Central Himalayan Environment Association
CHEA

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

INFINITE OPPORTUNITIES | GERMANY + INDIA

HIMALAYAN VULNERABILITY

UTTARAKHAND, 2013

Editors-
Subrat Sharma
Pushkin Phartiyal
Pitamber D Pant

LEARNING
FOR PLANNING
AND ACTIONS

HIMALAYAN VULNERABILITY

UTTARAKHAND, 2013

LEARNING
FOR PLANNING
AND ACTION

Editors
Subrat Sharma
Pushkin Phartiyal
Pitamber D Pant

This publication has been possible under an assignment on Uttarakhand Disaster - Lessons for future planning in the Indian Himalayan region supported by the Regional Economy Development Programme in Uttarakhand, GIZ

Designed & Published by
XPRESSIONS PRINT & GRAPHICS PVT LTD

ISBN
978-81-929285-0-0

CONTENTS

UTTARAKHAND RESCUE OPERATION

2,616
SORTIES BY INDIAN AIR FORCE-
EVACUATING AROUND
21,961 PERSONS.

~2,000
SORTIES EVACUATING NEARLY
~12,000
PERSONS BY CIVILIAN
HELICOPTERS HIRED
BY UTTARAKHAND STATE

72
HELIPADS WERE MOBILIZED FOR
EVACUATION AND DROPPING OF
RELIEF MATERIAL

~90,000
PERSONS WERE EVACUATED BY
~5,000
VEHICLES BY ROAD

16/06/13

UTTARAKHAND EXPERIENCED

LOSS OF MORE THAN

3,500
HUMAN LIVES

5,400
PERSONS MISSING

170,000
STRANDED

17,700
ANIMALS KILLED

2,174
ROADS DAMAGED

20,401 ha
OF CULTIVABLE LAND AFFECTED

50,000
FARMERS AFFECTED

PREFACE

The "REGIONAL ECONOMIC DEVELOPMENT PROGRAMME, Uttarakhand" has been a joint initiative of the Federal Republic of Germany and **the Government of India** in promoting Indo-German economic cooperation in a relatively backward region in India to bridge the existing economic divide between "the hills and the plains" by complementing and supporting various ongoing development efforts.

The RED Programme, since its inception in 2007, has ensured a steady flow of technical assistance from the German side which is intended to complement the Government of India's reform policies geared towards a more inclusive growth and reducing poverty by generating income and employment, particularly for the rural and marginal groups in Uttarakhand. The Programme is anchored in the Department of Rural Development of the Government of Uttarakhand in cooperation with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The disaster episode that struck Uttarakhand in June, 2013 severely impacted the infrastructure and has resulted in negative impact on the economic growth of the state. This recent tragedy has been a grim reminder to all of us of the vulnerability of humanity and its economic life from the fury of nature. It also provides a strong caution sign for the Indian Himalayan Region (IHR) that mostly lies in the Seismic Zone V, considered most prone to earthquakes. With this perspective the RED programme entrusted Central Himalayan Environment Association (CHEA) to undertake a process for reviewing the diverse impacts of the recent disaster , analysis of the situations and absence of provisions that could have reduced the damage to human life, infrastructure, local livelihoods – both on farm and off farm and loss of valuable resources such as fertile top soil and agriculture fields including the issues pertaining to governance, geo-engineering., social aspect and others.

The publication entitled The Himalayan Vulnerability: Uttarakhand, 2013 is one of the knowledge products developed to offer learning for planning and actions required to mitigating impact of extreme events. Since the basic objective of the intervention was to build upon the learning from Uttarakhand for the mountain states of IHR the process has encompassed through a series of well organized events and activities. This helped to attain the desired outcomes of the assignment. A state level workshop entitled **Uttarakhand 6/16: Analysis, Lessons**

and Mitigation Strategies was organised to capture lessons from the field, its subsequent analysis and developing a road map was a major mile stone of the process. Further engagement with the Indian Mountain Initiative (IMI) envisaged by CHEA in 2010 with intent to value the ecosystem services emanating from the region and to build resilience of the mountain communities, was a core action area. The participation and presentations at the third Sustainable Mountain Development Summit (SMDS) organised in Kohima (Nagaland) in September, 2013 provided a forum for sharing and learning on issues pertaining to disasters. The main seminars during the summit were focused on Water; Agriculture and Forests. Intense deliberations were made in the two side events **SAPCC – Indian Himalayan Caucus**: to bring together different state actors involved in the development of the State Action Plans for Climate Change, as well as, other agencies and organizations involved in the process to identify areas of shared objectives, collaboration, networking and co-sharing of knowledge and resources across the Indian Himalayan states; and Sharing on Disaster Management: an event organised to share and learn from the experiences from states like Ultrakhand, Sikkim and other areas, which have experiences on handling disasters in the recent past.

The papers presented in this publication provide a holistic overview of various sectors, existing gaps and need for planning. Though the views expressed are of individuals and do not carry an endorsement from either the State Government , GIZ or any entity involved in the publication but ertainly the concerns expressed are voices from the ground and require serious attention. To attain the desired economic growth and wellbeing of its people, it is vital to work towards required policy interventions, capacity building and planning at both the local to state head quarter levels of the government, civil society organisations and communities at large on issues pertaining to extreme events in the mountainous region.

I hope the different suggestions offered through the ideas provided by concerned academicians and practitioners will be useful towards building a safer and resilient region in the Indian Himalayas.

Subroto Roy
Programme Manager RED, Uttarakhand, GIZ

Dehradun, Uttarakhand
March, 2014

FROM EDITORS

HIMALAYAN DISASTERS: UTTARAKHAND 2013

LEARNING FOR PLANNING & ACTION

Subrat Sharma, Pushkin Phartiyal**, Pitamber D Pant****

Life in mountains had been always difficult but disasters take away things from people, including lives. "Have we deviated from the Progressive Learning?" is the perfect question (raised by one of the authors in this volume) in the present case of Himalayan scenario which is prone to disasters of various natures but mostly natural ones. Theme of the book revolves around recent major disaster occurred in Uttarakhand (June, 2013) which was an eye opener to all the stakeholders who one way or other have contributed in exceeding the carrying capacity of mountain ecosystem. In this backdrop we intend to take you in a journey through the time (ancient to modern history) and space (world to local) in the domain of knowledge related to natural disasters. Extreme events are not easy to understand and handle too, but their magnitude of devastation can be certainly minimized by respecting the laws of nature, and with adequate preparedness.

Still we have not captured the entire canvas, for example tourism sector. Tourism, still, is in an unorganized format in Uttarakahnd State but is an important livelihood option for many inhabitants through direct / indirect involvement. After June 2013, tourist inflow was badly affected for various reasons, most prominently due to road damages and weakened infrastructure. Due to magnitude of devastation and causalities in the event, a fearsome reputation was developed for traveling in this part of mountains. People from other parts of the country cancelled their travel plan even for the areas where life was normal. This process directly impacted to the tourism industry in the State, as apparent from the cancellation and refund of advance booking, for the period much after the event, in towns of Nainital and Almora where impacts of event were minimal and very soon normalcy restored.

Several experiences have indicated that risk resilience of society is a key area of concern but development of "Early Warning System" was never an area of real concern. Fortunately, our short term weather predications (also available on various sites of web) are quite helpful in travel planning of individuals but still not in practice as a part of system regulating and managing state affairs. The emerging need in the present highly technological world is to evolve a holistic and integrated approach which can reach to people in real time and reduces response time.

* G.B. Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora (Uttarakhand)

subrats63@gmail.com

** Central Himalayan Environmental Association (CHEA), Waldorf Compound, Nainital (Uttarakhand)

pushkin.lead@gmail.com

** Department of Geology, Kumaun University, Nainital (Uttarakhand)

drpdpant@gmail.com

Table 1. Disastrous event of June 2013 in Uttarakhand.

Date	Gaurikund	Rudraprayag	
	Rainfall (mm)	Rainfall (mm)	Water in relation to danger level (m) at 8 am
15.6.2013	250	41.4	7.88 m below
16.6.2013	250	105.2	0.88 m below
17.6.2013	180	100.2	7.50 m above
18.6.2013	0	62.1	0.65 above
19.6.2013	0	7.0	3.0 m below
20.6.2013	0	0	3.52 m below

Table developed from Rautela 2013[1]

Social dimension is an important area hence institutionalization in capacity building on mitigation and preparedness of the society is elementary issue of the current concern to provide inputs for mountain specific policy interventions by the relevant setup of government. Experiences from ground zero and their scientific explanations to realize the techno-socio-feasibility of various options in mitigation and reducing risk hazards have been described in the book to overview the history and magnitude of events and lessons learned. Throughout the world, insurance has been considered as an effective risk transfer mechanism but effective implementation for covering disaster at a large has yet to see the day of light. Policy framework is much required for insurance penetration in the Himalayan Mountains against extreme events which is much common elsewhere, viz., Europe. Among the various approaches described by various authors, this volume also opens a new point of discussion on water regulation through dams. One school suggests that several small dams may provide a mitigation measure in case of flood in mountains than making a large reservoir likes Tehri Dam. Very recently Arora et. al. 2013[2] argued that one of the envisaged roles of Tehri Dam is to store floodwaters in the reservoir to safeguard downstream habitants from floods and release in a regulated manner. The Dam served the purpose successfully during the high floods in year 2010, 2011, and 2013. Recent statistics (Table 2) supports the argument and it appears that large reservoirs can mitigate floods originating from upper catchments.

Table 2. Role of large reservoir in mitigating high floods in upper streams.

Between 16–18 June 2013	Discharge (Cumecs)	Remarks
At Haridwar	15,000	Water level of 295.90m. 1.9m above danger level. Flood is mainly due to discharge of Alaknand and tributaries in between Devprayag and Haridwar
Bhagirathi's peak discharge before Tehri dam	7,500	Totally accommodated by Tehri reservoir
Discharge from Tehri dam	500	If not controlled scenario – peak discharge at Haridware would be ~20,000 Cumecs

Table developed from Arora et. al. 2013.

Illustrating knowledge on technological interventions those may help in reducing the impacts of disaster is like reinventing the Wheel. Need is to enable environment through serious consideration for the approaches on effective preparedness to mitigate impacts.

[1]* Rautela, P. 2013. *Shiv ka mahatandav* (in Hindi). *Aapda Prabandhan*, 7(2): 1-3.

[2]*Arora, HL, Singh AK, and Agrawal, MK. 2013. Dams to mitigate floods. *Aapda Prabandhan*, 7(3-4): 2-4.

COMMENTARY

This section is simply not a description of an event, opinions and explanations of disasters in mountains, and event of June 2013 in Uttarakhand but much beyond that. Prominent scholars and practitioners, or combination of both, have discussed from their long term experiences and knowledge on various pertinent aspects of mountain societies, ecology, and governance. This section starts with positive note by Prof. T. S. Papola, based on his wide experiences in mountains, of Hindu Kush Himalayan Region in general and Indian Himalayan region in particular, on reconstruction and long term development needs in wider perspective.

Following the developmental needs, restoring methods for ecology of landslide damaged mountainscapes and various significant questions (scientific as well as social) have been raised by Prof S. P. Singh from his vast experiences gathered by doing ecology in the Himalayan region. He has clearly pointed out the need of blending of engineering, technology, and ecological aspects for ensuring that the planning is sustainable.

Roads are indicator of development through out the world and a vital life line in Indian mountains, but most vulnerable in case of any kind of disaster. Thus Dr R. S. Tolia, a vigilant practitioner and academician, identifies gap in proper governance and stress upon the need of road regulations in mountainous states. Prof. R. K. Pande, a mountain academician, through establishing and working experiences at Disaster Mitigation & Management Center, Government of Uttarakhand, provides a road map for Uttarakhand State besides highlighting the need for involving insurance sector and reinforcement of proper building engineering codes.

- Editors

01

UTTARAKHAND DISASTER: BEYOND RESCUE AND RELIEF

SOME LESSONS FOR RECONSTRUCTION AND LONG-TERM DEVELOPMENT

*T. S. Papola**

The June 16th (2013), Uttarakhand disaster and its aftermath not only sent shock waves across the nation and the world but also gave a serious jolt to scientists, development thinkers and practitioners forcing them to re-examine their perceptions and assessment of the development path that an ecologically fragile area like Uttarakhand should adopt. The immediate concern naturally had to be with rescue and relief to those directly affected by the disaster. How to reach the basic necessities like food and clothing, medicine and health care etc to the displaced survivors were obviously the immediate priorities of the government agencies and non-governmental organizations. As to how well these tasks have been accomplished is yet to be assessed. The process goes on - dead bodies are still being discovered (December, 2013) – and may probably take more time to complete. There appears to be a widespread consensus that while the magnitude and intensity of the disaster were unprecedented, its impact on the lives, resources and property could have been significantly lower, if development pattern adopted in the state was in accordance with its character of ecological fragility.

It is, therefore, necessary to give serious attention to the medium and long term aspects of reconstruction and development to evolve strategies that could minimize the damage that natural disasters may cause. Following are some major medium and long term considerations that need to be widely and seriously discussed with a view to arriving at a strategy of sustainable development of the State.

* Ex-Division Head, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu

Chairman, CHEA and Honorary Professor, Institute for Studies in Industrial Development (ISID)

4, Institutional Area, Vasant Kunj, New Delhi 1100701

trilokp41@gmail.com

MEDIUM-TERM IMPERATIVES

RESTORING LIVELIHOODS

Immediately following rescue and relief operations, restoring livelihoods to those who have lost their farms, business and jobs in the devastations caused by floods and landslides, is the obvious next priority. Agricultural land that has been washed away is unlikely to be restored, livestock lost are gone forever and providing cattle to farmers who have also lost their land cannot be sustainable as animal husbandry in the hills and mountains is carried out only as a part of the farming system rather than as business. Enterprises in small scale processing, shops and road side tea stalls and other outlets that have disappeared cannot be recreated as the capital invested in them has been lost and even if capital could be provided, market may have disappeared (e.g. roadside tea stalls, and outlets cannot be recreated if the road itself has been washed away!)

Yet, livelihoods have to be restored. A lot of innovative thinking and approaches is required to evolve a pattern of livelihoods that are sustainable even in the situation of depleted resource base and do not seriously impinge further upon the fragile resource base. Can setting up of a network of centers of production of "clean" skill-based rather than resources-based products be a possible solution? To the extent, the local resource base cannot support ecologically and economically sustainable livelihoods, should relocation of population from remote and isolated areas in the areas with better opportunities be considered? Mere compensation, howsoever substantial, may not be a solution.

RESTORING INFRASTRUCTURE

Rebuilding roads, schools, health centres and communication infrastructure that have been destroyed or damaged in the disaster is another important medium term priority. In the case of roads, a moot question is whether the same roads needed to be reconstructed. It is possible that the route and alignments of the lost road had not adequately considered the fragility or stability of the terrain. In such cases should alternatives not be explored? Also it is necessary that more environmentally suitable technologies, such as "green roads" and "bio engineering" are used in the construction of new roads. Similarly the choice of technology and material in construction of schools, health centres and other buildings should be guided by ecological considerations.

SOCIAL REHABILITATION

The disaster not only created physical havoc, but also led to large scale destruction of families as also of other social formations. Death of male breadwinners resulted in a large number of widowed women and orphaned children. In some cases, mother of young children died. And death of children in many cases devastated the families. Destruction of parts of or entire villages meant destruction of communities and other social entities. Some of these constituted losses which cannot be recovered. But restoring psychological and social balance in cases like that of widows and orphaned children through appropriate institutional and medico-psychological interventions, besides their economic rehabilitation must be explored. Non-government organizations and local PRI institutions can play useful roles in this regard.

LONG–TERM IMPERATIVES

MOUNTAIN SPECIFIC DEVELOPMENT PERSPECTIVE

One of the basic arguments for creation of a separate state comprising mostly the hilly and mountainous part of Uttar Pradesh was the need for a different development strategy for that area, for, among others, the reasons of its following distinctive characteristics:

- Inaccessibility
- Non-linearity/non-continuity of space
- Diversity of micro eco systems
- Fragility of terrain, disaster proneness
- Environmental sensitivity or resources

Twelve years after the formation of the new state, no hill/mountain specific development strategy is in sight. Most development efforts by and large, still replicate the plains model. Nor has any meaningful decentralization of planning and decision making, which was considered to be essential in a region with very high diversity among micro-ecosystems and watersheds, been initiated.

BALANCING ECONOMIC AND ENVIRONMENTAL NEEDS

A thorough review and assessment of the entire development strategy, in terms of its approach and sectoral programs and policies need to be undertaken, as an initial step to evolve a region-specific model of sustainable development. Some of the important elements of a new strategy for development of the hill and mountain region of the state are as follows:

- Explicit recognition of constraints and niche' of the mountain areas in the promotion of economic activities.
- Selection of activities on the criteria of maximum economic benefit to local population and minimum short and long term damage to ecology and environment.
- Assessment of carrying capacity of locations/areas for promoting activities (e.g. tourism) and settlement (towns/cities) and enforcement of suitable regulations to ensure sustainability.
- Assessments of the technologies used in infrastructure and other construction activities and discouragement of the use of environment-damaging and encouragement that of environment-friendly technologies.
- Use of resources to produce niche products, horticulture, medicinal herbs and plants, micro hydro power and eco-tourism.

DECENTRALIZED DEVELOPMENT PLANNING

Planning of livelihoods and development activities is needed to be undertaken on a highly decentralized basis at micro-eco system/micro-watershed level. It must be noted that piecemeal Environment Impact Assessment (EIA) on a project to project basis is not enough. Environment impact of the entire pattern of activities needs to be assessed with a view to ensuring sustainability of the overall development pattern at the micro watershed level, on the one hand, and meso and macro, regional level, on the other.

02

A NOTE ON UTTARAKHAND JUNE 2013

DISASTER AND SCOPE FOR ECOLOGICAL RECOVERY OF LANDSLIDES SITES

*S.P. Singh**

The young and rising Himalayas are highly vulnerable to landslides and other hazards, such as earthquakes and flash floods, particularly Glacier Lake outburst floods (GLOFs). Among the Himalayan regions the sparsely populated greater Himalayas are most prone to natural hazards. Apart from the landform, the terrain complexity also affects the vulnerability to natural hazards like landsliding. Uttarakhand the origin place of the Gangetic river system is possibly among the most landslide prone regions. The landslides that occurred on June 16/17, 2013 in Uttarakhand were exceptional in the scale of devastation and death toll, but every year the local people have to deal with this problem in much of the Himalayas. The problem is worsened when we do not have any effective system in place to deal with this kind of hazards.

In a landslide, there occur down slope movement of soil and silt, saprolite, vegetation and rocks under the influence of gravity. While in dry areas the mass movements largely involve rocks, in humid areas other comportments constitute most of it. The frequency of land sliding escalates because of human activities, such as road construction and land use change. Ecologists can help understanding the feedbacks between biotic and hydro-geomorphic processes[1] . There are evidences that the processes of landslides are changing under the influence of global climate change[2] . In the known history of Uttarakhand, rain fall in excess of 30 cm in two days time was not received in mid June, as it did on 16 / 17, 2013. Since the frequency of extreme weather events and uncertainty in their timings are to increase with climate change, the June event of Uttarakhand might be linked to global climate change, and we should be prepared for more of such events.

The event has several concerning social issues. Because of the information and communication technology this event of Uttarakhand is known widely. But does it mean that the Himalayan states now are in a better position to deal with calamities? The answer is both 'YES' and 'NO'; 'Yes', because there are more people in the country with more money to offer aid than in past. 'No', because you need much more than money to provide help in remote high Himalayas. For several days the sites of incidents and affected people remained disconnected in this highly connected modern world and there was no system in place to receive the aid and distribute commodities to people affected by the disaster. Agencies giving aid no more trust that money and commodities handed over to governments would reach the affected people. The crisis of the lack of faith is,

* Former Vice Chancellor; Former Advisor, State Planning Commission, Govt. of Uttarakhand

Chair of Excellence, FRI University, Dehradun

surpus@yahoo.com

1* Restrepo, C, Walker, LR, Shiels, AB, Bussman, R, Claessens, L, Fisch, S, Lozano, P, Negi, GCS, Paolini, L, Poveda, G, Ramos-Scharrón, C, Richter, M, and Velázquez, E. 2009. Landsliding and its multi-scale influences on mountainscapes. BioScience, 59: 685-698

2* Lateltin, O, Beer C, Raetzo H, and Caron, C. 1997. Landslides in Flysch terranes of Switzerland: Causal factors and climate change. Eclogae Geol. Helv., 90(3): 401-406.

perhaps the biggest problem of the present India. Then, the scale of tourism in high Himalayan locations is much bigger than number of people who can be served in the event of crisis like that of June 16/17, 2013.

Here I give, first a brief overview of the event in a wider context of development. Second, I shed light on the ecological aspects of land sliding in mountainscape, which have remained untouched in most discussions on June 16/17 event, though it is important from the stand point of restoration of the damaged sites. I do not dwell upon details of the meteorological aspects of the event, as it is being covered elsewhere in the present volume.

SOME QUESTIONS AND SCOPE OF PREVENTIVE MEASURES

This time landslides occurred well before the time they normally occur in this part of Himalayas. A well established management of meteorological stations and a well developed information network can clearly reduce the scale of human mortality, which was at least more than 10,000. This mega disaster has raised several questions (Table 1) which warrant immediate answers.

Table 1. Some questions related to the 16 June disaster in Uttarakhand.

- What were the physical (weather and geo-hydrological) causes of the recent disaster? It is consistent with the prediction of climate change that extreme weather events would increase and become more erratic. Could it be analyzed in view of that?
- Is it possible to develop a comprehensive vulnerability map of the Himalayas? What factors need to be considered (terrain, topographical immaturity, geo-hydrology, precipitation events, snow melt and glacier lake outburst floods, deforestation, anthropogenic infrastructure, landslide history)?
- Is it possible to use biotic features as indicators of landslides (e.g., presence of *Alnus nepalensis*)?
- Are mountain roads constructed with little regard to mountain specificities? Why green road technology was not adopted? Would it be adopted in future?
- What can be done when scientific knowledge is ignored? Remember in utter disregard to NIH, Rookie's research that Sukhatal (a valley fill) supplies 30% of total subsurface water to lake Nainital, it is being put to construction activities, instead of being conserved.
- What is the scope of developing a mountain-specific science of ecological restoration of landslide damaged sites or landslide affected mountainscapes?
- Do we have enough metrological stations? if not, what is the strategy to collect more site-specific data?
- What is the future strategy for upgrading communication to reduce disaster impact?.
- What is the relationship between hydro-electricity production and disaster? To what extent illegal structures were responsible for economic loss? How to ensure that they would not be constructed again?
- Are tourists well informed about likely disasters in mountains? As an example, are they told that the young and rising Himalayan Mountains are unusually vulnerable to landslides and landslips?
- Is the current scale of religion tourism sustainable? if not, what measures are going to be taken?
- Is there any disaster management system in place? It seems it hardly exists. Then, what can be done to create this service? Since disaster and tourism are highly seasonal, the individuals recruited would need to be given more duties to keep them occupied round the year. What could be the related responsibilities of such workers?
- How to make mountain transport safe?
- Are disasters like this going to aggravate the out migration on problem in mountains? If yes, what should be policy interventions and corresponding strategies?
- What kind of re-construction program our mountains are going to have?

As per deliberations in a recently held workshop, the state meteorological department did issue warning but concerned departments did not take it with seriousness, it deserved. How to inform people living in remote areas during an inclement weather is a great challenge in a sparsely populated part of Himalayas. However, the use of appropriate technology can address the problem. There is a need to create and communicate more information than simply about precipitation. They could be about the vulnerability of a place to heavy rainfall (how prone, it is to landslides), places where people can be given shelter after evacuation, source of light as electric supply disrupts at the time of disaster, escape routes to reach a safe place, if any, etc. But for this the vulnerable areas would need to be equipped with all necessary tools like GPS, light source, knowledge about the area, and creation of escape routes, etc.

Once the roads are severely damaged, there is little one can do to supply food and other aids. This problem could have been, at least partly solved by stocking remote tourists places with food grain, less-perishable cooked food, and medicines well before the start of tourism. By the end of tourist season the unconsumed items could be sold to shop keepers across the region. People suffered considerably after the disaster because of the unavailability of these basic things.

LEARNING TO LIVE WITH DISASTER

In Japan, they say that when you forget earthquakes they come and destroy your towns and cities. So always remain prepared for them. This also applies to landslides and other precipitation-related hazards in Himalayas. There is need to create a disaster management science to deal with hazards (Table 1). To make the job of recruited persons full time, we would need to create more activities for the workers. These could include independent monitoring of road construction and repair, ecological restoration of landslide damaged sites, control of forest fires, reporting of illegal construction activities and traffic regulation at sites where police is unavailable. Their services could be taken also for food grain distribution in a normal time. Needless to say, persons recruited should belong to high mountains, and could be connected with existing Van Panchayat institution. A cadre like this may be developed by taking services of retired army persons and persons from local Van Panchayats. They would need to be trained in remote sensing, use of GPS, restoration ecology of landslides, and construction of green roads.

Tourists could be charged some fee to provide this service. In brief, these persons would dedicate their time entirely to deal with landslide problems during three monsoon months and tourism during that period. Over the rest of the year they could distribute their time across the remaining activities, such as control forest fires and restoration of landslide damaged mountainscape.

SAFE TOURISM IN MOUNTAINS

Even without the June 2013 like disasters , safety aspect of tourism in Uttarakhand has been questionable, and warrants taking several steps.

- To regulate the number of tourists, they need to be registered, and accommodated in hotels and guest houses which are registered properly.
- Vehicle condition, speed, number of passengers, and movement should be regulated.
- Tourists should be fully informed about mountain hazards, limitations and positive points (Table 1); they should not be left at the mercy of hoteliers, travel agencies and others for information. They might encourage tourists to visit even when conditions are adverse.
- The government would need to go out of the way to win over the confidence of tourists which must have been shaken badly because of the June 2013 disaster.

The religious tourism in Uttarakhand is crowded and highly unregulated. There is a need to make tourist arrival well distributed over time and places.

There is a need to look at possibilities of promoting autumn and winter tourism. Winters in much of the Uttarakhand are relatively mild, stable, sunny, and almost disaster free. While in the northern plains the winter time is getting less sunny because of pollution and fog, it is clean and sunny in mountains. Often days in mountains are warmer than in adjacent plains because of bright sun. In winters rivers are calm and blue suitable for rafting and fishing. It is a good time for mountain climbing and tracking and festivities. All these may be combined with religious activities. Replica of celebrated Uttarakhand temples could be created in lower mountains at safe and spacious sites.

DISASTER, OUT MIGRATION, AND SETTLEMENTS OF AFFECTED VILLAGES

This disaster has also shaken the confidence of local people and if tourism is not restored quickly, it is likely to escalate migration, which already has led to depopulation in some pockets (Table 1). Depopulation is a matter of great concern with regard to security in border areas and management of mountain systems, crop biodiversity, and cultural diversity. Alternative employments including other forms of tourism should be explored before migration reaches the tipping point.

A map of vulnerability to landslide (*an approach has been demonstrated in the book- eds*) and floods should be prepared based on terrain morphology, immaturity of topography, hydrology, precipitation, glacier melt, deforestation, road construction etc.

- Alternative settlement sites and their development should be done before vulnerable villages are actually affected.
- The mountain states should be declared land-scarce states, and each place of habitable land should be used prudently.
- It is almost impossible to provide facilities to every isolated house in a different terrain. Policies that encourage the formation of denser settlements should be developed.

ROAD CONSTRUCTION

Wide roads should be avoided in mountains as they are difficult to be maintained on immature topography. Technology of green road which is available should be applied immediately. Narrow but well maintained roads should be preferred to wide and difficult to maintain roads. Also alternative of roads should be explored. Needless to say, it is difficult to connect every isolated location. Measures that lead to larger cluster of human settlements should be taken.

HYDROELECTRIC PROJECTS

Hydroelectric Projects (HPs) should be analyzed realistically keeping in view the following:

I. Cumulative impact of various HPs at a regional level, particularly in relation to disasters during construction as well as after construction.

II. Advantages and disadvantages of big and small HP projects in various mountain situations.

III. Linking HPs to local peoples' cooking energy needs. This issue should be further analyzed in view of the following:

  - The impact of access to clean cooking energy on women drudgery associated with collection of forest biomass.
  - Women and children health improvement with access to clean cooking energy and with increased time availability for child care. Nearly 16 million poor women are estimated to die prematurely each year worldwide because of pollution associated with fire wood used for cooking food.
  - Increase in biodiversity and carbon sink with reduced pressure on forests.

IV. To what extent the destruction of landscape due to the HPs can be reduced?

V. The impact of HPs on flow of various ecosystem services and hazards to downstream areas.

VI. Is engineering developed enough to ensure dam safety against landslides and earth quakes? if yes, what are the conditions, and how to create them.

RESTORING ECOLOGY OF LANDSLIDE DAMAGED MOUNTAINSCAPES

Though a very much mountain-specific issue, it has hardly drawn attention of researchers in Himalayas. Except for the research carried out by the ecology group of Kumaun University, Nainital[3,4] and some others, this area of research has remained unattended in spite of its well established importance for the Himalayas.

The occurrence of alder (*Alnus nepalensis*) is associated with landslides, and can be used on a bio-indicator of vulnerable sites [5,6]. There is a scope for identifying several more early colonizers (e.g., *Populus ciliata, Coriaria nepalensis, Rubus spp., Rhododendron spp*.). Chaudhry et. al.,[6] found that Himalayan alder has a tremendous capacity to ameliorate the harsh environment of landslide damaged mountainscape because of its high N_2 fixation capacity (up to 250 kg N_2 per ha per year).

Here I briefly describe land sliding and scope of research (Tables 2 and 3) in the context of landslide hazards in Himalayas.

- Landslide is a prime example of feedbacks between biotic and hydro-geomorphic processes. Vegetation can affect slope instability depending upon the mechanical properties of roots which differ widely across species, plant functional groups and vegetation types.
- Landslides can stop occurring after a certain scale of land sliding in a mountainscape thus indicating that a landscape can develop "landslide immunity". The research that enables us to find out the stage when a landslide damaged place is safe to live or safe for economic activities can be of great help in the land-scarce Himalayas.
- Since land sliding leads to ecological succession (Fig. 1), it is an important process in vegetation dynamics of a landscape with consequences on biodiversity. We need to investigate at which scale of land sliding biodiversity is maximized in a mountainscape.
- Landslidings result in a very heterogeneous surface that includes patches of primary substrates as well as patches with remains of roots and suckers. While center of land slide site is deeply scoured, at edges some soil is left intact. The center is not in direct access to seed dispersing animals, therefore its colonization is delayed compared to peripheral area of a landslide. Then, within a landslide, deposition zone has more fertile soil than zone from which substrates are displaced. The former recovers at a higher rate than the latter because of difference in seed bank and other propagating structures which reach there. The rate of colonization and the trajectory of succession are considerably affected by the availability of perches . The presence of species or their vegetatively propagating structures and their early arrival can greatly charge the course of succession by facilitating the growth of certain plant forms (Table 2), or suppressing them. Several studies indicate that landslides are important for many species.

[3]* Reddy, VS and Singh, JS. 1993. Changes in Vegetation and Soil during Succession Following Landslide Disturbance in the Central Himalaya. Journal of Environmental Management, 39(4): 235-250

[4]* Singh, JS and Singh, SP. 1992. Forests of Himalaya. Gyanodaya Prakashan, Nainital

[5]* Troup. RS. 1921. Silviculture of Indian Trees. Vol I-III. Reprint 1986. International book Distributors, Dehradun

[6]* Chaudhry, S, Singh, SP and Singh, JS. 1996. Performance of seedlings of various life forms on landslide- damaged sites in central Himalaya. Journal of Applied Ecology, 33: 109-117

Table 2. A summary of findings on recovery of landslide damaged sites is oak forest zone (*Quercus leucotrichophora* and *Q.floribunda*) of Kumaun Himalaya around 1900 m altitude[4,8] . The landslides had removed almost all existing vegetation, and landslide damaged sites were 1, 3, 6, 14, 21, 40 and 90 years old. The recovery documented from these sites of increasing age was natural. To what extent they were grazed or subject to biomass removal and burning was not known.

- Common annuals which colonized sites. *Achyranthus bidentata*, *Justicia simplex* and P*olygonum amplexicaule*.
- Perennial herbs shared vegetation with annuals from 6-13 yrs, at 20 yr, perennials dominated the herb layer, and hardly differed from that of the natural oak forest.
- Shrubs came at 13 yr age and resembled seedlings of that of undisturbed forests by 40 yr of age.
- Uttarakhand disaster
    - Local participation in global initiatives like addressing forest degradation (REDD+), biodiversity conservation.
- *Alnus nepalensis* (alder)& *Sapium insigne* arrived by the third year, and climate oaks dominate by 40 yr
- Vegetal cover effectively reduced soil and nutrient loss; the annual soil loss being 37 kg ha $^{-1}$ yr^{1} from 40 –yr-old site, compared to 81 kg/ha $^{-1}$ yr^{1}, from 6 yr old site. Soil C, P, Ca remmended by recovers by in 40 years and N1 K and Na by 20 years of age.

ECOSYSTEM ATTRIBUTES AND GEOMORPHIC PROCESSES

Under this research issues may include:

- Relationship between plant functional groups and slope stability.
- Identification of plant species which are useful indicators of stable or unstable slopes.
- How do plant attributes vary among landscapes that differ in vulnerability to slope failure?
- How do plant species vary in their influence on hydrological and mechanical process that influence slope stability?

Table 3. Comparison between oak (*Q. leucotrichophora* forest) and Pine (*Pinus roxburghii*) forest zones with regard to recovery of landslide damaged sites in Kumaun Himalaya[3, 9]

- Soil (0-10 cm soil) organic carbon and soil N in oak zone recovered in 45 years (i.e., in 45 years old-sites their concentration were similar to that of undamaged forest site). Legumes seem to play an importance role in soil recovery.
- In pine forest zone concentrations of soil nutrients in landslide damaged sites were lower than in oak forest zone.
- In pine zone, the annuals dominated the herb layer at all sites until 25 years of age (the oldest study site), while in oak zone perennials began to dominate the herb layer only after 15 years of age.
- Because of burning, shrubs' role is negligible in forest recovery in pine zone, while shrubs play an important role in oak zone.
- In oak zone early successional tree species were *Acer oblongum, Cornus oblonga* and *Alnus nepalensis*, and oak (*Q. floribunda*) seedlings first appeared at 15 yr-old-site age. In contrast in pine zone, *P. roxburghii* seedlings appeared first at 1 year age, almost right from the beginning.
- Experiments carried out at landslide damaged sites indicate that the recovery of land-slide damage site can be speeded up by nitrogen fixing species, *Alnus nepalensis* (alder). In the rhizosphere of alder concentration of N ranged between 0.38%-0.65%, compared to 0.04-0.31% in other species, and organic 1.28%-1.47% compared to 0.21-1.2% other species.

[8]*Pandey, AN and Singh, JS. 1985. Mechanization of ecosystem recovery: A case study from Kumaun Himalaya. Reclamation, Revegetation Research, 3:271-292

[9]* Reddy, VS. 1989. Analysis of soil and vegetation of landslide-damaged & undamaged forest sites in Kumaun Himlaya. PhD Thesis. Kumaun University, Nainital.

ECOSYSTEM RECOVERY FOLLOWING LANDSLIDE SITES

Research may need to address the following:

- Influence on ecosystem recovery of factors such as geologic substrate, land use and invasive species.
- Recovery of nutrient cycle (Table 2 and 3). A recently landslide damaged site may be very vulnerable to soil and nutrient losses, particularly when gulleys are formed.
- Biodiversity of past landslides (Table 2 and 3). Though landslides can severely damage forest and human infrastructure, they provide a kind of micro-refugia to several species.

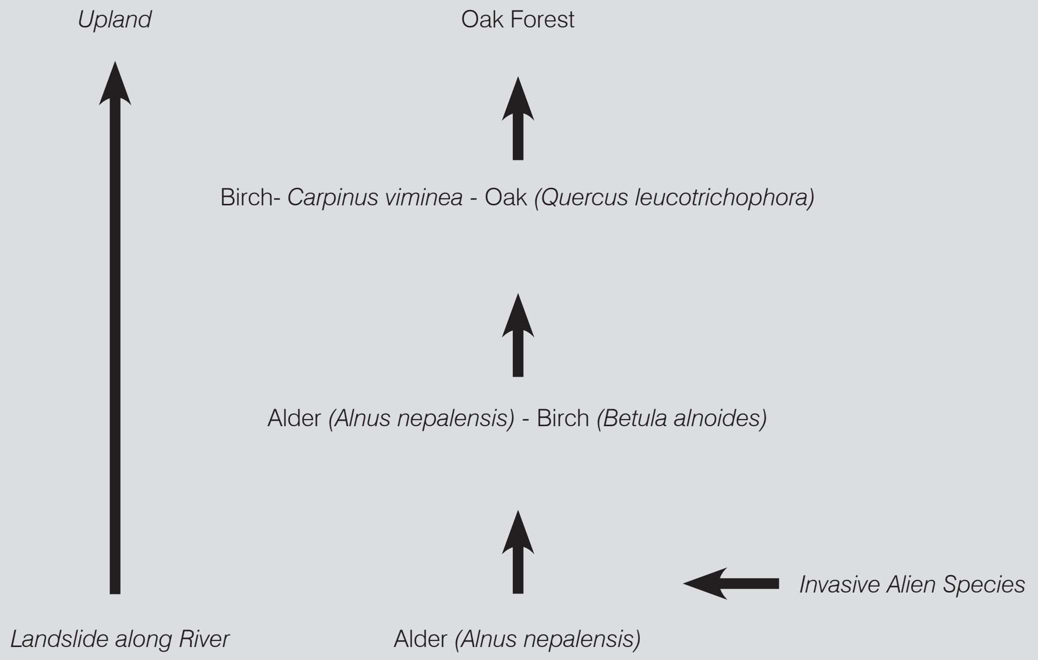


Fig. 1. Pattern of succession on landslide damaged slopes in Ukhimath

LANDSLIDES AND STRUCTURE OF MOUNTAINSCAPES

By changing spatial structure of mountainscapes, landsliding substantially changes hydrological cycles and distribution of propagules. Further, landsliding by transferring hill slope material into streams, extends its influence to rivers. Research is required to understand these interconnections. Studies on recovery of landslide damaged sites in Uttarakhand indicate that:

I. recovery time differs across various ecosystem components and processes;

II. generally in oak (*Quercus leucotrichophora* and *Quercus floribunda*) and pine (*Pinus roxburghii*) zones ecosystems return to original state rapidly in several features, such as species composition and surface soil formation;

III. the recovery rate can be enhanced by application of nitrogen fixers like alder (Table 2 & 3)

CONCLUSION

The people living in high Himalayas would need to learn to live with natural hazards, which are likely to increase in frequency and intensity in a warming world. They not only need access to modern tools and facilities to dael with disasters, but also employment in disaster management. How to win the confidence of tourists after the June tragedy is a great challenge, and calls for taking a series of measures, including extending religious tourism to winters when mountain life is almost free from landslides and road disruptions. There is a need to develop the science of ecological restoration of landslide damaged sites, as many times landslides result in lands with less steep slopes.

03

DISASTER AND ROADS IN THE MOUNTAINS

CASE OF UTTARAKHAND STATE

*R. S. Tolia**

Roads being a dynamic entity are vital life-line in the Indian mountains which are prone to all kinds of extreme events and natural hazards. Their construction is a major Planning target, to ensure complete connectivity to all habitations, being an integral part of country's 'More Inclusive' objective. Roads played important role in the growth of various infrastructures[1] and their functioning in remote locations of the Uttarakhand. The event in the month of June 2013 in Uttarakhand state showed total disruption of road connectivity as is apparent from blocking off of 2,092 roads while many of them were washed away along with 145 bridges. This situation has proved to be a major factor of the unprecedented distress caused to affected people and regions. Three months down the line, as many as 204 plus roads still remain to be opened for traffic. These hard facts underscore the need to re-visit the entire regime of road-making in the mountain regions and put in place the minimum regulations that are required for making mountain roads, which are environmentally compliant.

Road alignment and road constructions are major tasks in the mountainous slopes which require engineering skills of highest order. Some studies from the Himalayan region indicate to a major contribution of road construction to the environmental damages in the region. For example, road construction at Mussoorie area had contributed 5-10 per cent increase in watershed sediment yield[2], and construction of 44,000 km long road in the Himalayan region have generated 2650×10^6 m^3 of debris[3] .

ROAD REGULATIONS

Historically road-making commenced in the public sector after their control was transferred from the Army to the Public Works Department during the late 1850s. Road sector appears fragmented when it comes to the regulation, including construction, post care and control of road-side. In Uttarakhand, Border Roads Organisation (BRO, a Central Undertaking) controls major arteries in deep mountains which are now scenes of natural disasters. Other than BRO, National Highways (funded by the Central Government) are under State Public Works Department's (PWD) dedicated Divisions, thereafter State and District Highways. Rural Roads are now a major segment with huge investments through the *Pradhan Mantri Gram Sadak Yojana* (PMGSY).

* Ex-Chief Secretary, Govt of Uttarakhand; Ex-Chief Information Officer, Uttarakhand State Chair, Doon University, Dehradun

raghunandantolia4@gmail.com

[1]*Rawat, DS and Sharma, S. 1997. The development of a road network and its impact on the growth of infrastructure: A case study of Almora District in the Central Himalaya. Mountain Research & Development, 17(2): 117-126.

[2]* Haigh, MJ. 1979. Landslide sediment accumulations on the Mussoorie-Tehri road. Indian Journal of Soil Conservation, 7(2): 1-3.

[3]* Valdiya, KS. 1985. Accelerated erosion and landslide prone zones in the Central Himalayan region. In: Environmental Regeneration in Himalaya (ed. JS Singh) Gyanodaya Prakashan, Nainital. 12-38

A roadside Control Act, as was operational in Uttar Pradesh, already exists in the state of Uttarakhand, however, its actual practice is in question. During an interesting RTI[4] , PWD department has filed details of roads where appropriate notifications of its implementation were in operation, as well as, where this was yet to be done while the representative of the Border Roads Organisation was ignorant of any such Act.

NEED

For any effective regulation of all roads in Uttarakhand, now the first most important activity to be improved as a component of an effective and reformed architecture of disaster management, bringing all kinds of roads under an overall disaster management monitoring architecture is essential. It must include all kinds of roads, Central and Provincial, including the roads maintained by the Forest department which are equally important from the disaster management response action as witnessed in the Kedarnath episode.

UN-REALIZED ALTERNATIVE

All Forest roads must also now be looked upon as 'Alternate Roads', in the event of the main-road rendered not usable. The District Disaster Management Plans, mandated under the Disaster Management Act, must locate and show, as well as ensure through the Forest department, that Forest department maintained roads are available as 'alternate roads'. Often, their maintenance is not adequately supervised, or funded, but their importance is now underscored by the fact that their existence would be quite helpful in all post-disaster relief and reconstruction operations. As their maintenance is not constrained by factors like taking permission for maintenance, metalling or widening, these are to be seen as important as the main roads, in context of their use during emergencies. Their proper maintenance is already justified as being useful as an important component of Forest-fire management angle.

Next, to an overall architecture for all kinds of roads coming under a single monitoring mechanism for the sake of disaster management, is an issue of covering all roads also under what had once been popularized as constructing 'Green Roads'. For Sustainable Management of mountains, all roads must be made under an over-all environment framework of 'Green Road' making. The Indian Road Congress already has norms for Hill Road making, this must be made compliant to the 'Green Road' regime.

GREEN ROAD CONCEPT

In 2000, Ministry of Environment & Forests (Govt. of India) has notified (No. S.O.916 (E), dated 6th October 2000) draft proposals for (i) Location planning in Urban Areas in Hills, (ii) Rain Water Harvesting and (iii) Hill roads. These guidelines were prepared by G.B. Pant Institute of Himalayan Environment & Development (Kosi-Katarmal, Almora).

The Hill Roads component of the proposed Notification contained requirements like 'environment impact assessment', treatment of hill slope instabilities resulting from road cutting, cross drainage works and culverts. disposal of debris from construction sites dumped material to be treated using bio-engineering, norms for setting up of hot-mixing plants, treatment plan for quarrying and adequate provision of road side drains, avoiding fault- zones, following ridge- alignment, minimized loss to vegetal cover, prefer south and south-west alignment, etc. Despite the importance of this sector and regulations required the draft proposal could not be taken further. The right time has come to take this initiative further, and a beginning should be made by the Disaster Management and Forest Departments of Uttarakhand.

Green Road making concept has components in the Construction as well as Maintenance phases, first, with Cut and Fill Technology, Limited Blasting, Stabilisation of cut Slopes. etc., ending with Vegetative Cover, while the maintenance phase also has a few forest related components, e.g. in slope treatment and Strip Plantation and Vegetation. Thus, in the main in Road Regulation, following the Green Road Concept, Public Works and road construction organizations have a collaborative arrangement with the Forest Department. As the Green Road concept had never been given a fair trial, it is about time that the mountain states take up this Green Road Making and Regulation of Roads for Sustainable Development agenda, under the overall rubric of Disaster Management.

[4]* Filed during the tenure of author as the Chief Information Commissioner, Uttarakhand

MANAGEMENT AS GOVERNANCE

Disaster Management has been emphasized in the Twelfth Five Year Plan of the country as a major goal under the Governance sector, however because of unregulated and uncontrolled development in the mountains Uttarakhand State had to pay a huge penalty by the massive losses to human lives and destruction of infrastructure. Empirical estimates require need of a huge fund, thousands of crores, and years of concerted efforts to bring Uttarakhand where it was on the eve of 16 June.

Road regulation would require administrative and legal restructuring, sectoral budgetary support and substantive capacity building of technical man power, both, in the construction departments as well as in the Forestry sector's various wings, including Forestry Research and Training. Disaster Management in Mountain Regions has ingredients which can possibly be developed into a new Flagship Programme for all Indian Mountain States, or a sub-Sectoral Programme, to be introduced during the 12th Plan.

There is an urgent need to bring harmony, to achieve several national priorities, a far better disaster management regime being one of the major ones. Scientific Regulation of Roads involves (i) a major re-structuring the entire State Disaster Management Authority, (ii) enabling the existing Disaster Management architecture with strengthened and revamped State Authority, and (iii) consisting of various activities for Regulating State Rivers and River basins and all Roads and Road-side stretches making mountains safe for travelers. Role of civil society should be necessarily accompanied into real-time action, and also to craft architecture to respond to the felt-gaps. Regulations must not be perceived necessarily as being negative as their neglect in human and economic cost has been demonstrated by some recent tragic events.

04

DISASTER MITIGATION AND MANAGEMENT SYSTEM FOR UTTARAKHAND

A ROAD MAP

*R.K. Pande**

Uttarakhand is vulnerable to several forms of natural disasters including earthquakes, landslide, forest fire, cloudburst and flash flooding. The Intergovernmental Panel on Climate Change (IPCC[1]) recently concluded that human intervention has a discernible effect on global climate and global climate change also appears to aggravate the impact of El Niño. What does this mean for Uttarakhand - higher rates of erosion, permanent inundation, and flooding? Given the high dependence of the region on rain for potable water, changes in the rainfall pattern and excessive precipitation may cause serious problems, particularly in the region where concentration of human population has increased in unplanned manner and in risk zones. After a relatively calm period there is possibility that near future may witness a period of increased tectonic activity. Given the small size of Uttarakhand, the impact of a major earthquake can affect the entire community. Thus, Uttarakhand is exposed to multiple natural hazards (for example: 1991- Uttarkashi Earthquake, 1998 - Malpa and Okhimath Landslides, 1999 - Chamoli Earthquake, 2003 - Varunavat Landslide, 2013 Kedarnath Flash Flood). The levels of losses in major disasters demonstrate the economic importance of reducing vulnerability. This vulnerability has been compounded by the geographic situation of the state.

REASON FOR CONCERN

Any disastrous event can damage infrastructure and buildings. A disaster event causes a series of direct and indirect losses. The direct losses, borne by the property owner (as the case of building) and partially offset by insurance payments, can be approximated by the cost of repair and reconstruction. The indirect losses arise as a consequence of disruption of production and services and spread through the entire economy (as the case for road being out of service for an extended period), are difficult to estimate and can easily exceed direct losses (*eds- this sector explicitly discussed in Chapter 3*).

*** Ex- Executive Director, Disaster Mitigation & Management Center, Govt of Uttarakhand;**

Professor of Geography, Kuamun University, Nainital

ravindrapande@hotmail.com

[1]* IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Case - I

Landslide on 23rd September, 2004 amid heavy rains at Amparav around midnight caught the down slope inhabitants by surprise. Having forgotten that the Nala on the upslope draining through their habitations had been diverted, these people had never expected this to happen at a place that is not drained by any stream.

The post-disaster survey reveals that the area was earmarked as being highly sensitive to landsliding almost a century ago and elaborate landslide management plan was enacted in the zone for warding off this threat. The commercial interests along the road however lured the masses to encroach upon the zone earmarked as being highly sensitive, while the administration remained a silent spectator; both are therefore to be blamed for the present human misery. Restoration plan also has to draw lessons from the century old landslide management plan that is observed to be still effective.

Situated over the old landslide material and in close proximity of major tectonic discontinuities (Main Boundary Thrust, Kuriya Fault) makes this zone highly sensitive to the threat of flash floods and seismicity besides landsliding and land subsidence. Many buildings of mass occupancy are observed to be coming up in the region and there is an urgent need to regulate their construction for avoiding human sufferings in future.

Case – II

Investigations in the Thatyur Block (Dhanolti Tehsil, District Tehri Garhwal) covering parts of Rangaon, Rampur, Lagwalgaon, Dabla, Ghattudhar and Biragaon villages those are situated adjacent to the hill town of Mussoorie revealed that –

- major part of Rangaon village and agricultural fields, cattle yards and water mills of Rampur, Newaridhar, Langwalgaon, and Dabla villages were vulnerable to landslide hazard.
- the agricultural fields of nearby Biragaon and Ghattudhar were also prone to landslides.
- parts of Kempty and Kempty Lake area may also witness subsidence and landslides in the years to come.
- Kempty-Charogi Road was damaged at km 4 near Rangaon by debris flow brought by Rangaon-ka-Khala from the toe cutting of Surbee Resort slide.
- Kempty-Thatyur Road was badly damaged at km 2, where Surbee Resort slide has completely washed away >20 meters long stretch of road.
- Santuree Devi - Biragaon road was also damaged by landslide.

While disasters will continue to occur, there are few legally enforceable civil/structural engineering design standards in the state of Uttarakhand. The codes that do exist provide insufficient standards for critical facilities. Furthermore, they do not adequately address the important question of non-structural elements.

WHAT CAN BE DONE?

The concept of disaster management has expanded significantly. Originally focussed only on immediate pre-disaster preparedness and post-disaster response, the concept now encompasses the longer-term issues of hazard assessment, risk reduction, and rehabilitation. There is need that the State should develop a comprehensive disaster mitigation policy. Moreover, the need to establish, as appropriate, regional emergency response teams and regularly test district disaster management plans; and promote the establishment of appropriate building construction codes that include regulatory and enforcement mechanisms through the sharing of technical information and expertise is recognized. The Plan of Action should be committed to cooperate in the development, strengthening and implementation of disaster mitigation plans, including contingency and response arrangements.

With appropriate design and construction techniques, facilities can be protected so that they remain in operation after a hazardous event, and this protection costs are affordable. To improve resistance to the effects of natural hazards, better building practices are essential. Such codes must incorporate modern technical standards. The costs of improved standards and codes are minimal.

Some Regulatory Models for checking compliance

Singapore Model. This approach features a considerable degree of self-regulation, with professional engineers certifying that design and construction are in compliance with the specified standards. In-depth audits of a few randomly selected projects are conducted, with bad work leading to penalties.

French Model. An approach inspired by the Code Napoléon made the contractor liable for design and construction faults. This led to decennial insurance which, in turn, led to the need for bureaux de contrôle (check consultants). Consideration should be given to this excellent method of quality assurance.

Colombian Model. A system similar to the French model is used in Colombia, where the building owner employs both the designer and the inspector.

Engineering institutions have also an important role to play in Uttaranchal. Through their programs, engineering students are taught the principles and fundamentals of building design and construction. Once the basics are understood, engineering students should have no difficulty in understanding and applying codes and standards. However, existing programs and continuing education programs for practicing engineers should be strengthened so that students and professionals have a better understanding of the principles and their practical application. Legislation for the registration of engineers should be adopted.

The introduction of planning legislation will lead to a growing consciousness among planners of the need for tighter controls on the use of land. However, change will be slow. A greater financial commitment on the part of the governments may be required to ensure that land-use and zoning regulations are properly enforced.

Insurance is increasingly being looked upon as a tool for compensating for the losses incurred during disasters. At present there is no such provision. For reducing the burden upon public exchequer the state government looks forward to bringing the people of the disadvantaged sections of the society residing in disaster-prone areas under disaster insurance cover. The cost of the premium for BPL for the same is proposed to be covered by the CRF.

ROAD MAP

To achieve sustainable development in the State, mechanism should be developed to counteract natural disasters by (i) avoiding hazardous zones through identification of risks and vulnerable areas, (ii) designing, and use of appropriate technologies for constructing buildings and infrastructure at acceptable cost, and (iii) forcing a compulsory insurance of buildings against such risks.

The road maps, which have been identified as the essential core functions in the management of natural and technological hazards, the following deserve special mention:

- Developing an objective information system and identification of areas of refuge
- Generation and dissemination of basic knowledge that documents potential hazards and information on mitigation approaches both at government and private sector decision-makers
- Build and educate constituency for risk management

- Development and promulgation of standards
- Creating an open process for development decision makers
- Creating strategic alliances within government, merging natural and technological hazards and risk management
- Utilize regulation and insurance to drive mitigation
- Professionalize and standardize emergency management
- Preparation of community based disaster management action plans and creation of village/town level Disaster Intervention Teams.
- Ensure comprehensive, coordinated government response through fail-safe communication among various sectors and preparation of DMM Plans, and
- Capacity building, both institutional and personal

TECHNICAL NOTES

A wide spectrum of knowledge, learning, and efforts constitute section, '**Technical Notes**', which starts by reminding us existence of a knowledge base (documented nearly 5000 years before) as described in ancient literature of Vedas. This illustration tells us that how people of that time have recognized power of wind, water, and fire as well as their impacts (Chapter 5). Still our short term memory doesn't recall existing knowledge until a disaster occurs. Next presentation (Chapter 6) takes us to the recent scientific (!) but same knowledge domain with emphasis on climate variability due to threats of climate change and disaster risks of high elevation regions across the World. Following chapter (7) continues in high elevations where glaciers occur. They are source of water for millions of people in the plains but also pose threats to settlements and infrastructure in mountains from flash floods those may originate from glacial lakes (GLOF). Disaster of June 2013 in Uttarakhand occurred due to a GLOF or it was response of extreme rainfalls in North-western region has been discussed in Chapter 8. Following chapter (9) is an account of major natural disasters occurred in the State, before Kedarnath tragedy. We have heard, most of the time, stories of relief work and heroic work in saving human lives during an accident or after a disaster but an unsung part (in most of the coverage of recent Uttarakhand Disaster) has been presented in Chapter 10 where great efforts were made in managing animals during and after the Tragedy.

Road construction has been attributed to the occurrence of new landslide sites or acceleration in old sites as well as silting rivers. Chapter 11 describes some aspects of geology, road construction and landslides in Alaknanda Valley of the State while slope stability of a new road construction in Nainital has been geological investigated in Chapter 12. North-eastern region of Indian Himalaya is very prone to soil loss due to high rainfall intensity and precipitation it receives. Chapter 13 provides estimate of soil loss from a River Basin of Arunachal Pradesh in the Eastern Himalaya. It demonstrates use of technologies in analyzing real world situation through simulations which may help in planning process.

These insights, discussions, and lessons will certainly help to (i) understand extreme events, (ii) develop proper approaches in mitigation, and (iii) strength preparedness for minimizing devastation and losses.

- Editors

05

NATURE'S FORCES IN ANCIENT LITERATURE

RGVEDA

*S. Tabassum**

Learning is in bound mechanism for all most all the lives exist on the earth, and may be beyond that. Stored information, acquired from learning, helps in further improvement, and also in communicating knowledge to others, presented in that time frame or to future generations. Dissemination of existing knowledge exists in various forms and transcripts are one of the oldest mechanisms after cave paintings.

Indian sub-continent has evidence of human activities of *Homo sapiens*, as long as 75,000 years ago, or with earlier hominids including *Homo erectus* from about 500,000 years ago (Bongard-Levin 1979), and existence of a very old history of human civilization (e.g., Indus Valley Civilization). The Indus Valley civilization remained mysterious because historians have not been able to translate their complicated written language called 'Indus Script' (www1). Fortunately, the newer (than that of the time) available transcripts of ancient time were composed in '*Vedic Sanskrit*' and have been well read – '*The Vedas*', oldest of all the Indian texts.

Among the four canonical sacred texts of Vedas, The ***Rgveda*** is believed the oldest one having collection of ancient Indian sacred Vedic Sanskrit hymns, and contains several mythological and poetical accounts of the origin of the world, hymns praising the gods, and ancient prayers for life, prosperity, etc. (Werner 1994). This is an attempt to collect relevant *Mantras* (Chant) from *Rgveda* to realize the ancient wisdom on forces of nature and their effect to the human societies so some lessons may be drawn. English translation of some of the *Mantras* is given and number indicates *Mandal*, *Sukt*, and *Mantra*. For example, (1.160.04) denotes that this is 4th *Mantra* in160 *Sukta* of 1st *Mandal*.

Ancient wisdom illustrates physical features of earth and role of sun in the atmospheric processes -

- The earth is stable on its axis. (1.160.04)
- The sun rays travel over the atmosphere to water the clouds with its beautiful speed and water absorbing power. Thus rays come down and wetten the earth. (1.164.47)

* Associate Professor,
Department of Sanskrit, SSJ Campus, Kumaun University, Almora (Uttarakhand)
shalimat1@gmail.com

WIND

It appears that civilization of that time was more affected by the wind and related events hence wind power and its effects, even on mountains, have been described at several occasions.

- Winds can bring changes on the Resource Provider Earth. (7.58.01)
- Winds are independent, stable, heavenly, and resource provider. A crashing voice which shakes the enemies is fail to shake the mighty winds. (5.87.05)
- Winds, omnipotent and omnipresent are the messengers of changes as they rummage through the earth and the atmosphere. We cannot think how much powerful of these local winds. It pervades in all directions and sets the flora in the motion. (1.37.06)
- All the powerful earthly matters could be thrown by the winds. The earth shuddered like a weak and old king. (1.37.08)
- Winds blow by speed and force. All living things are scared by their motion. (7.58.02)
- When winds blow, they fell shower and shak the mountains. (8.07.04)
- When winds blow with full of speed, clouds and trees make crashing noise and re-vibrate the earth. (8.20.05)
- Winds echo through the mountains and tear them out. (4.16.06)
- Winds are almighty. The mountains are especially affected by the strength of the winds. The winds also destroy trees and small plains. They have a power of move anywhere like 'an adlib vagrant' with the living things in the earth. (1.39.05)
- At the time when winds prepare the clouds, like a prosperous rain, the earth shivered like a widow to see them. These winds with their special speed to vibrate the mountains and showed their power. (1.87.03)
- Winds blow with great speed when they resound in mountains and caves or rise to circulate in the upper atmosphere for the welfare of human being. They bring about turbulence among the flora on the earth are responsible for pollination and displacement of medicinal plants. (1.166.05)
- The Formidable Mountains are afraid of the harsh voice of winds and seamless sky also re-vibrates by the sound of the immortal winds. (5.60.03)
- The Formidable Mountains shivered when the strengthen winds pull the carts with their horses. (8.07.02)
- The Tempestuous wind blows in all directions like impetuous horses run free. Its journey is incredible as people are scared of weapons, The building and palaces are scared by its force. (1.166.04)
- Winds carry rain with their horses like a fire. They are omnipresent and non- violent as they rummage through the cloud like a formidable mountain. (3.26.04)
- All the Iceland ruffle, flora makes sorrow, water flows and shaking the earth by the harsh speed of winds. (8.20.04)
- Wind blows through traveling on its cart like horses. At this time all forest is set in motion by the fear of its harsh speed. (5.60.02)

RAIN AND WATER

Rain appears to be a more prominent feature of water in the sacred text. At several places effect and destroying power of rains have been illustrated.

- *Indra*, the God of Rain, provides the power of destroying enemies like the sun who fulfills the earth with its incredible light. (6.20.01)

- *Indra*, the God of Rain, is omnipotent elements in the earth. At the presence of fear Indra had conceived air and earth by his power of destroying enemies. At this time all the living things, even mountains shivered by the fear of Indra. (1.63.1)
- Omnipresent *Indra* is the harbingers of water in the earth. All rivers develop through rain but the whole world is afraid by the large amount of rain as it brings flood. (7.21.03)
- Omnipresent *Indra* destroys the enemies and also shutters or breaks down the various cities of demons with the help of his thunderbolt. (1.63.02)
- *Indra* puts down the mouth of large clouds and falls rain. God, *Indra*, always listens to the people. The earth owe with fear of non-fertilizing even the heaven also mourning without rain so god *Indra* escapes the earth and the heaven from this fear. (1.134.06)
- Like a river obey the seas, all human beings obey and pray *Indra* for escaping from his anger. (8.6.04)
- Like a river extends the Seas, chant increases the Immortal *Indra*. Nobody could remedied the anger of *Indra*. (8.06.35)

FIRE

Even small content on fire also appears.

- Fire destroys forest and spread over the earth automatically. (6.13.05)
- Fire provides strength to the keen powerful winds which are destroying the enemies and shuddering the earth. (6.67.09)

PREPAREDNESS AND PROTECTION

Some of the guidelines on protection are also provided.

- Winds tumbled things and inspired owe and fear and prompted people to build houses with strong foundation as their might could move the formidable mountains. (1.37.07)
- An ambitious and an intelligent people made a new technology between the earth, water and the atmosphere for there prosperity and protection. These new scientific technologies are dangerous for our earth, as it shudders by the loudness and force of these technologies. (1.151.01)
- Mountains are formidable as they not tempestuous from their place by the force and attacks of human beings. They always save them by the enemies. (8.07.35)
- Winds are more beneficial as they bring rain and prosperity for the welfare of human being. (8.20.01)
- Mountains always shudder by the harsh speed of winds. Like the mares go to fight the mountains go towards wind. It blows like a king who climbs on the cart by the help of mares. (10.169.02)

These quoted texts as well as other wisdom spread over the literature of the world (ancient or present) provide strength of natural elements and their destructive forces. It is a high time to recapitalize on the learning to save the mother earth and human civilizations.

REFERENCE

Rigveda Sanhita. Hindi Translation – Pandit Ram Govind Trivedir (Sayan Bhasya). Chaukhamba, Vidhya Bhawan, Varanasi.

Bongard-Levin, G. 1979. A History of India. Progress Publishers, Moscow. p. 11

Werner, Karel. 1994. A Popular Dictionary of Hinduism. Curzon Press., Richmond, UK. pp 185.

www1. https://sites.google.com/site/1ancientcivilizationsforkids/ancient-india

06

CLIMATE VARIABILITY AND DISASTER RISK

HIGH ELEVATION REGIONS OF THE WORLD

*Priti Attri and Smita Chaudhry**

The world's mountain systems, including the people in them, have gained an international focus during the last decades. Past efforts and accomplishments in this area include the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Man and the Biosphere (MAB-6) programme beginning in 1971, the successive worldwide establishment of regional multinational research institutions and cross-border research and information networks, the recognition of 'Mountains' in the political Agenda 21 of the U.N. Conference on Environment and Development (UNCED) 1992 in Rio de Janerio, Brazil (Chapter 13), and the follow-up Earth Summits Rio+5 and Rio+10, finally leading to the start of the Mountain Research Initiative (MRI) in 2001 (Becker & Bugmann, 2001).

Mountains cover 25% of the global land surface, providing home and living space for 26% of the world's population. In arid and semi-arid areas, where water is critical, mountains provide as much as 90-100% of the freshwater resources for drinking, irrigation, and industrial supply in the surrounding lowlands.

Mountain landscapes are extremely dynamic, and there are three main reasons for this. First, tectonic elevation of mountains accumulated enormous energy potential of the Earth gravitation. Second, they have been elevated to significant altitudes, and thus created great orogenic energy. Third, it is a typical characteristic of high mountains that they create an interruption in atmospheric water circulation with a significant part of the water accumulating in glaciers, snow cover, and in loose deposits, where they have the potential of contributing to landslides and mudflow processes. Dynamism of mountain landscape is further exacerbated by human activities such as deforestation, heavy grazing by livestock, road construction, development of mining industry etc.

* Institute of Environmental Studies, Kurukshetra University, Kurukshetra (Haryana)

pritiattri8@gmail.com, smitachaudhry@rediffmail.com

CLIMATE PROJECTIONS IN MOUNTAIN REGIONS

Mountains, with their steep relief, high precipitation, and quickly changing climatic patterns, are particularly sensitive to environmental change, with significant influence on human wellbeing (Korner & Oshawa, 2005). There is a high level of probability that future anthropogenically induced changes in the climate including enhanced heat waves, glacial retreat, and permafrost degradation are likely to lead to increasing slope instabilities, movement of mass, and glacial lake outburst floods (IPCC, 2012). Although the direct impacts of climate change will be most marked at high elevations, they will have a greater impact at lower elevations, the 'cascading' of effects will be felt from high to low altitude areas, for example, runoff at high altitude leading to floods and increased sand deposition on agricultural land at lower altitudes (Tse-ring et al., 2010).

Changes in atmospheric wind flow patterns may induce large and locally varying precipitation responses in mountain areas, which could be much stronger than average regional climate change (IPCC 2007).

A regional climate model study for the tropical Andes indicated more warming at higher elevations and an increase in inter-annual temperature variability for scenarios with greater global warming (Urrutia & Vuille, 2009). Higher elevation sites in the Rocky Mountains have experienced a threefold increase in warming compared to the global average during the last few decades. Climate models indicate above-average warming with the greatest warming at high latitudes from December to February, and from June to August in the mid-latitudes (Westerling et al., 2006).

As the largest high-elevation land mass in the world, the Himalaya-Tibet massif plays an important role in global climate and climate change. Warming is predicted to be well above the global average, which can be seen even in global climate projections (Figure 1).

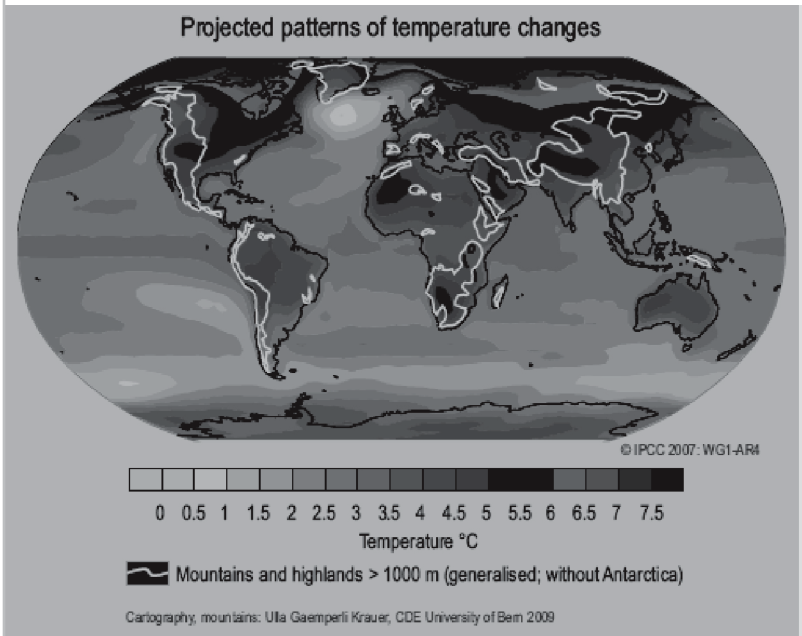


Figure 1. Changes in temperature at the end of the 21st century compared to 1990 for a high greenhouse gas emission scenario. White contours depict important mountain regions. (adapted from IPCC 2007, Fig. WGI-SPM-6)

In general, Europe has shown a greater warming trend since 1979 compared to the global mean, and the trends in mountainous regions are still higher (Böhm et al., 2001). Regional climate projections indicate warming of about 1.5 times the global average, with greater warming in summer. General warming is expected to lead to an upward shift of the glacier equilibrium line by 60 to 140 m per °C temperature increase along with a substantial glacier retreat during the 21st century (Oerlemans, 2003).

INCREASING SUSCEPTIBILITY TO DISASTERS

A natural hazard in itself does not necessarily cause a disaster; a disaster results when a natural hazard impacts on a vulnerable, exposed or ill-prepared community. Disasters are therefore not purely the result of natural events, but the product of such events within the social, political and economic context in which they occur. In addition to relief and geology, human activity can also influence the impact of hazards. Destruction of mountain forests or inappropriate farming practices can accelerate erosion and expose land to the risk of landslides, floods and avalanches.

Globally, climate change is very likely to increase the pressure exerted by non-seismic hazards. Higher temperatures will enhance the hydrological cycle and it is predicted that they will alter rainfall patterns and intensity. In the mountain regions of South and Southeast Asia, for example, changing monsoon patterns, including increased severity and frequency of storms as projected by climate models, may threaten agricultural production, food security and the livelihoods of millions of people, and damage vital infrastructure. Effects will not be limited to changes in precipitation: global warming reduces snow cover, melts away glaciers, and degrades permafrost (Bavay et al., 2009).

Casualties and damage due to hazards in mountain regions will increase irrespective of global warming, especially where populations are growing and infrastructure is developed at exposed locations. But climate change will definitely increase risk due to the fact that expected increases of heavy rainfall, heat waves, and glacier melt will amplify hazards in many mountains worldwide, and in areas where they have not been known in the past (Table 1). The Hindu Kush Himalaya (HKH) region has had an average of 76 disaster events each year. On average, more than 36,000 people are killed and 178 million affected each year due to natural disasters in the region (Figure 2 a & b).

Table 1: Climate change and incidence of hazards in mountain regions.

Hazard	Trend of expected change	Confidence in trend projection	Most affected regions	Economic importance
Seismic hazard	→	high	South America, Southeast Asia, North and Central America	very high
Snow avalanches	→	medium	Northern hemisphere, New Zealand	Low
Droughts	↗	high	Africa, Caucasus, Eastern Himalaya	high
Landslides and mud flows	↗	high	Southeast Asia, Central and South America	medium
Glacier lake outburst flood	↗	high	All regions with valley glaciers	low
Floods	↗	medium	Asia, Africa, North America	high
Forest and bush fires	↗	medium	Africa, North and Central America, Eurasia	Medium
Insect-borne diseases	↗	medium	Africa, Southern Asia, Central and South America	medium

Based on IPCC (2007), Iyngararasan (2002), and UNEP-WCMC Mountain Watch (2002)

The 2013 calamity in Uttarakhand is considered as India's worst natural disaster since the December 2004 Indian Ocean Tsunami. According to the government officials, more than 6000 missing and tens of thousands have been displaced. Prolonged heavy rainfall for nearly three days over a large area in Uttarakhand is perhaps unprecedented, and the cumulative effect of various parameters such as geological, tectonic, orographic, meteorological, environmental and anthropogenic factors, is the reason for the enormity of this disaster (Dubey et al., 2013). There have been various events in the past where life and property have been damaged due to hydro-meteorological calamities in Himalaya (Table 2). Most of these extreme events happen either in the south of the Higher Himalaya or at the foothills of Shiwaliks.

Table 2: Recent events of extreme rainfall, major flash floods and cloudbursts in the Himalaya

Type	Date of Occurrence	Affected area
GLOF/flash flood	31 July, 1991	Maling, Himachal Pradesh
Landslide	24 February, 1993	Jhakri, Himachal Pradesh
Flash flood	11 August, 1997	Himachal Pradesh
Cloudburst	9 June, 1997	Chandmari, Sikkim
Extreme rainfall/landslide	11-19 August, 1998	Guptkashi-Rudraprayag, Uttarakhand
Cloudburst/landslide	16 July, 2001	Rudraprayag, Uttarakhand
Cloudburst	31 August, 2001	Tehri, Uttarakhand
Cloudburst	10 August, 2002	Tehri, Uttarakhand
Cloudburst	16 July, 2003	Kullu, Himachal Pradesh
Extreme rainfall	17 July, 2004	Pasighat, Arunachal Pradesh
Cloudburst	6-8 August, 2010	Leh, Ladakh, J&K
Cloudburst	18-19 September, 2010	Almora and Pithoragarh, Uttarakhand

Adapted from: Dubey et al., 2013

SYSTEMS FOR MANAGING THE RISKS FROM CLIMATE EXTREMES AND DISASTERS

Managing climate-related disaster risks is a concern of multiple actors, working across scales from international, national, and sub-national and community levels, and often in partnership, to ultimately help individuals, households, communities, and societies to reduce their risks (Twigg, 2004; Schipper, 2009; Wisner, 2011). Figure 3 encapsulates the discussions to follow on the interface and interaction between different levels of actors, roles, and functions, with the centrality of national organizations and institutions engaging at the international level and creating enabling environments to support actions across the country, supported by scientific information and traditional knowledge.

The complexity and diversity of adaptation to climate change situations implies that there can be no single recommended approach for assessing, planning, and implementing adaptation options (Füssel, 2007; Hammill and Tanner, 2010; Lu, 2011). The Hyogo Framework for Action has encouraged countries to develop and implement a systematic disaster risk management approach, and in some cases has led to strategic shifts in the management of disaster risks, with governments and other actors giving greater attention to disaster risk reduction rather than more reactive measures. However, there is limited evidence and low agreement to suggest improvements in integration between efforts to implement the Hyogo Framework for Action, the United Nations Framework Convention on Climate Change, and broader development and environmental policy frameworks. ICIMOD (International Centre for Integrated Mountain Development) works in partnerships with regional and international organizations to facilitate knowledge exchange and is a platform for regional cooperation.

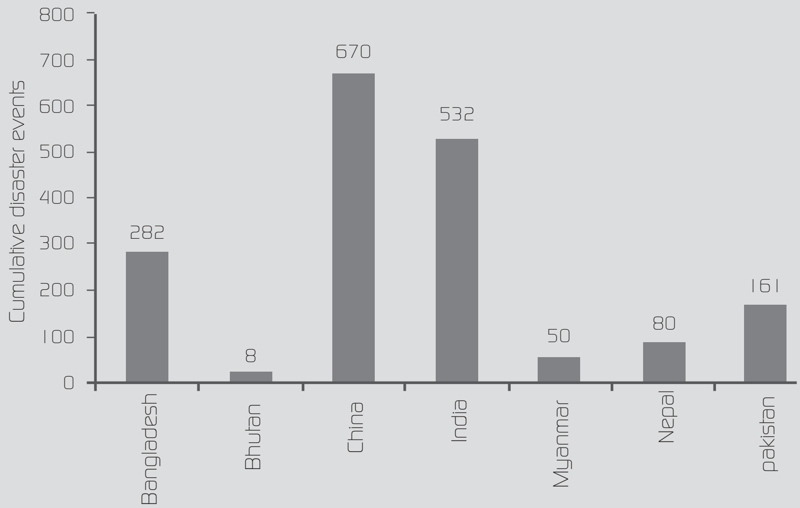


Figure 2 (a): Disaster statistics from 1990-2012 in Hindu Kush Himalayan region
Source: EM-DAT – The OFDA/CRED International Disaster Database

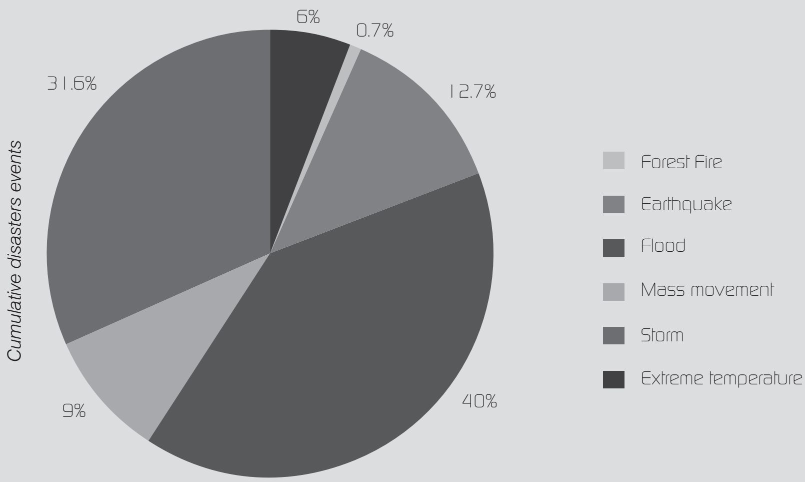


Figure 2(b): Percent of disasters in Hindu Kush Himalayan region from 1990-2012
Source: EM-DAT – The OFDA/CRED International Disaster Database

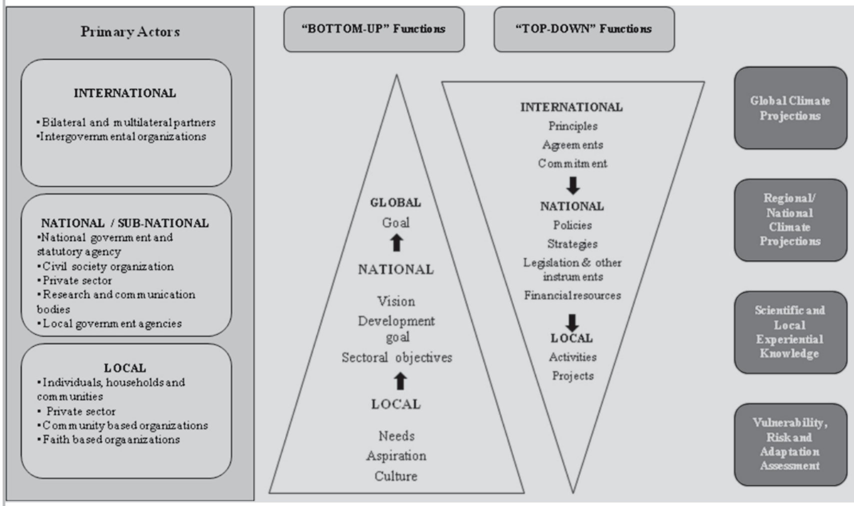


Figure 3: National system of actors and functions for managing disaster risk and adapting to climate change.

There is no separate policy for managing floods or flash floods in India. India's existing water and disaster management policies contain principles and strategies for flood management. At the national level, the first policy statement on flood control was made by the Government of India on 3 September 1954 (Mishra 2002). The central government has created committees, commissions, and task forces from time to time to study flood and erosion in different regions of India (e.g., High Level Committee on Floods, 1957; the Ministers' Committee on Flood Control, 1964; the National Commission on Floods, 1980; the National Commission for Integrated Water Resources Development, 1999; the Taskforce on Flood Management and Erosion Control, 2004) and their recommendations and suggestions are also acknowledged as policy guidelines for flood managers in national and state agencies. National Disaster Management Authority (NDMA) has prepared a set of guidelines for flood risk management to assist the ministries and departments of the national government, the state governments and local governance agencies (panchayat raj institutions and urban local bodies) in preparing flood management plans (NDMA 2008).

The National Disaster Management Authority is the supreme administrative institution for disaster management in India; under it are the various state disaster management authorities and district disaster management authorities. These institutions are governed by the National Disaster Management Act, 2005, and the National Disaster Management Policy, 2009.

RECOMMENDATIONS

There is sheer knowledge gap and lack of understanding on various mountain and climate linked issues, while no adequate shared understanding and action plan are in place for the regional problems as a whole, and no map of potential risks is available. A set of factors can be identified that make efforts to systematically manage current disaster risks more successfully. Systems to manage current disaster risk can be more successful if:

- Risks are recognized as dynamic and are mainstreamed and integrated into development policies, strategies, and actions, and into environmental management.
- Legislation for managing disaster risks is supported by clear regulations that are effectively enforced across scales and complemented by other sectoral development and management legislations where risk considerations are explicitly integrated.
- Disaster risk management functions are coordinated across sectors and scales and led by organizations at the highest political level.
- Risk is quantified and factored into national budgetary processes, and a range of measures including

budgeting for relief expenditure, reserve funds, and other forms of risk financing have been considered or implemented.

- Decisions are informed by comprehensive information about observed changes in weather, climate, vulnerability, exposure, and historic disaster losses, using a diversity of readily available tools and guidelines.
- Early warning systems deliver timely, relevant, and accurate predictions of hazards, and are developed and made operational in partnership with the public and trigger effective response actions.
- Strategies include a combination of hard infrastructure-based options responses and soft solutions such as individual and institutional capacity building and ecosystem-based responses, including conservation measures associated with, for example, forestry, river catchments, coastal wetlands, and biodiversity.

REFERENCES

Bavay, M, Lehning, M, Jonas, T, and Löwe, H 2009, 'Simulations of future snow cover and discharge in Alpine headwater catchments', Hydrological Processes vol. 23 no. 1, pp. 95-108.

Becker, A & Bugman, H 2001, 'Global Change and Mountain Regions', The Mountain Research Initiative, IGBP Report 49.

Böhm, R, Auer, I, Brunetti, M, Maugeri, M, Nanni, T, Schöner, W 2001, 'Regional temperature vari¬ability in the European Alps: 1760-1998 from homogenized instrumental time series', Int. J. Climatol. vol. 21, pp. 1779-1801.

Dubey, C S, Shukla, D P, Ningreichon, A S, Usham, A L 2013, 'Orographic control of the Kedarnath disaster', Current Science. Vol. 105, no. 11-10 Dec. 2013.

Füssel, H 2007, 'Adaptation planning for climate change: Concepts, assessment approaches, and key lessons', Sustainability Science, vol. 2, no. 2, pp. 265-275.

Hammill, A & Tanner, T 2010, 'Climate risk screening and assessment tools: making sense of a crowded field' In: Meeting of the OECD DAC-EPOC Joint Task Team on Climate Change and Development Co-operation, Amsterdam, The Netherlands, 12-13 October 2010.

IPCC, 2007, 'Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change', Solo¬mon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.), Cambridge University Press, Cambridge, U.K. and New York, USA.

IPCC, 2012, Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge/ New York: Cambridge University Press, pp. 582.

Iyngararasan, M, Tianchi, L, Shrestha, S, and Mool, P 2002, 'The challenges of mountain environ¬ments: Water, natural resources, hazards, desertification and the implications of climate change', Thematic Paper E1, Bishkek Global Mountain Summit.

Körner, C & Ohsawa, M 2005, ' Mountain systems', Chapter 24, In Millennium ecosystem assessment, 2005. Current state and trends: Findings of the condition and trends working group (Ecosystems and human well-being, Vol. 1). eds R Hasser, R Scholes, & N Ash, Island Press, Washington, DC.

Lu, X 2011, 'Provision of climate information for adaptation to climate change', Climate Research, vol. 47, pp. 83-94.

Mishra, DK 2008, 'Trapped between the devil and deep waters: The story of Bihar's Kosi River. New Delhi, India: Peoples' Science Institute, Dehradun and South Asia Network on Dams, Rivers and People.

NDMA, 2008, 'National disaster management guidelines: Management of floods', Delhi, India: National Disaster Management Authority, Government of India.

Oerlemans, J 2003, 'Climate sensitivity of glaciers in southern Norway: application of an energy-balance model to Nigardsbreen, Hellstugubreen and Alfotbreen', J. Glaciol, vol. 38, pp. 223-232.

Schipper, L 2009, 'Meeting at the crossroads? Exploring the linkages between climate change adaptation and disaster risk reduction', Climate and Development, vol. 1, pp. 16-30.

Tse-ring, K, Sharma, E, Chettri, N, & Shrestha, A 2010, 'Climate change vulnerability of mountain ecosystems in the Eastern Himalayas: Climate change impact and vulnerability in the Eastern Himalayas' – Synthesis report. Kathmandu: ICIMOD.

Twigg, J 2004, Project planning, In: Disaster Risk Reduction: Mitigation and Preparedness in Development and Emergency Programming. Humanitarian Practice Network, Overseas Development Institute, London, UK, pp. 31-60.

UNEP-WCMC 2002, 'Mountain Watch. Environmental Change & Sustainable Development in Mountains' UNEP-WCMC, Cambridge, UK.

Urrutia, R, Vuille, M, 2009, 'Climate change projections for the tropical Andes using a regional climate model: Temperature and precipitation simulations for the end of the 21st century', J. Geophys. Res., 114, D02108.

Westerling, AL, Hidalgo, HG, Cayan, DR, Swetnam, TW 2006, 'Warming and Earlier Spring In¬creases Western U.S. Forest Wildfire Activity', Science, vol. 313, pp. 940-943.

Wisner, B 2011, 'Are we there yet? Reflections on integrated disaster risk management after ten years', Journal of Integrated Disaster Risk Management, vol. 1, pp. 1-14.

07

FLASH FLOODS

A THREAT FROM GLACIAL LAKES

Sanjay K Jain & A K Lohani**

Flash floods are one of the most devastating natural disaster because of their rapid occurrence, little lead time for warning and tremendous amount of water and debris load transported with high energy. Intense rainfall floods (IRF), glacial lake outburst flood (GLOF), landslide dam outburst flood (LDOF) and flash flood due to rapid melting of snow and ice are the common types of flash floods encountered by the people of the Himalayas.

Since glaciation in the Himalayas is in a period of retreat, glacial lakes are growing and potentially posing a large risk to downstream settlements. As glaciers retreat, formation of glacial lakes takes place behind moraine or ice 'dams'. These 'dams' are generally weak and can breach suddenly, leading to a discharge of huge volume of water and debris. Such outbursts known as Glacial Lake Outburst Flood (GLOF) have the potential of releasing millions of cubic meters of water in a few hours causing catastrophic flooding downstream with serious damage to life and property.

Breaching and the instantaneous discharge of water from glacial lakes can cause flash floods which are big enough to create enormous damage in the downstream areas. Different type of lakes may have different levels of hazard potential. For instance, moraine dammed lakes located at the snout of a glacier have high probability of breaching and thus may have high hazard potential whereas erosion lakes have little chances of breaching and thus have low hazard potential. These floods pose severe geomorphological hazards and can wreak havoc on all manmade structures located along their path. Much of the damage created during GLOF events is associated with large amounts of debris that accompany the floodwaters. GLOF events have resulted in many deaths, as well as the destruction of houses, bridges, forests, and roads. Unrecoverable damage to settlements and farmland can take place at large distances from the outburst source. In most of the events livelihoods are disturbed for long periods.

Studies have shown that the risk of lake development is highest where the glaciers have a low slope angle and a low flow velocity or are stagnant. The potentially dangerous lakes can be identified based on the condition of lakes, dams, associated mother glaciers, and topographic features around the lakes and glaciers. The

* National Institute of Hydrology, Roorkee 247 667 (Uttarakhand)

sanjay.nih@gmail.com

criteria used to identify these lakes are based on field observations, processes and records of past events, geomorphological and geo-technical characteristics of the lake and surroundings, and other physical conditions.

The Kathmandu-based International Centre for Integrated Mountain Development (ICIMOD) reports (ICIMOD, 2010) that 20 glacial lakes in Nepal and 24 in Bhutan have become potentially dangerous as a result of climate change. As per the ICIMOD report, no glacial lake in Uttarakhnad Himalaya is vulnerable; however, there are 14 lakes in Tista river basin and 16 lakes in Himachal Pradesh which are potentially dangerous. A number of studies pertaining to GLOFs have been carried out at the National Institute of Hydrology, Roorkee, for river basins of Tista, Dhauli Ganga (Garhwal Himalaya), Twang (Arunachal Pradesh) and Bhutan. As per these studies, as such no lake is potentially dangerous in Dhauli Ganga whereas some lakes are vulnerable in Bhutan, Tista and Twang basins.

INTRODUCTION

A glacial lake is defined as water mass existing in a sufficient amount and extending with a free surface in, under, beside, and/or in front of a glacier and originating from glacier activities and/or retreating processes of a glacier. The isolated lakes found in the mountains and valleys far from the glaciers may not have a glacial origin. Due to the rapid rate of ice and snow melt, possibly caused by global warming, accumulation of water in these lakes has been increasing rapidly in Himalaya. The isolated lakes above 3,500 msl are considered to be the remnants of the glacial lakes left due to the retreat of the glaciers (Campbell, 2005).

The lakes located at the snout of the glacier are mainly dammed by the lateral terminal or end moraine, where there is high probability of breaching. Such lakes could be dangerous as they may hold a large quantity of water. Breaching and the instantaneous discharge of water from such lakes can cause flash floods enough to create enormous damage in the downstream areas. In order to assess the possible hazards from glacial lakes it is therefore essential to have a systematic inventory of all such lakes formed at the high altitudes. This is feasible by identifying them initially through satellite images (and aerial photographs, if available) and to assess their field setting subsequently. Besides making a temporal inventory, a regular monitoring of these lakes is also required to assess the change in their nature and aerial extent. The lakes are classified into Erosion, Valley trough, Cirque, Blocked, Moraine Dammed (Lateral Moraine and End Moraine Dammed lakes), and Supraglacial lakes (Campbell, 2005).

A Glacial Lake Outburst Flood (GLOF) is created when water dammed by a glacier or a moraine is released. Some of the glacial lakes are unstable and most of them are potentially susceptible to sudden discharge of large volumes of water and debris which causes floods downstream i.e., GLOF.

IDENTIFICATION OF GLACIAL LAKE

For glacial lakes identification from the satellite images, the image should be with minimum snow cover and cloud free. The detection of glacial lakes using multispectral imagery involves discriminating between water and other surface types. Delineating surface water can be achieved using the spectral reflectance differences. Water strongly absorbs in the near- and middle-infrared wavelengths (0.8–2.5μm). Vegetation and soil, in contrast, have higher reflectance in the near- and middle-infrared wavelengths; hence water bodies appear dark compared to their surroundings when using these wavelengths (Pietroniro and Leconte 2000). When applying basic techniques of multispectral classification similar to those used for the normalized difference vegetation index, NDVI (Hardy and Burgan 1999), a normalized difference water index (NDWI) for lake detection is represented as :

$$\text{NDWI} = \frac{\text{Green Band} - \text{NIR Band}}{\text{Green Band} - \text{NIR Band}} \quad (1)$$

As a result of spectral reflection, some self shadowed areas can be misclassified as lakes. These areas can be found with the help of DEM, by overlaying it on NDWI image. After that through manual delineation, lakes can be identified more clearly.

TRIGGERING/BURSTING MECHANISM OF GLOF

Different triggering mechanisms of GLOF events depend on the nature of the damming materials, the position of the lake, the volume of the water, the nature and position of the associated mother glacier, physical and topographical conditions, and other physical conditions of the surroundings (Figure 1).

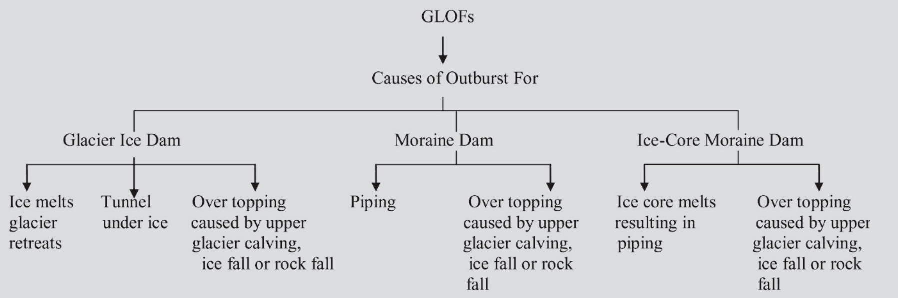


Figure 1. Causes of Glacial Lake Outburst Flood

Interaction between the above processes may strongly increase the risk of hazards. The most significant chain reaction in this context is probably the danger from ice avalanches, debris flows, rockfall or landslides reaching a lake and thus provoking a lake outburst. The mechanism of ice core-dammed and moraine-dammed lakes failure are as under: Ice-core dammed (glacier-dammed) lakes drain mainly in two ways – (i) through or underneath the ice , and (ii) over the ice .

Initiation of opening within or under the ice dam (glacier) occurs in six ways;

1. Floatation of the ice dam (a lake can only be drained sub-glacially if it can lift the damming ice barrier sufficiently for the water to find its way underneath).
2. Pressure deformation (plastic yielding of the ice dam due to a hydrostatic pressure difference between the lake water and the adjacent less dense ice of the dam; outward progression of cracks or crevasses under shear stress due to a combination of glacier flow and high hydrostatic pressure).
3. Melting of a tunnel through or under the ice
4. Drainage associated with tectonic activity
5. Water overflowing the ice dam generally along the lower margin
6. Sub-glacial melting by volcanic heat

The bursting mechanism for ice core-dammed lakes can be highly complex and involve most or some of the above-stated hypothesis. A landslide adjacent to the lake and subsequent partial abrasion on the ice can cause the draining of ice core-moraine-dammed lakes by overtopping as the water flows over, the glacier retreats, and the lake fills rapidly.

A moraine-dammed glacial lake is formed as the glacier recedes from the end moraine in a mountain valley. The moraine acts as an unstable dam to water melting from the glacier. In the last several centuries, many of the present moraine-dammed lakes were created by advances and retreats of valley glaciers. Moraine dams pose hazards because of their composition and location. Moraine dams are usually located downslope from steep crevassed glaciers and vertical rock slopes, and located upslope from steep canyons with easily erodible materials. Overtopping and breaching of the dam by waves generated by avalanches or glacier calving is the most common failure mechanism. The result of the dam failure is catastrophic downstream flooding. Some of the largest downstream flood peaks are produced from moraine-dam failures. Dam characteristics and failure mechanisms affect the flood peak.

CRITERIA FOR IDENTIFICATION OF POTENTIALLY DANGEROUS GLACIAL LAKES

The potentially dangerous lakes can be identified based on the condition of lakes, dams, associated mother glaciers, and topographic features around the lakes and glaciers. The criteria used to identify these lakes are based on field observations, processes and records of past events, geomorphological and geo-technical characteristics of the lake and surroundings, and other physical conditions. Identification was also based on the condition of lakes, dams, associated glaciers, and topographic features around the lakes and glaciers. The major criteria used are as follows (Mool et al. 2001a; Mool et al. 2001b; Mool and Bajracharya 2003; Bhagat et al. 2004; Sah et al. 2005; Roohi et al. 2005): (a) Large lake size and rapid growth in area, (b) Increase in lake water level, (c) Activity of supra-glacial lakes at different times, (d) Position of the lakes in relation to moraines and associated glacier, (e) Dam condition, (f) Glacier condition, and (g) Physical conditions of surroundings.

DAM CONDITION

(a) Narrow crest area, (b) No drainage outflow or outlet not well defined, (c) Steepness of slope of the moraine walls, (d) Existence and stability of ice core and/or permafrost within moraine, (e) Height of moraine, (f) Mass movement, or potential mass movement, on the inner slope and/or outer slope of moraine, (g) Breached and closed in the past and the lake refilled with water, (h) Seepage through the moraine walls.

GLACIER CONDITION

(a) Condition of associated glacier, (b) Hanging glacier in contact with lake, (c) Large glacier area, (d) Rapid glacier retreat, (e) Debris cover on the lower glacier tongue, (f) Gradient of glacier tongue, (g) Presence of crevasses and ponds on glacier surface, (h) Toppling/collapsing of ice from the glacier front, (i) Ice blocks draining to lake.

PHYSICAL CONDITIONS OF SURROUNDINGS

(a) Potential rockfall/slide (mass movement) sites around the lake, (b) Large snow avalanche sites immediately above the lake, (c) Neo-tectonic and earthquake activities around or near the lake, (d) Climatic conditions, especially large inter-annual variations, (e) Very recent moraines of tributary glaciers that were previously part of a former glacier complex, and with multiple lakes that have developed due to glacier retreat, (f) Sudden advance of a glacier towards a lower tributary or main glacier which has a well-developed frontal lake.

Once the dangerous lake is identified, simulation of the potentially dangerous lake using hydro dynamic modeling is to be carried out to know the flood at different locations. In NIH some of the studies on GLOF have been carried out for basins located in Eastern Himalaya and Bhutan Himalaya. In these studies, Lake Inventory has been prepared using satellite data. The area and perimeter etc. of all the lakes located in the basin were computed. Potentially dangerous lake has been identified with the help of remote sensing data. Data required for GLOF studies have been generated in GIS. GLOF simulation for potentially dangerous lake has been carried out using MIKE 11 software. In this way the flood caused due to GLOF can be estimated downstream of lake.

CONCLUSIONS

The Himalayan ice and glaciers are gradually melting due to global temperature rise resulting to significant shrinkage in snow-covered area, retreating of glaciers at rate of tens of meters per year and formation of glacier lakes. These changes are greatly affecting runoff patterns and increasing the risks of GLOF. Therefore, mapping and monitoring of glacial lake, landslide prone area, etc. is urgently required. There is a need to prepare comprehensive reports of the entire Himalayan region for better planning and management of these kinds of disasters. Also there is need for Flood Forecasting and Early Warning System in the Himalayan region so that timely actions can be taken to avoid such types of disasters.

REFERENCES

Bhagat, RM; Kalia, V; Sood, C; Mool, PK; Bajracharya, S (2004) Inventory of glaciers and glacial lakes and the identification of potential glacial lake outburst floods (GLOFs) affected by global warming in the mountains of the Himalayan region: Himachal Pradesh Himalaya, India. Unpublished project report, with database on CD-ROM, prepared for APN and ICIMOD, Kathmandu, by Himachal Pradesh Agricultural University, Palampur, India

Campbell, J. G., 2005, Inventory of Glaciers, Glacial Lakes and the Identification of Potential Glacial Lake Outburst Floods (GLOFs) Affected by Global Warming in the Mountains of India, Pakistan and China/ Tibet Autonomous Region, Technical Report of APN Project 2004-CMY-Campbell, available online at http://ns.apn.gr.jp/en/products/project_reports/2004/Final%20Report/2004_03_CMY_Campbell.pdf.

Hardy, C.C., and Burgan, R.E. 1999. Evaluation of NDVI for monitoring moisture in three vegetation types of the western U.S. Photogrammetric Engineering and Remote Sensing, 65: 603–610.

ICIMOD (2010), Formation of glacial lakes in the Hindu Kush-Himalayas and GLOF risk assessment, J.D. Ives, R.B. Shrestha and P.K. Mool, International Centre for Integrated Mountain Development, Kathmandu, May 2010.

Mool, PK; Bajracharya, SR; Joshi, SP (2001a) Inventory of glaciers, glacial lakes, and glacial lake outburst floods: Monitoring and early warning systems in the Hindu Kush-Himalayan regions - Nepal. Kathmandu: ICIMOD

Mool, PK; Wangda, D; Bajracharya, SR; Kunzang, K; Gurung, DR; Joshi, SP; (2001b) Inventory of glaciers, glacial lakes, and glacial lake outburst floods: Monitoring and early warning systems in the Hindu Kush-Himalayan region – Bhutan. Kathmandu: ICIMOD

Mool, PK; Bajracharya, SR (2003) Inventory of glaciers, glacial lakes and the identification of potential glacial lake outburst floods (GLOFs) affected by global warming in the mountains of Himalayan region: Tista Basin, Sikkim Himalaya, India. Unpublished project report, with database on CD-ROM, prepared for APN and ICIMOD, Kathmandu

Pietroniro, A., and Leconte, R. 2000. A review of Canadian remote sensing applications in hydrology, 1995–1999. Hydrological Processes, 14: 1641–1666.

Roohi, R; Ashraf, R; Naz, R; Hussain, SA; Chaudhry, MH (2005) Inventory of glaciers and glacial lakes outburst floods (GLOFs) affected by global warming in the mountains of Himalayan region, Indus Basin, Pakistan Himalaya. Report prepared for ICIMOD, Kathmandu, Nepal

Sah, M., Philip, G., Mool, P.K., Bajracharya, S., and Shrestha, B., (2005): Inventory of Glaciers and Glacial Lakes and the Identification of Potential Glacial Lake Outburst Floods (GLOFs), Draft Report, Wadia Institute of Himalayan Geology, Dehradun

08

UTTRAKHAND DISASTER JUNE 2013

AN ECOSYSTEM RESPONSE TO THE EXTREME RAINFALLS IN NORTH-WESTERN INDIAN HIMALAYA

*PS Negi**

INTRODUCTION

The Himalayan ecosystem mainly represented by mutual existence of living and non-living components that mainly includes glaciers, snow clad mountains, alpine meadows, quaternary deposits, perennial rivers and luxuriant forests and magnificent wildlife. The Himalaya is a youngest mountain chain in the World and due to the ongoing mountain building process and diversified climate, the ecosystem is highly vulnerable to the natural disasters, especially of earthquakes, floods, droughts, landslides and extreme snow and rainfall events. Himalayan region has a history of natural disasters that affected the ecosystem including inhabitants and natural resources in devastating way. During 16 - 17 June 2013, entire Northern India, especially Uttarakhand State has experienced a unique disaster that was witnessed by extreme climatic condition of heavy and incessant rains. The ecosystem responded to such a climatic abrasion and caused havoc in the upper catchments and downstream flood plain areas of the major rivers, viz., Ganga and Yamuna and their tributaries such as Alaknanda, Bhagirathi, Mandakini and Tons Rivers (Fig. 1). It was perhaps the worst disaster of recent centuries in which more than 5700 pilgrims and inhabitants were presumed dead and several thousand persons rescued. It was reported that about 80 percent road networks either badly damaged or washed away due to landslides and flash flood that resulted disruption to the entire communication system. The horrific extent of the devastation can be visualised by the fact that nearly 240 villages destroyed completely along with loss of 175 bridges, 1307 roads, 4207 houses, 649 cattle sheds and 9519 livestock. In addition to this loss, the fateful event has destroyed the valuable crops, agricultural, forest and horticultural land and various other natural resources that brought the livelihood, tourism and affiliated business to its abysmal and brought further misery to the local people. The backbone of the Himalayan Ecosystem i.e., forest has been destroyed both along the Ganga and Yamuna Valley. The cash crops that serve short term as well as long term source of economy to the inhabitants suffered at the nastiest degree (Uttarakhand State Government 2013).

Wadia Institute of Himalayan Geology,

33 GMS Road, DehraDun (Uttarakhand)

negi_pyarsingh@rediffmail.com

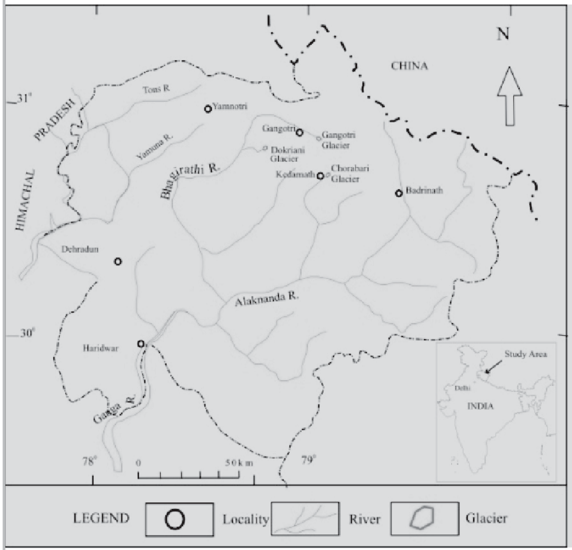


Fig. 1. Study Area and Important Locations

To mitigate the immediate impact of this climatic event in Uttrakhand State, search, rescue and relief operation has been carried out at large scale by the Uttrakhand Government, Indian Army, Indian Air Force, Indian Tibet Border Police (ITBP), National Disaster Response Force, The Sashastra Sena Bal and Non Governmental Organizations and at war footing level. Over 60 helicopters, 8100 army soldiers, 1000 ITBP, and 3000 Border Road Organization personnel along with district administration and local people were actively engaged in the task (Uttarakhand State Government 2013).

METHODOLOGY

The historical as well as current behaviour of the global climate and Indian monsoon system related to the North India was investigated. The facts and data pertaining to climate and monsoon were gathered from the various relevant national and international agencies. The pre disaster information and field investigation details collected earlier were compared to the post disaster scenario. Both, ground investigation and remote sensing data for pre and post events were considered along with the long term meteorological observations. The possible reason for heavy downpour and paramount damage occurred in Kedarnath temple, Rambara Township and neighbourhood areas was analysed in detail and causative factors were identified and discussed. The landscape features such as valley structure, ice-snow regime, glacial debris and Chorabari Lake structure etc, were investigated especially. These features were studied to understand the widespread impact of the disaster in general and devastation of human settlements, crops, natural resources and infrastructure, etc. in particular. The possible role played by Chorabari Lake Outburst and glacial debris in triggering the flash flood was analysed. The growing socio-ecological concern of forest and hydroelectric schemes linkage with the disaster has been discussed duly at local and regional scale. The recent World Bank Report was also taken into consideration during discussion. The holistic and integrated measures are outlined to mitigate such a disaster in future. Suitable recommendations were put forward for resurrection of places and shrines in alpine Himalayan region. The data and information related to the damage and deployment of man power in search, rescue and relief operation to mitigate the disaster was obtained from relevant state and central agencies.

DATA ANALYSIS AND DISCUSSION

The high intensity rainfall, i.e., 115 - 210 to 370 mm/day (Wadia Institute of Himalayan Geology 2013, Forest Research Institute 2013) at different parts of Uttarakhand State has activated glacier debris flow, landslides, washout of Quaternary deposits in the form of flash flood that caused heavy loss of human and animal lives and widespread devastation of natural resources, agricultural fields, human settlements and infrastructure. This type of large scale monsoon related disaster is not recorded in the history of the region and therefore is now coined as "Himalayan tsunami", which resulted to exceptionally higher causalities. Investigation revealed that all the famous shrines of the Uttarakhand State such as Badrinath ($30^0$74'N, $79^0$49'E, altitude 3133 m amsl), Kedarnath ($30^0$11'N, $79^0$04'E, altitude 3584 m amsl), Gangotri ($30^0$58'N, $78^0$55'E, altitude 3140 m amsl), Yamnotri ($31^0$01'N, $76^0$45'E, altitude 3291 m amsl) and Hemkund Shahib (30^0 69' N, 79^0 01' E, altitude 4632 m amsl) are located in the Alpine-Himalayan region and hence worst affected by this fury of the nature that is being considered to be rarest of the rare climatic event.

In fact an extreme climatic event that had occurred in troposphere region due to the interaction of Westerlies and Indian Monsoon is responsible for this natural catastrophe which has been witnessed by pre and post event cloud burst type of incidents at various places of Uttrakhand State, viz., Dhanolti, Rudraprayag, Mana village, Deoprayag, Thalisain, Chaukhutia and Lwar Dova etc. The Tropical Rainfall Data showed early arrival of monsoon with high density over northern India on June 16-17 (Tropical Rainfall Measuring Mission 2013). Over the affected area, the Indian Satellite Image also evidenced post event occurrence of rain clouds that had disturbed the mitigation work at worst extent due to continuous rainfalls (The Indian National Satellite System, ISRO 2013). Generally, sudden and intense precipitation of more than 100 mm/hour has been classified as cloud burst by the meteorologists (Deoja et al 2009). During the process of cloudburst the size of the droplet may rise 4-6 mm that fall at the velocity of 10 m/second (Singh & Sen 1996). The Northwestern Indian Himalaya jointly receives overall rains from Southwest Monsoon and Westerlies that is governed by the global pressure and wind belts. Westerlies or western disturbances are generally strong and high latitudinal winds and blow between 35^0 N - 65^0 N. During summer they move 5^0-10^0 N with northern swing of Sun, while during winter they move 5^0-10^0 S with southern swing of Sun. Therefore, Westerlies remain weak and hardly touches north India during summer monsoon while during winter season they cause considerable rains/snow in the Himalayan region. Historical data by India Meteorological Department (IMD) show that southwest monsoon cloud after reaching to the central India, get weaker and requires additional push of cloud that takes few weeks and ultimately provides successive and periodic precipitation in Himalayan region (Dash et al 2009). But the pace of advance of SW Monsoon this year had been the fastest during the year 1950-2013 that reached Western Himalaya within 15 days after onset took place over Kerala on 1st June (India Meteorological Department 2013). Accidently, during this event, due to some change in global climate pattern that led to development of low pressure area in northern India, Westerlies have acted abnormally and not moved towards higher latitudes and forcefully interacted with strong Southwest Monsoon (SW) wind that was enough to precipitate into heavy downpour and kept raining continuously further for few days in the affected area.

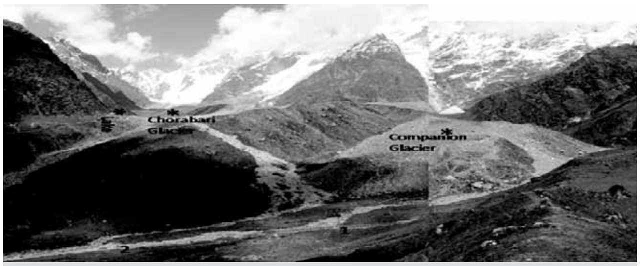


Fig. 2

Fig. 3

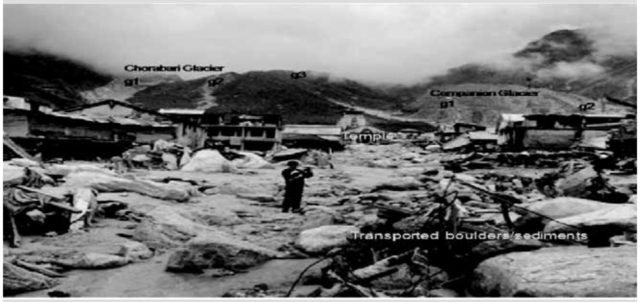


Fig. 4

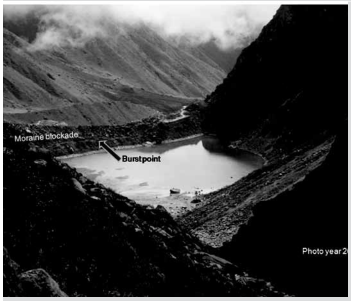


Fig. 5

The deep gullies that shown as G1, G2 and G3 in Fig. 4 (Indian Express 2013) developed due to high energy water erosion and incision of terminal/lateral moraine deposits of both the glaciers, especially of nearly 270 m high terminal moraine hump of Chorabari Glacier (CG) has contributed to the excessive debris flow with fluvial action. The size of boulders and volume of sediment transported along with the flash flood to the vicinity of Kedarnath temple/township, extent of the buildings destroyed and size/number of the toppled boulders on the roof/lintel of the houses are suggestive of episodic heavy water discharge in upstream area including Chorabari Lake (CL) burst that preceded and followed by continuous heavy rains. The CL is located nearly 85 m from the CG Snout at the elevation of 3900 m asl and was measured nearly 300m x 90m x 6-10 m for possible reservoir capacity before the event. This lake was formed due to the stream blocked by lateral moraine of CG and remained as a perennial lake till the year 1962. However, due to the lack of snow-glacier melt water supply from its micro-catchment that was linked to the CG, it became seasonal later on (Fig. 5). Due to the high snowfall on June 15, 2013 at the higher reaches, i.e., above than 5000 m asl and subsequent heavy rain during June 16-17, the CL filled up completely both by rain and snowmelt water. As soon as the accumulated high volume of water in the lake had crossed the storage capacity, the lake busted out along with loose moraine deposits that included big and small boulders, pebbles, sand and clay-silt and triggered flash flood/glacier debris flow downwards and resulted into catastrophe in Rambara and Kedarnath temple/township on June 17 morning that shown in Fig 6 and 7 (Indian Express 2013). Because of the increased velocity and viscosity of flash flood, the capacity to transport sediments and along with heavy boulders increased many times (Sasa 1985). The height of the marks of flood at the buildings suggested that more than 2 m high water column/ channel along with huge sediments/boulders was into action during the devastation at Kedarnath Township. The pre and post event flow of channel is shown in the Fig. 8 (Uttarakhand Tragedy 2013). The same water column/channel onwards multiplied in volume and velocity due to confluence of various other overflowing channels downstream that completely washed away Rambara town along with devastation at Gaurikund. The post event RISAT-1 image of Rambara released by National Remote Sensing Centre also witnessed complete devastation (Fig. 6b) while pre event photograph is indicating dense human settlement (Fig 6a).

Fig. 6a

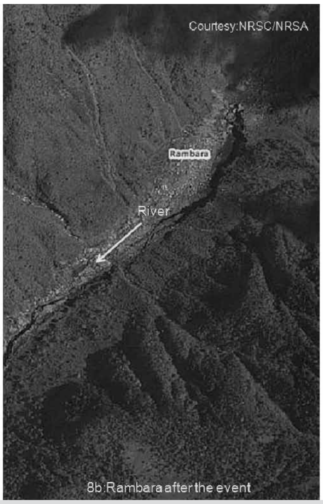


Fig. 6b

Due to the high elevation difference, i.e., 316 m between CL and Kedarnath township and 884 m between CL and Rambara, the velocity of flash flood/debris flow was very high that onwards has contributed to the intensity and extent of devastation. Further, due to the blocked main course of MR at northern point of the Kedarnath township, large volume of rain and snow-glacier melt water discharge gathered from 14.39 km^2 micro-watershed area of both the glaciers during pre and post event also exited from single passage of their micro-watershed outlets that diverted towards the township and amplified the devastation. The ground condition such as presence of sufficient fresh snow in higher reaches, heavy rains wash and active seasonal channels/rivulets all along the valley also contributed to the surplus Mandakini River water discharge. Especially, northern part of the MR Valley that constituted by 6 km wide cirque and includes five peaks ranging from lowest Hanuman Top Peak, i.e., 5320 m asl to the highest Kedarnath Peak,i.e., 6940 m asl,. The rain-snow-glacier melt water discharge from these peaks has contributed effectively to destabilize the hydrological regime of the area and accelerate the flash flood.

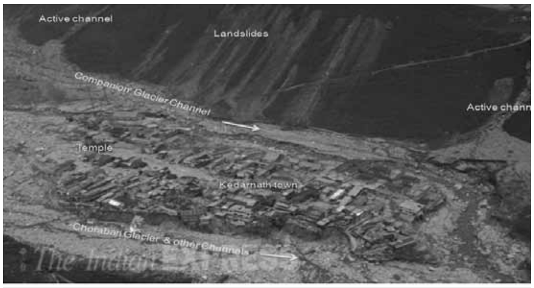


Fig. 7

Fig. 8

As a post event response and comments by some ecologists and environmentalist/naturalist, this climatic event and related large scale devastation had been attributed to the ground conditions such as landuse type, deteriorated forest, hydroelectric schemes and various other development activities, particularly in the Kedarnath Valley. But this climatic event hardly looked to be related to the ground conditions because (i) climatic event occurred high in troposphere, (ii) ground survey conducted during 2012 revealed that worst effected Kedarnath Valley from Gorikund to Kedarnath is having dense natural and well conserved forest being a part of Kedarnath Wildlife Sanctuary. Moreover, recent Forest Survey of India report that is based on the interpretation of IRS P6 LISS-III Satellite Data recorded during October 2008-March 2009, did not witness any decrease in forest cover in the worst affected areas, it rather showed marginal increase with present status of 45.80 % and 26.37% forest cover in Uttarakhand and Himachal Pradesh States respectively (Forest Survey of India 2011). The forest area in the Kedarnath Valley is also being increased annually due to the treeline dynamics towards the higher altitude @ 10m/year as a natural ecosystem process (Negi 2012) and (iii) after events, storage of 449% of seasonal water level in the reservoirs of most of the bigger dams such as Tehri, Kalagarh, Chibro etc., has saved the flash flood disaster in downstream areas. Of course, the loss of human and animal lives and property in down valleys is augmented due to the unscrupulous construction and encroachment along the river beds and flood plain areas.

It is revealed that catastrophic effect of this climatic event was a response of ecosystem and associated landscape to extreme rainfall that caused hydrological imbalance in the valley and adjoining areas. Although Dehra Dun City in outer Himalayan Range had received higher, i.e., 335-370 mm rainfalls than the Kedarnath that had received 115-210 mm in inner Himalayan range, but due to the narrow valley topography, dense settlement and fragile alpine ecosystem more loss of lives and property was reported in Mandakini River micro-watershed. This extreme event is a part of natural phenomenon that occurs rarely and may probably be considered a local effect of global climate change. But the recent scientific report prepared at global level has expressed the concern over Northwestern India to see extremely wet monsoon that have a chance of occurring every hundred years at present, are projected to occur every 10 years at the end of 21st century (World Bank 2013). The recurrence of devastating climatic events after such a short interval will pose real threat to the alpine ecosystem, sustainable development and open challenge to the disaster managers.

CONCLUSION AND RECOMMENDATIONS

It can be concluded that Uttarakhand Monsoon tragedy is an example to suggest that disaster managers are ill-equipped to deal such a catastrophe in high Himalayan Mountains where topography and weather are the most adverse factors, especially during rainy and winter season. However, no country in the World is fully equipped to mitigate such type of extreme climatic events without the loss of lives and property. These unforeseen events only can be mitigated by (i) pre and post event systematic disaster management plan exclusively for Himalayan terrain that requires coordinated efforts of both local as well as central arms of the governments including scientists, engineers, disaster experts, non-Governmental Organization and local people, (ii) network of Automatic Weather Systems and Doppler Radars for effective weather information, especially Early Warning System, (iii) short term as well as long term rescue and rehabilitation schemes to restore traditional socio-economic system of the affected area, (iv) Geological, Geomorphological and Earthquake investigation along with local factors (avalanche, glacial debris flow, river erosion etc.) before the resurrection of places of historical and religious importance that gathers heavy crowd ,(v) bio-engineering techniques along with civil engineering method for restoration of degraded landscapes, (vi) rope ways development to connect two valleys instead of road construction for local transport / tourism promotion and, (vii) preferences to ridge top settlement and disposal of excavated debris by Cut-and-Fill technique/Bio-engineering to minimise environmental deterioration and downstream sediment deposition.

ACKNOWLEDGEMENTS

Director, Wadia Institute of Himalayan Geology (WIHG) is acknowledged for providing basic facilities and encouragement. Gratefulness is also expressed to Dr. G. Philip and Dr. D.P. Dobhal of our institute for critical comments and valuable suggestions.

REFERENCES

Dash, SK, Kulkarni, MA, Mohanty, UC, and Prasad, K. 2009. Changes in the characteristics of rain events in India. Journal of Geophysical Research, 114: 1-12.

Deoja, B, Dhital, M, Thapa, B, and Wanger, A. 1991, Mountain Risks Engineering Handbook, Part 1& 2. ICIMOD, Nepal. pp 875.

Forest Survey of India. 2011. State of Forest Report 2011. DehraDun, Uttrakhand, India.

India Meteorological Department. 2013. Weekly weather report (week ending 19 June), Ministry of Earth Science, Govt. of India (ISSN0971-7595).

Indian Express. 2013 Pictures. Available from: http://www.indianexpress.com/picture-gallery/uttarakhand-floods-leave-trail-of-death-and-destruction-/2958-2.htm.[9 July 2013].

Negi, PS. 2012. Climate Change, Alpine treeline dynamics and associated terminology: focus on northwestern Indian Himalaya. Tropical Ecology, 53(3): 371-74.

Sasa, A. 1985. The mechanism of debris flow: Proceeding of the International Conference of Soil Mechanics. San Francisco, Foundation Engineering. pp 13-16.

Singh, GS and Sen, KK. 1996. Cause and consequences of cloudburst at Kullu District in the Himachal Himalaya. Hima- Paryavaran, 4(1): 13-16.

The Indian National Satellite System, ISRO 2013.

Tropical Rainfall Measuring Mission Satellite Data 2013. June 2013.

Uttarakhand State Government. 2013. Press notes/statements released by Uttarakhand State Government Media Centre, Dehra Dun (India) between 17thJune and 10th July.

Uttarakhand Tragedy Pictures. 2013. Available from:http://www.rediff.com/news/slide-show/slide-show-1-uttarakhand-tragedy-20130620.htm [5 July2013].

Wadia Institute of Himalayan Geology. 2013. Meteorological Record of Centre For Glaciology (Chorabari Glacier Snout Observatory), Dehra Dun, India.

World Bank. 2013. Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience, Washington, DC, Unported License (CC BY-NC-ND 3.0).

09

AN ACCOUNT OF MAJOR NATURAL DISASTERS OCCURRED IN UTTARAKHAND STATE

BEFORE KEDARNATH TRAGEDY

*Ranju J Pandey**

* Uttarakhand Open University, Haldwani, Distt. Nainital-263 139

ranjujpandey@gmail.com, rjpandey@uou.ac.in

INTRODUCTION

People have been living in mountains since ages, and are the homes of many people throughout the world, and India is no exception. Natural disasters have been leaving catastrophic effects upon men throughout the history of the world. India has about 50-60% of its total area vulnerable to seismic activities of varying intensity. The vulnerable areas are located more in the Himalayan region of the country. Uttarakhand (often referred as Indian Central Himalaya) is amongst the most vulnerable regions of the country, and earthquakes and landslides have old history of occurrence in the state of Uttarakhand.

The earthquake and landslides have become common phenomena in the Himalayan region. Seismically active & fragile Himalayan ranges are vulnerable to disasters like earthquakes and landslides which cause excessive injury to the inhabitants. Uttarakhand State is well known for its sensitivity due to geological and geographical reasons. In this area natural hazards cause a great problem and challenge particularly along two prominent geological structures: (1) Main Central Thrust, and (2) Main Boundary Thrust, where typical formation of splitting rock structures occurs with characteristic complex folds & reverse faults, etc., while geological development processes are still in a state of adjustments. The increasing interference caused by man with nature & insensitive developmental practices has heightened its fragility.

When a disaster strikes it not only causes havoc on us but also causes an excessive terror among the community and authorities. Disaster events in the past decades and a long history of destructive force of nature had implied us to think over issues of manageability. It is said that natural hazard may be inevitable but disaster is not inevitable. A disaster can be reduced, mitigate, checked and managed. Most of disasters are caused due to lack of preparedness and awareness. Well preparedness help to mitigate a disaster event.

MAJOR DISASTERS, BEFORE KEDARNATH, IN UTTARAKHAND

For centuries landslides & earthquakes have been part of the mountain's life, and the way in which these landscapes have changed.

A. EARTHQUAKES

Eurasian plate and Indian Plate join each other in Himalaya region hence the Himalaya region is considered as very sensitive instable and fragile. When the two plates strike against each other, immense tension prevails for some time and crosses the limit of elasticity then it results into the process of rupturing. The Central Himalayas came into existence after the southern Peninsula moved northward. The Himalayan sand and stones were converted into the long mountain chain of the Himalayas due to the movement of Indian plate Northwards and its collision with the Asian plate. Since then Himalayas are rising, resulting into several weaknesses in the terrain. The Main Central Thrust (MCT) is a major tectonic feature in higher Uttarakhand Himalayas (Considered to be of Pre-cambrian to Archaean age over the younger sedimentary).

A. 1. UTTARKASHI EARTHQUAKE

On October 20, 1991, at 2.53 am local time, an earthquake occurred in the Garhwal region. Magnitude of this earthquake was assigned as 6.1 by the Indian Meteorological Department (based on body wave data) while USGS assigned a surface wave magnitude of 7.1 at Richter scale. The earthquake caused strong ground shaking in the districts of Uttarakashi, Tehri & Chamoli. This event counts for loss of 768 human lives while 5,066 were injured. Official records state that 3,07,000 persons of 1,294 villages were effected in total. In addition to that this earthquake claimed 3,096 heads of livestock. The roads between Uttarkashi town and Gangotri were disrupted.

The earthquake caused strong ground shaking over a large area with worst effects suffered in Uttarkashi-Bhatwari region and nearly 42,400 houses were damaged. Damage was observed in un-reinforced masonry buildings as well as RC-frame building structures. Good construction performed much better than poor quality construction. The need for RC roof and gable bands in masonry buildings was clearly underlined by the performance of buildings at the ITBP campus at Mahidanda. The failure of Gawana bridge may be a case for revision of the Indian code. (Joshi, 2006). This case showed a poor response mechanism and absence of building codes application.

A.2. CHAMOLI EARTHQUAKE

Nearly after 8 years of Uttarkashi event another major earthquake hit the region on March 29, 1999 at 00:35 am local time. The intensity was recorded 6.8 on the Richter Scale which was more than the previous earthquake events of the country - 1991 (Uttarkashi), 1993 (Latur), & 1997 (Jabalpur). Despite of high intensity of this event, this earthquake counts for lesser loss of human lives (~104 persons) injuries to the people (more then 500 people) but loss to villages was more where about 2000 villages were reported collapsed (partially to complete). Thousands of people were rendered homeless (according to a report appeared in the Internet, the figure was 250,000). The entire district of Chamoli observed a total destruction of about 90% of the buildings.

The Chamoli earthquake told the story of carelessness in pre-disaster care in buildings. Most of the houses were built by traditional way of mud and brittle stones, while the building was required which could withstand the sideways – exerted force. An earthquake exerts the pressure up and down in all direction, but sideways pushing is prominent. Most of the houses in the Uttarakhand are not quake resistant. No efforts for findings and applying cheaper alternatives to strengthen the weak building not resistant to earthquake were made. Preliminary surveys in the area reveled that people were not aware of buildings codes and their implementation. (Joshi, 2006).

B. LANDSLIDES

According to the report of Wadia Institute of Himalayan Geology, around 200 earthquakes have been occurring every year and seismically weak Himalayan region of 0-0.5 Intensity on Richter scale. This facilitates the series of slope failures (Sanwal, 2002).

B.1. MALPA LANDSLIDE

Malpa is a place situated in District Pithoragarh on the famous trek route of Kailash Mansarover (in Tibet) from Indian side. The area around Malpa is considered as landslide prone and habitation is also situated on debris of an old landslide. In the morning (00:30 to 03:00 am) of 18th August a major landslide occurred which claimed human lives of more than two hundred persons including sixty pilgrims from different part of the country, and their support staff those were residing in the camp on the way to Tibet (Table 1). In addition to these enormous loss of cattle and houses occurred, including route camp of the Kumaun Mandal Vikas Nigam (government tour operator for Kailash Mansarovar Yatra). Various details of losses are given by Kumar and Satyal (1999).

Occurrence of Malpa landslide may be attributed on fragility of mountains due to geological condition of the terrain. The fractures and joints had weakened the area for wedge failure. The slope failure was caused due to the presence of main Central Vaikrita Thrust and Main Central Thrust in the south and Tethyan shear zone in the north. Heavy rainfall in the preceding days for a week had created pore water pressure in the fractures, which caused the slide (Sanwal, 2002). Malpa landslide told the story of no disaster planning and absence of hazard zonation.

Table 1. Profile of persons lost in the Malpa tragedy.

No.	Description	Loss of Human Lives
1	Kailash Mansarovar pilgrims of 12th group	60
2	Guides and workers of KMVN	5
3	Coolies of Kailash Pilgrims	59
4	Labour of GREF	9
5	Members of ITBP force	8
6	PWD Labour	4
7	Members of 5 families of Malpa	16
8	Constables of UP Police	3
9	Inhabitants of Gunji and Bundi present in Malpa at the time of the tragedy	32
10	Inhabitants of Dumling village Nepal	12
11	Hermit	1

B.2. OKHIMATH LANDSLIDE

The Okhimath region suffered a devastating landslide spread over about 20 sq. km of the area in valleys of Mandakini River and its tributaries (Madhmaheshwer and Kaliganga), and occurred in two phases. The first event occurred on 11-12 August, 1998 and second occurred after few days (18-19 August) in the form of small to medium debris, and large rock slide.

The loss of agriculture land was about 411.55 ha and 10-90% crop was also damaged. The private property loss was Rs. 14 million and government property loss was about Rs 27 millions. Due to the enormous damage to the PWD road, Rs 4.5 million were needed to reopen them and Rs. 32.2 million were needed for the safer communication on system. A suspension bridge on Madhmaheshwar River at Jugansu was totally washed away. The forest loss was estimated to be of Rs. 4.1.million.

The Okhimath area is seismically very active which lies in Zone V of the seismic map of India. Basic cause of the landslide was the geological structure of the area. Okhimath landslide told the story of lack of policy on disaster management and poor preparedness, as usual.

B.3. VARUNAVAT LANDSLIDE

After the rainy season, a disastrous landslide on the slopes of the Varunavat Parvat struck late in the night on 23 September 2003. This area is an example of debris slide with rockfall and rockslide in the middle of the slope (Gupta and Bisht 2004).

Main reasons of Varunavat landslide were continuously increasing development activities coupled with ill-conceived development of the region, and lack of land use planning and policy in the State. We can say that the natural disasters have increased due to the ecological imbalances. Apparent reason for the losses from landslides is uncontrolled development and construction.

EPILOGUE

Uttarakhand is exposed to multiple natural Hazards. The increasing settlements and more developmental activities provide more opportunities to people live in these mountains but human population is repeatedly threatened locally by natural hazards. Risk of damage to property from natural disasters has been increased due to higher concentration of population. Therefore, the prevention of any further increase in the risk of such damage represents a considerable challenge for the future. The lesson learnt from past disaster events stress upon the utilization of these experiences in future to mitigate the aftermaths of the tragedy in the form of three stages pre-disaster measures, mitigation measures and relief oriented measures.

Possible measures to prevent major losses, and economical and ecological safety to achieve sustainable development of the State must include (i) early warning systems, (ii) spatial planning. (iii) organizational measures to protect structures and to restore normalcy after a disaster.

“Prevention is better than cure”, is the highly attributive saying. Prevention is essential in order to guard life, property & environment and to eliminate or to diminish risk. Identification of risks and vulnerable areas must be followed by adopting appropriate designs for buildings and infrastructure at acceptable cost with facilitation from government, financing agencies and the insurance industry. It is note-worthy that developing a pre- or post-disaster management strategy would be much more economic and beneficial for the mankind rather than providing ad hoc relief after the disaster.

ACKNOWLEDGEMENT

The present work is under guidance of Dr. R.K. Pande, Kumaun University, Nainital, I take this opportunity of expressing my deep gratitude to my family for assistance and moral support.

REFERENCE

Kumar, K and Satyal, GS. 1999. Cost analysis of losses caused by the Malpa landslide in Kumaun Himalaya – A basic framework for risk assessment. Current Science, 77(8): 1023-1028

Gupta, Vikram and Bisht KS. 2004. The 23 September 2003 Varunavat Parvat landslides in Uttarkashi township, Uttaranchal. Current Science, 87(11):1600-1605

Joshi Ranju. 2006. Disaster Mitigation in Uttarakhand with special reference to Earthquake. Ph.D. Thesis. Kumaun University, Nainital

Sanwal, Dhriti. 2002. Disaster Management in Higher Uttaranchal Himalaya with special reference to Malpa, Okhimath, Uttarkashi and Chamoli Disasters. Ph.D. Thesis. Kumoun University, Nainital

10

UTTRAKHAND DISASTER

ONE VIEW OF LIVESTOCK MANAGEMENT DURING AND AFTER TRAGEDY

Ashutosh Joshi & Rakesh S. Negi***

INTRODUCTION

Rural society of Uttarakhand, 'The Land of Gods', is dependent on animal husbandry, an integral part of the agricultural based activities, for their livelihood. Remuneration from livestock is throughout the year in the form of wool, products of milk, poultry, and meat. Animals are also used as a means of transportation, predominantly in the interior of the mountains. In the far flung areas animals like horses, mules, and ponies are a good livelihood option as they are widely used for transportation. Treks of mountain pilgrims provide another livelihood opportunity to a large sector of human population living there or elsewhere by dropping travelers and carrying their luggage who visit these pilgrimages of Kedarnath, Hem Kund Sahib, Gaumukh, Yamunotri, Mansarovar, etc.

The event of June 2013, flashfloods at various places in the higher regions, led to complete destruction of basic infrastructure in that area. Beside the loss of human lives in this catastrophe, a number of horses and other animals died through debris of landslides and were also washed away by the floods. To mitigate the situation the Department of Animal Husbandry, Uttarakhand set up control rooms at various levels (state, region, and district) for flow of information and to monitor various operations.

Five hilly districts were most affected where major destruction of land, buildings, wealth/belongings and animals occurred. Among them, District Rudraprayag was the most affected. All path ways and roads were completely washed away (Fig. 1) in Hemkund (District Chamoli), Gaumukh and Yamunotri (District Uttarkhashi). Major destruction to all forms of life and land was seen in Jaunpur Development Block of District Tehri Garhwal and Dharchula and Munsiyari in District Pithoragarh. Nearly 20,000 heads of animals were reported lost or dead till 20th Aug 2013 (Table 1).

* OIC, Uttarakhand Animal Welfare Board, Dehradun (Uttarakhand)

uttarakhandawb@gmail.com

** Chief Veterinary Officer, Dehradun (Uttarakhand)

drrsnegi@hotmail.com

Fig. 1. Life risk crossings at points of destroyed bridge and path

Unfortunately, at the time of this catastrophic event there was a deficit of requisite manpower in the various institutions of the department due to various reasons (Table 2). In these circumstances to combat the situation, Department of Animal Husbandry started work through a coordinated effort of departmental force (veterinary officers & other staff) with Indian Army & Para Military Forces, NGOs, and other volunteers to protect and rescue animals affected in this event in all the five worst affected districts (Fig. 2). Veterinary staff of neighbouring districts was also deployed on rotational policy to meet the demand of this situation. Additionally, Officers (Veterinary doctors and paramedical staff) of Remount Veterinary Corps of Indian Army constantly provided services at trek route of Hem Kund Sahib (Chamoli district).

Table 1. District wise animal mortality (till 20th Aug 2013) due to catastrophic event of June 2013.

Region	District	Cow	Buffalo	Ox	Horses/ Mules	Sheep/ Goats	Poultry	Others	Total
Kumaun	Nainital	8	7	5	4	12	0	0	36
	US Nagar	0	0	0	0	2	15	0	17
	Almora	9	8	4	2	100	4	0	127
	Bageshwar	8	6	7	4	464	0	1	490
	Pithoragarh	294	62	100	293	4320	554	90	5713
	Champawat	5	7	15	2	5	5261	0	5295
Garhwal	Dehradun	18	57	9	1	13	5	11	114
	Pauri	31	8	11	2	33	185	0	270
	Tehri	232	88	74	12	351	9	39	805
	Chamoli	12	30	24	131	744	0	0	941
	Rudraprayag	24	59	30	1259	3214	300	0	4886
	Uttarkashi	46	37	19	12	1078	0	0	1192
	Haridwar	16	46	16	0	0	0	3	81
	Total	703	415	314	1722	10336	6333	144	19967

Table 2. Status of full time working veterinary staff in worst affected districts.

S. No.	District	Govt. Veterinary Hospitals				Stock Man Centres LEOs are deployed here	
		Veterinary Officers		Veterinary Pharmacists			
		No. of Post Sanctioned	No. of VOs Serving	No. of Post Sanctioned	No. of VPs serving	No. of Post Sanctioned	No. of LEOs serving
1.	Rudraprayag	17	11	13	05	43	21
2.	Chamoli	33	22	22	04	60	27
3.	TehriGarhwal	36	31	32	17	82	57
4.	Uttarkashi	31	22	24	11	58	46
5.	Pithoragarh	37	27	27	16	76	37
	TOTAL	154	113	118	53	319	188

Fig. 2. On site treatment of injured animals after the disaster

ADOPTED MEASURES TO MITIGATE THE DISASTER

1. ESTABLISHING COMMUNICATION WITH AFFECTED PEOPLE TO RESOLVE PROBLEMS

Six Task Forces were constituted by Relief Commissioner (Dr B.V.R.C Purshotam, IAS) in worst affected district of Rudraprayag. Every team (doctors, veterinary doctor, support staff, and staff of revenue department) constituted under leadership of a Magistrate/Officer on Special Duty. These teams visited villages as per pre-defined schedule. This multi tasking team analyzed needs of the villagers on various aspects and done need full at the ground with the help of team members on health and other aspects. Based on discussions in open meetings with villagers, each team leader also prepared a detailed feedback report for various actions required by other agencies.

2. RESCUE OF ANIMALS AND SUPPLY OF CATTLE FEED IN DIFFICULT AREAS

Flood and landslides completely destroyed roads and treks. Indian air force rescued many persons through air operations but stranded people in between places were rescued by constructing temporary bridges, rope ways, rope bridges, etc. by the army and other para-military forces. But these temporary measures were risky and/or un-utilizable to rescue animals from these areas. Risk of temporary bridge may be understood by the loss of one senior officer (Shree Ajay Arora ADM) who slipped from the bridge while on his way to duty at the Kedarnath temple.

Table 3. Animals rescued and stranded till 20th August, 2013.

District	Animals Stranded	Rescued	Still Stranded
Rudraprayag	840	837	03
Chamoli	1320	1320	-

Maximum animals were stranded in the interiors of Kedarnath and Hem Kund Sahib area. Situation was very challenging in that area due to complete destruction of infrastructure to approach various sites. Due to non availability of alternate routes the area remained inaccessible for a month or so. More than 1330 livestock and their owners (333 in number) stuck alone in the Govindghat and Ghangharia for more than a month. Initially livestock feed was sent through helicopters (Table 4). Later on rope trolley was established to cross over areas of difficulty. This mechanism helped to reach livestock feed, donated by various non-governmental agencies, at far places. The animals were rescued when 'Border Road Orgnaization' constructed a bridge on 20th July 2013 on Alaknanda.

Table 4. Animal feed supplied and distributed in most affected district (till 20th August, 2013)

District	Supplied	Distributed	Balance	Remarks
Rudraprayag	110.72	61.75	48.97	4.6 Qtl. air lifted, rest by road
Chamoli	847.88	806.48.	41.40	128.40 Qtl. air lifted, 464.88 Qtl. by rope trolley remaining by road or locally distributed

The difficult period after disaster also witnessed people's response to save the animals. For example, Mrs Gauri Maulekhi (Head, P.F.A, Uttarakhand) played a significant role by supporting government staff through organizing camps, rescuing more than 25 animals, and awarding six relief workers a cash prize of Rs 50,000/-. Various organizations played an imminent role and came forward to help animals and provided animal feed (Table 5).

Table 5. List of some of the organization helped in welfare of animals

Sl No	Organization	Help
1	SPCA, Dehradun	10.00 Quintal Gram for mules
2	Brooks Hospital India	50.00 Quintal Equine Feed for mules
3	Uttarakhand AHD (local purchase)	264.60 Quintal Kutta for mules
4	Various N.G.Os + PFA	76.00 Quintal Kutta for mules
5	R.V.C. (Indian Army)	100.00 Quintal Crushed Jai seeds + 100.00 Quintal Jai Hay
6	AWBI (MoEF, Govt. of India)	60.00 Quintal Equine Feed + 194.80 Quintal Compact Feed Blocks
7	Pet Lovers, Thane	76.00 Quintal
8	Uttarakhand Livestock Dev. Board	As per directions from Uttarakhand government this organization is meeting all the surplus demands of Relief Feed. This board is biggest manufacturer of animal feed from Government Sector in Uttarakhand.

EXAMPLES OF INSPIRATIONS - A pony, stranded midstream in the Alaknanda at Son Prayag, was rescued by the helicopter and was bought to GuptKashi. Later on that pony was named as “Hope”. This rescue operation became a source of inspiration for the worker and volunteers engaged in the rescue mission.

Near Bheem Bali in Kedarnath temple a pony’s hoof got stuck in a steel vessel (*Lota*). The injured animal was discovered after some time by the rescue workers working in Kedarnath area, and was a cause of suffering for the pony. The steel vessel made a deep wound in hoof. The then Minister for Animal Husbandry, Uttarakhand Government ordered a quick treatment for the wounded animal. She was searched, got operated by the veterinary staff, and later on rescued to the KVK near Gupt Kashi. She was named as “*Hope-2”*. She also became a source of inspiration for various workers and agencies involved in such operations. The rescue workers for their outstanding work were awarded by Relief Commissioner.

3. ESTABLISHMENT OF TEMPORARY SHELTERS AND HEALTH CARE

In an inhospitable environment, like situations after catastrophe, various health problems are faced by animals. Further, due to high human causalities in this event many animals were left without their masters and without care for a long time. These animals were rescued by efforts of government and non government organisations. At the places where immediate rescue was not possible temporary sheds by polythene were created either at new places or in partially damaged buildings. Animals brought to these shelters were given medical treatment and owners visited these places to locate their animals. Those who were able to identify their animals were handed over to them. A Permanent shelter and make sahift hospital was established at KVK, Guptkashi was made by orders of the Relief Commissioner to act as a temporary shelter for housing the rescued animals and providing them the necessary treatment and food. More than 1200 animals and 300 owners were brought to safe places after construction of temporary bridge on 20th July, 2013. At present almost all the animals in every district have been treated, and are secure and safe (Table 6).

Table 6. Sick & Injured Animals under treatment (till 20th Aug. 2013)

District	Animals							
	Cow	Buffalo	Ox	Horses/ Mules	Sheep/ Goats	Poultry	Others	Total
US Nagar	0	0	0	1	0	0	0	1
Almora	1	3	0	0	0	0	0	4
Bageshwar	0	0	0	0	11	0	0	11
Pithoragarh	13	7	0	0	110	0	0	130
Champawat	1	0	0	0	0	0	0	1
Pauri	0	6	2	0	0	0	0	8
Chamoli	115	76	0	246	2962	0	0	3399
Rudraprayag	860	554	195	379	1058	0	52	3098
Uttarkashi	0	0	0	1	0	0	0	1
Haridwar	11	0	0	0	0	0	0	11
Total	1001	646	197	627	4141	0	52	6664

4. PROPER DISPOSAL OF DEAD ANIMALS & IMMUNIZATION

Presence of spoiled dead bodies made rescue mission a difficult task. To control the occurrence and spread of epidemics and outbreak of diseases immediate safety measures were taken. While Health Department handled dead bodies of humans, Animal Husbandry Department handled dead bodies of animals.

Uttarakhand State received help from Haryana Government (Animal Husbandry Department) by providing vaccines for animals (H.S. Vaccine -1.0 Lakh dose, and B.Q. Vaccine 0.16 Lakh dose). Indian Immunologicals, Hyderabad also donated 2.0 Lakh doses of F.M.D. Vaccine to the State. More than 3 lakhs of the animals in the state were vaccinated by 20 August 2013. Their district wise details are given in Table 7.

Table 7. District wise details of vaccination given to animals (till 20th august, 2013)

Region	Districts	No. of Control Rooms	No. of Rescue Teams	No. of Animals Vaccinated
Kumaun Region	Nainital	2	8	4018
	US Nagar	1	7	68208
	Almora	1	11	2241
	Bageshwar	1	5	3590
	Pithoragarh	1	27	22617
	Champawat	1	7	1154
Garhwali Region	Dehradun	2	6	48588
	Pauri	2	15	10711
	Tehri	1	9	3545
	Chamoli	1	9	7754
	Rudraprayag	1	3	41238
	Uttarkashi	1	9	30115
	Haridwar	1	6	63063
	Total	16	122	306842

5. FINANCIAL RELIEF AND OPPORTUNITIES CREATION TO CHECK MIGRATION

This disaster was a setback to people having local employment in that area, and engaged in animal based livelihoods. To provide them relief for loss of livelihood source State Government decided to compensate by providing cost of animal as per following norms Rs. 20,000/- (Cow & Buffalo), Rs. 15,000/- (Bullock), Rs. 25,000/- (Equines), Rs. 3,000/- (Sheep & Goat), and Rs. 100/- for Poultry.

Tourism based livelihood options are main activities due to influx of pilgrims in *Char Dham Yatra* but major routes were washed away which will affect tourism activities in those areas, and may influence out migration of people in search of livelihood opportunities at other places. In current situation, re-construction of approach roads may take more time to restore normalcy. In such situation transportation of material is expected with the help of ponies and horses. Hence these animals will play a major role in restoring efforts. Keeping in view this, state has approved a scheme to motivate locals for promoting equine based livelihood. For this purpose Rs 3.0 crores have been marked under National Agricultural Development Programme. This scheme will provide a subsidy of fifty per cent on purchase of a horse/pony.

Keeping in view the difficult circumstances, Central Government also provided funds of Rs 5.46 crore under different centrally sponsored schemes (ESVDH, fodder development, ASCAD, ISS, NPCB, etc.). Indian Animal Welfare Board under Ministry of Environment & Forests, Govt. of India, also helped through granting Rs 8.0 lakh for various logistic supports to the Uttarakhand Government.

11

ALAKNANDA VALLEY, UTTARAKHAND

SOME ASPECTS OF GEOLOGY, ROAD CONSTRUCTION AND LANDSLIDES

Girish Chandra S Negi & Varun Joshi***

* G.B. Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora (Uttarakhand)

negigcs@gmail.com

** University School of Environmental Management, Guru Govind Singh Indraprastha University, New Delhi

INTRODUCTION

The Himalayas have evolved through a series of land formation processes, which have been active over geological time, and current environment is the resultant of these processes. The ongoing tectonic processes in this youngest mountain chain on the earth have made these lofty ranges one of the most fragile ecosystems of the world. The central Himalayan region in India, the source of the holy river Ganga, is seismically and tectonically a very sensitive domain and characterized by deep slopes, hogback topography and due type structural valleys and comprises of very severely deformed rock in the form of nappe sheets, which are prone to landsliding (Valdiya, 1987). There is not a single year when this region does not witness a disaster of one kind or the other that includes: flash floods, landslides, earthquakes and avalanches. Landslides occur due to combination of several terrain parameters like, seismicity, flooding, slope instability, rock type structure etc. coupled with rainfall. Among them, various types of rocks play an important role in the occurrence of landslides. The nature of rocks having fracture, lineation, foliation, joint, etc., provide resistance to stability and instability to landslides. The faulted belts and the areas suffering from environmental degradation are known to face problems of accelerated soil erosion and mass wasting. The severity of these events is further aggravated due to anthropogenic activities, such as vegetation removal from forests, construction of roads, unplanned urbanization, harnessing river water for power generation etc. (Bansal and Mathur, 1976). The continued pressure on vegetation for fuel, fodder, timber and other resources has added to the fragility of hill slopes leading to greater magnitude of soil erosion and landslides (Agrawal et al. 1997; Sastry et al. 1981), leading to their slow recovery (Pandey and Singh, 1985). It has been estimated that more than 50% landsides are due to road construction alone and generate debris to the tune of 550 m^3/km/yr (Valdiya, 1987), and each km. of road cutting displace 40-80,000 m^3 debris and generate unstable cut slopes (Gupta, 1990). In Kumaun lesser Himalaya (a part of the central Himalaya), Joshi & Goel (1988) found that anthropogenic (12%) and technogenic (50%) landslides together account for 62% of total landslides. Most of the landslides found in the settlement areas (3.2 landslides /km^2) were of shallow depth and the presence of water play a major role in triggering them. The morphometric parameters of landslides (e.g., displacement index) being the least (16.8%), suggest that these landslides are unstable and likely to be reactivated.

Among the processes that continuously modify mountainscapes, land - sliding stands out a major actor because of its severe and long-lasting negative effects on natural and human-dominated ecosystems (Restrepo et al. 2008). There is mounting evidence that the frequency and magnitude of landsliding is changing in many parts of the world in response to climate change (Lateltin et al. 1997). This is not surprising, given that precipitation is one of the two external triggering mechanisms—the other being seismic activity—involved in the formation of landslides. Evidence from the past clearly indicates that cycles of elevated landslide activity have been followed by cycles of low activity, and that these are correlated with climate fluctuations over a variety of timescales (Gonzalez-Diez et al., 1996; Thomas, 2000). In addition, the annual rainfall pattern and long term changes in precipitation also affects the landslide occurrence. The amount, type and annual distribution of rainfall also influence the other factors that control landslides, such as vegetation, soil and steepness of slopes (Valdiya 1987; Bhandari & Gupta, 1985).

CASE STUDY OF ALAKNANDA VALLEY

Alaknanda is a major tributary of Ganga river that has its origin in Uttarakhand State in India. In its course of about 142 km, it drains approximately 11000 km^2 area. The Catchments of Alaknanda river extend between 29°58'34" to 31°04'20"N and 78 °34'31" to 80 °17'54" E. The Alaknanda basin comprises a wide variety of landforms developed under glacial, periglacial, glacio-fluvial and fluvial processes. It presents a highly diversified ecological region that covers a wide range of climatic conditions ranging from subtropical, temperate, sub alpine, alpine and permanent snow bound area, under altitudinal variation of 642-7817 m. The altitudinal zone (1000-2000 m asl.) has been facing degradation of ecosystem due to increasing population pressure and developmental activities (Singh and Singh, 1992). The increasing population and its developmental needs in conjunction with vagaries of climatic adversities and the hard and soft lithology and tectonic set up play an important role and lead to instability of hill slopes in this region, thus resulting in accelerated rates of soil erosion and mass wasting processes (Joshi and Goel, 1988).

In Alaknanda valley (that also includes Mandakini valley) landslides are one of the major natural calamities that occur in disastrous form in this region every year. Landslides were frequently observed in phyllite rocks, which are highly jointed fractured, foliation and also have seepage. Quartizite rocks having (deep towards roadside) more than 45^0 deep, highly jointed and 3-9 sets fractured are very common in landslide areas. Landslides were also observed along the meandering side of river due to toe erosion. Presence of gouges and mylonites in the rock along the fault and thrust also may be the probable site for landslides are mainly of debris slide type in the Alaknanda valley area and most of the landslides are due to road construction. Due to high channel gradient slope failure is common along the river Alaknanda and its tributaries. The failure of slopes causes huge landslides, many times blocking the river and causes flash floods in the down stream. Available information suggests that the Alaknanda river valley has been temporally blocked many times due to the activation of landslides resulting in the flash floods (Joshi et al. 2003). Geological factors are mainly been responsible, despite other factors, for the development of various types of landslides.

In the Alaknanada valley, to understand the relationship of landslides with geomorphological features, slope and aspects of the hills, land use and land cover and road construction, landslides were mapped by Murthy et al. (2004) using IRS LISS-III / PAN data of 1999 in conjunction with field data and collateral information. As on 1999 satellite data there were 791 landslides in the total study area. The area occupied by landslides (both old as well as active) accounted for 29.5 km^2 in 1986, which has increased to 37.3 km^2 in 1995, an increase of 7.8 km^2. This is due to the fact that there were already old landslides that got activated (2.2 km^2) and slope failures in other land cover types for various reasons, which are natural as well as anthropogenic (Murthy et al. 2004). They found that the geomorphology of the Alaknanda valley with various geomorphological classes is related to the frequency of landslides, which is highest in the denudational hills (447) and consequently the landslide hazard factor (LHF) is also highest (7.9115). Accordingly, the highest incidence of landslide per km^2 is recorded for river terraces (0.672), which correspond with the influence of toe erosion experienced in such areas followed by dissected hills and terraces. Slope was found another very important factor in determining the landslide occurrence. Substrate rock characteristics determine the slope stability relationship between the slope, lithology and the frequency of landslides. In the Alaknanda valley no landslides occurred in the slopes from <1.23° to 5.71°. The moderately low slopes (>5.71° - 25°) had the frequency of 55 landslides, followed by moderate slopes (221) and moderately high slopes (215). The maximum landslide frequency was recorded in the high slopes (290). But in the very high slopes (75-90°) the frequency was very low (10) as this area was absolutely devoid of any human interference. Aspect was found another important factor along with slope that governs the slope stability. In this study the west and south-west aspects showed first highest and second highest area-normalized incidence of landslides 0.0829 and 0.0777, as the aspect to some extent decides the amount of rainfall received by an area in a mountainous terrain, coupled with surface drainage it may influence the occurrence of landslides differently with different aspects. The road network was also found an anthropogenic triggering factor of the landslides. It was found that as one moves away from the road the susceptibility to landslides decreases. The landslide incidence per Km^2 was found highest (0.4838) within the 100m buffer of road and this value was 0.0366 within the >600 m buffer.

Integration of various spatial layers considered for landslide hazard zonation mapping (Murthy et al. 2004) it was found that out of the total study area (11,863 km^2), 30% area falls under moderate hazard zone, followed by low (22%), very low (20%), very high (18%) and high (11%) hazard zones. It was calculated that out of 2433 human settlements (revenue villages) in the Alaknanda valley, 1626 fall in very high landslide hazard zone, followed by high (448 villages), moderate (342 villages), 10 in low and 7 in very low hazard zone. This indicates that alarming situation of the risk faced by the village people in the Alaknanda valley. In the areas covered by Oak and Pine forests lithological units such as, Mica rich quartzite, Mica-schist, Slate-phyllite, Phyllite, and Schistose grit were prevalent among the others about 26 lithological units found in the Alaknanda valley. As indicated earlier the forests are mostly prevalent below 2000 m, which is the most populated belt of this region. In the Alaknanda valley lithological units such as quartzite (that occupy about 20% of the Alaknanda valley) recorded the highest LHF (7.679) and landslide incidence (0.11 per km^2). The high values were also computed for Phyllite (LHF= 5.699 and landslide incidence 0.376 per km^2) and Augen gneiss and mica schist (LHF= 4.64 and landslide incidence 0.128 per km^2) that occupy about 5% and 10% area of the Alaknanada valley, respectively. These estimates are only indicative and needs further ground level information to arrive at definitive conclusion before taking suitable measures to reduce landslide hazards. However, it can be emphasized that similar studies in collaboration with specialized Institutions should be carried out in other parts of the region (e.g., Yamuna and Bhagirathi river valleys of Uttarakhand) in the wake of recent Kedarnath tragedy to understand the relationship between geology, landslides and developmental activities (primarily road construction) and come up with corrective measures to reduce loss to people and property.

LANDSLIDE STABILIZATION

Measures for landslide and slope stabilization often consist of a rock blanket, gabions, concrete walls, or other conventional erosion control and slope stability systems. These traditional measures are increasingly being substituted by vegetated structures that are environmentally friendlier, also known as biotechnical slope protection (Gray and Sotir, 1996). This method utilizes mechanical elements (structures) in combination with biological elements (plants) to prevent and arrest slope failures and erosion (Gray and Leiser, 1982). Common biotechnical systems are geonets anchored by soil nails that hold in place soil seeded with grass. Also common are geocells with seeded soils in the interstices. Biotechnical slope-protection systems blend into the landscape emphasize the use of natural, locally available materials, such as soil, rock, timber, and vegetation. Soil bioengineering stabilization, on the other hand, can be regarded as a specialized subset of biotechnical stabilization in which live plant parts, i.e., roots, stems and branches, serve as the main structural/mechanical elements in the slope protection system (Gray and Sotir, 1996). As bioengineered structures that utilize tree species become older, they have the added benefit that they become more stable, and eventually assist in the natural succession and long-term colonization of forest species. In most cases, native grasses, shrubs, and trees are used as the vegetation in bioengineering stabilization. Willow has been very successful in many parts of the world. In tropical and subtropical areas the use of *Vetiver* grass hedgerows (VGHR) for stabilization has become very popular because of the fast growth and deep root penetration of this grass (Yoon, 1994). However, if exotic species of plants or trees are introduced, there is a real danger that they will conflict with native plant life (Brown, 1994). Thus the bioengineering approach to slope stabilization requires cooperation of geoscience and plant-science disciplines working in parallel and in unison.

In Uttarakhand certain attempts have been made in the direction of landslide and slope stabilization. Himalayan Environmental Studies and Conservation Organization (HESCO), Dehradun found following plants useful for restoration of landslide sites in various localities of Uttarakhand: (a) Tree Species (*Wendlendia excelsa* and *Erythrina suberosa;* (b) Shrubs *(Vitex negundo, Agave cantula* and *Adhatoda vasica*); and (c) Grasses: (*Veteveria zizaniodes, Saccharum spontaneum, Cymbopogon flurosence, Eulaliopsis binata, Pogonanthrum* spp. and *Eriophorum comosum*). HESCO promoted indigenous grasses in the preliminary treatment of the landslides along with construction of check-dams where gradient is higher and deep gully formation is found to prevent excessive soil run-off. GBPIHED took up several landslide sites in Kumaun hills for their stabilization and treated them with bioengineering measures (Agrawal & Rikhari, 1998).

ACKNOWLEDGEMENT

This study draws heavily from a joint project between Space Application Centre (SAC), Ahmedabad and GBPIHED, Almora (Uttarakhand), to which the authors were the members of the team of Investigators. Therefore acknowledgement is due to the team members from SAC, Ahmedabad, funding from Ministry of Environment & Forests (Govt. of India), and Director, GBPIHED for facilities provided to prepare this manuscript.

REFERENCES

Agrawal, D.K. & H.C. Rikhari, 1998. Mountain risk engineering: Low cost biological and physical measures for control of small hill slope instabilities. Pp. 119-144. In: Research for Mountain Development: Some Initiatives and Accomplishments. Gyanodaya Prakashan, Nainital.

Agrawal, D.K., A.P. Krishna, V. Joshi, K. Kumar & L.M.S. Palni. 1997. (Eds.) Perspectives of the Mountain Risk engineering in the Himalayan Region. Gyanodaya Prakashan, Naini Tal, India. 244 p.

Bansal, R.C. & H.N. Mathur, 1976. Landslides: The nightmares of hill roads. Soil Conservation Digest 4 (1): 36-37.

Bhandari, R.K. & C. Gupta, 1985. Problems of landslides in the Himalaya and future directions. In: Singh, J.S. (ed.), Environmental Regeneration in Himalaya: Concepts and Strategies. Central Himalayan Environment Association, Naini Tal, India. Pp. 17-37.

Brown, N. 1994. Rehabilitation of natural forests un the humid tropics. In: Barker, D.H. (ed.), Vegetation and Slopes, Proc., Int'l. conf. at Univ. Museum, Oxford, 29-30 Sept. 1994, Thomas Telford, London, 1995, pp. 152-160.

Restrepo, C., L.R. Walker, A.B. Shiels, R. Bussmann, L. Claessens, S. Fisch, P. Lozano, G.C.S. Negi, L. Paolini, G. Poveda, C. Ramos-Scharron, M. Richter and E. Velazquez, 2008. Landsliding and Its Multiscale Influence on Mountainscapes. Bioscience 59 (8): 685-698.

Gupta, K.M.1990. Himalaya: Man and nature. Lancers Books, New Delhi. 277 p.

Gonzalez-Diez AG, Salas L, de Teran JRD, Cendreno A. 1996. Late Quaternary climate changes and mass movement frequency and magnitude in the Cantabrian region, Spain. Geomorphology 15: 291–309.

Gray, D.H. and Sotir, R.B. 1996. Biotechnical and Soil Bioengineering Slope Stabilization – A Practical Guide for Erosion Control, John Wiley & Sons, Inc., New York, 378 pp.

Gray, D.H. and Leiser, A.T. 1982. Biotechnical Slope Protection and Erosion Control, Van Nostrand Reinhold Company, New York, 271 pp.

Joshi, M. & O.P. Goel. 1988. Geological and geomorphological investigations of landslides in the Kumaun lesser Himalaya: Its causes and preventions. Technical Report submitted to Ministry of Environment & Forests, Govt. of India, New Delhi. 262 p.

Joshi, V., T.V.R. Murthy, A.S. Arya, A. Narayana, A.K. Naithani & J.K. Garg. 2003. Landslide hazard zonation of Dharasu-Tehri-Ghansali area of Garhwal Himalaya, India, using remote sensing and GIS techniques. Journal of Nepal Geological Society 28: 85-94.

Kumar, K., D.S. Rawat, G.C.S. Negi, P.K. Samal, V. Joshi, G.S. Satyal, A.S. Mehta & L.M.S. Palni, 2002. Village Environment Action Plan: A Community Manual. GBPIHED, Kosi-Katarmal, Almora.

Lateltin O, Beer C, Raetzo H, Caron C. 1997. Landslides in flysch terranes of Switzerland: Causal factors and climate change. Eclogae Geologicae Helvetiae 90: 401–406.

Murthy, T.V.S., M.M. Kimothi, T.S. Singh, V. Joshi, G.C.S. Negi, R.K. Maikhuri & J.K. Garg. 2004. Himalayan Ecosystem: Alaknanda Valley (Vegetation dynamics, landslide hazard assessment, fodder and fuelwood utilization). Technical Report of a joint project between Space Application Centre, Ahmedabad and G.B. Pant Institute of Himalayan Environment & Development, Almora (Uttarakhand). 232 p.

Pandey, A.N. & J.S. Singh, 1985. Mechanism of ecosystem recovery: A case study from Kumaun Himalaya. Reclamation & Revegetation Research 3: 271-292.

Sastry, G., H.N. Mathur & K.G. Tejwani. 1981. Landslide control in north-western outer Himalayas- A case study. Bulletin No. R8/D6. Central Soil and Water Conservation Research & training Institute, Dehra Dun, India.

Singh, J.S. & S.P. Singh, 1992. Forests of Himalaya: Structure, Functioning and Impact of Man. Gyanodaya Prakashan, Naini Tal. 294 p.

Thomas MF. 2000. Late Quaternary environmental changes and the alluvial record in humid tropical environments. Quaternary International 72:23–36.

Valdiya, K.S. 1987. Environmental Geology- Indian Context. Tata-McGraw Hill, New Delhi, India.

Yoon, P.K., 1994. Important biological considerations in use of Vetiver grass hedgerows (VGHR) for slope protection and stabilisation," in Vegetation and Slopes – Stabilisation, Protection and Ecology, Proc., int'l. conf., Univ. Museum, Oxford, 29-30 Sept. 1994, Thomas Telford, London, 1995a, pp. 212-221.

12

GEOLOGICAL INVESTIGATION OF NAINITAL BYPASS:

A SPECIAL EMPHASIS ON SLOPE STABILITY ANALYSIS, KUMAUN LESSER HIMALAYA

M.K. Puniya, Priya Joshi** & P.D. Pant***

INTRODUCTION

Slope failures by various modes are common phenomenon in hilly regions. In the southern margin of Kumaun Sub Himalaya the frequency of landslides is high due to structural and neotectonic activity along the MBT zone (Valdiya and Bartariya, 1989, Valdiya, 2001, 2003). In recent past Malpa rock fall in 1998 (Pant and Luirei, 1999), Okhimath landslide along Mandakini valley in 1998 (Sah and Bisht, 1998), Amiya landslide of southern Kumaun (Pant and Luirei, 2005) has devastatingly affected Uttarakhand. To prevent or reduce the landslide phenomena, stability analysis is worldwide accepted. However, in Nainital hills, landslide hazard maps and investigation have been carried out by Hukku et al. (1974, 1977), Pande (1974), Sharma (1981) and Anbalagan et al., (1996).

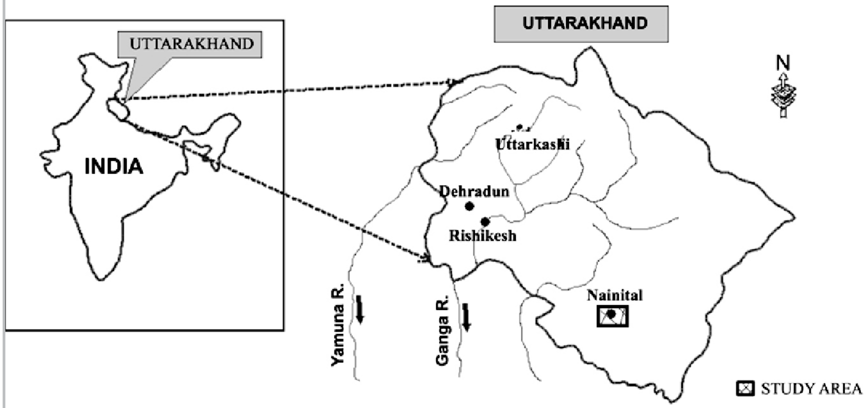
The present study area stretching east from 79°26'59 E- 29 °21'36 N to 79 °25'56.7 E - 29°22'38 N lies SW of Nainital (below Fig.1- Location Map). Each monsoon trigger slopes instability, as more than 60% of the slope along the road side is made up of colluvial sediments and the rocks exposed are highly crushed and sheared. So present attempt is based on the planar and wedge failure analysis as well as engineering geological mapping of the proposed study area. Finally factor of safety has been calculated using techniques proposed by Hock and Bray (1981) and rock mass classified into various division with the help of Rock Mass Rating (RMR) after Bieniawski (1989) and Singh and Goel (1999).

* Department of Geology,
Kurukshetra University,
Kurukshetra (Haryana)
136 119

@gmail.com

** Department of Geology,
Centre of Advanced Study,
Kumaun University Nainital
(Uttarakhand) 263 002

drpdpant@gmail.com



GEOLOGY AND TECTONIC SETUP

The geological setting of this part of Kumaun Himalaya has been studied in details by Valdiya (1979, 1980b, 1988), Pande (1974) and Pal and Merh (1974). The general geology of the study area is Slates of Manora Member, Purple Shale of Hanumangarhi Member, Dolomite of Pashandevi Member, and Rthymites of Barapathar Member (Table I). In some places Pyriteous Slates of Kailakhan member are also exposed. These lithologies are correlatable to Krol and Infra Krol formations (Valdiya, 1980).

In the study area, the active tectonic movements are controlled by Main Boundary Thrust (MBT) which is characterized by imbricating thrusts and faults (Valdiya et al, 1984), as the area lie very close to MBT. Other major faults in the surrounding areas are Lake Fault (Middlemiss, 1890) it has dextrally offset the MBT near Beluwakhan, west of Jeolikot (Valdiya et al., 1984), Kuriya Fault (Hukku et al., 1974; Pande, 1974; Sharma, 1981).

Table 1. Lithotectonic succession of the study area (Valdiya, 1988)

	Shiwalik	
	……………………….MBT……………………….	
	Tal Fm	NaraiNagar Member
		Giwalikhet Member
Mussoorie Group	Krol Fm	Sherwood Member (Krol E)
		Bist College Member
		Pashandevi Member (Krol D)
		Barapathar Member (Krol C)
		Hanumangarhi Member (Krol B)
		Manora Member (Krol A)
	Blaini Fm	Kailakhan Slate (Infra Krol)
		Pangot Member (Blaini)
	Jaunsar Group	

METHODOLOGY

Geological data were obtained through engineering geological mapping of the area on 1:20600 scales. All the discontinuities data has been collected i.e., bedding / foliation, joints, minor faults, shear zones, Uniaxial compressive strength (UCS), Rock Quality Designation (RQD), spacing of discontinuities, weathering condition, persistence, aperture, termination of joints, ground water data, slope angle, overburden thickness, road alignment and precipitation data (from 2007 to July, 2010). Based on the field data RMR basic classification has been carried out for each out crop present along the Nainital bypass (Balidyakhan-Khurpatal). On the basis of structural analysis, locations which are prone to wedge and planer failure are identified and finally factor of safety has been calculated for every outcrop by Hock and Bray (1981). Beside this, wedge models were prepared by rock science software SWEDGE, and various engineering factors were calculated for some selected locations. Hence, the factor of safety is calculated according to Hoek and Bray (1981).

Factor of Safety for wedge failure can be given by-

$$F = \sin\beta.\ \tan\o \ \frac{1}{\sin 1/2\ \xi.\ \tan\psi}$$

Where β =angle between line of intersection of discontinuity and the bisector, $\o$ frictional angle, ξ wedge angle, ψ plunge of line of intersection of two discontinuities.
Factor of Safety for plane failure (Markland, 1972) can be calculated by-

$$F = [cA + (W.\cos\psi - U - V\sin\psi)\tan\o\,] \,/\, W.\sin\psi + V.\cos\psi$$

Where c=Cohesion, W= Weight of sliding block, U=Uplift force due to water pressure on the sliding surface, V= Force due to water pressure in the tension crack, ψ = Dip of failure plane, $\o$ =Frictional Angle of slope material.

Geological cross sections were made for every location where outcrops are exposed and the main joint which effect stability of the slope is observed with respect to road alignment.

OBSERVATIONS

At various locations on the Nainital bypass, wherever outcrop was exposed data has been collected (Fig. 2). Starting from location PR-1 till location PR-55 the lithology being the slate of Manora Member and shale of Hanumangarhi Member. Predominantly slates are found but somewhere shales are also observed. The strength of these slates and shale ranges from weak to very weak. From location PR 61 to PR71 the lithology is dolomite; compact, hard in strength. In locations PS1, PS40 and PS41 the lithology is alternate shale with marlite and some layers of sand, generally known as rhythmites of Barapathar Member. In-between outcrops and slope wash materials were also observed.

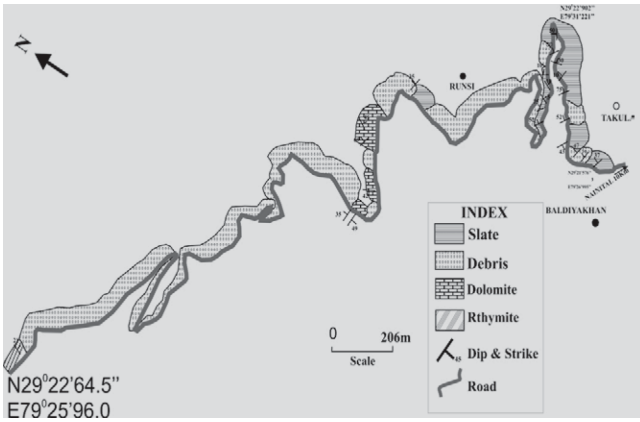


Fig. 2. Traverse map of the study area along Nainital bypass showing composition on slope forming material various and localities from where the data has been collected.

Approximate by 2-4 Km road is covered with debris. All along the road ground water seepage is observed along the small scale fault plane and shear zone. Besides mega scopical structures (Figs. 3 a, b) microstructures are also identified (Figs. 3 c,d). Field study and lab analysis shows that area has suffered very high deformation conditions. All the discontinuity data is collected and its shows that 3-4 joint sets are present in the area. At some locations, rocks are in highly crushed condition. Collected data is plotted on the map and litho logical and structural map prepared (Fig.2). On the basis of all these criteria, slope stability is interpreted. As stated above approximately 60% area is covered by slope wash material that is highly permeable and a major threat for the stability of the road. Debris deposit flow downwards during rainy season (Fig. 3 e, f) and results into debris flow and slumping problem for the road.

RESULTS AND DISCUSSION

Stability of slope after excavation is important concern in the field of engineering geosciences. So keeping this thing in our mind present study is confined towards the under construction Nainital Bypass road. The safety factor calculated in the present investigation has been summarized in Table 3. Taking frictional angle 25^{o} for slate and 27^{0} for dolomite and cohesion 40 KMp calculations weredone (Waltham, 2001). For calculation, density taken for Dolomite is 2750 – 2800kg/m^3 and for Slate 2720 – 2840kg/m^3 (after Lama & Vutukuri, 1978).

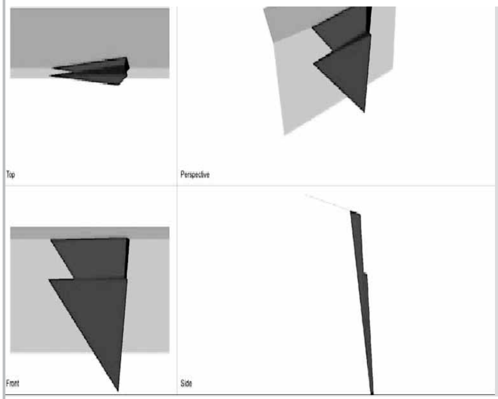


Fig. 4. Stereo plot of discontinuities showing planer failure at PR 06.

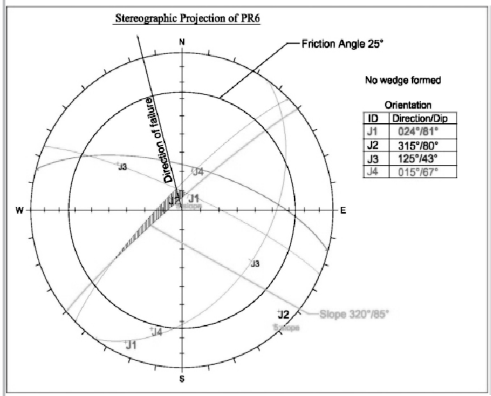


Fig. 5. Planar Failure condition of PR 06 site.

In this study total 23 sites have been investigated for wedge and planar failure. Out of these sites 5 come under the planar and 8 sites show wedge failure condition. It has been observed that in most of the planar failure condition J2 (discontinuity) is responsible. Study area is highly deformed, so J2 joint frequently changing its orientation i.e. NE, NW and SW direction that's makes the planar failure condition with slope direction (Figs. 4 and 5). Figures 4 and 6 are showing planar failure condition in which both slope and J2 are dipping towards NW and making an unstable condition, its deterministic analysis is presenting in Table 2 and wedge model in Fig. 5.

Figure 3.

(a) Normal faulting in Hanumangarhi slate,

(b) Reverse faulting in Manora slate

(c) Rhythmites of Barapathar member,

(d) Cheveron folding in Manora slate

(e) Damage to road during rainfall, and

(f) Before rainfall

Table 2. Deterministic analysis of wedge failures in Nainital bypass.

Deterministic Analysis		
Factor of Safety	0.1142	
Line of Intersection	Plunge	78°
	Trend	345°
Wedge Data	Volume	19m3
	Weight	53.51 Tones
	Driving Force	52.44 Tones
	Resisting Force	5.99 Tones

Similarly wedge failure condition is analyzed and found that J2 and J3 discontinuities are responsible at most of the places (Fig. 4 and 6). Stereo plots (Figs. 4 and 6) are showing two wedge J1 & J2 joints forming stable condition but it can fail in future. Second wedge is unstable and presenting threat for the road. In above condition, slope face inclined towards West and the intersection of discontinuity (failure direction) is towards the SW with plunge 630. Besides these studies, RMR study is showing Lower III class (Bieniawski, 1984) condition at every present out crop along the road and Rock Quality Designation (RQD) is showing very poor rock condition (Fig. 7). All the geotechnical parameters are showing unfavorable condition for the slope stability. All the results are presented in Table 3.

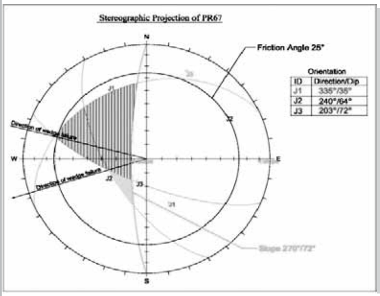


Fig. 6. Wedge failure analysis of PR 67 site.

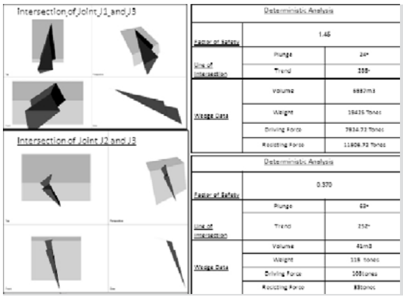


Fig. 7. Deterministic analysis of rocky slopes of the study area.

Table 3: Results of wedge failure analysis for various outcrops studied along Nainital bypass.

Location	Rock Type	Slope Angle (Degree)	RQD	RMR	Type of Failure	Responsible discontinuity	Factor of Safety
PR-1	Slate	70-75	<25	51-52	Planar	J2	0.613
PR-4	Slate	70-80	39	55-54	Planar	J2	0.958
PR-6	Slate	80-90	<25	49-46	Wedge	J4 & J2	0.794
PR-7	Slate	85	<25	45-49	Wedge	J2 & J3	0.67
PR-10	Slate	70	<25	43-44	Stable		
PR-12	Slate	70	<25	42-45	Wedge	J2 & J3	0.731
PR-13	Slate	60	<25	47-43	Wedge	J2 & J3	0.93
PR-14	Slate	70	<25	47-43	Planar	J2	0.136
PR-15	Slate	85	<25	47-42			
PR-19	Slate	80	<25	46-49	Stable		
PR-20	Slate	85-90	<25	45-43			
PR-22	Slate	80-85	<25	48-44	Wedge	J2 & J3	0.9
PR-24	Slate	60-70	<25	51-46	Stable		
PR-54	Slate	75-80	<25	50-51			
PR-55	Slate	70	<25	33-32	Wedge	J1 & J2	0.775
PR-61	Slate	80	<25	54	Stable		
PR-62	Dolomite	72-80	<25	45-52			
PR-64	Dolomite	55-60	<25	61-71	Planar	J2	0.176
PR-67	Dolomite	60-70	<25	48-52	Wedge	J2 & J3	0.676
PR-71	Dolomite	70	<25	47-53	Planar	J3	0.145
PS-1	Rthymite	70-75	<25	47-49	Stable		
PS-40	Rthymite	80	<25	48-59			
PS-41	Rthymite	60	<25	49-56	Wedge	J1 & J2	0.586

Along with the geotechnical and geological data precipitation data (Table. 4) has been collected to know the impact of surface water on the stability of the area. Rain data has been collected since January 1, 2007 to July 11, 2013 that indicates that study area receives 2641.8mm rain fall from 2007 to July 2013. So, heavy rainfall is also a major cause for instability of the slope in the area. Heavy rainfall during month of June 2013 causes breakage of road at various places (Fig. 3 e, f) and in some locations 20-30m of road is collapsed due to sliding. The streams flowing across the road section affect the stability of the road, huge amount of debris is carried by these streams (Nihal River) which erode the adjacent retaining wall and the slope face.

Table 4. Rainfall data (Source: Aryabhatta Research Institute of Observational Sciences (ARIES, Nainital)

Month	2007	2008	2009	2010	2011	2012	2013
January	2.4	8.3	0.5	6.5	3.7	72.9	45.1
February	231.2	38.7	45.1	52.2	54.7	6.2	205.5
March	111.3	7.3	14.3	6.5	15.1	61.4	4.1
April	21.5	57.9	25	0.00	61	18.9	8
May	120.2	41.4	66.9	37.6	74	21	5.9
June	326.7	344.7	143.8	182.1	490.8	128.9	703.9
July	394.9	612.7	485	887.4	762.8	779.9	181.2 11/7/2013
August	926.3	517.2	705.6	1816.8	860.9	356	
September	597.10	384.1	414.7	894.7	337.9	299.7	
October	26.1	2.1	239	0.00	14.5	27.3	
November	0.00	0.00	35.4	1.4	0.00	0.00	
December	3.4	0.00	1.5	0.00	0.00	4.5	
Total	2761.1	2021.9	2176.8	3885.2	2675.4	1176.7	1153.7

CONCLUSIONS

As the rocks in the area are highly crushed, so the major portion of the hill slopes are made up of colluvial sediments. The area received 2641mm average rainfall every year since January 2007. Hence this heavy precipitation reduces the stability of the slope forming material and manifest in debris flow, slumping and rock slides. Slope angle is relatively high >600 at most of the places that is also a threat for the stability of the road. Wherever, rock exposed RMR comes under the lower III class and factor of safety ranging from 0.143 to 0.95 the site is landslide prone. Factor of safety and RMR are supposed to support each other. Graphical analysis of the discontinuity data is showing 13 sites are under the landslide prone conditions. Present study shows 19m3 to 43m3 volume wedges are formed; those are serious problem for the stability. Planers failures are formed due to the parallel alignment of the road and slope face i.e. NW, West to the discontinuity. Neotectonic activity in the area (Valdiya et al., 1984) is another important factor that influences the stability of the area. All these factors affect the stability of the area.

ACKNOWLEDGEMENTS

The authors are thankful to Head, Department of Geology (CAS), Kumaun University Nainital for necessary facilities. We are thankful to Mr. Kaveen Thakur (Energy Infratech Pvt.Ltd.) and special thanks to Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital for providing the rainfall data.

REFERENCES

Anbalagan,R. and Singh,B. 1996. `Landslide hazard and risk assessment mapping of mountainous terrain - a case study from Kumaun Himalaya, India' Engineering Geology. 43: 237-246.

Bieniawski, Z.T., 1989. Enginnering Rock Mass Classification, John Wiley and Sons Inc., NewYork.1-251.

Hukku, B.M., Srivastava, A.K. and Jaitle, G.N., 1974. Evolution of lakes around Nainital and the problem of hillside instability, Him .Geol. 4: 516-531.

Hoek, E. and Bray, J.W., 1981. Rock Slope Engineering. Stephen Austin & Sons Limited Publishers, Hertford.1-358.

Hukku, B.M., Srivastava, A.K. and Jaitle, G.N., 1977. Measurements of slope movements in Nainital area, Jour. Engin.Geol.457-467.

Lama, R.D. and Vutukuri, V.S. 1978.Handbook on mechanical properties of rocks. Trans. Tech. PubL, 4: 317-399.

Markland, J.T., 1972. A useful technique for estimating the stability of rock slopes when the rigid wedge sliding type of failure is expected. Imperial College Rock Mechanism Research Report, No. 19: 1-10.

Middlemiss, C.S., 1890. Geological sketch of Nainital with some remarks on the natural conditions governing the mountain slopes. Rec. Geol. Surv. Ind. 21: 213- 234.

Pal,D. and Merh, S.S., 1974. Stratigraphy and structure of the Nainital area in Kumaun Himalaya, Him.Geol.4: 547-562.

Pande, I.C., 1974. Tectonic interpretation of the geology of Nainital area, Him. Geol. 4: 532-546.

Pant, P.D. and Luirei, Khayingshing (1999) Malpa rockfalls of 18th August 1998 in northeastern Kumaun Himalaya. Jour. Geol. Soc. India, v. 54: 415-420.

Pant, P. D. and Luirei, Khayingshing (2005) Amiya Landslide in the Catchment of Gaula River, Southern Kumaun, Uttrakhand. Jour. Geol. Soc. India, v.65: 291-295.

Sah, M.P. and Bisht, K.S. 1998. Catastrophic mass movement of August 1998 in Okhimath area Garhwal Himalaya. In: Proceeding of International workshop cum Training Programme on Landslide Hazard and Risk Assessment and Damage Control for Sustainable Development, New Delhi, 259-282.

Sharma, A.K., 1981. Structural study of the area East of Nainital, with special reference to the Hillside Instability, Unpub.PhD.Thesis, Kumaun Univ., Nainital.1-126.

Singh.B. and Goel. R.K., 1999. Rock Mass Classification: A practical Approch in Civil Engineering, Elsevier Publication, New York, 1-267.

Valdiya, K.S.,1979. An outline of the structural setup of the Kumaun Himalaya, Jour.Geol. Soc.Ind. 20:145-157.

Valdiya, K.S., 1980 b. Geology of Kumaun Lesser Himalaya. Wadia Institute of Himalayan Geology, Dehradun, 1-291.

Valdiya, K.S., 1984. Aspects of Tectonics: Focus on South- Central Asia. Tata McGraw- Hill Pub. Co. Ltd., New Delhi, 1-319.

Valdiya, K.S. 1988. Geology and Natural Environment of Nainital Hills, Kumaun Himalaya.GyanodayaPrakashan, Nainital, 1-160.

Valdiya, K.S., and Bartariya, S.K., 1989. Problem of Mass Movement in a part of Kumaun Himalaya. Current Science, 89.

Valdiya, K.S. 2001. Reactivation of terrane-defining boundary thrusts in central sector of the Himalaya: Implications. Curr.Sci., v.81:1418-1431.

Valdiya, K.S. 2003. Reactivation of Himalayan Frontal Fault: Implications. Curr Sci., v.85:1031-1040.

Waltham, A.C. 2001. Foundations of Engineering Geology. 2nd Edition. Spon Press. London, 1-692.

13

THE EASTERN HIMALAYA

SOIL LOSS ESTIMATION OF KALE RIVER BASIN, ARUNACHAL PRADESH

Jumri Riba & Ramesh C Joshi***

INTRODUCTION

Soil erosion and sedimentation are amongst the most severe problems faced today in land and environmental management. Soil erosion is a complex dynamic process where surface to subsurface soils are detached and transported to the lower reaches. In this part of the Himalaya Jhum cultivation (slash and burn) along the slopes accelerates the removal of productive surface soils. The detached soils and regolith are further transported from the rugged high topography of Arunachal Pradesh to the low lying Brahmaputra plains by fluvial processes. The Eastern Himalaya, which is considered as "Biodiversity hotspot" is threatened due to severe erosion, sedimentation and deforestation, which are the most, talked environmental issues in India. The entire Himalayan region is afflicted with a harsh problem of soil erosion. The rivers flowing through this region transport heavy load of sediment. It is estimated that the Himalayan and Tibetan regions cover about 5% of the Earth's land surface, but supply about 25% of the dissolved load to the world oceans (Raymo, M.E. and Ruddiman, W.F. 1992). The estimated soil loss in the Kale River Basin (ziro), from nine experimental plots shows the soil loss of 0.45 t $ha^{-2}yr^{-1}$(from agriculture plot) 0.22 t ha^{-2} yr^{-1}(from the barren plot) and 0.19 t ha^{-2} yr^{-1} from forest cover area (Joshi, et al. 2007).

This study is based on the universal soil loss equation which enables to predict the average rate of soil erosion for each feasible alternative combination of crop system management practices in association with a specified soil type, rainfall pattern, and topography (Wishmeier and Smith 1978). Soil loss is most prominent on the surfaces disturbed by the human activities such as deforestation, agriculture, constructional works, mining, quarrying, settlement, etc. More than 50% of the world's pastureland and about 80% of agricultural land suffer from significant erosion (Pimentel, et al, 1994). Anthropogenic factors in the Himalayan region have been widely responsible for high soil erosion. The total soil loss and its intensity depends upon surface runoff and infiltration, these two major factor are controlled by the physical properties of soil, such as porosity, organic matter, clay content, and soil bulk density (E. Oyarzon Carlos 1995).

* Department of Geography, Rajeev Gandhi University, Rono Hills, Doimukh 791 112 (Arunachal Pradesh)

** Department of Geography, Kumaun University, Nainital 263 002 (Uttarakhand)

joshircj@yahoo.co.in

STUDY AREA

Study area is located in the eastern Himalaya, Arunachal Pradesh, which has a temperate mountain environment. This area extends between 27°25'52'' to 27°38'37'' North latitude to 93°45'30'' to 93°55'50'' East longitudes covering an area of about 204.06 square Kilometer (Fig:1). This area is inhabited largely by Apatani Tribe in the upper course and by Nyishi Tribe in the lower course of the watershed. People in this basin are largely dependent on forest resources they practice both sedentary and traditional slash and burn cultivation. Slash and burn cultivation is also known as jhumming, which is often considered responsible for causing soil erosion (Rawat. et al. 2010). Geologically the valley is sedimented with the beds of gravel, sand, grit, clay and peat. The base of the valley is made of gneiss and schist and the altitude of the area ranges between 700m to 2700m above mean sea level. (Joshi, et. al. 2007) The compositions of bedrock distribution of the area comprised of Granite (36.37%) Quartzite - Schistose to Massive (38.2%) Quaternary Deposit (13.52%) and Gneiss (11.37%) (Final Technical Report, Project, 2008)

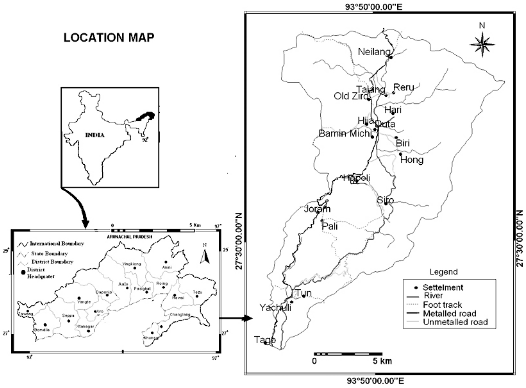


Fig. 1. Location and other details of the area.

MATERIAL AND METHOD

The revised universal soil loss equation (RUSLE) is based on the formula (A = R*K*LS*C*P). Where "A" is the estimate of average annual soil loss (t ha^{-1} yr^{-1}) caused by sheet and rill erosion. "R" is the rainfall erosivity factor (MJ mm ha^{-1} h^{-1} yr^{-1}). "K" is the soil erodibility factor (t h ha^{-1} MJ^{-1} mm^{-1}) which measure the susceptibility of soil to be eroded under standard conditions. "LS" is the topographic factor, derived from a combination of the slope steepness and slope length measurements. "C" is the cover and management factor (non dimensional). P is the support practice factor. All the layers were developed and overlaid for getting the final soil loss of the area.

The numerical value used for the rainfall erosivity factor (R), both in USLE and in RUSLE, quantify the effect of raindrop impact and also reflects the amount and rate of runoff likely to be associated with the rain. For the calculation of precipitation factor monthly rainfall data was analyzed using the formula given below

$$R = \sum_{i=1}^{12} 1.735 \times 10^{(1.5 \log P_i^2/P - 0.8188)}$$

Where R = rainfall erosivity factor in MJ mm ha^{-1} h^{-1} yr^{-1}. P_i = Monthly rainfall in mm and P = Annual rainfall in mm.

The soil texture and other soil characteristics affect the susceptibility of soil erosion. The 'K' factor or the soil erodibility factor is defined as the soil loss rate per erosion index unit of a specified soil on a standard unit plot and expressed as ha h ha^{-1} MJ^{-1} mm^{-1}. The soil erodiblity factor of the area is calculated by carrying out Physico-chemical analysis of the soil samples collected from the physiographic units based on the standard of USDA classification as followed by (Joshi et.al. 2007). For the present study, seven physiographic units were delineated (Fig: 3) using satellite data, DEM, Dissection index, slope and altitude. Soil samples are collected from these delineated physiographic units (Fig: 4). Soil samples were collected using a cylindrical barrel corer of 5.5 cm in diameter up to 30 cm depth. Further, each sample was divided into three sub samples at an interval 10 cm depth. Physico-chemical analysis for all the collectaed samples were carried out taking three replications and the average of two nearest observation to enhance the accuracy. Soil texture is measured with the help of Bouyoucos hydrometer (ASTM type no.152 H was calibrated at 67°F). Soil texture classes are determined based on the sand, silt and clay percentage using USDA textural classification chart. pH was determined using pH tool kit. Soil organic carbon was determined through Walkley-Black method (1934). Total Nitrogen was determined with the help of Kjeldahl Nitrogen auto analyzer and Molybdenum blue methods is used for the determination of available phosphorus. The final values of K factor is obtained using Nomograph developed by Wischmeier and Mannering (1969) which shows the percentage of silt, percent sand and organic matter.

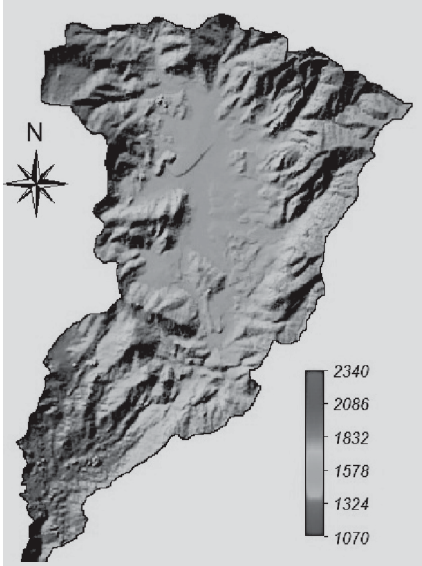


Fig 2: DEM (3D Display)

The effect of topography on erosion in RUSLE is accounted by the topographic factor (LS). Erosion is proportional to slope length (L) and steepness (S). Slope length is defined as the horizontal distance from the origin of the overland flow to the point where either the slope gradient decreases enough that deposition begins or runoff becomes concentrated in a defined channel (Wischmeier and Smith 1978). There are two approaches to resolve the problem of calculating the LS-factor. They are in situ measurement and calculating it from Digital Elevation Model (Fig: 2). For the present study it was difficult, to collect accurate measures in situ due to rugged topography so the Digital Elevation Model is used. Surveys of India Topographical maps are used to digitize contour lines in the ILWIS 3.4 platform. The vector layer containing contour data is rasterised by linear interpolation method to generate Digital Elevation Model (DEM). The methodology suggested by Hengl et al. (2003), ITC, Netherlands has been followed for DEM optimization and reduction of errors like paddy terraces, outliers, etc. Slope in percent (S %) and slop in degree is derived from the DEM.In the first step, the slope length for below 21 % is calculated, by following the modified equation of Wischmeier and Smith (1978).

$$LS1 = (L / 22.1) *(65.41 \sin^2\theta + 4.56 \sin \theta + 0.065)$$

In the second step, the slope length for more than 21 % or above is calculated by the following equation suggested by Gaudasasmita (1987).

$$LS2 = (L / 22.1)^{0.7} * (6.432 * \sin (S^{0.79}) * \cos (S))$$

Where: LS1 and LS2 = Slope length and gradient factors

L = Slope length

S = Angle of the slope.

Finally, a slope length and slope gradient layer (LS factor) is generated with the help of slope in percent map in addition to LS1 and LS2 maps. The map calculation is as follows:

LS Factor = iff (Slope < 21, LS1, LS2)

For cover management practice "C" factor for the study area is determined from the landuse /landcover map prepared using IRS LISS III Data by Digital Image Processing with ground truth verification. The corresponding value given in the USLE landcover and management factors are allocated accordingly for each Landuse / Landcover type identified for the basin.

Support Practice Factor (P) or the Conservation practice is the ratio of soil loss with a specific support practice to the corresponding loss with up and down slope cultivation (contouring, strip-cropping, terracing, etc). In the study area, no major conservation practices are followed. The values for P-factor were assigned from the values published in various literatures (Jain et. al., 2001).Rain energy is directly related to erosion yield. The monthly rainfall data of Ziro locality for a period of 13 years (1991 to 2005) is used to find the R-value of the area. The rainfall erosivity factors ranges from 79.58 MJ mm ha^{-1} h^{-1} yr^{-1} (2003) to 2388.12 MJ mm ha^{-1} h^{-1} yr^{-1} (1991). The average "R" value for the watershed is 447.97MJ mm ha^{-1} h^{-1} yr^{-1}.The season wise erosive energy is shown in (Table 1). Erosivity in the winter period is calculated by taking the monthly rainfall for the month of December, January and February. The total erosive power during winter is 18.91 MJ mm ha^{-1} h^{-1} yr^{-1}. The erosivity of the winter period ranges from 0.07 MJ mm ha^{-1} h^{-1} yr^{-1} (2002) to 5.81 MJ mm ha^{-1} h^{-1} yr^{-1} (1992) and lowest erosivity index is found during the winter. The R- factor for the summer season is calculated by taking the rainfall data for the month of March, April and May. The calculated result shows that the erosive power during this season is comparatively higher than post monsoon and winter season(Table:1) .The total R factor for the summer period is 778.79 MJ mm ha^{-1} h^{-1} yr^{-1} and the erosive power of the watershed during the summer season ranges from 0.35 MJ mm ha^{-1} h^{-1} yr^{-1} (1999) to 253.60 MJ mm ha^{-1} h^{-1} yr^{-1} (1991). The highest calculated erosive power of the watershed is during the monsoon period i.e. June to September (4985.25 MJ mm ha^{-1} h^{-1} yr^{1}) during this period, the basin receives the maximum amount of rainfall. The final calculated result for R factor shows a positive correlation between the amounts of rainfall and erosivity.

Table 1: Rainfall

Year	Total	Winter	Summer	Monsoon	Post Monsoon
1991	2388.11	2.11	253.6	2125.85	6.55
1992	288.32	5.81	26.95	253.72	1.84
1993	496.04	0.44	112.55	382.57	0.48
1994	248.83	0.89	110.63	135.52	1.79
1995	443.68	0.14	10.56	432.8	0.18
1996	146.2	0.44	10.83	132.14	2.79
1999	521.04	0.05	0.35	520.56	0.08
2000	284.95	0.11	27.08	257.59	0.17
2001	425.59	0.14	151.66	273.19	0.6
2002	221.15	0.07	22.18	198.71	0.19
2003	79.59	0.5	12.08	64.34	2.67
2004	141.33	0.08	18.55	101.05	21.65
2005	138.83	8.16	21.77	107.22	1.68
Average	447.97	1.45	59.90	383.48	3.13
SD*	600.82	2.56	75.66	541.49	5.84

The soil erodibility factor (K) in RUSLE accounts for the influence of soil properties on soil loss during storm events on upland areas. In practical terms, the "K" factor (Fig 8) is the average long-term soil and soil-profile response to the erosive power of rainstorms due to several processes. These processes consist of soil detachment and transport by raindrop impact and surface flow, localized deposition due to topography and tillage-induced roughness, and rainwater infiltration into the soil profile (Renard et al. 1997). The calculated K factor for the area is as shown in (Table 2).

Table 2: Physiography soil texture and organic material

Physiographic Unit	Texture	Clay (%)	Silt (%)	Sand (%)	Organic Material	K
Isolated Hills	Loamy sand	6.69	16.38	76.92	1.24	0.18.0
Valley Floor Adjoining Dissected Hills	Sandy loam	10.90	27.19	61.90	1.25	0.18.0
Valley Floor	Silt loam	25.47	51.00	23.53	1.02	0.03.0
High Relief Dissected Hills	Loamy sand	2.33	16.42	81.25	1.12	0.19.0
Low Relief Subdued Hills	Sandy loam	4.50	25.50	70.00	0.86	0.12.0
Steep Side Slope Valley	Loamy sand	2.20	15.80	82.00	1.11	0.05.0
Weathered High Hills	sandy	1.73	12.27	86.00	1.04	0.05.0

The estimation of slope length (LS) factor allows the introduction of three-dimensional hydrological and topographic effects of converging and diverging terrain on soil erosion (Panuska, JC et. al., 1991). The topographic factors L and S are adjust to the erosion rated based upon the length and steepness of the slope. The erosivity power of runoff increases with the velocity of the runoff water. Steep slopes produce high runoff velocities and soil loss increases with increasing slope due to the greater volume of runoff accumulating on the longer slope lengths. The slope length is the distance from the point of origin of the runoff to the point where the slope steepness decreases sufficiently to cause deposition or to the point where runoff enters a well-defined channel. Often the L and S factors are combined into a single topographic factor, LS (Fig. 6). The calculated LS factor for the area is as shown in (Table 3).

Table 3: Topographic factor (LS)

Topographic factor (LS)	Area In Area Km^2	Frequency
$<$ 0.358	18.54	9.08
10-20	67.07	32.86
20 - 30	59.03	28.94
30-60	40.91	20.05
$>$ 60	18.52	9.07
Total	204.06	100

COVER MANAGEMENT FACTOR (C)

The cover and management factor C, is the ratio of soil loss from land use under specified conditions from continuously fallow and tilled land. The RUSLE developed it for use on agricultural fields but it is also used in nonagricultural conditions by appropriate selection of the C factor by relating the land use conditions to some agricultural situation.

Table 4: C, P and K factor, P and K factor

Land use/Land cover	Area in km^2	Area in %	C factors	P Factor	K factor
Settled cultivation	16.74	8.20	0.28	0.6	0.03
Bamboo & Pine groove	13.47	6.60	0.01	0.8	0.18
Scrub forest	14.89	7.29	0.14	0.8	0.12
Dry farming	13.96	6.84	0.4	0.7	0.10
Open forest	68.57	33.60	0.1	0.8	0.12
Dense Forest	48.76	23.89	0.004	0.8	0.05
Moderately Dense forest	9.52	4.67	0.04	0.8	0.13
Shifting cultivation (degraded area)	8.90	4.36	0.33	1	0.19
Built up area	9.25	4.53	0.024	1	
Total	204.06	100.00			

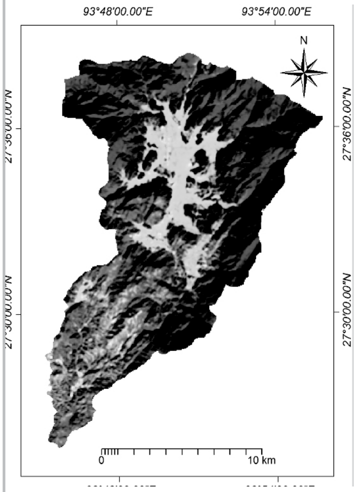


Fig 3: Satellite picture of the study area

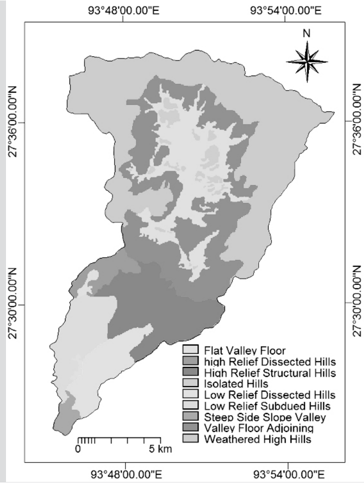


Fig 4: Physiographic unit

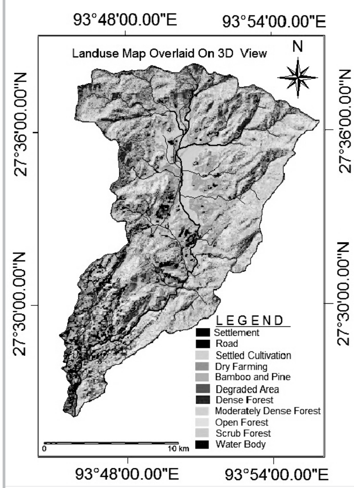


Fig 5: Land use Map

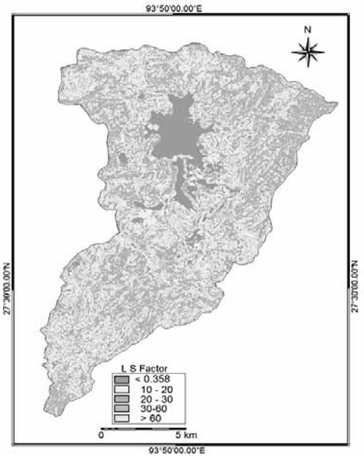


Fig 6: LS Factor Map

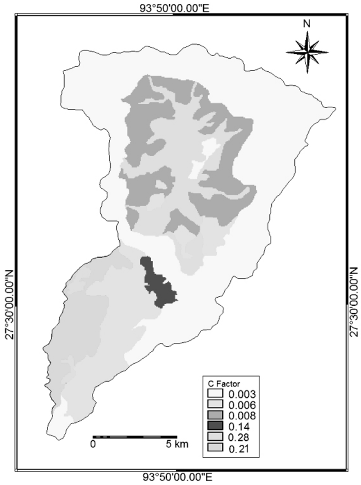


Fig 7: C Factor Map

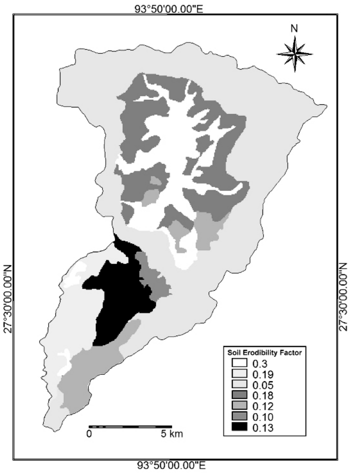


Fig 8: K factor Map

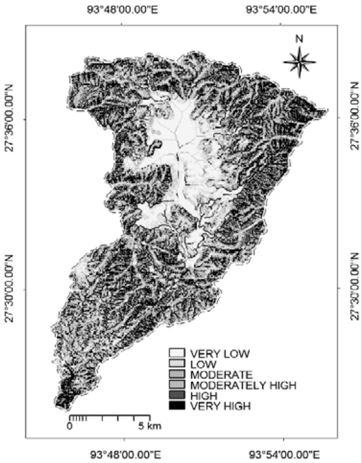


Fig 9: Sediment transport Index

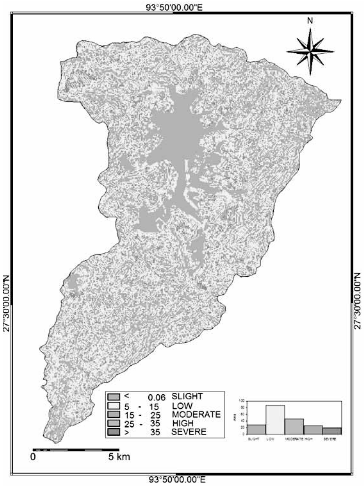


Fig 10: soil loss map

The soil cover (C) has a direct affect on the amount of soil erosion from a watershed. As per Wischmeier and Smith (1978). The Site preparations that remove all vegetation and also the root zone of the soil not only leave the surface completely without protection, but also remove the residual effects of prior vegetation. C factor (Fig: 7) for the study area is determined from the landuse /landcover. The corresponding value given in the USLE landcover and management factors are allocated accordingly for each landuse type of the basin. The study area has been classified into ten land use classes namely; (1) Agriculture (Wet rice cultivation), (2) Bamboo & Pine groove (3) *Scrub forest* (4) *Dry farming* (5) *Open forest* (6) *Dense Forest* (7) *Moderately Dense forest* (8) *Built up area* (Helipad, Settlement and road) (10). *Shifting cultivation (degraded area)* (Fig: 5). Finally, crop management factor was assigned for different land use (Table:4).

SOIL LOSS FROM THE BASIN

The spatial distribution of the soil loss in the basin is obtained by summing the entire factor ((R, K, LS, C. P) and the estimated soil loss of the basin is 3316.45 t yr^{-1} (Table: 5). Slope is found to be the most dominant physical determinants, which controls the soil loss in the Kale river basin, the tendency of soil loss in the basin is found to be increasing with the increase in the slope gradient. The soil loss of the basin has been classified into five categories. The spatial distribution of the soil loss class severe has the highest soil loss intensity i.e. 35 t ha^{-1} yr^{-1} to 59 t ha^{-1} yr^{-1} and its distribution is dominant in the area with higher slope gradient especially in the northern part of the basin area with high relief, the total soil loss from this class is 924.56 t yr^1. The soil loss class slight has the lowest soil loss intensity with less than 0.06 t ha^{-1} yr^1 to 5 t ha^{-1} yr^1 this category covers an area of 27.47 km^2 i.e. 13.46% of the total area of the basin. The spatial distribution of this class is found confined in the area with low slope gradient particularly in the flat valley floor area of the basin which is used for wet rice cultivation and the annual soil loss from this category is 51.18 t yr^1. The class low (5 t ha^{-1} yr^1 to 15 t ha^{-1} yr^1), moderate (15 t ha^{-1} yr^1 to 25 t ha^{-1} yr^1) and high (25 t ha^{-1} yr^1 to 35 t ha^{-1} yr^1) covers an area of 87.09 km^2, 45.55 km^2 and 25.25 km^2 each. Correspondingly the total soil loss for these classes is 961.04 t yr^1, 1166.06 t yr^1 and 213.60 t yr^1. These three class are sparsely distributed in all part of the basin area.has the lowest soil loss intensity with less than 0.06 t ha^{-1} yr^1 to 5 t ha^{-1} yr^1 this category covers an area of 27.47 km^2 i.e. 13.46% of the total area of the basin. The spatial distribution of this class is found confined in the area with low slope gradient particularly in the flat valley floor area of the basin which is used for wet rice cultivation and the annual soil loss from this category is 51.18 t yr^1. The class low (5 t ha^{-1} yr^1 to 15 t ha^{-1} yr^1), moderate (15 t ha^{-1} yr^1 to 25 t ha^{-1} yr^1) and high (25 t ha^{-1} yr^1 to 35 t ha^{-1} yr^1) covers an area of 87.09 km^2, 45.55 km^2 and 25.25 km^2 each. Correspondingly the total soil loss for these classes is 961.04 t yr^1, 1166.06 t yr^1 and 213.60 t yr^1. These three class are sparsely distributed in all part of the basin area.

Table 5: Soil Loss

Class	Category t ha^{-1} yr^1	Area Km^2	Frequency	Total soil loss in t yr^1
Slight	<0.06 - 5	27.47	13.46	51.18
Low	5 -15	87.09	42.67	961.04
Moderate	15 - 25	45.55	31.05	1166.06
High	25- 35	25.25	3.62	213.60
Severe	>35.00	18.74	9.20	924.56
Total		204.09	100.00	3316.45

CONCLUSION

The people living in such a close proximity with the forests are heavily dependent on forest and shifting agriculture. They have innate knowledge of environment and its conservation. This knowledge, embedded in their cultural practices in the form of rituals and religious ceremonies, passed down from generation to generation. This helps them to protect their rich biodiversity and environment. (*Human Development Report,* of Arunachal Pradesh, 2005). However, indigenous knowledge system though, vital for the sustainability is not enough to conserve the rich biodiversity. So, more technical and scientific studies should be done to enhance their traditional conservation ethics.

The result of soil loss estimation shows that the soil loss of the Kale river basin is greatly influenced by three factors i.e., rainfall, cover & management practice (anthropogenic) and topographic factor. The area with high relief and higher slope gradient of the basin have high rate of soil loss intensity. The lower portion of the basin shows area, dominated with shifting cultivation, mass degradation of forest resources has a very high susceptibility of soil loss, and the highest soil loss intensity in the basin is found in this land use category. The valley area and the upper portion of the basin with subdued slopes is used by the Apatani tribes for sedentary agriculture and dry farming shows lower soil loss intensity. To some extend conservation practice (C) is comparatively better in the upper portion than the lower portion of the basin.

ACKNOWLEDGEMENT

G.B. Pant Institute of Himalayan Environment and Development, Kosi, Katarmal, Uttarakhand is duly acknowledged for the generous financial assistance to carry out this work as a part of the research project entitled "Changing land use/Land cover and soil Loss in the Indian Eastern Himalaya, a Drainage Basin input-Output analysis, Arunachal Pradesh. We would like to acknowledge the help rendered by Dr. Tage Rupa, Assistant Professor, Rajiv Gandhi University during the field work.

REFERENCE

E. Oyarzon Carlos.1995. Land use, Hydrological properties and soil erodibilities in the Bio-Bio River basin, central Chile. Mountain Research and Development, 15(4): 331-338.

Final Technical Report on Project (2008) submitted to GBPIHED: "Changing Landuse/Landover and Soil Loss in the Indian Eastern Himalaya a Drainage Basin Input-Output Analysis, Arunachal Pradesh" pp.14.

Human Development Report. 2005. Department of Planning, Govt. of Arunachal Pradesh, p. 8.

Jain, KS et. al., 2001. Estimation of Soil Erosion for a Himalayan Watershed Using GIS Technique. Water Resource Management, 15: 41-54.

Joshi, RC, Rupa T, and Jumri, R. 2007. Landform development in Lacustrine catchment of the Kale River, Arunachal Pradesh. The Himalayan Geographer, I: 86-92.

Panuska, JC et. al. 1991. Terrain analysis: Integration into the agricultural non –point sources (AGNPS) pollution model. Journal of Soil and Water Conservation, 46 (1): 54-64.

Pimentel, D and Wilson, A. 1994. Food, land, population and the U.S. economy. Carrying capacity Network 2000 P street N.W Suite 240 Washington, DC. 20036 (202):296-4548 http:/dieoff.org/page1.htm

Rawat. JS, Riba, B, and Rina T. 2010. Jhumming, a traditional life style than merely a cultivation method. Current Science, 98(8): 998-999.

Raymo, ME and Ruddiman, WF. 1992. Tectonic forcing of Late Cenozoic climate. Nature, 359: 117-122

Wishmeier, WH and Smith, DD. 1978. Predicting Rainfall Erosion Losses – A guide to Conservation Planning, US Department of Agriculture, Agriculture, Hand Book No. 537, Washington DC. p 63.

EXPRESSIONS |

This section reflects ideas and feelings of real concern for the mountain societies. Being a social worker working on water sector Ms Chicu (Expressions 14) shares various issues particularly on vulnerability for Himalayan Disasters while voices from people working in the social sector (Patwal & Budakoti) are afraid of changes in village life and patterns (Expressions 15). Fortunately the long experience of Dr. Srivastava working in the agriculture sector of the Himalaya provides us options for livelihood security on the face of vulnerability from disasters (Expressions 16).

An interesting point of debate on use of hydropower projects in the mountains arises from the vast experiences of Dr. Pant who point outs vulnerability of energy sector on account of mountain disasters as well as their use in reducing impacts (Expressions 17). In this row of experimental sharing the expressions of a historian (Dr Pande) offers much insight on the fact that our memories live very short. He provides a historical account of various disaster occurred in the Himalayan region and various efforts put in the place but we failed to learn from them (Expressions 18). History is a continuous dialogue between past and present

These expressions provide a wide canvas to place action points for an efficient planning and a future of sustainable development of the mountains of Indian Himalayan Region.

- Editors

14

HIMALAYAN DISASTERS - VULNERABILITY AND ISSUES

*Chicu Lokgariwari**

INTRODUCTION

The Himalayan region is a dangerous place to be with an average of 76 natural disasters affecting over a million people every year. And it is not nature that makes them so. It is true that some conditions in the mountains- their geology and their location- make them more susceptible to landslides and earthquakes. In addition to this geological fact, climate change is altering rainfall patterns. There are leading to more instances of very intense rainfall; a corresponding increase in the intensity of these events is also documented. This has led to several flood events in the last few years. However, are these disasters? It is loss of life and property that makes a climate event a disaster. This vulnerability to climate events is influenced by poverty which reduces peoples' access to alternatives and security networks, by changes in livelihood which increase dependence on external market-driven factors, and by a lack of safety systems. In that event, it is distressing that we still do not have systems set up in place in the Indian Himalaya to prevent this egregious loss of life.

Between 15 and 20 June 2013, people sat glued to their television and computer screens as one horrifying image from Uttarakhand succeeded another. This is when intense rainfall in parts of the state caused flooding and infrastructure damage. 315 mm of rainfall fell in Kedarnath in 24 hours on 16-17 June, a period when there was still snow on the ground. The rain and resultant snowmelt caused flooding and the overtopping of Chorabari lake, which resulted in a huge flash flood that bore away the towns of Kedarnath and Rambara[1] . This event coincided with the annual inflow of pilgrims for the Chardham Yatra- five and a half lakh pilgrims undertook the journey in 2013. These pilgrims were unable to correctly gauge the weather and make informed choices about whether to proceed; on the part of the tour guides and other tourism operators, there was every incentive to make the gamble to continue onwards.

The statistics remain difficult to comprehend. 6,000 people dead- and that is only the people of whom there were records. There are no statistics for the thousands of impoverished men who migrate from Nepal and various states of India every year to work as unofficial porters and muleteers during the Chardham Yatra. The viewers gaped at scenes of surging rivers, houses carried away like matchboxes, and roads effortlessly torn up along the Yatra route. Local residents know however, that the events of 15 June in Kedarnath were scarcely

* India Water Portal, Sheetla (Mukteshwar), Distt. Nainital
chicu.l@gmail.com

[1]*Dobhal, DP, Gupta, AK, Mehta, M, and Khandelwal, DD. 2013. Kedarnath Disaster- Facts and possible causes. Current Science, 105(2): 171-174.

isolated. At the same time, great losses were being borne by the residents of Pithoragarh and Bageshwar. Some news reports confirmed that over 1,000 people were stranded in villages but relief and rescue operations focus only on pilgrim centres[2]. Later that monsoon, extreme rainfall occured on 29 June and 15-17 August in the same districts. This news did not appear in any but the local newspapers; while there was considerable damage to property, there was no loss of life. Damages due to landslides and local floods in the monsoon are common throughout the Himalaya. In Nagaland alone, the monsoon of 2013 led to damages worth Rs. 6.5 crores to the water supply systems [3] . These incidents too receive little or no attention in the national media. This neglect is part of a global phenomenon where media and aid organisations tend to focus on events that are dramatically sudden-onset and of large magnitude rather than the slow onset and pervasive hazards that threaten as many lives and livelihoods as more visible disasters[4] .

FACTORS GOVERNING IMPACT OF CLIMATE EVENTS

Extreme rainfall events had also occurred in 2010[5] and 2011 in the Central Himalaya. Again, while there was loss to property, comparatively few lives were lost. Sadly, the credit for this does not lie with the authorities, but with the people themselves. Due to their years of long and bitter experience, local residents have developed an ability to gauge the weather and the land. This local knowledge is constantly evolving with continuous observations of changes in weather patterns and local vulnerabilities and with knowledge inputs from 'outside' such as through improved access to weather reporting services [6] . This is not always foolproof in the case of extreme rainfall or landslides. It is certainly not efficient in the case of earthquakes, as was tragically demonstrated during the Sikkim earthquake of November 2011. It is laying a heavy burden on the people of the Himalayas to expect them to predict all disasters.

Along with local knowledge, communities have also developed support systems, which largely hinge on diversifying risk. This is proving crucial to survival. Work carried out in the Pithoragarh and Almora districts of Uttarakhand after the monsoons in 2010 and in Pithoragarh in 2013 by the Peoples' Science Institute and Himmothhan, indicates that climate change increases the incidence of disasters, but poverty and market-driven changes in lifestyles are the primary factors influencing vulnerability to disasters. Increasing the diversity of livelihoods increases resilience to disasters. People whose family members were working outside the valley had access to money, and an alternative source of shelter. This alternative residence is important since recurring events have led to 200 villages in the state being declared unsafe, with 85 needing immediate location- a difficult proposition for a cash-strapped state[7] . On the other hand, subsistence farmers and agricultural labourers are hardest hit by these events since all their resources and livelihood options are concentrated in one small patch of land.

While poverty increased the vulnerability of individuals, unplanned tourism increases the vulnerability of the state. There has been a sharp influx of tourism in this region over the last 10 years. In Kedarnath, the number grew from just over a lakh in 1990 to five and a half lakhs this year. This tourism is arguably important for the livelihood of the state; however is the state infrastructure able to meet this influx? Uttarakhand is not alone in bearing the brunt of unchecked tourism; increasing numbers of pilgrims for the Amarnath Yatra - 6.4 lakh people visited in 2011- is having catastrophic effects on the fragile ecology of the area.

MANAGING DISASTERS

How is this loss of life, of property, and of our biodiversity to be lessened? The steps in disaster management as commonly understood are response, relief and rehabilitation. To this, prevention needs to be added. This is acknowledged by the National Disaster Management Authority (NDMA) who recommend the inclusion of disaster prevention, mitigation and preparedness activities within the scheme of disaster management. It recommends several measures at various levels from the national to the individual[8] . Implementation of existing guidelines and systems will go a long way in safeguarding our Himalayan states.

The National Disaster Management Authority (NDMA) was established with the vision of a disaster- resilient India; created by enabling prevention, mitigation, preparedness, and effective response. With this goal, the

[2]*Basu S, 2013. Twice hit by flood, Pithoragarh awaits attention. Down to Earth, June 27 2013. Online URL: http://www.downtoearth.org.in/content/twice-hit-flood-pithoragarh-gets-no-relief

[3]*Public Health and Engineering Department of Nagaland, 2013. Sustainability of drinking water supply systems in hilly areas-unique problems and the need of finding solutions submitted for the 3rd Sustainable Mountain Development Summit, Kohima, 2013.

[4]*Wisner, B, & Gaillard, JC. 2009. An introduction to neglected disasters. Jàmbá: Journal of Disaster Risk Studies, 2(3): 151-158.

[5]*Sharma, S. 2012. Catastrophic hydrological event of 18-19 September 2010 in the Indian Central Himalayan region – Cause and Needs. Current Science, 102(2): 327-332.

[6]*Wisner, B. 2010. Local Knowledge and Disaster Risk Reduction. Keynote address at the meeting on Indigenous Knowledge, Global Platform for Disaster Reduction. Geneva, 17 June 2009. Revised 25 June 2009.

[7]*Trivedi, A. 06 August 2012. 'More than 200 villages in Uttarakhand face threat, 85 need immediate relocation'. Hindustan Times.

[8]*Bhattacharjee, B. 2012. National Disaster Management Guidelines- National Disaster Management Information and Communication System (NDMICS) 2011.A publication of the National Disaster Management Authority, Government of India ISBN: 978-93-80440-12-5, February 2012, New Delhi

NDMA developed a mission involving various agencies at the national, state and local levels. The objectives that govern these initiatives are:

- Promoting a culture of prevention and preparedness - by centre-staging DM as an overriding priority at all levels and at all times.
- Encouraging mitigation measures based on state-of-the-art technology and environmental sustainability.
- Mainstreaming DM concerns into the development planning process.
- Putting in place a streamlined institutional techno-legal framework in order to create and preserve the integrity of an enabling regulatory environment and a compliance regime.
- Developing contemporary forecasting and early warning systems backed by responsive and fail-safe communications and Information Technology (IT) support.
- Promoting a productive partnership with the Media, NGOs and the Corporate Sector in the areas of awareness generation and capacity development.
- Ensuring efficient response and relief with a caring humane approach towards the vulnerable sections of the society.
- Making reconstruction an opportunity to build back better and construct disaster-resilient structures and habitats.

These objectives therefore encompass incorporating disaster management principles across all development measures, ensuring compliance with recommended measures, ensuring forecasting and warning, and increasing the efficiency of response. As an example, the published guidelines for establishing a National Disaster Management Information and Communication System provides for a chain of trained personnel and established at the national, state and district levels which will enable the prediction, and warning of impending disasters as well as for effectively managing rescue and restoration efforts. The National Plan for Disaster Management was to encompass the mitigation of disasters, implementation of mitigation measures, and capacity building for immediate and efficient response.

The NDMA has in place a comprehensive plan for disaster management, which includes regional as well as 'last-mile' initiatives. If implemented, the Authority is capable of realising it's vision of a resilient nation.

EFFICACY OF THE PRESENT DISASTER MANAGEMENT MISSION

How effective have these measures been in the eight years since the NDMA was established? The Comptroller and Auditor General of India recently published a report that is scathing in its evaluation of the progress made towards disaster management in India. The report [9] states "The system which came into effect post the Disaster Management Act 2005 is yet to achieve its desired impact. The National Disaster Management Authority which was conceived as the apex planning and supervising body, was found ineffective in its functioning in most of the core areas. It neither had information and control over the progress of work at the state level not was it successful in implementation of various projects". As of November 2013, Assam, Himachal Pradesh, Uttarakhand, Tripura, Mizoram and Nagaland have websites hosted for the State Disaster Management Authorities which provide information about who to contact in case of an emergency, some disaster preparedness manuals, and information about training conducted.

[9]*Comptroller and Auditor General of India, 2012. Performance Audit of Disaster Preparedness in India. Report no 5 of 2013. Ministry of Home Affairs, Government of India. Page 5.

The performance audit indicted disaster preparedness in India at all levels; the lack of meetings of the National Executive Committee, absence of a National Plan for Disaster Management, mismanagement of state disaster response funds, lack of an efficient communications system despite expenses incurred, lack of training and capacity building, have all contributed to increasing the vulnerability of the nation to disaster.

The conditions in the Himalayan states, if anything, are worse than those in the plains. The CAG report conducted an indepth case study of 9 states, of which Uttarakhand was the only representative from the Himalaya. In Uttarakhand, the state and district authorities were non-functional, with the state executive

[10]*Hobley, D.E.J., et al., 2012, Reconstruction of a major storm event from its geomorphic signature: The Ladakh floods, 6 August 2010, Geology, v. 40, p. 483-486, doi:10.1130/G32935.1.

[11]* Sati SP, Sundriyal YP, Rana N, Dangwal S, 2011. Recent landslides in Uttarakhand: nature's fury or human folly. Current Science, Vol. 100, No. 11, 10 June 2011.

[12]*Molden, David. 2013. Managing Disasters, Sustaining Development: a narrative of the fragile Hindu Kush Himalayas. Presented at the 3rd Sustainable Mountain Development Summit, Kohima, 23 September 2013. Transcript available online.

meeting having never met since its conception while the district disaster management authority had met only twice (in April and May 2011) since it was constituted in 2007. In addition to these, there was a lack of a state disaster management plan, irregularities in the management of the state disaster response fund, lack of an early warning and communication system, no measures taken to rehabilitate villages identified for immediate relocation in 2008, and lack of capacity building. Some measures such as establishment of communication equipment and emergency operations centers had been taken at the time of the audit.

INCLUDING REGIONAL NUANCES

The institutional framework at present as envisioned in the National Policy on Disaster Management works as per the political boundaries, with management at the national, state and district levels.

However, some Himalayan states due to their contiguous location and shared geography are vulnerable to the same sort of disasters; the periods at which they are most vulnerable overlap. Intense rainfall events that lead to landslides occur at the same time in the Central Himalayan states of Uttarakhand and Himachal Pradesh, and often in Jammu and Kashmir as well. August 2010 illustrated this; at the same time that Ladakh was struggling to deal with a major landslide that devastated Leh and other towns and killed 230 people[10] , 220 people were killed by landslides in Uttarakhand[11] . It is a duplication of the effort required if response and rescue efforts are planned separately. The North Eastern states are vulnerable to earthquakes. Especially in the case of larger events where the National Disaster Response Forces need to be called in, a regional disaster management plan and mechanism will allow for more efficient deployment of available resources.

The Himalayan states differ from each other in some vulnerabilities. Uttarakhand faces a large influx of visitors to the landslide prone Garhwal region every year during the Chardham Yatra period. Kashmir faces the same surge of visitors during the Amarnath Yatra, but is additionally susceptible to cold waves. The North-eastern states do not face this surge of tourism, but relatively poor connectivity means that large sections are cut off by landslides in the monsoon. As of now, the National Disaster Management Authority does not consider these regional nuances. Effective mitigation will need to take these factors into account while planning for disaster mitigation and response.

ESTABLISHMENT OF BOTH REGION WIDE AND LOCAL WEATHER FORECASTING AND WARNING SYSTEMS

The efficiency and impact of such two-tier warning systems are illustrated by the flood monitoring networks that are being set up in the Himalayan regions today [12]. HKH-HYCOS is a flood warning system where regions that we can take better advantage of, where we can share information across borders. HYCOS is trying to set up an end-to-end system where we can share data and get that data moving across borders 'at a rate faster than floods' as the motto says. While this is in operation now, its use can be vastly increased by nations sharing their flood and weather data. However, regional solutions do not provide accurate information at the local level. This omission is especially high in terms of highly local events that require immediate response like flash floods. Some communities, such as in some areas of Assam, are using simple and easily fabricated devices that detect the water level in a stream. When the water level goes up, it sends up a signal to an alarm or a telephone system. This can be highly instrumental in saving lives provided that the communities are trained to use this type of system so that they don't have to wait for complicated systems that often rely on someone very far away, with the resultant lag in response.

Warning systems necessarily depend on the establishment of a very strong weather monitoring system. As of now, while the density of weather stations is adequate in lower altitudes, it declines significantly as we go higher. This limits our knowledge of intense rainfall and other storms occurring at high altitudes, which further limits our ability to forecast glacial lake outburst floods and flash floods caused by landslides.

[13]*Yudhbir and Gergan J.T. 2004. Status Report for Initiating Landslide Studies in Sikkim. DST Project no ES/11/09/. Online URL: http://www.indiawaterportal.org/articles/understanding-how-predict-where-next-landslide-will-happen-sikkim-analysis-using-status.

[14]*Kohli K, 2011. Inducing vulnerabilities in a fragile landscape. Economic and Political Weekly. December 17, 2011. Online URL: http://www.indiawaterportal.org/articles/inducing-vulnerabilities-fragile-landscape-implications-hydropower-development-seismically.

CHECKS ON HAPHAZARD CONSTRUCTION

Construction of roads and tunnels needs to be done only after a thorough check on the vulnerability of the slope in question. The Wadia Institute of Geology has recommended detailed studies of the landslide vulnerability of the region, following which a zoning map can be prepared. These studies include the preparation of topographic maps, geomorphology maps, and overburden maps. They also recommend a network of automatic rainguages on slopes with a known history of landslides[13] . In the meantime, much loss can be averted by placing a check on illegal construction especially on or near riverbeds. Losses during the Sikkim earthquake of 2011 were concentrated near dam and tunnel sites [14]. Similarly, the floods in Uttarakhand in the years 2010, 2011 and 2013 have decimated hotels, restaurants and other structures that were built along river beds with little thought given to flood clearance. All of the township that had sprung up at Kedarnath, was constructed with little regard to the streams that led down to the temple, with disastrous results.

FROM PLANNING TO IMPLEMENTATION

The knowledge of what needs to be done to prevent loss due to extreme events is commonly available. This knowledge has been acknowledged and incorporated into the mission created by the NDMA. Despite that, we see that implementation is not yet satisfactory. The reasons for this need to be investigated if appropriate incentives for the implementation of disaster mitigation measures are to be offered.

Political will is necessary to ensure implementation of a nation-wide mission such as that of increasing resilience to disasters. This 'will' respond to the following incentives: political, economic, legal, administrative and moral/ ethical [15]. Each of these influence each other; and are influenced by various stakeholders. For example, the desire of administrative staff to ensure the safety of a state may be underdone by lack of funds. Community disaster for reduced vulnerability to future disasters may take a back seat to the urgent necessity of securing a livelihood today. This complex interconnection between stakeholders, their incentives to implement disaster risk reduction measures, and their incentives to ignore these measures makes it difficult to select a single initiative or group of initiatives to ensure compliance. Rather than incentives, education and awareness raising has the potential to tip the scale in favour of implementing disaster mitigation methods. Lack of incentive to implement disaster mitigation measures can also be read as increased importance being given to the substitute. If people disregard laws that prohibit construction on river banks, it is because a certain value is ascribed to a river view; hotel rooms that overlook the river are preferred by tourists. Hesitation to limit the number of visitors to pilgrimage points indicates a dependence on the income generated from this trade as also a reluctance to anger a voting population. Creating awareness of the risks involved has the potential to increase the 'value' ascribed to disaster management, which is then the incentive required to successfully implement these measures.

This is not an easy task, simple because of the diversity of people that need to be included in this campaign; the list includes politicians, administrative officials, development workers, media personnel, funding organisations, religious leaders, and communities, to name but a few. The positive note is that it has been done before, and on a larger scale. India's polio eradication drive is a stunning example of an entire nation working towards a common goal; each national campaign involved 2.3 million health workers, the campaign gave birth to innovative strategies to reach migrant and transit populations, involved all sections of the community from celebrities to religious leaders in creating awareness, initiated research, and gave birth to a surveillance programme more robust than any seen before[16] .

At it's peak, polio affected 1.5 lakh children in the country. Natural disasters in the Indian Himalaya alone affect 2 lakh people each year. Today, India has been declared as polio free nation. It is time to assess whether India can sustain yet another life saving campaign- that of a disaster-resilient population.

[15]* Wisner, B, George Kent, Jean Carmalt, Brian Cook, JC Gaillard, Allan Lavell, Marcus Oxley, Terry Gibson, Ilan Kelman, Dewald van Niekerk, Jonatan Lassa, Zen Delica Willison, Mihir Bhatt, Omar-Dario Cardona, Djillali Benouar, Lizardo Narvaez, 2011. Political Will for Disaster Reduction: What Incentives Build It, And Why Is It So Hard To Achieve? A Contribution to the Review of the draft GAR 2011, Chapters 5, 6 & 7.

[16]*Ministry of Health and Family Welfare, 2012. 'From 2,00,000 to Zero: The journey to a polio-free India'. Polio Summit 2012. Available online:http://www.unicef.org/india/Polio_Booklet-final_%2822-02-2012%29V3.pdf.

15

HIMALAYAN TSUNAMI TRIGGERS EXODUS FROM UTTARAKHAND

Bharat Patwal & Devendra K Budakoti**

Our friends working in the development sector, particularly those working in the hills, question why are those well settled in the plains so worried about the issue of migration from the hill villages. Why don't they ask themselves, why their kith and kin left the village in the first place and what they have done and or propose to do for their for own people or villagers who are still staying back or left behind in the village. Most of them have no answers to that and still romanticize the village and village life. People have been leaving the village since independence first for jobs, later for well settled life and then education and career of their children. Subsequently many others settled in the towns and cities in the plains and looked back only in nostalgic moments. Life continued to be hard in the village and agriculture continues to be of subsistence level and women drudgery continues till date. Earlier while men went out to look for livelihood and employment, the families still stayed back. In the eighties and nineties of the last century, wife accompanies her husband and once the children were born and of school going age, they then permanently settled down and went to village only on holidays and or for some rituals to attend. Those slightly better off and men who were employed outside and could afford better education then in the village school preferred to move closer to urban centers near their village. In an urban scenario a woman has and sees more options to choose to make her life situation congenial for the future of her children and thereby for her family. Today a village woman is also seeing and listening to the comforts of urban life and openly wishes and assert to move away from daily drudgery and for better future for the children. The new generation has lost hope for a better future in the village and is looking forward to any available opportunity to move out. Since the formation of the state and seeing the status of its development, the hills will soon see many ghost villages. The 2011 census figures of the state have already shown the demographic shift from the hills to the plains/*Terai* regions. The population density has increased many folds in the plain/*Terai* areas of the state and shows negative growth rate in many hill areas. At the rate of development, some observers had thought that the negative growth rate will be common in most hill areas and this will be a reality within a decade or so. The Tipping Point of exodus from the hill region is the disaster in Uttarakhand and its ramification.

* Institute for Development Support, Kandoliya Road, Pauri Garhwal (Uttrakhand)

bharatpatwal@gmail.com

ghughuti@gmail.com

According to a joint report on the Damage and Needs Assessment done by Asian Development Bank, Government of Uttarakhand and the World Bank, mentions that "*Many buildings were washed away either due to rising water levels or due to erosion of the foundations and slopes caused by high speed currents. At many locations entire settlements have been washed away, while many buildings that were partially damaged are now unsafe for habitation and may require total rebuilding*". According to the government of Uttarakhand data, 3,077 units were damaged in both the urban and rural areas and in addition to loss of personal property. There was also damage to the infrastructure including equipment and amenities which led to the disruption of the routine functioning of these facilities in the affected areas. As per the information obtained from the Government of Uttarakhand, a total of about 995 Public Buildings were damaged which includes Education, Health, Women & Child Development Centre, Block Offices and Other Residential Buildings.

It is well know that roads are the lifeline in the hill areas and the cloud burst and torrential rains resulted in erosion of long stretches of roads, major landslides and caving of roads and pathways, and complete disruption of vehicular movement and road connectivity. The disaster has caused damages to about 2,174 roads, 85 motor bridges and 140 bridle bridges and connectivity to about 4,200 villages have been affected as the report mentions.

Many families have been affected by this disaster and the report mentions that, *"The Uttarakhand economy mainly relies on the Tourism industry, agriculture, livestock and horticulture".* As per the report, about 200,000 people engaged in agriculture, horticulture and livestock management have lost their livelihood as a result of this disaster. About 83,320 households lost their tourism linked livelihoods. This include small businesses such as hotels and restaurants (6,500), petty traders (23,000) such as road side tea stalls and roadside eateries (dhabas), fruit and vegetable vendors, handicraft vendors, taxi and bus drivers, palanquin bearers (dandi kathi) who carry pilgrims and goods up the steep slopes of the two dhams, and the priests. Due to the loss of livelihoods that are dependent on this sector, there is a threat of forced migration.

According to a preliminary PRA survey done by Institute for Development Support (IDS), in some of the affected villages of Rudraprayag district, more than 300 families have migrated from their native places. More are planning to move as soon they have made necessary arrangements to move out. Many feel that within 5 to 6 years, there will be a major demographic shift from the hills to the plains and towards the urban centers of the hills. Presently the process of migration has started with families shifted for the education of the children. Many are buying or in the process of looking for purchasing land in the plains and others have made up their mind to shift out of village. The land prices in the plains have skyrocketed due to this and property dealers are busy negotiating with potential parties. In the coming decade, one will see only the real BPL in villages and only a few diehards will stay back for psychological reasons, mostly the aged ones and some 'mad' like us……….... may still like to go back, in valley of Gods, Ghosts and Ghour-home.

16

NORTH-WEST HIMALAYA - RECENT DISASTERS

ENVIRONMENT FRAGILITY AND LIVELIHOOD SECURITY

*Anil K Srivastva**

INTRODUCTION

While mountains are of great value for the ecosystem services and niche potential, the Himalaya represent one of the most fragile, vulnerable and economically challenged ecosystem. This statement is highlighted enough in the form of unprecedented loss of habitat, infrastructure, livelihood and life in recent disaster in Kedarnath (June 2013). The disaster, which has severely affected the economy of the Uttarakhand state, has also raised serious questions about the approach and path of biophysical and socio-economic development of the region.

The north-west region of Himalaya (NHWR, consisting states of J&K, HP and UK) is spread into 33 million ha, habited by 25 million humans, and 19 million livestock. This scenario is highly critical. The population pressure on farm land is very high in mountains, being 1047/km^2 compared to national figure of only 704/km^2. Agriculture represents dominant livelihood activity, and serious ecological degradation occurs due to deforestation, excessive grazing and cultivation of marginal lands. The growing anthropogenic disturbances and disregard to ecological considerations have aggravated the magnitude of disaster which led to heavy loss of resources, infrastructure and life.

Thus, the mountain ecosystems need high priority to natural resources management and community based action plan (Table 1). Restoring ecological balance, under taking bioengineering measures for treating the affected and potential vulnerable areas should form basic strategy. Ensuring livelihood by promoting secondary agriculture and alternate employment opportunities should naturally form major action plan for the disaster prone and affected areas.

* ICAR Consultant- Integrated Farming Systems, Ex-Director and Emeritus Scientist (Retd.) (ICAR), VPKAS, Almora; Member RAC-ICAR RCER, Patna, Steering Committee for Hills, BAIF

Res: 108-B, Sailok Phase-II, Post- Kanwali, GMS Road, Dehradun248001, (Uttarakhand)
aksrivastva4@yahoo.com, aksrivastva@icar.org.in

Table 1. Major Issues in the Himalayan region

Issues	Concern
Environmental: Revival of traditional customs, sacred forest, dedicated memorial forests and agro-eco based land use. -	• General absence of environment friendly development and conservation efforts. • Over exploitation of vegetation. • Lack of soil conservation and water harvesting with protected drainage systems and safe disposal of water. • Environment sensitive resource conservation and utilisation; diversified integrated farming systems with dominance of livestock, fruits and perennial vegetation.
Terrain and habitat security	• This is largely triggered by anthropogenic, climatic, geological and disregard to traditional norms and practices.
Livelihood and farming related: Thrust to fuel, fodder, water and food security -	• Lack of food, fuel, fodder and livelihood security leading to over exploitation resulting to resource degradation and environmental deterioration.
Institutional, academic, research and technology development	• Responsive mechanism for curriculum modification, need based research and technology development on emerging issues in a problem solving approach. Mountain specificities entail no borrowed knowledge and technologies.
Socio economic aspects: Community skill and capacity	• Skill and capabilities of community and development agencies sensitive enough to mountain specificities. It is essential to provide year round livelihood security to mountain rural people.
Dedicated hill cadre of farmers', technical and development personnel: Dedicated farmers centric institutions: Integrating indigenous knowledge and experience into action plan and practice.	• Strong component of non-arable land; both individual and community owned. • Conservation and habitat protection in mountains. • While working for disaster management lets appreciate the fact that there is gross deficiency of relevant and dependable data base and processed information.

LINKAGES BETWEEN ECOLOGY, ECONOMICS, AND VULNERABILITY

Three (Eradication of poverty and hunger, Gender equality and women empowerment, and Environment protection) out of the eight Millennium Development Goals are matter of concern directly to the people of the Himalaya. The NWHR is characterized by high altitude, steep slopes, dominance of shallow and gravelly soil (7.5-15.0 cm depth and > 40% gravel), loss of forest cover, severe degradation and inaccessibility (only 9 km of roads compared to 37 km/100 km^2 in India). Stress is manifold for Himalayan ecosystem for meeting the increasing community needs of society, and conserving and aggrading the natural resources.

The deficiency of development strategies in the hills is that, when one talks about agriculture, it refers only to crop production and overlooks its linkages with forests which are an integral part of the hill farming system. Mountain people significantly derive their sustenance from livestock farming. The region supports rather large population of livestock of more than 19 million. Whereas, the agro ecosystem of NW Himalaya provides green fodder only for four months of the summer. This results in gross deficit of fodder to the extent of >50% the region (Bisht et al., 2009), which is very critical. Ecologically, the agro-ecosystem of the Himalaya needs at least 5 unit of forest cover to sustain one unit of hill farming (Singh 2004) while projected growth of human population, which at present is 2.9 crores in NWHR, is expected to further stress the environment. The region has 30-40% shortages of fodder, and rural population in NWHR, consuming an average of 3 trees but there is no "fuel wood management regime" in place. NCA (1976) called for an effective rural fuel supply policy. It is widely concluded that environment degradation and destruction is directly related to poverty and unemployment. Hence, livelihood and economic security have to be the foremost in agenda for development.

Degradation of natural resources is the loss of beneficial goods and services derived from terrestrial ecosystems, which include soil, vegetation, other plant and animal life, and the ecological and hydrological processes that operate within these systems. Traditionally, the hill farming system and mountain community evolved in harmony and conformity with the hill ecosystem and natural resources. However, over period of time, the anthropogenic factors, competing demands, from other economic sectors, resulting over exploitation of natural resources, have led to severe problem of degradation. Now, the farming community, scientists and development agencies face twin challenges of improving the natural resource base and enhancing the farm productivity. The natural resource base provides, contributes and facilitates not only farming but survival of biological system possible. The forest cover varied from 14,668 km^2 (HP) to 24,495 km^2 (UK). Among the more visible forms of land degradation desertification, deforestation, overgrazing, and soil erosion are major ones, and can result from either human activities or natural causes. Similarly, hill agriculture presents several constraints including poor productivity, degradation of water sheds, economic non-viability, lack of alternate livelihood and poverty (Srivastva, 2006).

In NWHR, out of the total area of 33.14 million ha, only 2 million ha is under agriculture. Per capita availability of cultivable land in the region is only 750-900 m^2, as compared to the national average of 1370 m^2. Cultivable land is limited to nearly 11 per cent of the region, and only 10-12 per cent of that is under irrigation. Another 15 per cent has sufficient moisture conditions. Hence water is most critical natural resource, factor in ensuring high productivity. On natural account average annual rainfall received in NW Himalaya is 1336 mm, whereas Almora (UK) receives around 1150 mm rainfall. Since, rainfall being inadequate and concentrated during monsoon in NWHR, further complicates the problems of rainfed areas. Prevalence of steep slopes results in heavy runoff and soil erosion. Estimates from high, medium and low productivity sites for runoff (23%, 30% and 37% of rainfall, respectively) and soil-erosion (12, 17 and 24 t/ha/year soil loss, respectively) shows a wide variation. Table 2 compares various situations of soil erosion and Table 3 demonstrates a typical water budget of the NWHR.

Monsoon period generally involve heavy rain storm and excess runoff triggers slope failures, absence of drainage systems, water harvesting, storage of harvested water and lack of safe disposal of excess water. Stream bank erosion causing scouring and collapse of side slopes. Thus action for ensuring safety, protection and contingency measures has to be planned, and provided on a regular basis. The fragile nature of mountains demand very high priority on protection and conservation of resources along with their utilisation linked to the capability. It is relevant to consider the following aspects while formulating the disaster management strategy - limitations of terrain, steep slopes, and soil sink, insufficient and/or degraded drainage systems, and absence of safe disposal of runoff water.

Table 2. Soil Erosion Estimates

World	36 billion t/yr	6 times natural rate of formation (World Watch Institute)
India	5.3 billion t/yr	>5 times rate of formation 16 t/ha/yr (Dhruvanarayana and Rambabu, 1983)
North West Himalaya	0.0035 billion t/yr or 35 million t/yr	Dhruvanarayana and Rambabu, 1983

Table 3. Typical water budget estimated for the NW Himalayan Region

Factors	Water Budget		
a. Precipitation	1,200 mm		
b. Effective rainfall	1,000 mm		
Growing conditions	Favourable	Moderate	Poor
c. Runoff (% of rainfall)	23%	30%	37%
d. Runoff (in mm)	230 mm	300 mm	370 mm
e. Balance water (b-d)	770 mm	700 mm	630 mm
f. Contribution from upstream runoff	45 mm	56 mm	65 mm
g. Balance water (e+f)	815 mm	756 mm	695 mm
h. Deep percolation losses (%)	10 %	15 %	20 %
I. Balance water (g-h)	734 mm	643 mm	556 mm
j. Water available for crop cultivation (at 80%)	585 mm	515 mm	445 mm

SUSTAINABLE ENHANCEMENT OF FARM PRODUCTIVITY

In NWHR, almost 88% of the farming community consists of small and marginal farmers who own 55% of agriculture land. Only 0.4 to 0.6 ha of cultivable land is available per family whereas about 30% equivalent is available as non-arable land with community in the region (Baseline Survey, NAIP, VPKAS, 2009). This landholding may consist of several plots distributed in large area of the village. However, large proportion of culturable wasteland (0.62 million ha) and current fallow (0.2 million ha) could be utilised for production of fodder. Similarly, considerable area existing under forest floor (joint forest management in *Van Panchayats*) could be successfully utilized for fodder production. The land use data in Uttarakhand also show a steep rise in both the 'current fallow' and 'cultivable waste' areas, indicating a considerable decline in the net sown area. The abandonment of farms and fields lead to their degradation and subsequent enhancing the risk of disaster. This has further increased the marginalization of mountain farming communities, especially in areas of high incidence of out-migration. The disaster management strategy for the region should have strong component of the community based non-arable land development and management.

REDUCING RISK AND MANAGING NATURAL RESOURCE IN ARABLE LAND: Soil has to be considered as sink for water, organic carbon, and plant nutrients. The approach of treating the inter-terrace (within fields) and terrace level (at bunds) along with the drainage line, as indicated above for non-arable land, is to be adopted for arable lands as well. Slope management by leveling of fields reading to inward slope and the optimum cropping makes strong impact on soil erosion. The unpuddled rainfed rice and finger millet resulted in 27 to 29% runoff, whereas it was 34 and 36% under maize and hybrid Napier. However, soil loss was only 5.6 t under hybrid Napier against severe erosion of 15 t under finger millet, 18 t under rice and 22 t/ha/yr under maize crop. Raising the height of risers and protecting them by plantation is very effective. Plantation of vegetative hedge on terrace risers was carried out. Plantation of major species included *Setaria* grass slips (60,000 in numbers covering 15,000 running meters) and hybrid *napier*. This treatment is widely practiced. Drainage line treatment included stream bed management loose bolder gabion check dams and brush wood check dams, need to be carried out.

For an area of 2,000 ha in 5 districts of 3 states in the NWHR principles of resource conservation practiced, involving 3,737 families, in arable land included slope management, rain water management, diversification of farming and perennial vegetation. Some of the measures taken were (i) protected cultivation, (ii) plantation of fodder grasses and improvement of terrace risers, (iii) inclusion of perennial vegetation - diversification to fruit cultivation, (iv) water harvesting and multiple uses of water fisheries, and (v) improvement in livestock which made possible composting at higher rate improving soil condition and productivity. Considering the typical terrain conditions, it is possible to have 2,500 to 3,750 ponds of the size of around 200 m^3. This possibility was effectively replicated by 50 ponds in non- arable lands of the targeted districts. Development of protected cultivation supported by water harvesting ponds will serve twin purposes of protection and very high production and profit. The harvested water ponds could also be used for fisheries. This has been taken to the field by the author and his team in NWHR having 268 number of water harvesting pond coupled with 296 polyhouses. A number of 158 ponds were as well used for harvested water fisheries.

INTEGRATED NON-ARABLE LAND MANAGEMENT

It is commonly realised that non arable lands are crucial for meeting the environmental and community needs in the mountains. The land use statistics highlights that additional 29% area is available either owned by community or individual families. However, there is gross absence of suitable policies or development efforts those may harvest contribution of fodder, fuel, water and environmental security with equity from such lands. The efforts made by the author and his team across the NWHR bears testimony to this possibility.

Livestock fodder problem is more acute than human food problem in NWHR. It has to be realized that the feed and fodder requirement cannot be met by purchases from outside. The huge animal population (19 million) and poor fodder availability (30 to 40% of the requirements) has widen the gap between demand and supply of forage crops in the region. In all the three states of NWH (J&K, HP, and UK) considerable area including wastelands are available which can be used to increase the fodder production. When we induct or diversify farming systems then the new additional demand has to be accommodated from the prevailing production system, e.g., high production maize-PHT-agro processing-cattle, poultry or fishmeal preparation.

Excluding the local inhabitant out of the forests has also impacted the non- arable land in the vicinity since, the pressure to meet fuel wood and fodder has largely concentrated and lack of management has aggravated the ecological degradation of these lands. This leads to the only available option of increasing fodder production from the non-cultivated agricultural lands, fallow, wastelands, pastures and forest areas.

CONCLUSION

The management programme should take into cognizance of following points for comprehensive contingency planning and alternate strategies in place.

Approach	Focus	Action
Resource Value System	• Economic benefit from ecosystem services • Niche Potentials	• Healthy Environment cess on Tourists • Carbon sequestration-carbon credits • Organic and healthy food • Development of market chain
Development Ethics	• Paradigm shift • Traditional knowledge, & skills	• Revisiting the Norms, Guidelines and Policies • Addressing to the community and regional needs
Village	• Community centric resource management	• Knowledge centres • Indigenous seeds & landraces • Village schools

The future challenges of mountain eco-system, agriculture and society with regard to natural disasters are serious and we have to probably think and act beyond our regular disciplines and specializations, aiming at security and prosperity of rural community in conformity with ecological principles. Thus conservation, protection and economic development can be synergistically dovetailed in the mountain region providing sustainable livelihood with equity. Let's look forward to safe Himalayas supported by most modern scientific development, responsive community and responsible governance.

REFERENCES

Bisht, JK, Srivastva, AK, and Gupta, HS. 2009. Sustainable fodder production management in NW Himalaya. VPKAS, Almora, pp 1-62

Dhruvanarayana, VV, and Rambabu. 1983. Estimation of soil erosion in India. J. Irrig. Drainage Engng., 109: 419-434.

National Commission on Agriculture (NCA). 1976. Report of the NCA, Part XIII. Rural Employment and Special Area Programme. Min. of Agriculture and Irrg. Govt. of India, New Delhi, pp 191.

Singh, JS. 2004. Sustainable development of Indian Himalayan region-linking ecological and economic concerns. Pt Pant Memorial Lecture –X. GBPIHED, Kosi Katarmal, Almora. 28 p

Srivastva, AK. 2006. Sustainability of hill agriculture agro-ecosystems and watersheds. In: Sustainable production from Agricultural Watersheds in North West Himalaya, H.S., Gupta, A.K., Srivastva, J.C., Bhatt, (Ed.), Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, pp. 22-49.

17

HYDROPOWER IN UTTARAKHAND: CONTEXT OF DISASTER

VULNERABILITY OR MITIGATION MEASURE ??

*Anant K Pant**

* Adjunct Professor, Birla Institute of Advance Studies, Bhimtal (Distt Nainital)

anant.abha@gmail.com

The creation of Uttarkhand as a separate state was seen as better and equitable development of the region due to owing treasure of natural resources, particularly water. Water availability in mountains promises a potential for developing hydropower but usually tapped marginally. The calamity of 16-17th June 2013 raises serious concern due to unplanned growth in fragile environment where destruction of urban structures of a town along the river bank was associated, by people, with additional unwarned flow from a reservoir. So the need of care in developing water resources and hydropower is even more apparent.

Table 1. Hydropower potential of Himalayan Region (above 20MW)

Region	Potential in TWH (1960 Survey)	Potential in TWH (1978 reassessment)	% Change
Northern*	56.4	147.3	+161
Eastern	19.1	37.6	+97
North-Eastern	65.5	105.5	+61
Total	141.0	290.4	+106

**Northern region comprises J&K, Haryana, H.P., Uttarakhand, U.P. and Bihar.*

Himalayan mountains provide three main river systems viz., Indus, Ganga and Brahmaputra to Indian sub-continent. Restricting ourselves to Uttarakhand, rivers are part of the Ganga River System. All the estimates have put annual water flow in this river system at about 50 million hectare meters, however in the absence of specific estimate of the flow within Uttarakhand a contribution of State is estimated flow of about 10 million hectare meters. By adding rainfall and snowmelt data, it can be taken to be more than half at about 6 million hectare meters. The available flow in winter months is very meager. From March onwards snow melting helps a little but there are indications that this is reducing due to receding glaciers. The Tehri Dam, though controversial on many counts, does provide a live storage capacity of about 0.2 cubic km (2x108 m^3). This is equivalent to increasing the river flow in lean months by about 20%. Also significant potential for power generation and water storage through smaller hydro does exist, which is of great importance for remotely located communities.

It is accepted by most that agriculture, including horticulture and floriculture, needs to be made more productive to retain population in mountains. This can only be done by making more water available and also round the year. In hilly terrains of Uttarakhand surface water from rivers, streams and lakes appeared the only option. This would require storage for some of the excess water available during the monsoon period. Large dams have been built the world over for this. These have additional benefits of generating electricity and as measure of flood control. In India, Bhakra dam has returned the investment many times over. Mangla Dam in Pakistan provides for 3,000 MW of electrical power besides irrigation. In Uttarakhand itself Tehri Dam was built for these reasons.

Nevertheless, this approach cannot be taken under consideration for many reasons. Tehri project itself was met with great deal of resistance. Even now there are genuine concerns of likely disaster due to any failure. This sentiment cannot be ignored by technical arguments in its favour. The region is seismically active. In Japan, where the level of rigour and specifications are much more stringent, one disaster has put all the development of nuclear power on hold and it is in process of phasing them out. Besides, even accepting the safety aspects, there are other adverse impacts of environmental and social nature which would preclude such consideration.

On the other hand, storage has to be created to harness the monsoon flows. The alternative is distributing the storage in a large number of small dams and check dams starting from the higher reaches. This top down approach for harnessing rivers was suggested by a great initiative, by Indian Council of World Affairs, taken in early eighties in respect of resources of the Himalayas. This initiative roped in all the nations of the Himalayan region (Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan and India but also included Shri Lanka). This was in fact a precursor of SAARC. Except Afghanistan, which could not effectively join because of internal conflict, the experts of all other countries participated first in carrying out country studies and then synthesizing a regional study which indicated many possibilities of collaborative development making the whole bigger than the sum of individual efforts. The first phase of the country study for India was completed in 1984 and showed great possibilities of development, provided the resources that are utilized wisely.

In higher reaches there is hardly any dislocation of population. Many of the sites like Nagni above Harsil have very little tree cover. The land would be non agricultural government land and the benefits will start accruing to people who are the most vulnerable socially and economically due to remoteness. An added benefit would be improved communications. This along with the other necessary measures of watershed developments, rainwater harvesting for local community needs and afforestation would add to surface and ground water resources and recharge the dying springs. The costs may be a little higher on purely economic grounds but would far outweigh the indirect impacts. A consortium named Water for Welfare was set up with grant from the State Government and secretariat located in IIT Roorkee. It did produce some documents including a draft for Water Utilization and Conservation policy in 2008. No policy action, however, has been taken at the Government Level.

In spite of some adverse effects, hydropower is the best source of energy, if judiciously developed. The additional water availability in leaner months will enable leaving more environmental flow in the affected river stretches without reducing the capacity of the hydroelectric projects, thus retaining their economic viability. These projects would be run off the river projects with small diurnal storage thus civil works would be of much smaller magnitudes and land requirements will be corresponding less. Even so very large projects would needed to be relooked and possibly converted into a chain of smaller ones even at the cost of reducing the power output and increased per unit costs. Leaving environmental aspects aside, the acceptability of local people needs to be there and very large projects are unlikely to be accepted easily in current environment.

In conclusion, it needs to be emphasized that harnessing of water resources can be done in sustainable manner by distributing the storage and taking a more cautious approach of having smaller power projects. This may even be economically justifiable as the gestation periods will be reduced and the benefits will start accruing earlier. Even the power generation from existing schemes will increase because of increase in flow. The need is to carry out detailed surveys for storage sites and working out changes in hydropower projects without losing further time. Any water which flows down untapped is lost forever.

SOURCE MATERIAL

1. "Assessment and development of Himalayan Water Resources for Regional Cooperation and National Development" Country Report of the First phase of Study; Staish Chandra and A K Pant, April 1984.
2. UPCL, Dehradun Website.
3. UREDA, Dehradun, Website
4. UJVN, Dehradun Website.
5. THDC website
6. Water Policy and Conservation of Water,Water for Welfare Secretariat, Feb. 2008.
7. Characteristics of Himalayn Rivers, A N Khosla, 1949
8. Report of Irrigation Commission 1972
9. Report of National Commission on Agriculture, 1976
10. Central Water and Power Commission report on Hydropower potential, 1960
11. Report of Technical group of CEA 1978
12. Five year plan documents

18

HAVE WE DEVIATED FROM THE PROGRESSIVE LEARNING?

LESSONS FROM THE PAST

*Girija P Pande**

It was long acknowledged that disaster events were not the product of natural forces alone. Instead, disasters represent the juxtaposition of physical agents with vulnerable places and populations.

-Tierney, Kathleen J

Knowing why these events happen contribute to information gathering, a better perception of risk and of mitigation as well.

-Tirthankar Roy

On 16th and 17th June last year, Uttarakhand experienced one of the horrific disasters in the recent history of Himalayan region. The floods and landslides that ensued in the region have left thousands of people dead or missing and hundreds homeless. This is not the first event of this kind but certainly one of the most severe calamities in the last 200 years. The event occurred in the peak tourist and pilgrimage season at the beginning of monsoon when no one was expecting such rains. Over 60 hours of continuous rain destructed the normal life. Due to this heavy downpour and flash-flood, the town of Rāmbārā, Sonprayāg and Gaurikund washed off on the evening of 16thJune taking hundreds of lives.

According to one eye witness, who lost his entire family in this catastrophic event, on the fateful morning of 17th June at around 6.45 am the glacial water from moraine dammed lake spurted into the valley with mud and boulders and within no time it had engulfed large part of township developed around the shrine of Kedarnath. In fact the calamity was not confined to Kedarnath valley it self; it had devastated several other parts of eastern Uttarakhand, Kinnor district of Himachal Pradesh and also more than twenty districts of western Nepal. Besides Saraswāti and Mandākini, many other rivers such as Dhauli (west), Nandākini, the Bhāgirathi, Yamunā, Tauns, Pindar, Nayār, Rāmgangā (west), Rāmgangā (east), Gorigangā, Dhauli (east), Kāli (Mahākāli), Sutlej and Vaspa also turned furious due to excessive rainfall causing heavy destruction to agriculture, irrigation, drinking water schemes and many hydropower projects along their banks.

* Professor & Director, School of Social Sciences, Uttarakhand Open University, Haldwani (Distt. Nainital) 263 139

girija.pande@gmail.com

As per one estimate, more than 200 bridges and 1,636 roads were destroyed in this disaster and the region suffered a loss of property worth rupees 12,000 Crs. The alarming situation was due to the failure of system in communicating the incident to the management mechanism which came to know only after 48 hours of the calamity and ultimately turned helpless. The way the whole situation was handled, somebody idomised it as 'the disastrous management of Uttarakhand Disaster'.

Looking at the scenario it is possible to draw two lessons from the Uttarakhand Disaster. First the natural disasters not only destroy lives and property but also disturb the social rules by which societies organise themselves and the second is that we never learn from the past.

HISTORY OF DISASTERS

Himalayan history is full of disasters (Table 1 and Annexure 1). The deceased bodies noticed, in 1942, by a forest officer and later recovered from the Roopkund may be termed as first example of natural disaster in the recorded history of the Uttarakhand. These human bodies are said to be more then 700 years old. This incident is depicted, in detail, in our oral traditions and several stories. Archaeo-seismological evidences also indicate a devastating earthquake occurred in the Himalaya sometime between AD 1000 and AD 1290.

Among the historically known earthquakes, western Nepal witnessed one major event in 1255. Mugnier points out that it as a highly damaging earthquake in which one third of the population of the Kathmandu was wiped out. Destruction to the palace of Ajaya Malla, the medieval king of Nepal who was also killed during the earthquake, exemplifies the severity of damage in this disaster. Bilham's findings suggest two more devastating earthquakes of 8 & 7 M_w scale that occurred in 1505 in Lo Mustang and 1555 in Srinagar. However we do not find any other example for such calamities in the Himalayan region or in Uttarakhand for rest of the medieval period.

Table 1. Major disasters during recent history of Uttarakhand.

2001	Cloud Burst in Chamoli	21 people died
2003	Cloud burst in Sarnaul in Yamuna valley	207 animal died
	Varunavrat Parvat, Uttarkashi	Huge damage to property
2004	Badrinath landslide /flashflood	16 people killed
2005	Cloud burst in Govind Ghat	11 people died
2007	Cloud burst in Pathar Katta (Gairsan)	8 people and 19 animals died
	Landslide in Baram in Gori Valley	15 people died
2009	Munsyari-La Jhekla landslide/ flashflood	40 people died
2010	Cloud burst and landslide in Sumgarh in Kapkot	18 school children died
	Cloud burst and land slide in Devli, Balta, Pilkha villages in Almora	36 people died
	Floods in Yamuna and Kosi catchments	Loss of human lives, damage to Infrastructure & downstream flooding in plains
2012	Uttarkashi floods	39 people died
2012	Okhimath landslide	69 people died
2013	Kedarnath valley & Parts of Pithoragarh	Approx. 10,000 deaths, damage to property

Compilation from various sources.

If we leave the medieval disasters and reconstruct the chronology of the disasters in the region we find details on earthquake, outbreak of glacial lakes, landslides, and floods which had adversely affected Uttarakhand (Annexure 1). Raper in his descriptions of Garhwal mentions that Uttarkashi was badly devastated in the earthquake of 1803. The Garhwal earthquake of 1803 was a major devastating natural disaster in Uttarakhand. Records indicate that an earthquake of 8 M_w in the night of September 1, 1803 shook the whole Garhwal from Badrinath to Gangotri. Thousands of people buried in their houses within that moment. It is believed that over 50 percent of Garhwal was destroyed in this disaster. The capital town of Srinagar devastated badly while Devprayag was terribly shaken. Most of the houses were destroyed, and terrace and cupola of Raghu Nath Mandir damaged severely. The destruction was not confined to Alaknanda valley but Bhagirathi valley was also experienced same. 'The town of Barahat now known as Uttarkashi was destroyed badly. Baird-Smith and Hodgson not only provide vivid details but report intense damage including shattered condition of temples and houses from this region. Hodgson mentions that a village and fort near Uttarkashi was buried in a huge landslide. The temple of Gangotri was also damaged in this calamity. The details indicate that earthquake was severe at Srinagar, the capital and economic centre of Garhwal. The disaster was so severe that it changed the course of social life for several decades.

Nearly half a century later of this earthquake, in1857, huge landslide dammed the Mandakani forming a lake. This temporary lake broke after 3 days resulting into a flood in downstream which caused heavy damage in the Alaknanda valley. In 1868, a landslide near Jhinji village blocked the Birahi river and formed a lake. This artificial lake was called Godiyar Tal. Later, a massive rock fell into the lake driving away half of its water. This instantaneous spilling over of water resulted into flash flood in the Alaknanda valley. Since the event happened so suddenly, people downstream were caught unaware as a result 73 people were killed at Chamoli. Atkinson describes the incident as -

> 'In 1869, a landslide rolled down into Godyar Tal, a tributary of Birahi Ganga and drove out half of the lake, instantaneously causing the river to overflow and even flooding the Alaknanda so greatly as to carry away two large wooden bridges, a sweep away some 73 persons who were sleeping on its bank at Chamoli'

The Birahi watershed is considered to be one of the most fearsome region in terms of its unpredictable character. In 1893, valley once again faced the similar devastation when a massive rock slipped near Gauna village blocking the river Birahi. It created a vast lake of 270m high, 3 km wide at the base and 600m wide at the crest.

Heim & Ganseer mention that Birahi river was dammed for one year due to the land slide. They further mentioned that 'the heap of the scree material made of limestone and dolomite cover about 1.5 square kilometers and had a maximum thickness of 300 meters. They estimated volume of about 15,00,00,000 cubic meters, 4 km long lake with a maximum width of 0.07 km, and height of the rock fall (1000 to 1200m). The artificial reservoir broke on 26th August 1894 causing unprecedented damage to the village in the valley and Srinagar town, however no damage to human life was observed in this incident because of the 'advance warning system'. The water level of the Alaknanda, 130km downstream around Srinagar, raised upto 50m sweeping away the entire town. Further downstream around Haridwar the water level rose to nearly 4m. It will be appropriate to mention here that the then administration visualised the possible consequence of breaching of the dam and prepared them for the situation. Bill Tilman who is credited with the first person to climb Nanda Devi in 1935, narrates the farsightedness of the colonial administration as:

> 'Climbing up the north side of the Birehi valley we could see where the river widened out into the Gohna lake, the result of a great landslip, which occurred in 1893, damming up the Birehi until a lake of many square miles was formed. A first report from the local headman that a mountain had fallen was ignored but when Lt. Col. Pulford, R.E. superintending engineer visited the place, it was found that a succession of slips had formed a huge dam. Viewing the magnitude of the blocked river he opined that nothing would happen until the water topped the dam, which would take a year. Inspite of other experts holding contrary views, his suggestion was adopted and acted upon. An engineer was put to watch the rise of the water and a light

> telegraph line was erected for the purpose of warning the towns and villages downstream in the Ganga valley. Measuring pillars beyond which the inhabitants were warned to retreat marked out the danger limits of the expected flood. Suspension bridges were taken down and pilgrim traffic diverted to other route'.

The Alaknanda valley has history of recurring floods. In 1930, Alaknanda turned furious near Badrinath raising the water level upto 9 meters. It destroyed several houses in the Badrinath town. In 1970 the Alaknanda valley once again witnessed the natural calamity. It was the major flood disaster of the recent past in Uttarakhand whose impact was extended from Hanumanchatti and Raini in the hills to Haridwar and Pathari in down plains.

The 1880 was another fateful year that added one more chapter in the history of disaster in the Uttarakhand. Atkinson mentions that due to heavy rains causing floods, the old business town of Baramdeo in the banks of river Kali (Sharda) near Punyagiri washed off. The flood destroyed the market and police station. The same year Nainital, a popular European hill station had also faced the devastation. While the floods were the major cause of devastation in the Himalaya, the landslides were also an important factor for natural calamities in the region, e.g. landslide of 1866, 1879 and 1880 in Nainital. The landslip of 1866 got widened in 1879 at Sher ka Danda. The official communications suggest that in 1860 Mr. Garstin noticed the vulnerability of the area and marked the famous hotel Victoria unsafe. The report mentions that later the watchful eyes of Dr. Walker, a local resident also prevented the authorities to sale the land in such an unsafe zone for building purposes. H C Conybeare, in his report to the Secretary to Government, N W Provinces & Oudh narrates the disaster as:

> On the fatal 18th September a slight earthquake shook the town.... What happened in the present case was a dislocation of whole hill crust, shale and boulders together. Wet weather springs had probably sapped the foundation of that crust for years..... There is belief that at the time of catastrophe considerable percolation was taking place..... a stream hitherto unknown may now be seen trickling down the exposed face of the later. Immediately after the landslip several streams were visible. Dr Walker noticed that 'whole hill crust had sunk some 6 inches from a crack in the lofty road known as mall road'.
>
> Conybeare further mentions the eye witness account of Major Macmullen that 'a crushing and rusting sound together with some shricks appeared. I ran into the Varandah when I saw a huge mass of debris shale etc,. was rolling down like a wave on to the Assembly Room. .. I saw several people swept into the lake.
>
> Col Dalmahoy mentions that he saw a large cloud of dust just below Old Government house was emerging. In a few seconds it reached Bell's shop... which appeared to rock and collapsed. The whole mass was then driven on to the Assembly Room which simply disappeared into the lake. . I saw that there were people about both at the Victoria Hotel and down below, who had been swallowed up, but could not distinguish who they are. ...The destruction of life is a subject of that cannot be dismissed with equal brevity. The dead and missing muster 151 of whom 43 are British or Eurasian. At around the Victoria Hotel are known to have perished 30 Europeans, 4 natives 25 hotel servants who were swept away...It is lucky that most of the of Mr. Tyalor's labourers had followed Sir Henry Ramsay to the lower end of the lake. It should perhaps be added that further search for bodies in this direction is useless and even dangerous. Useless from the great depth of the deposit; dangerous because interference with the natural slop of the loose shingle might burry the searchers themselves'

The local administration did its utmost in rescuing the victims; interestingly Col Henry Ramsay was himself present at the site and was monitoring the operations. The incident forced the local administration to review the natural settings of the town and prepare a disaster management plan for the town. As a consequence a network of drainage system was developed to prevent such calamities.

Atkinson mentions that the same year due to the heavy rains the old business town of Baramdeo Mandi in the banks of river Kali (Sharda) near Punyagiri washed off. The flood destroyed the market and police station. The Kosi valley also received heavy floods causing devastation to crop along the river banks downstream Bhujan till Ramnagar. In 1904, the Himalaya witnessed another major disaster with extended impact in the mountains.

On 4th April 1904 the earthquake known as Kangra Earthquake shook Dharamshala, Mussoorie and Lahore area. The geographical journal of 1905 portrays the destruction as:

> At Lahore the cathedral was seriously damaged, as well as the Jumma Masjid, one of the finest mosques in India, and many other buildings, both public and private. Some loss of life occurred here, but this was far exceeded at Dharmsala, where both the cantonment and civil station were practically destroyed, many Europeans being among the victims. Owing to the collapse of the stone-built barracks, the Gurkha regiments, especially the 7th Gurkha, suffered terribly, no fewer than 470 in all being killed. At Kangra three European missionaries were among the victims. Other places at which damage was done were Delhi, Amritsar, DehraDun, Amballa, Shimla, and Srinagar, though at none of these was the loss of life exceptionally high.

R D Oldham in his report remarked on this disaster

> 'The focus evidently lay in the Kangra valley, or between it and the Dhaoladhar range, but, if newspaper accounts are to be trusted, the shock seems to have been more violent at Mussori than would have been anticipated, and this suggests the possibility that it originated in a movement along the great boundary fault of the Himalayas'

It is interesting to note that while the western part of the Himalaya experienced disastrous natural phenomenon, the north-eastern Himalaya was unaffected from such natural phenomenon. The history of disaster in the N E Himalaya shows that the region has also gone through devastating experience of natural calamities in 19th and 20th century. The memories of disastrous earthquake of 1897 in Uppar Assam valley still prevails in the folklore of the region. It was one of the most devastating natural calamities of 19th century which severely affected at large. Babu Abhay Shankar Guha, the Deputy Collector of Borpeta, Assam in his report mentions about the unusual phenomenon that took place in this disaster. He points out:

> 'one of the most curious phenomenon resulting from the earthquake of 12th June was the lowering of the high and raising of low places. Many localities which never used to be under water before were flooded immediately after the earthquake; on the one hand, beds of river have been raised..... He further mentions that Singra was a deep stream before the earthquake and we could not generally fathom it with the bamboo poles, about 20 feet long which we carried for pushing the boats. But after the earthquake it became so shallow that our canoes, which drew about a foot of water, grounded in several places. I observed same phenomenon in the Chaulkhoa, Mera Manas and Kailda river.

Oldham in his report gives vivid account of the disaster and mentions that

> 'at about quarter past 5 in the afternoon of 12th June 1897 there burst on the western portion of Assam an earthquake which for violence and extant, has not been surpassed by any of which we have historic record. In the hills landslip have caused a great deal of damage, granaries have been wrecked and much grain lost'.

The report mentions that in 'Sri Nadi, and Kulsi river the flood level rose upto 5 feet. The water of river Scob raised upto 200 feet near Sinya village. The earthquake also raised the river bed in several place. Oldham says that the floods of 1897 were more extensive in downstream the Brahmaputra and the flood levels rose higher than they had been known before. The affect of the flood was remarkable. The trees were uprooted and soil was washed away and inside channels the rush of the water was upstream. Interestingly it was for the first time that disaster and its aftermath were scientifically and extensively surveyed and recorded to make assessment of loss and study the natural phenomenon. Oldham also remarks on the poor state of keeping scientific data of such calamities and mentions that in India there is no regular system of recording earthquakes, such as has been established in Japan. Oldham states that 31,20,000 sq km got affected by this earthquake and buildings, palaces, bridges demolished heavily, it were those structures having traditional wooden frame remained intact in this disastrous incident. Within 53 year of the disaster of 1887 the North Eastern Himalaya once again witnessed disaster of similar nature. A Mishmi villager mentions that how the river Siyang dried up for approximately 24 hours and people ran to river bed to gather fishes. Besides the main rivers, a number of their tributaries were completely blocked for a time. River Tidding, Yepak and Sap-Chu, the tributaries of the

Lohit and many others on Dihang got blocked for at least for twenty-four hours. The description of the disaster shows that on the evening of 15 August 1950 one of the biggest earthquakes took place in south-eastern Tibet, close to the Assam. The calamity brought in incalculable damage in the mountains, but there was little and direct loss of life. However the upheaval deeply changed the nature of mighty river Brahmaputra. Interestingly since that date the Brahmaputra has overflowed its bank every year; the commercial town of Sadiya washed off completely. Today the Sadia township had shifted far from its initial location. Similarly the Dibrugarh town was severely affected in this calamity.

While discussing significance of 'History' noted historian EH Carr argued that it is a continuous dialogue between past and present. History allows us to place the present time in perspective. The history of disasters indicates that natural calamities are not new to human beings.

RECONNECTING SOCIETIES AND SOCIAL INSTITUTIONS

Horrific disasters are still engraved in the collective memories of the communities and represented in their folklore too. The socially produced perception engraved and historical variations provide us sufficient clues to understand the nature of natural calamities and their dynamism too. Pamadoran argues that the new approach to development distracted the essential part of livelihood strategies of village communities and tried to obsolete their collective experience and local knowledge. The experience of disasters in Uttarakhand has shown that we have also been ignoring such collective experiences and have not learnt from the past. In fact if we analyse the available information it appears that the impact of disaster had been massive in the past and remained similar in the present. As per UN statistic, every year two hundred million people approximately get affected by natural disasters, which is seven times higher than the people affected by war globally. In fact memory of disaster in modern society remains short lived. In regional context Bhatt points out that if we look at the human loss in Ganga Basin, between different phases of time it is clear that in 60s (1961-70) the human loss due to various natural calamities was 9,439 which increased to 25,545 between 1971-80.

Interestingly, natural disasters have been an ingrained part of Indian history; however historians for a long have paid a little attention to study such natural phenomenon. The history of calamities indicates that these catastrophic incidents were not new to human beings. For thousands of years societies faced fearful natural catastrophes and the impact of such catastrophes has been enormous in the past and which has deeply influenced the present as well.

Looking at history while one observes that the whole human history is full of descriptions of natural disasters, one also comes across fascinating examples of disaster management mechanisms of traditional societies which they adopted or evolved over time interacting with nature. The hills have been inhabited for centuries and people have lived in harmony with nature. Over the period of time they have learnt to live with a whole array of natural disasters be it earthquakes, landslides, cloud bursts, forest fires, avalanches and so on. For instance, the recurring landslide in the village of Hokara obliged the inhabitants to dedicate the surrounding forest to the deity for conservation to minimise the threat. Thus a large patch of sacred forest was developed to control the calamity. In many other high altitude villages the tradition of Shingul was developed to control landslides and protect the village from snow avalanches. The farsightedness of traditional communities may be observed in many other examples. The choice of locations in Malpa for night stay by the Shauka communities of Chaundas and Byas valleys which practice transhumance, is indicative of their understanding of the nature and vulnerability of sites as well. Another interesting example which needs mention is the site and architectural know how of Kedarnath temple. Thus the lessons here from the past are obvious.

The disaster history is not all a story of chaos; rather it is a contrivance for an effective disaster management. Roy rightly argues that history of disaster is a story of construction of more useful knowledge about the interaction between human society and natural environment. The description given above also takes us to the argument that disasters are natural phenomenon with social connotations. They are as much social texts as they are material occurrences. In other words, the calamities are physical but are socially interpreted and conceptualized, and victims perceive them accordingly.

The description illustrates that the Himalaya like other mountains is highly fragile and sensitive zone. Therefore, individual cultures living in a fragile landscape have devised particular answer to the question of prevention and reconstruction with the experience as they have confronted with recurring disasters. Societies have developed local strategies to minimise and manage its impact. However, in a globalised world with neo-liberal policies where resources and nature is seen as commodity we have underestimated and forgotten the societal capacities to cope with disasters. Donald Worster states that both economy and ideology and more specifically capitalism plays decisive role in the use of nature, which ultimately works as catalyst. Such capitalist ideologies have been driving forces for the past two centuries that had made the societies a risk taking society. Bleek rightly remarks that in recent times we have grown a tendency 'Risikogesellschaft' (risk taking). The recent disaster in Uttarakhand also wires in with above argument.

The Uttarakhand disaster brings to light the fact that the degree of devastation was not only because of natural phenomenon; it was also an outcome of clash between prevailing economics and ecology of the region. The fact is that we have not been able to maintain balance between these two in the mountains. Capra's argument gives perspective to it when he says 'nature is cyclical where as our industrial systems are linear. Our business take resources transform them and sell the products to consumers. Sustainable patterns of production and consumption need to be cyclical, imitating cyclical processes in nature. To achieve such cyclical patterns we need to fundamentally redesign our business and economy'. It appears that for the past few decades the pilgrimage has turned into product where volume is central not the salvation. Both globalisation and neoliberal economies have shaped the region and nature of pilgrimage in recent decades. Such changes have resulted into unsustainable and unwanted pressure on natural and social ecosystem causing heavy damage. In fact without understanding the dynamics of nature we have been adopting policies of unregulated exploitation of resources and encouraging unplanned and unmanaged urbanisation in one of the most sensitive and fragile zones in the high mountains. Ashish Bose observed that such imbalance in ecosystem in 'the new state of Uttaranchal will have more than its share of natural disasters if the greedy contractors and timber bandits who are in league with corrupt politicians and bureaucrats get away and fool the people in the name of development of infrastructure.' The short term economic profits have been chosen over long period of time, further our over confidence on technological advancement have also led to an increase rather than reduction of risk of disaster. The history offers us numerous examples of deliberate risk taking and its consequences. Eric Jones in his book European Miracles says that Chinese and Indian face high risk of environmentally induced natural disasters. The history of disasters may play significant and positive role in the construction of useful knowledge about interaction of societies and natural environment and also about their response and strategies to the disasters. In this sense disaster history has relevance not only to the historians but also to those engaged in disaster management. Roy states that 'we tend to belief that an adequate response to natural disaster requires a degree of preparedness and a strong state. However history shows that, preparedness and state capacity depends in the past, on how events were explained, how social cooperation formed and fell apart', and how state responded to such phenomenon. Human understanding of disasters as physical phenomenon is relatively a new area of research and in India perhaps it has not yet taken serious shape. Thus it is now a high time to learn from the past and respect the traditional wisdom and take lessons from it for mitigating the adversities of the disasters and fury of nature.

BIBILIOGRAPHY

Athavale, R N, Two Undocumented historic earthquakes and additional information on the major earthquake of 1 September 1803 from north India, Current Science, Vol 69, No 3, 10 August 1995, p 279

Aryal, Komal Raj, The History of Disaster Incidents and Impacts in Nepal 1900–2005, International Journal of Disaster Risk Science. 2012, 3 (3), pp147–154

Atkinson, E. T, The Himalayan Gazetteer, Vol. 3, Part-I, p.42

Bandyopadhyay, Jayanta, Human Footprint on the Devabhoomi, Economic and Political Weekly, Vol - XLVIII No. 28, July 13, 2013

Bhatt, Chandi Prasad, Impact of Natural Disaster on the Environment & Development: Examples from Himalaya and Eastern and Western Ghats, Science and Culture, January- February,2000, pp. 20-25.

Bhatt, Chandi Prasad, The Future of Large Projects in the Himalaya, PAHAR, Nainital, 1992

Bilham, Roger, Earthquakes in India and the Himalaya: Tectonics, geodesy and history Annals of Geophysics, Vol. 47, N. 2/3, April/June 2004

Bilham, Roger and Nicholas Ambraseys, Apparent Himalayan Slip deficit from the summation of the seismic moments for Himalayan earthquakes,1500-1555, Current Science, Vol. 88,No.10, 25 May 2005,pp 1658-63

Bose, Ashish, Are Natural Disasters Manmade? Economic and Political Weekly, Vol. 35, No. 43/44 (Oct. 21-Nov. 3, 2000), pp. 3793-3794

Capra Fritzof, The Web of Life, Harper Collins, 1997, p 291

Das, Bishnu Prasad, The devastating landslips were caused by the undercutting of fragile hillsides for highways rather than by dams, which actually helped mitigate the floods, The Hindu,

Furedi, Frank, The Changing Meaning of Disaster, Area, Vol. 39, No. 4 (Dec., 2007), pp. 482-489

Handa, O. C. and M. Jain, Art and Architecture of Uttarakhand, 2009, Pentagon Press, New Delhi.

Hawken, Paul, The Ecology of Commerce, Harper Colilins, New York, 1993, p. 220

Hodgson, J. A. Journal of a survey to the heads of the rivers, Ganges and Jumna, Asiatic Researches, 1822, Vol. 14, pp. 60–152.

Kingdon-Ward F., Aftermath of the Great Assam Earthquake of 1950, The Geographical Journal, Vol. 121, No. 3 (Sep.,1955), pp. 290-303

Letter from HC Conybeare, CS on Special Duty to Secretary to Government, NWP & Oudh, 11thOctober,1880, Nainital, NAI, Ned Delhi

Majumdar, D.N, Roopkund Rahasya (Hindi Tr.), PAHAR-18, 2013, pp 125-36

Mangelshaagen Franz, Disaster and Political Culture in Germany since 1500

Oldham RD, Report of the Great Earthquake of 12th June 1897, (Memoirs of Geological Survey of India , Vol XXIX, GSI,1898-99)

Rajendran,C.P., Rajendran Kusala, Sanwal, Jaishri and Sandiford, Mike; Archaeological and Historical Database on the Medieval Earthquakes of the Central Himalaya: Ambiguities and Inferences, Seismological Research Letters Volume 84, Number 6 November/December 2013, pp.1098- 1108

Raper, F.V., Narratives of a Survey for the Purpose of Discovering the Resources of the Ganges, Asiatic Researches, 1810, Vol.11, pp 446–563.

Roy, Tirthankar, Natural Disasters and Indian History, Oxford University Press, 2012, pp 165

The Geographical Journal, Vol XXV, January–June, 1905, London, p. 548

Tierney, Kathleen J., From the Margins to the Mainstream? Disaster Research at the Crossroads, Annual Review of Sociology, Vol. 33 (2007), pp. 503-525

Ulrich Beck, Risk Societies: Towards a New Modernity (tr.Mark Ritter), 1992, Sage Publication, London.

Ward Diane Raines, Water Wars: Drought, Flood Folly and Politics of Thrust, 2002, New York.

Annexure 1. Major events in Uttarakhand during 19th century and 20th century.

Year	Event	Impact
1803	Garhwal Earthquake	Huge damage in Srinagar
1857	Landslide	Lake was formed in Nandakani and broke causing flood in downstream
1867	Sher Ka Danda Landslide in Nainital	Loss of property, flat land emerged
1868	Landslide in Birahi catchment	Godiyar Tal was created. Dam breached later broke and loss of 73 human lives
1880	Landslide in Nainital	Caused 151 deaths
1880	Floods in Kosi,	Washed off agricultural land and crops in the valley from Bhujan to Ramngar
1893-94 1970	Gauna Landslide in Birahi river Lake breached partially Lake broke	Gauna Tal was formed Floods in Alaknanda 55 people died
1894 -95	Landslide in Mandakani near Jaggi-Bedula	Caused flood downstream
1898	land slide in Kailakhan, Nainital	
1924	Landslide in Manora	causing huge damage in and around Beer Bhatti
1935	Land slide in village Dar in Darma valley	forced people to migrate to safer places
1937	Village Garbyang started sinking	Still continuing
1951	Floods in river Nayar	Washed off Satpuli town, many people died 22 buses and and crop was devastated
1968	Landslide in Raini	Rishi Ganga was blocked. Dam breached in 1970 causing flood in downstream
1970	Floods in Syana Nala in Dubata, Dharchula	12 people died. 35 houses damages
	Floods in Kanaudia Gad	Belakuchi was washed off. 70 people died
1976	Landslide in village Baghar near Kapkot	11 people and 45 animals died
1977	Tawaghat landslide	Flashflood, 44 people died
1978	Floods and landslides in Bhagarathi ,	25 people died
1979	Okhimath landslide	39 people died
1979	Landslide in village Kontha in Mandakani valley	50 people died
1980	Landslides in Gyansun town	45 people died
1982	Karmi Landslide & Floods	33 people died
1983	Floods in Karmi Gad, Karmi	37 people and 72 animals dies, 18 water mills and 8 bridges devastated
1990	Land slide in Neelkanth (Rishikesh)	100 people died
1991	Earthquake	800 People died

1991	Floods in Devar Khadera, Panduli Pipal Hat	29 people and 28 animals died
1996	Cloud burst in village Rauntali in Pithoragarh	19 people died
1998	Okhimath landslide (Bhenti-Paundar)	69 people died
1998	Mapla Landslide & flood	261 people died
1999	Chamoli earthquake	100 people died

Compilation from various sources.

Central Himalayan environment Association (CHEA) was founded on October 2, 1981, on a day which has a special significance for India, being the birthday of the Father of the Nation, Mohandas Karamchand Gandhi. Arguably CHEA is one of the earliest societies founded in the Northern India which had Environment and Livelihood of the people of the Himalayas as its core concern.

CHEA is registered under Indian Societies Act of 1860, Foreign Contribution Regulation Act of 1976, section 12 A and 80 G of the Income Tax Act 1961.

CHEA is accredited as Scientific and Industrial Research Organisation (SIRO) by Government of India

06, Waldorf Compound,
Nainital, 263001, Uttarakhand, India
t/f. +91-5942 233099'
e. office@cheaindia.org
w. www.cheaindia.org

The "REGIONAL ECONOMIC DEVELOPMENT PROGRAMME in Uttarakhand" " is an initiative of the Federal Republic of Germany in promoting Indo-German economic cooperation by assisting a relatively backward region in India to bridge the existing economic divide between "the hills and the plains" by complementing and supporting ongoing development efforts.

The RED Programme envisages a steady flow of technical assistance from the German side which is intended to complement the Government of India's reform policies geared towards a more inclusive growth and reducing poverty by generating income and employment, particularly for the rural and marginal groups in Uttarakhand.

The Programme is anchored in the Department of Rural Development of the GOU in cooperation with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Details at http://red-uttarakhand.org/

CENTRAL
HIMALAYAN
ENVIRONMENT
ASSOCIATION

06, Waldorf Compound,
Mallital, Nainital, 263001
Uttarakhand, India
t. 91 - 05942 233099
t./f. 91 – 05942 233099
e. cheaindia@gmail.com
office@cheaindia.org