	Very High	
Avalanche	No Occurrence	No Occurrence	No Occurrence	
Earthquake	Very High	Low	High	
Flood/Cloud burst	High	High	Moderate	
GLOF	No Occurrence	No Occurrence	No Occurrence	

The top 5 hazards in Pithoragarh district are: Floods/Cloudbursts, Earthquakes, Landslides, Droughts, and Avalanches.

Frequency of occurrence of earthquakes is very high in this district, although the majority are low intensity tremors that do not cause much damage or loss of life. Floods/cloudbursts have become increasingly frequent, and have a high impact since they often disrupt lives in the affected villages for a month or more. The frequency as well as impact of droughts are perceived to be moderate; although they have not caused a severe crisis yet, growing irregularities in precipitation are noted which do not augur well for the future. Vulnerability to landslides is noted to be very high; vulnerability to earthquakes is the next highest, and vulnerability to floods/cloudbursts is considered to be moderate.

v. Tawang district (Eastern Himalayas)

	Frequency	Impact	Vulnerability	Top 5 Hazards
Drought	Very High	Moderate	Low	1. Landslide 2. Flood/Cloudburst 3. Drought 4. Earthquake 5. Avalanche
Desertification	No Occurrence	No Occurrence	No Occurrence	
Landslide	Very High	Very High	High	
Avalanche	Low	Low	High	
Earthquake	Very High	Low	Low	

Flood/Cloud burst	Low	High	Very High	
GLOF	No Occurrence	No Occurrence	No Occurrence	

The top 5 hazards in Tawang district are: Landslides, Floods/Cloudbursts, Droughts, Earthquakes, and Avalanches.

The district consultations noted very high frequency of droughts, earthquakes and landslides. Landslides are also reported to have very high impacts with significant damage to road network, historical monuments, and life and property. Although frequency of occurrence of floods/cloudbursts is low, people attribute high vulnerability to these events. Vulnerability to landslides and avalanches is also perceived to be significantlly high. Discussions on the frequency of events revealed that desertification and GLOF have no occurrence in the region.

vi. West Kameng district (Eastern Himalayas)

	Frequency	Impact	Vulnerability	Top 5 Hazards
Drought	Moderate	Low	Moderate	1. Landslide 2. Flood/Cloudburst 3. Drought 4. Earthquake 5. ---
Desertification	No Occurrence	No Occurrence	No Occurrence	
Landslide	Very High	High	Very High	
Avalanche	No Occurrence	No Occurrence	No Occurrence	
Earthquake	Very High	Low	Low	
Flood/Cloud burst	Low	Moderate	Very High	
GLOF	No Occurrence	No Occurrence	No Occurrence	

In W. Kameng district, 4 hazards are prioritised: Landslides, Floods/Cloudbursts, Droughts, and Earthquakes.

Landslides and earthquakes are the most common in terms of occurrence. Landslides have high impact, and the community perceives very high vulnerability to these, with loss of land and damage to road networks being the primary concerns. Except in the case of one event, in the 1950s, earthquakes do not appear to have caused much damage though. Although the frequency of occurrence floods/cloudbursts is lower, the communities perceive high vulnerability to these events as well. The community reported no occurrence of desertification, avalanches and GLOFs in the area.

vii. Himalayan Regions

Combining the inputs from across the Himalayan region, the rankings of the natural hazards are given below. The consultations regarding the available datasets, technologies and the processes for the early warning and disaster relief information system concentrated on the hazards accordingly.

	All Himalayas	Western Himalayas	Central Himalayas	Eastern Himalayas
1.	Landslide	Flood/ Cloudburst	Flood/ Cloudburst	Landslide
2.	Flood/ Cloudburst	Earthquake*	Earthquake*	Flood/ Cloudburst
3.	Earthquake*	Avalanche	Landslide	Drought
4.	Drought	GLOF	Drought	Earthquake*
5.	Avalanche	Landslide	Avalanche	Avalanche
6.	GLOF	Drought	GLOF	GLOF
7.	Desertification	Desertification	Desertification	Desertification

** Earthquake / tremors were taken in the same category. Hence low intensity tremors were recorded frequently across the Himalayan belt, which lies in Zone 5 and Zone 4 (highest risks zone in terms of earthquake hazard zonation). Although they were frequent, the tremors didn't appear to do much tangible damage.*

The participants of the consultations appreciated the initiative; both community elders and local R&D institutes participated enthusiastically. The consultations brought out the concerns of target communities regarding the impact of the natural disasters on livelihoods and the vulnerability of the population thereby.

The impacts on food security, in the context of frequent disasters and droughts, and decreasing production of and access to food, as well as increase in food prices, were also issues that the community indicated concern over. The consultations in Chamoli after the occurrence of the 2013 flashfloods, identified post-disaster conflicts over land and water resources (as traditional land and village boundaries become obscured) as a major concern along with outmigration of populations that had lost their livelihoods; the participants were keen on contributing towards a model that they could finally be part of.

3.2. Inputs for Early Warning System

The feedback on Early Warning Systems (EWS) from various stakeholders generated a large data set, which was then categorised to feed into the model. The findings are summarised below.

3.2.1. Challenges for community based EWS:

i. Community Engagement:

Although communities have indicated interest in community-based EWS, sustaining this interest and ensuring regular hazard surveillance and monitoring, is likely to be difficult. Over an extended duration, communities might tend to lose interest in monitoring hazards, because of the infrequent occurrence of the hazard events. Communities could show interest immediately after a recent disaster, but this could wane with time, since continual surveillance is a tedious task. Communities would also assign lower priority to regular DRR meetings due to time constraints given other livelihood and domestic responsibilities. Given a short summer in the Himalayas for agriculture and other activities, it would be a challenge to retain the attention of the communities on DRR activities. The most vulnerable segments of the community (e.g. minorities/lower castes, children, people with disability) would tend to demonstrate lowest levels of participation, due to lower confidence and assertion. Community members also lack interest in participating in meetings immediately after the trauma of surviving a natural hazard.

ii. Clarity of Warning Messages:

Low technical capacity of the community representatives engaged in surveillance and data collection & analysis, might generate false warnings at times and people might lose faith/interest in the mechanism. False warnings also have the potential to create unnecessary panic/reactions which can take its toll on the local residents and authorities. Warnings issued could also lack clarity on action required in that community members in charge may not be able to accurately identify the areas affected, or estimate the potential losses and the duration of the event and thereby the timeframe within which such losses could occur, and issue suitable instructions for preparatory and damage-mitigating response actions. Following a standard for developing warning messages within and across the region might help address this issue. Further, lack of proper delineation and communication of responsibilities (who provides forecasts of hazards and who provides warnings of risks), could result in lack of clarity on whether the information shared is a forecast or a warning. Assigning these roles clearly would be required for an effective EWS.

iii. Cooperation/ Coordination Among Stakeholders:

An EWS system relies data on various parameters usually generated by various entities and an effective communication channel. Hence its effectiveness is determined by the coordination among the stakeholders involved. Lack of cooperation among the stakeholders could however lead to lack of data sharing and communication roadblocks. Absence of a single authority and lack of clarity of roles among various stakeholders could be the cause of much confusion. Often, proliferation of communication technologies particularly the internet and cellular networks, is useful in disseminating warnings since they help in expanding the coverage and reducing time lags; however, this could also create problems of untargeted communication inducing wrong responses due to misinterpretation.[1] For instance, although the Internet has been a useful communication medium for hurricane warning dissemination in Latin America, the Caribbean

[1] *UNICEF: Global Survey EWS*

and North America, etc., warnings on El Niño disseminated via the internet had prompted inappropriate responses among agricultural operators causing unnecessary losses.

iv. Resource Constraints:

Lack of funds available for maintenance and/or replacement of the equipment used for surveillance often compromises on the accuracy of community-anchored surveillance systems, and thereby their effectiveness, and frequently lead to their discontinuation. Lack of capacity and technical skills, inadequate/no incentives, and lack of avenues for human resources development, and lack of support for modification/updation of surveillance processes, reduces the effectiveness of such systems. Sustainable support system and linkages, along with effective community structures, are required for the maintenance and timely replacement of equipment and adequate human resource development.

v. Technological Barriers:

Low-technology systems are necessary in remote target areas, tailored to the low infrastructural conditions in these areas, and at par with the technology adoption capacity of the concerned community. Existing telecommunication network and access to technology for the target area plays a vital role in determining the approach/processes to be followed and the success of an EWS. There is also a need to blend in traditional knowledge and information acquired through educational and awareness-raising programmes so that the proposed approach is not alien to the communities.

vi. Localisation of Messages:

One of the most important reasons for people failing to heed warnings is that the messages do not address their values, interests and needs. Individuals may perceive the warning as irrelevant or find it impossible to heed (e.g. they might be reluctant to abandon assets upon which their livelihoods depend, such as livestock). Early warning systems can also underestimate the risks communities face because of inadequate risk assessment for particular target groups. Most warnings are delivered to the whole population through the media, and are not tailored to the needs of individual groups and do not lay down exact measures to follow. Lack of public interest in warnings also occurs because early warning systems only provide information on impending crises. People need to be periodically informed about the hazards and the level of risk they pose, and how this may be changing. The concerned details should not be technical and should remind the population of similar events to help them visualise the possible scale of impact.

3.2.2. Indicators for EWS

i. Landslide

i-a. Scientific Indicators

- *Visible rapid mass-movements*: Falling of rocks, soil, debris etc. in small amounts at regular intervals.
- *Signs of slow mass movement - outdoors*: Soil moving away from foundations; ancillary structures such as decks and patios tilting and/or moving relative to the main buildings; tilting or cracking of concrete floors and foundations; new cracks or unusual bulges in the ground, street pavements or sidewalks; sunken or down-dropped road beds; leaning telephone poles, trees, retaining walls or fences; offset fence lines; uprooted trees and cracked tree trunks in slopes.
- *Signs of slow mass movement - indoors*: Broken water lines and other underground utilities; sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb.
- *Hydrological indicators*: Collection of large amounts of water near certain slopes (sometimes occurs due to leakages in water pipes or unattended taps); springs, seeps, or saturated ground in areas that have not typically been wet before; rapid increase in

> *Threshold levels*
> *- On an average, a rainfall-duration of 10 hours or less with a rainfall-intensity in excess of 12 mm/hour is required to trigger slope failure, but a rainfall-duration of 100 hours (4 days+) or longer with an average intensity of 2 mm/hour can also trigger landslides in the Himalaya.*
> *- Daily rainfall amount exceeding 144 mm, spells a risk of landslide on Himalayan slopes.*

stream water levels, possibly accompanied by increased turbidity (soil content); sudden decrease in creek water levels though rain is still falling or just recently stopped.

- *Auditory indicators*: Unusual sounds, such as trees cracking or boulders knocking together, might indicate moving debris; a faint rumbling sound that increases in volume is noticeable as the landslide nears.
- *Weather based indicators*: Continuous high intensity rainfall [characterization of landslide-triggering rainfall has been used to establish the relation between rainfall and landslides in various parts of the world].
  The most commonly investigated rainfall parameters in relation with landslide initiation include - cumulative rainfall, antecedent rainfall, rainfall intensity, and rainfall duration. Attempts have been made to define thresholds employing various combinations of these parameters. Since the majority of slope failures are triggered by extreme rainfall, a number of researchers have attempted to establish rainfall intensity thresholds so that slope failure predictions could be made accurately.

i-b. Traditional Indicators:

- Southward movement of black clouds in the western Himalayas might indicate possibility of cloudburst and resulting landslides. *(Reliability rating*: 4/5)*
- When shape of cloud is like a demon's face it can lead to cloudburst, causing landslides *(Reliability rating: 5/5)*
- When birds vacate their nests, it can indicate possibility of cloudburst, causing landslide *(Reliability rating: 1/5)*
- Insects moving towards higher grounds indicate possibility of heavy rain and landslides *(Reliability rating: 3/5)*
- When birds flock together, there are chances of heavy snowfall *(Reliability rating: 1/5)*
- Snakes coming out of their holes in the earth may indicate chances of heavy rain/flood and thereby increase chances of landslides. *(Reliability rating: 1/5)*
- When grasshoppers are suddenly visible in very high numbers, they indicate possibility of high rainfall. *(Reliability rating: 3/5)*
- Brisk movement of fish in water can indicate potential of heavy rains and may cause landslides *(Reliability rating: 3/5)*
- Early ripening of fruits (apricot, apple) can indicate risk of flood / cloudburst in western Himalayas and can result in landslides *(Reliability rating: 2/5)*

ii. Flood/Cloudburst

ii-a. Scientific Indicators

- *Meteorological indicators*: A depression caused by low atmospheric pressure. A sudden cold and strong wind. Unusual rainfall (very heavy rainfall in a shorter duration or continuous longer duration rainfall can cause floods); increased size of rain droplets.
- *Hydrological indicators*: Increase in water flow of streams and rivers (increase in water levels could indicate upcoming flood/flashflood). Sudden reduction in discharge of water in stream or rivulets (could imply that water flows are impeded, and the water is collected somewhere, and might result in sudden discharge, leading to flashfloods or landslides).

Threshold levels
- Rainfall rate of 100 mm (3.94 inches) per hour is the threshold for a cloudburst. Some consider 130 mm (5 inches) of rainfall per hour as the threshold.
- During a cloudburst, rain droplets become 100 times bigger than normal, about 4-6mm.

ii-b. Traditional indicators

- Southward movement of black clouds in western Himalayas might indicate possibility of cloudburst. *(Reliability rating*: 4/5)*
- If the moon appears to have coloured (red, blue, yellow) edges visible around it, this is followed by rains or sandstorm *(Reliability rating: 3/5)*
- The shape of a demon's face in the cloud, is the portent of a cloudburst *(Reliability rating: 5/5)*
- When birds vacate their nests, a cloudburst may be imminent *(Reliability rating: 1/5)*
- Insects moving towards higher grounds indicates the possibility of heavy rain / floods *(Reliability rating: 3/5)*
- Snakes coming out of their holes in the earth may indicate chances of heavy rain/floods *(Reliability rating: 1/5)*

- When grasshoppers are suddenly visible in very high numbers, they indicate possibility of high rainfall *(Reliability rating: 3/5)*
- Brisk movement of fish in water can indicate potential of heavy rains *(Reliability rating: 3/5)*
- Early ripening of fruits (apricot, apple) can indicate risk of flood / cloudburst in western Himalayas *(Reliability rating: 2/5)*

iii. Earthquake

iii-a. Scientific Indicators
No scientific indicators are available.

iii-b. Traditional indicators
- Restless cows in cattlesheds could indicate an impending earthquake *(Reliability rating: 1/5)*
- Mice / rats run out of house before an earthquake *(Reliability rating: 4/5)*

iv. Drought

iv-a. Scientific Indicators
- *Observations*: Drying up of water holes; withering of certain plants in sandy areas.
- *Meteorological indicators*: Steep drop in annual precipitation, determined on the basis of Standardised Precipitation Index (SPI).
  Tracking annual rainfall and comparing it to the long-term mean annual precipitation can help predict drought [SPI is calculated based on the long-term (longer than 30 years is desirable) precipitation record for a particular location].

> *Threshold levels*
> *- SPI value of -1.5 is used as threshold value for drought prediction i.e. SPI value from -3 to -1.5 as drought and SPI value from -1.5 to +3 as no drought category.*
> *- When annual rainfall in an area falls below the threshold of 75% of the long-term mean annual precipitation, it indicates advent of drought.*

iv-b. Traditional indicators
- Occurrence of locusts indicate advent of drought in the western Himalayas *(Reliability rating: 5/5)*
- When yaks become agitated or aggressive, it is often an indication of drought / prolonged summers *(Reliability rating: 4/5)*
- Fast ripening of fruits and early flowering can indicate drought and long summers in the central Himalayas *(Reliability rating: 2/5)*
- Flowering of fodder grass is considered to indicate possibility of drought *(Reliability rating: 4/5)*
- Decrease in the size of fruits or lack of fruiting of fruit-bearing trees indicate the possibility of drought *(Reliability rating: 3/5)*
- Flowering of bamboo is an indicator of drought *(Reliability rating: 4/5)*
- A significant decrease in discharge of perennial springs (a measure of ground water level) can indicate the onset of drought *(Reliability rating: 5/5)*
- ‘Fireballs seen in forests’ (ie, forest fires) indicates possibility of drought *(Reliability rating: 1/5)*

v. Avalanche

v-a. Scientific Indicators
- *Meteorological indicators*: Rising temperatures during a storm accompanied by increased snow of fresh snow tends to cause avalanches; low temperatures during a smawfall on the other hand, would imply low snow density (water content) contributing to low mobility and reduced chances of slippage. Likelihood of an avalanche occurrence is higher when the snowfall is higher. Hence, sudden and very heavy snowfall on a steep slope tends to trigger an avalanche; care needs to be taken when there are human settlements at the base of such a slope.

v-b. Traditional indicators

- Deep blue or grey sky during sunset is an indicator of avalanches *(Reliability rating: 2/5)*
- The colour of water in rivers and streams turning to deep blue, ie, clear skies and low temperatures, indicates chances of heavy snowfall which in turn could result in avalanches *(Reliability rating: 4/5)*
- Increase in food intake of deer may indicate possibility of heavy snowfall and avalanches *(Reliability rating: 3/5)*
- When animals such as Himalayan Tahr and deer descend to lower grounds, this is usually followed by heavy snow and avalanches *(Reliability rating: 1/5)*
- When birds flock together, there are chances of heavy snowfall, followed by avalanches *(Reliability rating: 1/5)*

Threshold levels
- Snowfall and precipitation intensity as a threshold for snow instability - snowfall intensity (depth/hour cm/hr) > 2.5 cm/hr
- Storms with high precipitation intensity (>4cm/hour) and significant new snow accumulation (>50 cm in a 12 hr period) can cause loose dry or wet snow avalanches
- Persistent slab and Deep persistent slab avalanches can occur on surprisingly low angle terrain (as little as 15^{o}), with accumulation of wind driven snow or new snowfall on a slope at a rate of 3-5 cm/hour (3mm/hour water equivalent) or more; total snowfall accumulation of 30-50cm or more (30mm of water equivalent) in a 12 hour period or less; air temperatures warming at a rate of 3^{o}C per hour or more, especially if temperature rises above 0^{o}C as a result.
Slab avalanches are more likely to occur when wind speeds exceed a threshold of about 7 m/s

vi. GLOF

vi-a. Scientific Indicators

- *Characteristics of specific lake(s)*: Rapid expansion, increasing water level, intermittent activity of supra-glacial lakes.
- *Moraine dam characteristics*: narrow crest, no drainage outflow or outlet not well formed, steep & high moraine walls, existence and stability of ice core and / or permafrost within moraine, mass movement (or potential for it) on the moraine slopes, lake breached in the past and refilling, seepage through moraine walls.
- *Glacier characteristics*: Hanging glacier in contact with or close to lake, rapid glacier retreat, debris cover on lower glacier tongue, steep slope of glacier tongue, presence of crevasses of ice from the glacier front, icebergs breaking off the glacier terminus and floating into lake. Water loading and changes in glacial morphometry.

Threshold levels
- Lake Outburst Hazard Scoring System based on: Volume of Lake (Threshold), Lake level relative freeboard (Threshold), Seepage evident through dam (Threshold), Ice-cored moraine dam (Threshold), Calving risk from ice cliff (Trigger), Ice / rock avalanche (Trigger), Supra-glacial or englacial drainage (Trigger), and Compound risk.
This assigns the outburst likelihood score and hazard rating as: 0 = Zero, upto 50 = minimal, upto 100 = moderate, upto 125 = high, 150+ = very high. Where total score exceeds 100, outburst could occur at any time. Hazard classes are defined in terms of thresholds & triggers. Lower limit of high hazard is defined by threshold index of 70 and trigger index of 30.

- *Characteristics of surrounding environment (of specific lake/glacier)*: potential rock fall and/or slide sites around the lake, large snow avalanche sites immediately above, sudden advance of a glacier towards a lower tributary or main glacier that has a well-developed frontal lake.
- *Vulnerability rating*: Vulnerability rating may be derived along the following scales, based on study of maps of the glacier/lake and surrounding area:
  - Lithology / compactness of deposit/sediment (glacial deposit =1, Cohesive sediment = 2, Loose sediment = 3) with overall weightage of 2.
  - Gradient / slope map (0–2° = 1, 2-11° = 2, >11° = 3) with overall weightage of 1.
  - River sinuosity / river meandering (Inside bend of a meander = 1, Straight = 2, Outside bend of a meander = 3) with overall weightage of 1.
  - Secondary landslide susceptibility (bedrock with no feasibility for failure = 0.25, bedrock with feasibility of failure = 1, highly or completely weathered rock = 2, unconsolidated sediment & existing slips = 3) with overall weightage of 2.
  - Landuse (Scrub / forest, no human activities = 0, Pasture = 1, Agriculture, commercial forestry = 2, Infrastructure = 2.5, Settlement = 3) with overall weightage of 3.

Maximum probable thresholds can be calculated within a particular geographical area with regard to rainfall, slope elevation, slope load, soil retention ability and root cohesion.

- *Qualitative probability*:
  - Dam type: ice- probability high; moraine- probability medium high; bedrock- low.
  - Freeboard relative to dam: low- probability high; medium- probability medium; high- probability low.
  - Dam height to width ratio: large- probability high; medium- probability medium; small- probability low.
  - Impact waves by ice/rock falls reaching the lake: frequent- probability high; sporadic- probability medium; unlikely- probability low.
  - Extreme meteorologic events (high temperature / precipitation): frequent- probability high; sporadic- probability medium; unlikely- probability low.

vi-b. Traditional indicators
Traditional indicators are not available.

vii. Desertification

vii-a. Scientific Indicators

- *Physical parameters*: High aridity (as measured by aridity index), high rainfall variability, high soil erosion-wind erosion with distinct deposition & deflection areas and high rate of run-off and water erosion, evident crusting & compaction of soil, soil salinization, acidification and alkalinization, reduced area of water bodies, reduced infiltration, increased sedimentation, high rate of evapo-transpiration, sequential changes in depth of ground water.
  Risk of desertification is indicated by: increasing number of dry months, increase in average depth of ground water table, increasing salt content in irrigation water, indicative physiography and drainage (as mentioned above), inappropriate soil management practices, and increasing soil loss through erosion; combined effect of interactions of status, rate, inherent risk along with animal and population pressures.
  Status of desertification is indicated by the following physical parameters: surface area affected by soluble salts; appearance of sand sheets, hummocks, nebkas or dunes; effect on surface by rain – formation of splash, rills or gullies; area displaying crusting and compaction.
  Rate of desertification would be indicated by: increase in salt affected area; amount of transported sand (m3 / year), soil loss (t / ha / year); growth rate of areas affected by wind erosion as percent of the total productive land; increase of areas where subsoil is exposed or of surface affected gullies, sediment deposits in dams.
- *Biological parameters*: Vegetation degradation, low range carrying capacity, reduced desirable/native plant species and increase in undesirable plant species, low vegetation cover, undesirable changes in density, morphology, root depth, richness, endemism, growth rate, Leaf Area Index - LAI, albedo, Normalized Difference Vegetation Index - NDVI, soil organic matter content.
  Status of desertification is indicated by the following biological parameters: reduction of canopy cover of perennial plants; reduced level of organic matter.
  Rate of desertification would be indicated by: decline in percent of biomass, decrease in area of woodland, depleting range cover and range condition trend line.

Threshold levels
- Severe Desertification - vegetation scarce and short, coverage of vegetation ＜10%. Big areas of concentrated the quicksand hills present; area of quicksand about 50% of the land.
- Medium Desertification - coverage of stable perennial vegetation 10-20%; surface of land seriously damaged by wind erosion; shrub-coppice dunes and big areas of quicksand; area of quicksand about 30%-50% of the land.
- Slight Desertification - Semi-sand and semi-grass, coverage of vegetation 20-40%; surface of land partially damaged by wind erosion and small plot of quicksand appeared; area of quicksand about 10-30% of the land.

vii-b. Traditional indicators
Traditional indicators are not available.

3.2.3. Information resources

- Cell phone applications and internet-based portals could be used (www.accuweather.com etc) for accessing information on weather.

- Government facilities that determine and record weather variations could also serve as souces of weather information. For instance, in the state of Uttarakhand, meteorological stations have been set up in government colleges, and data can be accessed from these stations. Long-term weather data may be accessed from the Indian Meteorological Department (IMD) which has made detailed location specific data available regarding temperature, snow and rainfall. Hazard zonation maps are also available with NDMA for Earthquakes and Landslides. However, communities do encounter challenges in accessing and utilising the information available on weather and hydrology. Although available in the public domain, the complexity of the technology and language used are deterrants for access by communities, while experts alone would be able to understand the information available from IMD. Hazard zonation maps that are available for Earthquake and Landslides are at a macro level, and cannot be used for micro-scale, community-level applications.

3.2.4. Technologies for surveillance

- *Rain gauge*: Rain gauges that enable measurement of the volume of rainfall in a given duration, could be used by communities to monitor precipitation and determine whether rainfall or snowfall is substantially more than average, and assess the possibility of reaching a tipping point that could trigger landslides or avalanches. These rain gauges could be set up at gram panchayats and a few people trained to use them. They would need to be set up at different elevation levels. Various models of ran gauge are available: e.g. Tipping Bucket Style Rain Gauge, Tilting Siphon Rain Gauge, Rainfall Data Logging System with battery operated logger, wireless rain gauge with battery operated transmitter.
- *Thermometers*: Thermometers could be used for air temperature measurement. Various types of thermometers for air temperature are available: tube thermometers, digital and wireless thermometers, analog thermometers, web/alert thermometers. Web/alert thermometers create user-defined alerts for high or low extremes of temperature, humidity and precipitation, and severe weather; it uploads data to a free online account and custom alerts can be sent to cell phone or email.
- *Anemometers*: Handheld anemometer or mounted anemometers with rotating vanes may be used for noting wind observations at fixed locations on the two parameters of wind speed and wind direction.
- *Snow gauge*: These guages may be used to measure the amount of solid precipitation in an area. Apart from traditional snow gauges, automated remote reading gauges, Snow Pillow snow sensor connected to a manometer, Electronic Snow Density Gauge, are also available, although their usage by communities may be difficult. Along with these, Inclinometer or Slope meters are used for avalanche prone terrains. Study of snow also requires: snow depth probes, snow board, tube sampler, spatula, Ram Penetrometers. Snow micro-pen is a high-resolution snow penetrometer and can be used in snow profiling, avalanche forecasting.
- *Weather stations*: Weather monitoring could also be made a part of the local school curriculum; extended weather stations (cost: 2000 GBP) or compact weather monitoring systems (cost: 70-120 GBP) could be set up at schools and teachers could be trained in managing them.
- *Water level markers*: Level recorders/markers could be established in streams, rivulets, rivers, under bridges etc.
- *Extensometer:* Measuring landslide movement may be done by using an extensometer, which can detect movement of the ground surface between stable ground and sliding ground. Immediate detection of landslide provided by real-time systems can be crucial in saving lives and property. Solar-powered radiotelemetry system for remote transmission of real-time landslide data is in use, but can be expensive and require installation by experts. Optical fiber borehole sensors are used for landslide tracking over a longer period of time.
- *Survey pillars for landslides*: A simple method of monitoring landslides is through the installation of a few survey pillars within the landslide zone and on its periphery, linked with a few reference pillars installed on undisturbed and stable ground. Periodic observations of their relative position and angle of survey pillars, particularly in the pre-monsoons, and during high rainfall and post-monsoon periods give a fairly good idea about the extent and rate of surface movement/amount of subsidence, and also surface stress variations.
- *Maps*: Land use and land cover maps (LULC) could be used for monitoring landslides.
- *Satellite imagery and GIS*: Risk mapping can be done through remote sensing data and GIS-based analysis. For instance, desertification risk could be assessed through GIS-based analysis of parent soil, slope of soil, depth of soil, texture of soil, climate quality, landuse, elevation, wind & water erosion; random monitoring based on remote sensing could identify ecological changes and help in predicting a GLOF. InSAR (Interferometric Synthetic Aperture Radar) and Ground based LiDAR (Light Detection and

Ranging - remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflection) can be used to monitor landslide area, because it can acquire three dimensional data of wide area over a short period of time. For snow avalanche, pulsed Doppler radar is used for measuring the velocity remotely.

3.2.5. Communication channels & technologies

i. Media:

Considering its wide outreach, Doordarshan (India's national television network) could be used for disseminating information on weather and related warnings. Local radio, particularly the local language news coverage on radio, and newspapers could also be used for relaying weather information and alerts, along with other news of daily interest to local communities. Multi-functional channels work better since the equipment and channels would be maintained and used because they have become a part of the daily life of the communities, and the warnings, when issued, would be attended to. For instance, in Central America, radio-based systems were initially developed to provide flood warnings, and also serve other basic communication functions today, ensuring that they are always in use and attended to when a warning is issued. Multi-functionality does not always have to imply regular use by the communities served however, therefore linking warning functions to systems that serve scientific or any other on-going use can serve the same purpose.[2]

ii. Community to community:

Community-to-community communication is considered a better option than most others for early warnings. It would be better to retrofit disaster warnings with existing community-to-community communication systems, if any, rather creating a new one. Meetings with different stakeholders, village leaders, authorities, and NGOs should be conducted to identify the existing practice for such communication. Religious institutions - Mosques, Temples, Monasteries, Churches, Gurdwaras etc. could also be used to send out alerts. Most of them have speakers/public address systems that have a very good reach in the served community. Specific warning sounds could be used for this purpose and the community should be trained to identify these and take pre-defined actions. Traditional warning methods (such as drums) could be used for sending out alert signals.

iii. Customised infrastructure:

Community operated kiosks could be used for updates on weather and other hazards. Such systems (http://www.apcost.gov.in/APCOST/Projects/VIS.html) have been piloted by NRDMS in the southern Indian state of Andhra Pradesh.

iv. Communication content:

Effective early warning systems require strong technical foundations and good knowledge of the risks. At the same time, a good EWS must also be strongly "people centred" – with clear messages and dissemination systems that reach those at risk. The content of the warning messages must be as simple as possible for end-users to understand them clearly, and should be provided in a timely manner to facilitate appropriate action. Although false alarms are risks that must be acknowledged, the credibility of the message is crucial.[3]

v. Communication technologies:

Message delivery systems must be as cost effective, replicable and simple.

- Ham Radio, satellite phones and walkie-talkies could be considered, and the community trained to use those that are feasible. Use of Ham radio and satellite phones (digital radio) are however not allowed by

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[2] *UN-ISDR/Platform for the Promotion of Early Warning*

[3] *Community-Based Flood Early Warning Systems, Philippine Atmospheric, Geophysical & Astronomical Services Administration (PAGASA)*

the government in areas close to the international borders, and hence might be restricted in most areas across the Himalayas.

- Cellular technology would be a useful mode for disseminating weather information and alerts, since most people even in remote villages have cell phone access. SMS could also be used for issuing early warnings. An SMS technology is being used by army, which refers to IMD information, simplifies it and sends out SMSs to panchayat (village governance council) members in nearby villages on a regular basis. The flip side however is that the cell phone towers are usually damaged during a disaster, and hence care should be taken that cell phone towers are set up in safe places (where there is lower risk of being damaged by floods and landslides).
- Police wireless systems could also be used to issue warnings (- these were used during the Leh disaster, 2010).
- Vans with loud speakers can be used for alert announcements, as could sirens.

3.2.6. Data storage & analysis mechanisms

i. Process:

There is a need for a data collection system to be institutionalized and school teachers can be trained for the purpose. A simple interface can be built, wherein the community is only responsible for data input, and data storage should be automated (no pen and paper). Simple India-made data loggers could be used for the purpose. It was deemed difficult for communities to store and analyse information, as data needs to be recorded and updated on a regular basis. Hence the data should be relayed to a central facility for analysis or interpretation by relevant experts or the designated scientific agency. The data transfer and analysis should tie-up with an existing system. Quick validation of collected data needs to be done with the concerned authorities prior to issuing an early warning.

ii. Scope/coverage:

Data should be collected for a grid covering 30-40 sq. kms, in order to ensure a comprehensive understanding of the conditions in a specific area. Data collection and analysis should follow a seasonal calendar, with a particular focus on the seasons in which e.g. avalanches, floods, drought are more likely.

3.2.7. Stakeholders, structures and infrastructure

i. Relevant stakeholders & structures:

- *Communities*: Panchayat (village governance council) members should play an important role in the DRR system since they are key representatives of the decentralised governance structures in place, and usually have high influence with the community. Local youth could also play a key role as they are keen observers and can quickly adapt to newer technologies. In Leh, the National Disaster Management Authority (NDMA) and AIDMI have initiated community-based action on disaster risk reduction involving elected representatives, communities, village heads and villagers. 200 govt schools in the district have been trained, and basic equipment have also been issued for measurement and recording. These agencies and members of community-based systems could be collaborated with. Communities can be trained on EWS and DRR through folklore and folk media. Manuals and procedures needs to be agreed on in consultation with communities.
- *Government and army*: Government authorities should be involved in decisions on relaying warnings and the process of communicating them. Army personnel could also be involved since they have a significant presence in these remote reaches and are well equipped with advanced equipment for communication.
- *Non-state actors*: DMMC (Uttarakhand) and SEEDS (not in Himalayas) have carried out considerable work in DRR and can be effective partners for installing a Himalaya-specific DRR system.
- *Multi-actor coordination*: A well functioning and sustainable early warning system is a result of collective effort involving individuals, community groups, organizations and institutions. It is therefore very important to maintain effective links and close coordination between stakeholders. The key players concerned with different data elements/resposibinities have to meet regularly to ensure they understand all other components and what other parties need from them. Operational procedures such as evacuations have to be practiced and tested on a regular basis.

ii. Infrastructure

Data collection, analysis, and communication can tie up with existing village resource centres in the Himalayan region.

3.3. Feedback for Relief Information System

3.3.1. Challenges for community based RIS

i. Coordination between agencies:

Assessment of disaster impacts is difficult often immediately after the disaster. Most Himalayan districts have no common platform for disaster relief that enable the government, volunteers and NGOs to provide aid in an organised manner. Without adequate coordination mechanisms, acquiring data becomes difficult for the agencies providing relief, and leads to considerable chaos. Usually, the local government (lowest tier of grassroots governance) is also not well versed with the coordination process.

ii. Data availability:

Many organizations conducting assessment lack required skills and trainings to collect relevant data, leading to lack of clarity, wastage of resources. A common assessment format needs to be created (common for all agencies and government) for post-disaster damage assessment. There are minimum standards for food, water, hygiene, etc., as part of relief, established by Sphere, and the assessment needs to be designed to measure needs against these standards.

iii. Community expectations & bias:

There is considerable difference between the expectations of people affected by disasters and the nature and extent of assistance that various agencies can provide. Fly-in organisations, the government, and local NGOs, conduct assessments which increase the expectations of the affected people; much of these remain unmet however. On the other hand, communities often tend to exaggerate the damage suffered, in order to access a higher compensation.

3.3.2. Essential components of damage assessment & reporting

i. Overview:

A brief overview / description of what has happened, is an essential part of first RIS communication: this should include:

- documentation of the type of disaster,
- date and time,
- affected area,
- number of persons dead/Injured.
- the severity of the disaster (without necessarily providing precise figures); and
- a forecast of possible future developments including new risks.[4]

ii. Affected population:

The RIS should be able to provide data on:

- the number of people affected and their location(s); the data should be disaggregated as far as possible by sex, age, disability, etc.
- deaths, permanent disabilities, major injuries, minor injuries and missing persons.

[4] *Asian Disaster Preparedness Center*

- track any likely movements of people, and the security of the affected population; whether there are special security risks for women, girls, children and vulnerable people.
- whether there is equal access for all to existing facilities including at public places, health centres and schools.

iii. Sector-wise priorities:

Information should be collected and made available on various sectors, e.g nutrition, shelter, water, sanitation etc., for enabling quicker and more efficient relief communication and response. The information should indicate the immediate priorities for external relief, where it is required and the approximate quantities.

Sectoral information needs are as follows:

iii-a. Water Supply Sanitation and Hygiene (WASH):

- Whether all groups within the population have safe and equitable access to WASH resources and facilities.
- Whether all people have safe and equitable access to a sufficient quantity of water for drinking, cooking and personal and domestic hygiene and whether water is potable.
- Whether people have adequate facilities to collect, store and use sufficient quantities of water and can ensure that drinking water remains safe until it is consumed.
- Whether the living environment in general and specifically the habitat, food production areas, public centres and surroundings of drinking water sources are free from human faecal contamination.
- Whether people have adequate, appropriate and acceptable toilet facilities, sufficiently close to their dwellings, to allow rapid, safe and secure access at all times, day and night.
- If there are current, prevalent or possible water and sanitation-related diseases noticed and what is the likely extent and expected evolution of problems.
- Whether health risks and other risks posed by water erosion and standing water, including stormwater, floodwater, domestic wastewater and wastewater from medical facilities, etc.

iii-b. Food Security and Nutrition Assessment:

- Whether people are at increased risk of undernutrition, as per internationally accepted standards for type, degree and extent of undernutrition. Information should identify those most affected and those most at risk.
- Whether safe and appropriate infant and young child feeding for the population is being practiced; whether mothers and caregivers of infants and young children have access to timely and appropriate feeding support that minimises risks and optimises nutrition, health and survival outcomes.
- Whether food is/can be stored, prepared and consumed in a safe and appropriate manner at both household and community levels.

iii-c. Shelter, settlement and non-food items:

- Whether people have sufficient covered living space providing thermal comfort, fresh air and protection from the climate ensuring their privacy, safety and health.
- Whether the affected population has sufficient clothing, blankets and bedding, sufficient individual, general household and shelter support items to ensure their personal comfort, health, dignity, safety and well-being.
- Whether the disaster-affected population has access to culturally appropriate items for preparing and storing food, and for cooking, eating and drinking.
- Whether the disaster-affected population has access to a safe, fuel-efficient stove and an accessible supply of fuel or domestic energy, or to communal cooking facilities; Whether each household has access to appropriate means of providing sustainable artificial lighting to ensure personal safety.

iii-d. Health Systems

- Whether people have equal access to effective, safe and quality health services that are standardised; whether services are provided by trained and competent health work-forces who have an adequate mix of knowledge and skills to meet the health needs of the population.
- Whether people have access to a consistent supply of essential medicines and consumables.
- Whether people have access to free primary healthcare services for the duration of the disaster.

- Whether people have access to information and services designed to prevent communicable diseases; whether people have access to effective diagnosis and treatment for those infectious diseases that contribute most significantly to preventable excess morbidity and mortality.
- Whether children have access to priority health services that are designed to address the major causes of newborn and childhood morbidity and mortality.
- Whether people have access to the priority reproductive health services of the Minimum Initial Service Package (MISP) at the onset of an emergency and comprehensive RH as the situation stabilises.
- Whether people have access to effective injury care during disasters to prevent avoidable morbidity, mortality and disability.
- Whether people have access to health services that prevent or reduce mental health problems and associated impaired functioning.

iv. Access conditions:

The information should indicate the access conditions and alternative routes/modes, and suggest the best-suited logistical means for delivering the necessary relief supplies.

v. Local action:

The information should also indicate actions being taken locally; and local coping capacities (including locally available resources).

vi. Message structure:

- A FLASH Report (sometimes called an SOS Report) should be circulated quickly. Its purpose is simply to confirm that the disaster has actually occurred, to give a first indication of the sort of external relief that might be required, and to inform the recipients that further reports will follow shortly.
- An INITIAL Report should follow the flash report as soon as possible (within a matter of hours). Its purpose is to inform the recipients of the severity of the disaster and, more importantly, the information needed to start mobilizing resources from outside to help the affected area.
- Assessment reports provide invaluable information to other humanitarian agencies, create baseline data and increase the transparency of response decisions. Regardless of variations in individual agency design, assessment reports should be clear and concise, enable users to identify priorities for action and describe their methodology to demonstrate the reliability of data and enable a comparative analysis if required.

3.3.3. Source of information

Demographic data is normally available with the concerned government authorities, which could be used to assess the number of people affected. Damage to private infrastructure and loss of human lives may be assessed by ground surveys and interviews with the affected populations.

3.3.4. Process & equipment for communication

i. Processes:

Need assessment information should be collected at village level. The affected population should be interacted with in a language and manner that they can understand. They should be engaged in a meaningful consultation process regarding decisions that affect their lives, without creating additional risks. Teams should include people familiar with the language(s) and location and possessing the ability to communicate with people in culturally acceptable ways. Care should be taken while conducting the community consultations on sensitive issues to avoid adverse impacts (e.g. repeated assessments of sensitive protection concerns such as gender-based violence can often be more harmful than beneficial to communities and individuals.)

A mix of quantitative and qualitative methods appropriate to the context should be used. Assessment teams should, as far as possible, be composed of a mix of women and men, generalists and specialists, including those with skills in collecting gender-sensitive data and communicating with children. Coordinators need to be appointed to receive and process the data.

ii. Equipment:

- A communication network of radios that works even when commercial power is down, would guarantee communication in cases of emergency.
- Mobile phones may be used as alternatives.
- Police wireless systems, walkie talkies, etc. may also be used for this purpose.
- Hand Crank Weather Radios are effective and a failed power source won't leave the community un-informed. One can simply crank your the radio to charge it to receive important weather and emergency broadcasts.

3.3.5. Existing programme/infrastructure base

i. Personnel:

- School teachers could constitute an effective and widespread relief network.
- Army personnel present in the region are always the first responders for rescue and could be engaged in this process.
- NGOs and CBOs present in the area can play an important role in RIS data collection and communication.
- Monks and members/staff of local religious institutions could also be trained for relief activities.
- NSS, NYK, Civil Defence, Red Cross Volunteers could be engaged. In Uttarakhand, the NSS is well-organised and reliable.
- Anganwadi workers and other health workers working at grassroot levels (ASHAs) may be engaged.

It is essential that the volunteers are trained. They should not be an additional burden on the administration and should not themselves be at risk. Too many volunteers could create chaos and unnecessary hindrances.

ii. Infrastructure:

- There could be tie-ups with village resource centres for communication.

3.3.6. RIS Good practices

- *Focus on Children*: Since children often form the larger part of an affected population, it is crucial that their views and experiences are elicited during emergency assessments, and to ensure that no child or young person is excluded from humanitarian assistance. Children and young people are prone to the harmful impacts of their vulnerability in certain situations, such as malnutrition, exploitation, abduction and recruitment into armed groups, sexual violence, and lack of opportunity to participate in decision-making.
- *Focus on elderly:* Isolation and physical weakness are significant factors exacerbating vulnerability in older people in disasters, along with disruption to family and community support structures, chronic health and mobility problems, and declining mental health. Special efforts must be made to identify and reach housebound older people and households headed by older people.
- *Assessing vulnerability:* The risks faced by people following a disaster will vary for different groups and individuals. Some people may be vulnerable due to individual factors such as their age (particularly the very young and the very old) and illness (especially people living with HIV and AIDS). Apart from these, social and contextual factors that contribute to vulnerability are discrimination and marginalisation (e.g. low status and power of women and girls); social isolation; environmental degradation; climate variability; poverty; lack of land tenure; poor governance; ethnicity; class or caste; and religious or political affiliations.
- *Data-gathering and checklists:* Assessment information including population movements and numbers should be cross-checked, validated and referenced to as many sources as possible. If multi-sectoral assessments are not initially possible, pay attention to linkages with other individual sector and cross-cutting assessments. Many assessment checklists are available, based on agreed humanitarian standards. Checklists enhance the coherence and accessibility of data to other agencies, ensure that all key areas have been examined and reduce organisational or individual bias.