The residents of the two districts classified themselves into four categories of economic status using their own criteria: Category 1, extremely poor; Category 2, poor; Category 3, marginally poor; and Category 4, other. The numbers interviewed in each wealth category are shown in Table 3. The sources of income identified by the different wealth groups are summarized in Table 4. Of the poorest families, 86% of households in Almora and 94% in Tehri Garhwal were dependent on a combination of agriculture and labour as their main source of income, but the corresponding values in the wealthiest households were only 40% and 31%. The better-off households thus appear to be comparatively less vulnerable as they depend on more diversified sources of income such as businesses, salaries and remittances.

Information on perceptions of change was obtained from detailed interviews and larger focus group discussions. Regardless of the socio-economic status of the households, water was seen as the most important resource required in agriculture. Given that arable land, especially irrigated land, is a scarce resource in mountains, it is not surprising that in a society characterized by caste and class differentiation, the proportion of poor households with access to irrigated land was extremely low. Farmers without irrigated land depend solely on annual rains. In the past, some communities had adapted their agricultural activities to make use of the small amounts of rainfall falling in the non-monsoon months, but according to the communities, this phenomenon has now ceased almost completely. The winter precipitation is crucial for re-charging groundwater. Some springs had dried up completely, affecting the availability of water for people, livestock and irrigation. The overall rainfall was thought to have declined, but at the same time, there were more periods of high-intensity rainfall, which can lead to floods, landslides and soil erosion. This high-intensity rainfall is also associated with high surface runoff and limited infiltration of water to underground aquifers. The major observations are summarized in Table 5 and discussed in the following.

The winter precipitation has become extremely erratic and unpredictable. Some communities reported that there were no winter rains and that it now rained in March–April, when the winter crop is ready for harvest, causing the cereals to rot. Villages at high altitudes used to have moderate to heavy snowfall in December–March, with up to 1 m (several feet) of snow that would lie for a long time. Currently, it only snows for 1–2 months and with low intensity. It has not snowed in Almora for 3–4 years. Medium-altitude villages that were accustomed to moderate to low snowfall now receive very little, if any. Snowmelt used to be an important source of water for agriculture as it extends the availability of water from precipitation for long after the precipitation event.

The dry season has become longer, in line with the lack of precipitation. In 2006-07 and 2008-09, there was almost no winter rain and farmers in Uttarakhand experienced drought-like conditions. This could explain the strong perception of the communities that dry spells that usually lasted less than 2 months had now extended to more than 7 (Tehri) or 8 (Almora) months. Farmers also attributed an increase in the incidence of forest fires to the prolonged dry spells; fires are degrading the forests near villages and preventing natural regeneration by damaging the germination and growth of seedlings.

There was a significant perception that the temperature had increased with warmer summers and milder winters. People in all the communities studied felt that the warm season had been prolonged by several months and observed an overall increase in the intensity and frequency of hot days.

Impacts of change on livelihoods and community well-being

The communities ranked prolonged dry spells and increasing temperatures as having the most significant negative impact on their livelihoods. Increased attacks by insects and pests, forest

fires and landslides were identified as the major weather-induced hazards. Widespread crop damage caused by wild animals (wild boars, monkeys, porcupines and other herbivores) was also attributed to forest degradation, partly associated with changes in the climate. Positive impacts associated with changes in weather patterns included a decline in the duration and intensity of frost, reduced damage by hailstorms and, in some communities, an overall decrease in the frequency and intensity of storms.

Agriculture is dependent on a proper combination of weather and associated factors and is thus highly vulnerable to climate change—any slight change can have a severe impact on the yield of staple and cash crops. Close to 85% of the population of Uttarakhand is directly or indirectly dependent on agriculture for subsistence and income; a reduction in harvests greatly impacts the food security and the ultimate source of income of these households.

Anything affects a harvest

A lack of sufficient water immediately decreases the agricultural harvest. Similarly, the timing of rainfall is important—a delay in the monsoon forces farmers to delay the sowing of rice, especially on rain-fed fields and the yield declines considerably. Conversely, incidences of intense rainfall erode the nutritious topsoil, causing landslides that destroy farmland, block roads and thus interrupt access to markets and lead to loss of life and property. Changes in precipitation can also affect the incidence of pests. Farmers reported a significant increase in kurmula (white grub) over the past 5–7 years, which damaged major cash crops such as potatoes, other tubers, kidney beans, pulses and vegetables and reduced cash income. A lack of snow was thought to be the cause because heavy snowfall kills the eggs; warmer temperatures might also be conducive to the growth of this pest. As harvests fail, communities are becoming dependent on external markets. Previously, households could rely on two types of cereals to fulfil their basic needs for at least 11 months of the year, but now some respondents said that they only had enough food to last for 2–3 months of the year. However, this should not only be attributed to climate change. Among other reasons, high rates of male out-migration and the associated reduction in the workforce had led to widespread phenomenon of land growing fallow.

A new phenomenon observed in Uttarakhand is the double flowering of apple and Malta orange trees, leading to two harvests in a year. This adversely affected the fruit quality; fruits were smaller and less tasty (and not fit for sale). ‘Over the past few years the climate has changed drastically. There is very little snowfall and the weather has become quite warm and it seems that this is affecting the flowering pattern of apple and Malta trees here’, reasoned a villager. Horticulturalists are concerned that the double fruiting could result in crop losses and impair the overall health of the orchard as it prevents the trees from recuperating between crops and makes them weaker.

Women work more

Nearly two-thirds of the respondents (61%) thought that an increase in male migration rates was leading to increased feminization of agriculture, which was increasing women’s workloads. Around 80% believed that they have to travel longer distances to fetch fodder—the burden of fetching fuel and fodder falls solely on women. Similarly, drinking water has to be carried from the nearest springs (some of which are drying up), or someone has to wait in a queue for 2–3 h (or more) at the tap, another responsibility adding to the workload. Measures to counter the impacts of climate change—for example, repeat sowing in the event of crop failures; spreading traditional and chemical fertilizers and pesticides; and walking longer distances to fetch water and fodder—are all activities implemented by women and adding to their regular workload. The limited number of oxen available for ploughing in the

villages (and the inability to afford to rent these animals) is compelling women to use shovels to plough their fields. However, land is increasingly left uncultivated as a result of both high levels of out-migration and decreasing productivity. Changes in animal husbandry practices (moving from bigger to smaller ruminants) have reduced the time required to tend them from the previous 3–4 h to 1.5 h a day, relieving some of the workload for women.

Conversely, as household food production is becoming insufficient, more food needs to be purchased from the market and men, as the main cash income earners, are driven to seek wage labour wherever possible, adding to their workloads.

Health and nutrition suffer

The occurrence of disease and illness is perceived to have increased. Common ailments include colds, fever, jaundice, typhoid and kidney stones. Elders believe that the warmer temperature is conducive to germs. Unused to purchasing market food, communities do not trust bought grain and suspect that chemicals used in the production process could also be causing illness. The use of traditional knowledge of medicinal herbs to treat sickness is fading and the plants are also being lost as a result of forest degradation and over-exploitation. The drying up of springs adds pressure to the remaining springs and this could be leading to water pollution, explaining the increase in water-borne diseases. Women suffer the most when households lack adequate quantities of food—they consume food after serving the men and children and might have to sleep hungry. Accidents are also becoming more common as women travel farther to fetch fuel wood and fodder and have to climb steep slopes and slippery ridges.

Community-based responses to change

Mountain agriculture has traditionally been highly dynamic, with farmers continuously having to adjust to extreme environmental and climatic conditions over time. However, farmers have been unable to adjust their agricultural processes to the fast pace of change in weather patterns experienced in recent years. They are mainly adopting short-term measures to cope with climate stresses; adaptive measures are difficult to introduce in agriculture without extensive financial and physical resources.

Responses to erratic rainfall and reduced water availability

In response to erratic rainfall patterns, farmers were adjusting their agricultural calendar on a yearly basis by delaying or advancing the sowing of rice and other crops that depend on the monsoon precipitation. Winter crops such as potatoes and wheat were also planted earlier or later in some places, depending on the arrival of the winter rain. Farmers reported that in 2009-10 they had planted their winter crops up to 30 days late in expectation of rain. As a result, the harvesting of these crops also had to be delayed to allow maturing. When there was an early season crop failure because of inadequate rainfall, households that could afford a second batch of seeds either re-sowed the crop or replaced it. Rice was replaced with soybean, mustard, pulses, or madira (fodder grass); maize with soybean or vegetables; and mandua (millet) with pulses, soybean or potato.

In the past, communities in Almora had had a traditional irrigation system with water-sharing rules and regulations using *guhls* (water channels), but this mechanism had fallen out of use. Following the lack of rainfall and prolonged dry spells, this traditional rotational irrigation system has now been revived. The system fulfils everyone's needs and eliminates conflict over shared water. However, farmers situated at the end of the *ghuls*, mainly from the lowest economic strata, reported that they had to postpone sowing of rice by between 15 and 30 days while waiting for their turn for water and this adversely affected their harvest. Another

response to decreased water availability was protection of catchment areas by planting oak trees around spring catchments near villages.

Aajeevika (an IFAD-funded project) distributed improved seeds of numerous vegetables such as eggplant, tomato and capsicum, which are tolerant to water stress and germinate well, giving a high yield despite dry conditions and a lack of water. Unfortunately, other seeds provided for millets, pulses and beans gave only mediocre results. The same project also provided *Aloe vera* plants, which thrive in arid and semi-arid conditions.

Living with rising temperatures

As a result of rising temperatures, potatoes were found to mature faster and could be harvested in 3–3.5 months instead of the traditional 5–6 months. This additional time offers new opportunities to farmers and was successfully used to grow cauliflower and peas as cash crops for a higher income. Other new crops introduced included ginger and turmeric, both because they withstand water and temperature stress better and because they are popular cash crops that fetch a good price in the market. In addition, prolonged growing seasons now allow more than one crop cycle per year and rising temperatures were found to be suitable for new crops, such as groundnuts and fruits, such as mango and banana, which were described as being larger and better tasting and even fit for sale.

Combating the increased incidence of pests and disease

Traditionally, ash, cow urine and salt have been used as pesticides, but their effectiveness appears to be decreasing, as illustrated by the drastic increase in pests. Fires are lit post-harvest to kill insects and pests but can also kill earthworms and other micro-organisms beneficial to the soil. 'Earlier, traditional methods of pest control like spraying of salt or ash were effective in controlling the pests, but now, because of the increase in pest infestation, these methods have become ineffective', said Ram Singh, from Gud Gadoli village, in Almora. Chemical pesticides have been more effective in reducing crop pests and damage, but according to the farmers, their effectiveness is also reduced after 2–3 years of use. Uttarakhand Parvatiya Aajeevika Sanvardhan Company (UPASaC), created to implement Aajeevika, is providing ingeniously designed traps that have been used successfully to attract and kill kurmula (white grub).

Dealing with environmental and socio-economic change

Corn husks and leaves are being used as alternative fuels to reduce the hard work of collecting fuel wood as this resource becomes increasingly scarce. Farmers reported that medicinal plants were also rarer, possibly as a result of a combination of over-exploitation and forest degradation and thus people have become more dependent on more costly Western medicine.

Changes in livestock composition had also been made in order to cope with fodder and water scarcity and the reduced workforce resulting from the high levels of out-migration. Households were reducing the number of large ruminants and focusing on rearing goats, which require less labour, fodder and stall-feeding. Goats also have more than one offspring per litter and offer increased gains for farmers. When agricultural yields were insufficient for household needs, small/marginal farmers traditionally supplemented their incomes through wage labour on other farms or by rearing other people's livestock. With decreasing agricultural productivity, the number of people in search of wage labour is increasing, while the demand for wage labour has fallen and farmers have to look for work in nearby markets or towns. Decreasing agricultural productivity is also an important push factor for seasonal and rural/urban migration. At the same time, the tourist season appears to have lengthened with the lengthening of the summer in the Uttarakhand mountain areas, providing more

income-generating opportunities. Young people in particular are shifting to non-farm activities—running roadside eateries near tourist circuits, taxi driving and running other small businesses—disillusioned by agriculture and attaching little value to it. This phenomenon appears to be mainly due to changes in norms and values, but climate change is an aggravating factor.

Differences in vulnerability and adaptive capacity

Socio-economic and socio-political factors also play a role, in addition to the geo-physical environment, in determining the vulnerability and adaptive capacity of communities. The poorest households' excessive dependence on agriculture pre-determines their vulnerability. Literacy and an educational background are also crucial in seeking other professions or income opportunities in the endeavour to adapt to changing conditions. Among the four income categories, only 35% of the respondents in the extremely poor category were literate, compared with 51% in the wealthiest category. Wage labour was seen as the only livelihood option apart from agriculture for the non-literate. The relationship between poverty and literacy is a vicious cycle: Poor households do not have access to higher education or vocational training (or even basic education in some cases) since they cannot pay the costs, whereas the wealthy can afford to send their children to nearby towns or cities for higher education. In addition, the poorest households had the fewest migrants and thus the least access to financial remittances as well as to new skills, knowledge and other strategies for improving well-being.

The low incomes of the poor also resulted in low savings. In Tehri Garhwal, the average monthly income of people in Category 1, the poorest, was ₹969 (approximately $20) compared with ₹13,000 (around $265) for those in Category 4, the wealthiest. With this income, it is difficult to even meet daily requirements and savings are practically non-existent. The lack of financial capital also makes it difficult for the poorest to diversify their livelihoods, for example by setting up a small business. Poor farmers do not have enough collateral for a bank loan and farmers are anyway hesitant to apply for loans because of the volatility of their income. The main asset base was landholdings and these were small and unviable for both Category 1 and Category 2 respondents. Households in Category 1 had average landholdings of 0.13 ha, of which only 0.005 ha was irrigated. In terms of their adaptive capacity, the poorest were unable to risk diversifying crops, for example by growing cash crops instead of staples, for fear that they would lose their food security and they also could not afford some of the coping strategies. For example, a second batch of seeds was too expensive for repeat sowing.

Socially discriminated groups such as women and Dalits (the lowest caste group, previously considered untouchable) are more vulnerable to the impacts of climate change. Patriarchy is still widespread and women are economically poorer and also have limited access to resources. Within households, in terms of nutrition, women are the last to eat and the first to be affected by a food deficiency; they have greater responsibility for activities such as fetching fodder, fuel and drinking water and are also more prone to accidents when involved in these activities. Coping strategies require labour that is usually provided by women—repeat sowing, spreading pesticides and fertilizers and ploughing with shovels. The Dalit groups have smaller landholdings and are dependent on wage labour in other people's fields. Thus they suffer the most as agricultural productivity, the main source of income, declines.

The lack of access of the rural poor to markets and institutions is a major constraint in tackling the impacts of climate change. Health centres and veterinary hospitals were on average 15 km away, agriculture and allied departments more than 35 km away. As a resident of Bageshwar said, 'It takes one full day to go to the government offices and get home, so we

approach them very rarely'. Many villages are not connected by motorable roads and others do not have regular transport facilities, further limiting accessibility. Thus access to social safety nets, another key determinant of adaptive capacity, is also limited, particularly for more remote communities and marginalized groups.

Institutional opportunities and constraints

Institutions can be crucial in determining and influencing the adaptive capacity of any group, particularly by structuring impacts and vulnerability, mediating between individual and collective responses to climate impacts and thereby shaping outcomes of adaptation and delivering external resources to communities in order to facilitate adaptation. Some of the more important formal and informal institutions active in the study area are listed below together with the associated opportunities and constraints.

Traditional institutions (formal and informal)

Traditional water harvesting systems—In Almora, indigenous water harvesting systems were set up to counter the frequent water shortages and make use of the high surface runoff in the hills. Some of these traditional structures are still in use today, but many are on the verge of decline. Revitalizing these structures and combining their use with the traditional institutional mechanisms for water sharing could be an important way of adapting to increasing water stress of the type faced by the communities in the years preceding this study.

Van panchayats—Van panchayats are autonomous democratic local institutions characteristic of Uttarakhand. They are an institutionalized form of resource management through state community partnerships that regulate the utilization and protection of forests and forest products. Each van panchayat functions according to specific rules and regulations, which are based upon the traditional knowledge of the communities. Strengthening the existing 12,000 or so van panchayats in Uttarakhand and increasing their awareness of climate change related risks could be an effective strategy for guaranteeing the sustainable use of forest products and forest regeneration, as well as for sustainable water management.

Formal institutions

Gram panchayats—The gram panchayat, headed by a gram pradhan, is the lowest rung of the three-tiered local self-governance system. The gram panchayat oversees a cluster of 3–4 villages. It channels government funds for small-scale development and is responsible for the public distribution system (PDS) as well as for issuing the 'below poverty line' (BPL) cards, which determine subsidized rations and work allowances under the Mahatma Gandhi National Rural Employment Guarantee Act (NREGA). Unfortunately, the lack of transparency in the use of these funds and corruption in the issuance of BPL cards has damaged the credibility of these institutions and limits their effectiveness in assisting the coping and adaptive strategies of the most disadvantaged.

Fair price shops—The government ensures the supply of essential commodities under the PDS through networks of fair price shops that ensure affordable prices. With the shortfall in household food production and the need to purchase food, fair price shops have an important role to play in food security protection, but they need to enhance the quantity and quality and ensure a regular supply of food products.

Agriculture and other departments—The state departments for agriculture, fisheries, animal husbandry and horticulture were set up to provide agricultural extension services. Unfortunately, the officials in these departments lack awareness of climate change and believe that 'there is no need to worry unnecessarily', which was reflected in the complete lack of funds for climate change awareness or adaptation programmes and limits their role in

assisting rural farmers with tackling the impacts of climate change. These departments are perceived by the communities to be poorly managed and to distribute untimely and inadequate outreach services. Making these departments aware of the challenges that rural communities are already facing, partly as a result of climate change, strengthening their human and financial resources and ensuring transparency will be very important.

Revenue Department—Some compensation for crop damage due to drought was provided by the state through the Revenue Department, but communities claimed that the compensation provided was insufficient and distributed inequitably. Introduction of crop insurance is one way of strengthening the social safety net for rural communities and could be another important step in enhancing the resilience of the rural poor.

Conclusions

Poor farmers do not only face rapidly changing socio-economic conditions, they have also been coping to the best of their ability and resources with water and temperature stresses resulting from climate variability and change. These stresses are expected to continue and increase and the constant coping will have consequences, eventually depleting the asset base of the rural communities if new measures are not taken. Young people are already disillusioned and most try to leave if they can. The trend of seeing agriculture as an unviable livelihood option and leaving has implications for households and food security. Assisting farmers with adding value and productivity to agriculture will be of the utmost importance, for example, through the development of value chains for high-value products. But other livelihood options and associated human capital development will also have to be promoted by involving actors from the state government, local institutions, NGOs and primarily the stakeholders. Persistent poverty and social inequality need to be addressed, in particular supporting women and members of the lower castes.

Gender and Uttarakhand SAPCC—Inputs from Alternative Futures, in partnership with CBGA and CHEA

Inputs from the Workshop of November 2012

Background and Context[52]

The National Context

The National Action Plan on Climate Change (NAPCC) clearly states that '*the impacts of climate change could prove particularly severe for women. With climate change, there would be increasing scarcity of water, reduction in yields of forest biomass and increased risks to human health with children, women and the elderly in a household becoming the most vulnerable. With the possibility of decline in availability of foodgrains, the threat of malnutrition may also increase. All these would add to deprivations that women already encounter and so in each of the adaptation programme, special attention should be paid to the aspects of gender'.*

[52] The format follows the structure of the UAPCC June 2012 and these paragraphs/bullets can be inserted within the sections.

UAPCC Revision Process: First Ever Meet on Gender and SAPCC

The country's first ever inter-departmental Roundtable on mainstreaming gender in a State-level Action Plan on Climate Change (SAPCC) was hosted by the Uttarakhand Forest Department, the nodal departments for the Uttarakhand SAPCC (UAPCC), in collaboration with the Centre for Public Policy, Doon University; and supported by Alternative Futures, a Delhi-based development and policy research organization and Central Himalayan Environment Association (CHEA), a Nainital-based grassroots development organization. The invitation from Mr Jai Raj, Additional Principal Chief Conservator of Forests (APCCF), the nodal officer for the UAPCC, signalled the importance of integrating gender concerns in the UAPCC for all relevant departments.

The day-long Roundtable, inaugurated by Prof. V K Jain, Vice-chancellor, Doon University and chaired by Dr R S Tolia, former Chief Secretary and Chair, School of Public Policy at Doon University, was held at the university campus on 27 November 2012.

Section 3 - Overarching State Framework

(c)

Section 4 – Sectoral Implementation Approaches

[Note: This section requires a strong gender analysis in each of the elements.]

Section 5 – Agriculture

Section 5.5 – Issues, Challenges and Priorities
Section 5.5.1

Section 5.5.2

Under *Economic Security of Farmers*

- Institutional and policy reform as part of the State responsibility towards gender equality by promoting ownership of land by women farmers through *joint pattas* or as single owners.

6 – Forests and Biodiversity

Section 6.3 – Issues, Challenges and Priorities

- The upward shift of the tree line and plants will have severe repercussions on poor people's livelihoods, especially increasing the burden of women who are responsible for fetching fodder and firewood, access edible parts of plants to augment their food security and gather non-timber forest products for a livelihood.

Section 6.4 – Relevant Existing Initiatives

The Van Panchayats and the Gram Panchayats are two pillars of power that are often in conflict with each other. There is a need to address how the two institutions can work together and yet maintain

their core competence, perhaps by including management of forests as part of the village plan to be co-signed by heads of both the institutions.

There is also a need to converge schemes like MGNREGA, watershed development and forest management under Van Panchayat to address the multiple needs of ensuring adequate water-table for forests to rejuvenate and employment of people to do this task.

(Narrative on the presentations)

Addressing climate change is a great challenge for developing States like Uttarakhand where a large section of the population depends upon climate-sensitive sectors like agriculture and forestry for its livelihoods. Women are hit hardest by climate change because they are more vulnerable and have fewer means to be able to adapt to the adverse effects of climate change. Government's policies and programmes have to be gender-responsive and significant financial resources will be required to adapt to the adverse effects and reduce the impacts of climate change. The government has to play a major role to make its programmes and schemes gender-just and to finance the adaptation policy so that benefits flow to vulnerable women.

As climate change is not gender-neutral, hence adaptation policies and the budget should address gender-based disadvantages.

Policies and programmes affect men and women differently

Government policies, programmes and schemes affect men and women differently though this may be unintentional. This is because of the existing gender gap where women have fewer entitlements and face greater socio-economic barriers. Thus, programmes and schemes may be **'gender-blind'** where these do not at all take into account the gender differences and are often implicitly male biased. For example, introducing flexibility in the timings of agricultural extension work can ensure that extension services can start later in the day to reach out to women in late evenings when the women have time after attending to the farm and home. A national private financial institution working on micro-credit with women SHGs has ensured that local bank officials keep flexible timings so that they are available during the hours that work for women.

'Gender-neutral' programmes often reinforce gender inequalities. For example, the failure of the *Kisan* Credit Cards is largely due to the fact that they take into cognisance only land as an asset and majority of land-owners are male farmers. Women's productive 'assets' like livestock, her labour or peer women farmers' group are not recognized as valid collaterals for the KCCs. **'Gender-sensitive'** programmes transform gender relations to promote gender equality. The Van Panchayats or the ATMA programme are good examples of including women in decision-making structures but implementation of these in a gender-sensitive manner requires attention to details such as mandating inclusion of women members to complete the quorum of a meeting; promoting and training women farmers groups to participate fully in ATMA institutions; and recognising women farmers' groups as peer-certified entities to receive benefits from agriculture-related programmes even where these women farmers are tillers on farms that belong to outsiders. Gender-budgeting is also a gender-sensitive initiative of the GoI and the Uttarakhand government.

'Gender-transformative' initiatives promote structural and sustainable changes in gender relations. The 50% reservation for women in Uttarakhand PRIs is a good example but this needs to be supported by simultaneous work on empowering both women leaders and men to share power on

more a more equal footing. And **'gender-just'** programmes and schemes are those where men and women gain equally from the interventions.

The matrix below gives some examples of how to make some of the adaptation interventions more gender-transformative or gender-just:

Adaptive interventions	Gender analysis	What government/applied climate research can do
Organic farming	♦ More food security for both women and men ♦ More labour and time invested by women ♦ Less information/knowledge/inputs accessed by women ♦ Less participation in decision making bodies	♦ Promote vermi-composting as a women's enterprise so women have a choice to make or buy ♦ Provide organic manure through women's groups ♦ Provide weather-related information (over mobile phones) to women farmers/groups ♦ Provide rain gauges with women
Rain-water harvesting	♦ Benefits women more	♦ Promote because it also gives water for kitchen gardens + animals and household consumption
Mixed cropping/agro-forestry	♦ Food security for both women and men ♦ Women gain by food variety/nutrition ♦ Women invest more labour, time	♦ Promote joint pattas ♦ Provide seeds/manure for kitchen gardens ♦ Promote simple labour saving technologies
Adaptive Interventions	♦ Gender Analysis	♦ What government/applied climate research can do
Agriculture tools – SHG-run a village resource centre	♦ Benefits both in food production. ♦ Empowers women [untimely rains so use of pump sets]	♦ Women groups to be given tools by Panchayats/blocks
Promoting millets	♦ Benefits food security for both women and men ♦ Promotes women's traditional knowledge	♦ Panchayat to give seeds/inputs/training to women ♦ Women as trainers as part of extension programme
Seed banks/ grain banks/ fodder banks	♦ Resilience for both women & men ♦ Empowers women	♦ Mandatory in every panchayat through women's groups

Study of adaptation budget and adaptation-related gender-budgeting in Uttarakhand

Adaptation is loosely defined here as all those measures that increase the resilience of the people and the state to the inevitable impacts of climate change. These measures might be special schemes for

climate change or they may be other developmental schemes and programmes of the state that would increase the capabilities of the system and people (poverty alleviation, employment, education, nutrition etc.) to deal with the impacts. Thus, vide this loose definition, almost all the development expenditure of the government is termed as its adaptation expenditure. This would be in the nature of climate-resilient benefits from developmental programmes and thus their contribution to increasing adaptive capacities.

This in-depth analysis of the schemes that make up the adaptation strategies of the state government identified both state-level and central-level schemes under the following adaptation-oriented categories: (i) Poverty Alleviation, livelihood and food security, (ii) Land development, drought-proofing, irrigation and flood control, (iii) Agriculture and allied activities, (iv) Forestry, biodiversity and wildlife conservation, (v) Water resources and (vi) Disaster management.

Table 1 shows that out of the six areas identified, except for disaster management, all the other sectors have shown significant budgetary improvement over the last 2 years. The total adaptation expenditure in the state has been steadily increasing over the years from 1.52 % of GSDP in 2009-10 to 2.54% of GSDP in 2011-12 BE.

Figure 1 shows the sectoral distribution of this adaptation budget. Components such as poverty alleviation, livelihood and food security, land development and agriculture and allied services together constitute nearly 71.57% of the total adaptation expenditure. Climate-sensitive sectors such as forestry and wild life, water resources and disaster management have been given low priority and risk financing has been given the least priority in 2011-12. Forestry, biodiversity, wildlife conservation, disaster management and risk financing together constitute about 30% of overall adaptation budget in Uttarakhand. Out of 11.69% of total budgeted expenditure for adaptation in 2011-12, disaster management constitutes only 0.02% of GSDP, a very insignificant budget to meet climate change–related disaster predictions in Uttarakhand. This asymmetrical allocation will pose difficulties in making the State's developmental planning climate resilient.

Gender Budgeting

Given that the effects of climate change are not gender neutral and its impacts would be disproportionately borne by women, there is a need to engender both our adaptation strategies for climate change and our adaptation budgets. Budgets should address gender-based disadvantages to make the State climate-resilient.

The National Mission for the Empowerment of Women 2010 defines gender budgeting (GB) as 'a process that entails incorporating a gender perspective at all levels and stages of the budgetary process—planning/policy/ programme formulation, assessment of needs of target groups, allocation of resources, implementation, impact assessment and prioritization of resources'. India is one of the first countries to institutionalize gender budgeting within the Ministry of Finance, while following the budgetary accounting framework and analysing the possibilities of changes in the budgetary classification. India integrates gender budgeting in its mainstream budgets.

The 12th Five Year Plan notes that 'the scope of the GB Statement must be expanded to cover all Union Ministries and Departments by making it mandatory for all to report under the same'. The Budget Circular for Union Government for 2013/14 observes that for Statement No. 20 on gender budgeting in Expenditure Budget Vol.1, 'all Ministries and Departments are required to carefully

scrutinize their Detailed Demands for Grants and identify such programmes/schemes as fulfil the above objectives, along with their budgeted provisions for inclusion in the above Statement. Information in the format of the statement (Statement No. 20, Expenditure Budget Vol. 1) may be sent in two parts, Part "A" reflecting 100% provisions and Part "B" reflecting the specified percentage provisions for pro-women allocations respectively'. In the Union Budget, the GBS covers 33 Demands for Grants under 27 ministries/departments.

Gender budgeting in the Union Govt. is not only confined to conventionally perceived 'women-related' sectors but is also extended to other areas like science and technology, biotechnology, industrial policy and promotion.

Gender-budgeting in Uttarakhand

Gender budgeting exercise was introduced in Uttarakhand in 2007-08 in 18 Departments which reported budgets of ₹330.38 crore. The amounts being reported in the GBS have gone up substantially since then and in 2012-13, 29 departments reported an allocation of ₹2227.67 crore. The reporting structure in GBS in Uttarakhand follows the same format as that given at the Union level and is reported in two parts: Part '1' reflects 100% provisions for women and Part '2' reflects the specified percentage provisions of pro-women allocations (provisions >30%). The line departments propose allocations under GBS and the Department of Finance compiles the final statement.

The Uttarakhand GBS (2011) in its introduction notes that the exercise should go beyond the traditional departments of health, education and women empowerment and be extended to other mainstream departments as well. Yet the GBS for 2012-13 has only conventional departments reporting under it.

On the basis of the assumptions followed for computing the Adaptation expenditure, a similar exercise was carried out in this study to compute the adaptation expenditure flowing through the budgets to the women in the State. Table 2 shows the allocations computed under the various departments in the GBS.

Way Forward in climate-responsive GBS in Uttarakhand

- Changing GB from being an ex-post exercise to influencing the process of budget formulation and including the assumptions underlying the reporting in the GBS; attachment of explanatory memorandum that explains its inclusion in the budget document.
- Including all pro-women schemes reported in the Annual Plan of the State in the GBS (e.g. Human Resource Development Department activities, training for women under sericulture, assistance to stabilization and training for women under Cooperation, etc.)
- Generating gender-disaggregated data on beneficiaries of government programmes/schemes.
- Ensuring that budgetary allocations correspond to the proportion of women working in each sector.
- Undertaking benefit-incidence analysis in programmes/schemes reaching out to women.
- Orienting budgetary allocations towards women-specific concern areas like reduction of drudgery, especially in the wake of climate change.
- Introducing gender-responsive interventions, with requisite allocations, in the *indivisible* sectors such as water, sanitation, road transport, energy and tourism so that the benefits flow to women.

- Improving the gender-responsiveness of programmes and schemes in the *divisible* sectors—like how the basic design of a scheme can be made more gender responsive and how the operational guidelines and financial norms of a scheme can be made more gender responsive.
- Enabling convergence across departments in planning and budgeting from a gender lens.
- Ensuring that all departments report under the GBS through proper guidelines.

Table 1: Adaptation expenditure in Uttarakhand

Key adaptation sectors	2009-10 (As % of TBE)	2010-11 (As % of TBE)	2011-12 (As % of TBE)
Poverty alleviation, livelihood and food security	2.59	3.99	3.84
Land development, drought proofing, irrigation and flood control	2.36	3.14	3.42
Agriculture and allied activities	0.66	0.75	1.35
Forestry, bio-diversity, wildlife conservation	0.48	0.51	0.63
Water resources	0.94	0.80	2.38
Disaster management	0.03	0.10	0.02
Risk financing	0.03	0.05	0.05
As % of TBE	7.09	9.35	11.69
As % of GSDP (current prices)	1.52	1.82	2.54

Figure- 1 Share of various sectors in adaptation expenditure

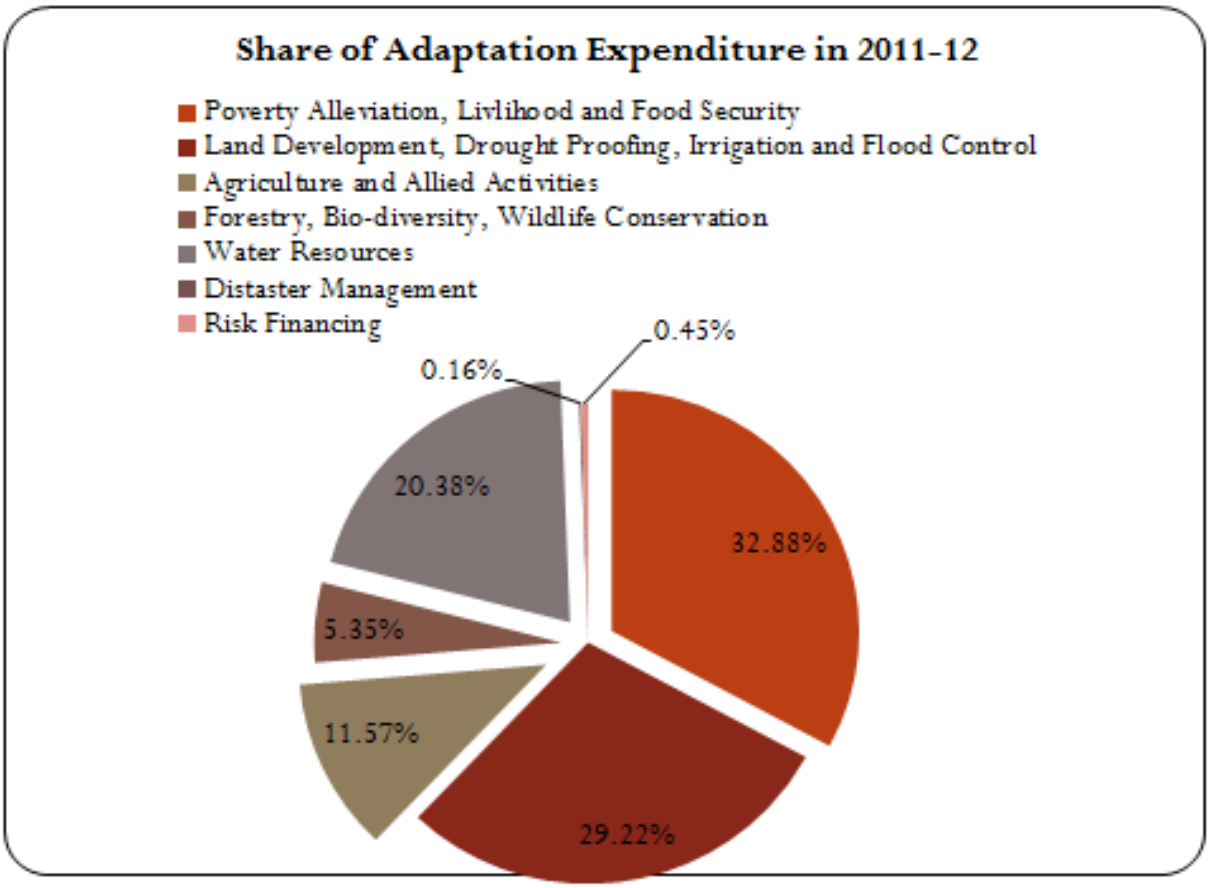

Table 2. Gender budgeting in key adaptation sector in 2012-13 for Uttarakhand (₹ in crores)							
	Part 1			Part 2			Total Part 1 + Part 2 Expenditure
	Plan	Non Plan	Total	Plan	Non Plan	Total	
Agriculture	0.0	0.0	0.0	10.6	0.0	10.6	10.6
Watershed management	0.0	0.0	0.0	12.9	0.0	12.9	12.9
Rural development	0.0	0.0	0.0	42.4	0.0	42.4	42.4
Food	0.7	0.0	0.7	0.0	175.0	175.0	175.7
Forestry	0.6	0.0	0.6	0.7	0.0	0.7	1.2
Dairy development	1.8	0.0	1.8	0.4	0.0	0.4	2.3
Animal husbandry	0.0	0.0	0.0		0.0		0.4
Horticulture	0.0	0.0	0.0	2.5	0.0	2.5	2.5
Sericulture	0.0	0.0	0.0	0.6	0.0	0.6	0.6

Table 3. Integrating gender into the budget process/budget cycle

State of budget process	Potential opportunities
Budget preparation	1. Gender-specific budget **initiatives** set forth in the budget policy. 2. Gender policies incorporated into overall budget **guidelines and instructions** from the central budget office. 3. Gender-specific **priorities** set for budget allocations within departments for specific agencies.
Budget approval	1. Creation of specific gender guidelines for expenditure and revenue **legislation** in the overall framework for legislative decision-making. 2. Integration of gender-specific **language** in legislation establishing new programs and agencies. 3. Use of gender-responsive budgeting **guidelines** in allocating discretionary **resources.** 4. Incorporation of gender **outcomes into fiscal notes** accompanying new spending and revenue legislation.
Budget execution	1. Creation of **guidelines for spending** where there is discretion given to departments by legislative bodies. 2. Development of gender **guidelines for outsourcing, procurement and grant disbursement.** 3. Implementation of gender goals in **staffing.**
Audit and evaluation	1. Incorporation of a gender dimension into **financial audits** that focus on expenditures and compliance. 2. Incorporation of a gender dimension into **performance audits** that focus on outputs and outcomes. 3. **Audit for compliance** with gender goals and guidelines.

Source: National Mission for Empowerment of Women, at
http://www.nmew.gov.in/index1.php?lang=1&level=0&linkid=28&lid=94&ltypeid=2&domid=4

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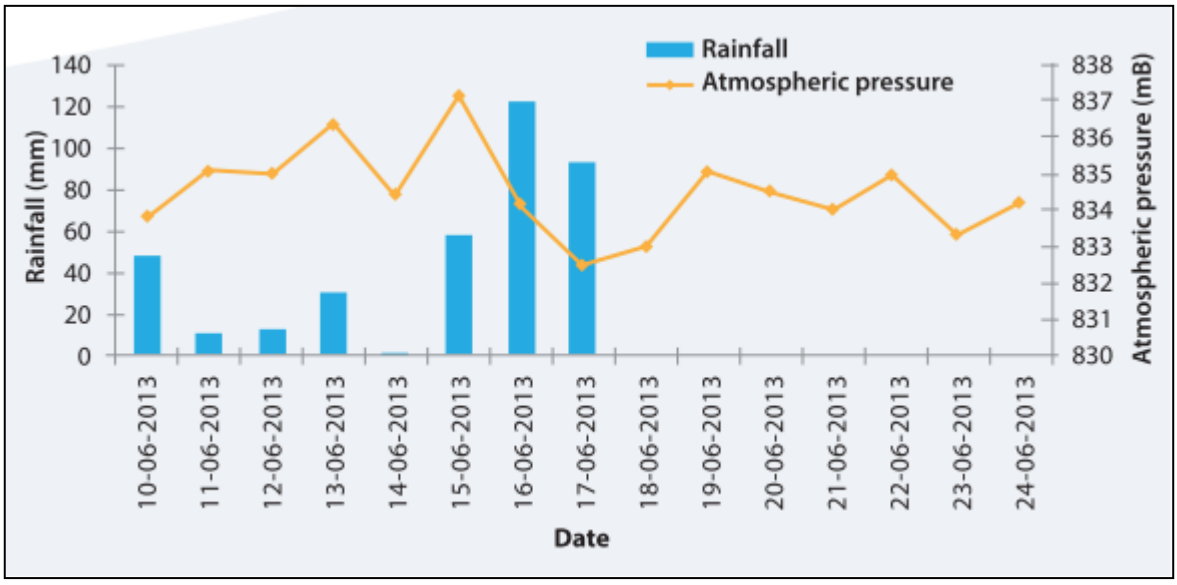
Annexure 3 — Brief Notes on Uttarakhand Flood Disaster 2013[53]

During the month of June, 2013, cloud bursts and heavy (64.5 - 124.4 mm) to very heavy (124.5 – 244.4 mm) rainfall hit several parts of the higher reaches within Uttarakhand. This unprecedented rainfall resulted in a sudden increase in water levels giving rise to flash floods in the Mandakini, Alakananda, Bhagirathi and other river basins and also caused extensive river bed and toe erosion and landslides at various locations. The worst impact happened in the Mandakini river valley around the Kedarnath shrine region (Rudraprayag district) and its downstream areas. Rock falls resulted in the partial blockade and impoundment on the river channel to the left of Kedarnath. Adding to this, continuous rains and melting of the Chorabari glacier (that feeds the Gandhi Sarovar Lake or Chorbari Lake) caused waters in the Chorabari Lake to rise. The lake's weak moraine barrier gave way and a huge volume of water along with large glacial boulders came down the channel to the east, devastating Kedarnath town, Rambara, Gaurikund and other places in its wake.

The heavy rainfall across the upper reaches of the Himalayan terrain spread through Yamunotri, Gangotri, Badrinath, Hemkund Sahib and other mountains along the Kailash Mansarovar route. The districts of Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi were among those most affected by this disaster. The flooded rivers reaching downstream carrying heavy amount of debris and sediment caused further devastation in the lower districts, though to a lesser extent, when compared to the higher Himalayan districts of Uttarakhand.

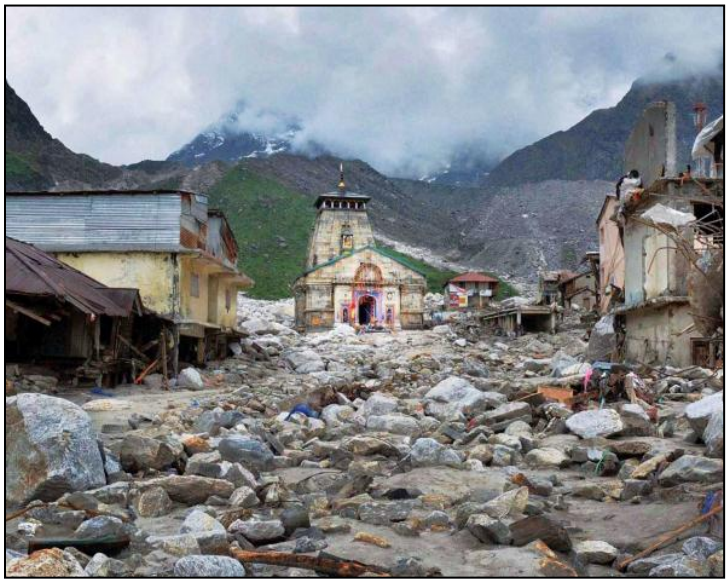
Figure: Rainfall and atmospheric pressure recorded at Kopardhar Observatory
(Near Ghuttu (WIHG) that is approximately 38 km (aerial distance) from Kedarnath)



[53] Sourced from "India Uttarakhand Disaster June 2013: Joint Rapid Damage and Needs Assessment"

This event coincided with the peak tourist and pilgrimage season within the state, thus significantly increasing the number of causalities, missing and affected populace, thereby compounding the impact of the disaster. The continuous rain disrupted normal life resulting in a total of 580 human lives being lost, over 5400 persons missing and left over 70,000 tourists and 100,000 local inhabitants stranded in the upper reaches of the mountain terrain.

In addition, the disaster has not only led to damages of physical infrastructure in the state, but has also resulted in damage and loss to natural infrastructure including forests and the associated Non Timber Forest Product (NTFP). Such losses, in the short term, has affected the resilience of people to manage their daily needs of cooking, heating and lighting and in the medium to long term will impact the livelihood of those that depend on those resources, particularly on the pilgrim circuit.



The Joint Rapid Damage Needs and Assessment (JRDNA)

The JRDNA report was a joint collaborative effort of the Government of Uttarakhand (GoUK), the World Bank (WB) and the Asian Development Bank (ADB) in response to a request from GoUK and the Government of India (GoI). The mission team, in partnership with GoUK, comprised of experts from different sectors in order to be able to produce a multi-sectoral assessment of the damages and needs. A sector-by-sector analysis of the damage was undertaken, utilizing specific templates for information recording and gathering in order to ensure consistency of information, non-duplication and comparability of the data. The total cost of reconstruction and repair due to losses in the Forests and Biodiversity Sector has been estimated to be about ₹ 54.2 crores.

While the main focus of the assessment was to estimate the damages to physical assets and the corresponding needs, this rapid assessment has been broadly based on the Damage and Loss Assessment (DaLA) methodology developed by the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC) and further updated and expanded by the World Bank's GFDRR. It provides a preliminary estimate of the total cost of damages and identifies the needs for reconstruction. It is envisaged that detailed sectoral analyses would inform project design and implementation for the reconstruction activities to be undertaken.

Reconstruction Measures

Following are the reconstruction measures that are being taken. The main support is being provided through the following agencies: NDRF, CSS, WB, ADB and ACA/SPA:

Uttarakhand Disaster Recovery Project (World Bank Assisted)
Based on the findings from the JRDNA, The Uttarakhand Disaster Recovery Project (UDRP) through the Government of Uttarakhand was launched. The objective of UDRP is to restore housing, rural connectivity and build resilience of communities in Uttarakhand and increase the technical capacity of the state entities to respond promptly and effectively to an eligible crisis or emergency.

There are six components to the project, the first component being resilient infrastructure reconstruction. The objective of this component is to focus on the immediate needs of reconstruction of damaged houses and public buildings. The aim is to reduce the vulnerability of the affected population and restore access to the basic services of governance. The second component is the rural road connectivity. The objective of this component is to restore the connectivity lost due to the disaster through the reconstruction of damaged roads and bridges including: village roads, Other District Roads (ODRs), bridle roads and bridle bridges. The third component is the technical assistance and capacity building for disaster risk management. The objective of this component is to enhance the capabilities of government entities and others in risk mitigation and response. The fourth component is the financing disaster response expenses. This component will support the financing of eligible expenses already incurred by the state during the immediate post-disaster response period. The fifth component is the implementation support. This component will support the incremental operating costs of the project, including the operation of the Project Management Unit (PMU) and the respective Project Implementation Units (PIUs). Finally, the sixth component is the contingency emergency response. The total Project Cost is estimated to be worth US $250.00 million. The Core Committee, the High Powered Committee, the PMU and the PIU have already been set up and tenders have been floated for reconstruction projects (roads, buildings etc.)

Uttarakhand Emergency Assistance Project (ADB Assisted)
The Uttarakhand Emergency Assistance Project has been launched, through the State Disaster Management Authority (SDMA), to assist the Government of Uttarakhand (GoUK) to meet reconstruction needs due to disaster in Uttarakhand in June 2013 that severely affected several parts of Uttarakhand. The project is estimated to cost US $205.00 million. The impact of the project is improved economic and social condition in Uttarakhand after 2013 disaster. The outcome of the project is to restore basic public and social infrastructure, improve disaster preparedness, project management and institutional effectiveness. The design and construction standards for the physical infrastructure will be raised to an appropriate level and the focus will be to build back the same or better. The revised high flood levels of the rivers, natural streams and drainage channels will also be considered, while designing facilities, Geotechnical studies will be undertaken and slope stabilization measures considered for slide zones, wherever applicable

National and International Coordination[54]

DMMC has effective working linkages with National Institute of Disaster Management (NIDM), New Delhi. DMMC is also closely linked with several other ATIs, Research Institutes, Universities, organizations, NGOs, experts of Uttarakhand and other states and shares data/information with them. Disaster Mitigation and Management Centre (DMMC) has also completed ADB sponsored Technical Assistance on 'Strengthening of Disaster Management Strategies' for Uttarakhand and Disaster Risk Management Programme of the Government of India and United Nations Development Program (UNDP). UNDP in Uttarakhand is also supporting the state in building institutional mechanism for streamlining interventions in disaster risk reduction and climate change adaptation.

GIS Database

Database on the various critical infrastructures is an important resource for quick decision making so as to better manage the disaster situation. DMMC has prepared a detailed database of all critical resources for the entire state of Uttarakhand under the Geographic Information System (GIS) environment. DMMC is utilising the satellite data for preparing input theme maps into the GIS environment.

Layers for drainage, habitation, roads, irrigation, health infrastructure, police and revenue police infrastructure, wireless communication facilities and FCI Godowns are presently available with DMMC for the entire state. Besides the disaster management works this database is also being utilised by different departments for their planning and resource mobilisation related needs.

Documentation

DMMC prepares detailed reports of the various disasters and these are being utilised for experience sharing, seeking information regarding the particular event as also database creation. The DMMC has also got a video film by TIFAC on earthquakes (Surviving Nature's Fury) dubbed into Hindi. DMMC has prepared the following video films on disasters as also for mass awareness: Surkshi Jeevan Ki Or Pratyaksh Hi Praman Budhakedar Landslide Tragedy of 2002 Khetgaon Landslide Tragedy of 2002

Communication

Effective communication is a must for effective management of the disaster situation and therefore DMMC is emphasizing upon strengthening normal communication network as also erecting alternative backup communication infrastructure DMMC has police wireless connectivity at State Emergency Operation Centre, videoconferencing facility with all the 13 districts and 22 state headquarters and MHA. Satellite phones have been set up in ten districts as also in the DMMC and SEOC for providing alternative communication. DMMC is currently using SMS gateway service for emergency alerts. A HAM radio club has been formed in DMMC for providing alternative communication as also for promoting this hobby.

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[54] Disaster Mitigation and Management Center, GoUK

UTTARAKHAND ACTION PLAN ON CLIMATE CHANGE

(UAPCC)

Uttarakhand is most vulnerable to climate-mediated risks. Mountainous regions are particularly vulnerable to climate change and have shown 'above average warming' in the 20th Century. It may have a huge impact on the natural resources of the region, which not only provide life supporting, provisioning, regulating and cultural 'eco-system' services to the locals, but millions of Indians living downstream. Climate change escalates the already existing vulnerabilities (social, ecological, economic and cultural) and inequities of Uttarakhand and could manifest disastrously if not addressed adequately.

The challenge for the state is to holistically converge these existing initiatives and make additional efforts to integrate climate concerns and response measures into all aspects of the development process, from policy and planning to implementation. The state has adopted this as the underlying principle in the formulation of the Uttarakhand Action Plan for Climate Change (UAPCC) and aims to become a green and carbon neutral state by 2020.

Annexure P-8

Investigations in the areas around Okhimath in Rudraprayag district on the aftermath of landslide incidences of September, 2012

A report

Disaster Mitigation and Management Centre
Department of Disaster Management
Uttarakhand Secretariat
Dehradun 0 248 001

October, 2012

Foreword

Abnormally high precipitation in the area around Okhimath, in the catchment of Mandakini river that has its confluence with Alaknanda at Rudraprayag, on 13th and 14th September, 2012 induced landslides and debris flows around many villages. These inflicted heavy loss of human lives, property and infrastructure in Jua, Kimara, Bamankholi, Premnagar, Dangwari, Mangoli, Chunni, Salami and Giriagaon villages of Okhimath tehsil of Rudraprayag district. It was followed by landslides in Kirora Malla and Timli villages in Jakholi tehsil in the morning hours of 16th September, 2012. As many as 69 human lives were lost in these incidences. In terms of human lives lost this is thus the biggest tragedy since the creation of the state.

This report is the outcome of the field investigations carried out in the disaster hit areas between 17th and 23rd September, 2012 by Disaster Mitigation and Management Centre (DMMC) team comprising of Shri Bhupendra Bhaisora, Shri Sushil Khanduri and Shri Saklani. Site inspection and other investigations were carried out in the presence of the concerned Patwari, Gram Pradhan and local people.

Assistance provided by the officials of Rudraprayag district administration and other departments during the field work is duly acknowledged. Dr. P.K. Champatiray, Head, Geosciences Division of Indian Institute of Remote Sensing (IIRS), Dehradun is thanked for sharing pre and post – disaster satellite imageries of the area. GIS analysis and study of the satellite imageries was done at GIS Laboratory of DMMC by Ms Chanderkala, Ms Suman Ghildiyal, and Shri Ashish Rawat. All are thanked for their contribution and assistance.

8th October, 2012
Dehradun

(Piyoosh Rautela)
ED, DMMC

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The area

The area devastated by disasters during monsoons of 2012 is located in Okhimath and Jakholi tehsils of Rudraprayag district and falls in the catchment of Mandakini river that has its confluence with Alaknanda river at Rudraprayag.

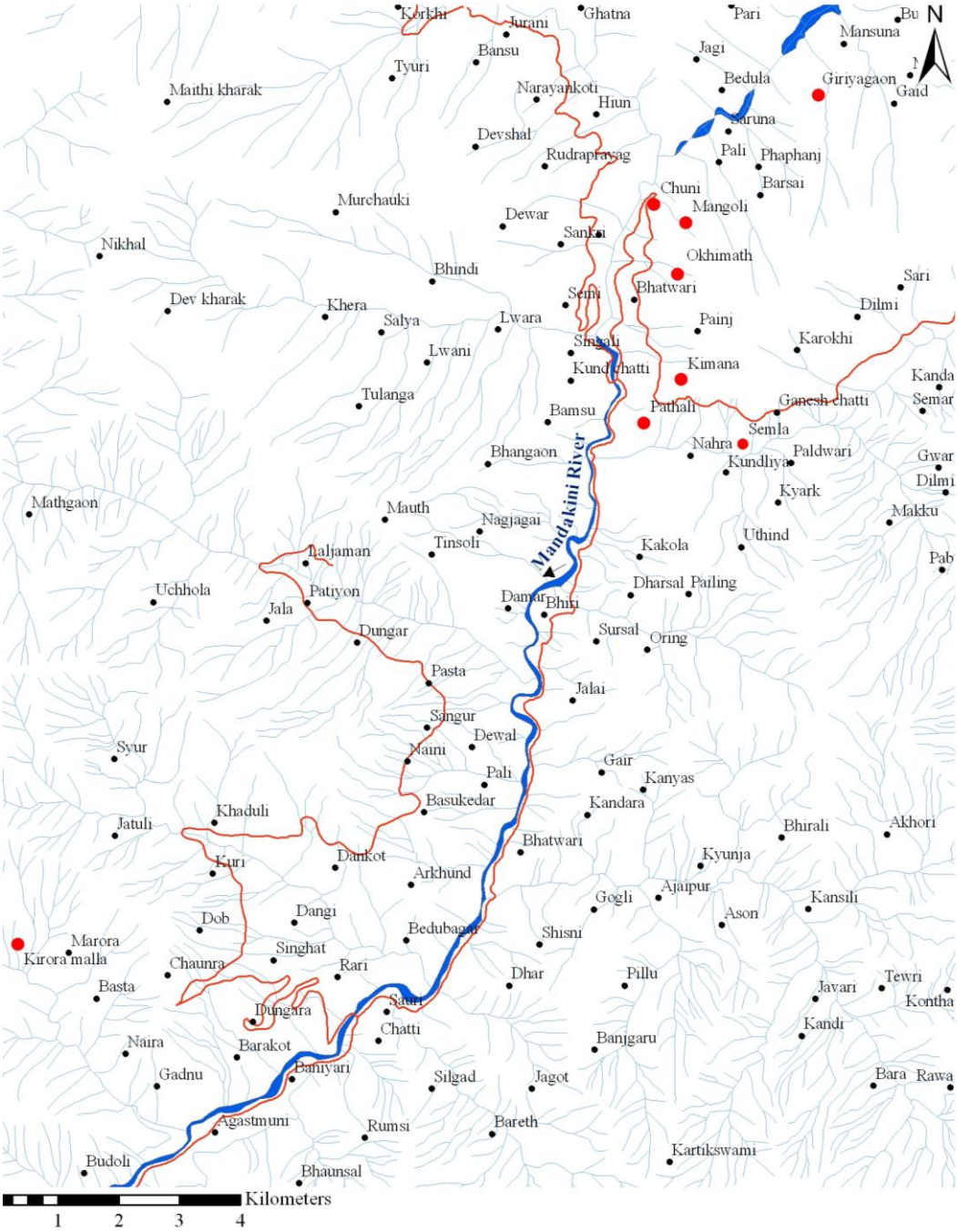

Fig. 1. Location map of the disaster affected area around Okhimath in Rudraprayag district. The affected habitations are shown in red.

The area can be approached by the link roads bifurcating from the Kedarnath National Highway and most areas are in close proximity of the road head. Okhimath (Fig. 2) is located at a distance of 37 km from Rudraprayag. For reaching Okhimath National Highway has to be left at Kund that is at a distance of 30 km from Rudraprayag. For reaching Kirora the National Highway has to be left at Agastyamuni, that is at a distance of 18 km from Rudraprayag, and one has to travel further on the link road to Jakholi for 22 km.

Fig. 2. Panoramic view of Okhimath town showing scars made by the debris descending down the steep slope.

The area is observed to be dissected by several ridges and the ground elevations generally vary from 1200 to 2600 meters above mean sea level. Hundreds of meter high steep cliffs are common feature of the topography of the area. Geomorphic features of fluvial / fluvio-glacial and colluvial origin are generally observed in the area.

The area is drained by Madhyamaheshwar and Kali Ganga rivers that are the main tributaries of Mandakini river. The streams and rivers in the area are generally observed to flow with great force through steep and narrow channels; often resulting in excessive bank erosion and ultimate collapse of the banks.

Subtropical and temperate montane type of vegetation is generally observed in the area. The area is generally observed to have moderate to thick forest cover.

The area has tropical climate and experiences high monsoonal rainfall. The summers are pleasant while the winters are cold. Average summer temperature remains around 25° C while the winter temperature may even drop to 0° C. The rainfall pattern in the area shows high spatial variability that is largely controlled by slope aspect.

Major disaster incidences in the district

Rudraprayag district is prone to multiple disasters. The district falls in Zone V of the Seismic Zoning Map of India (Fig. 3) and has been devastated by seismic tremors in the past.

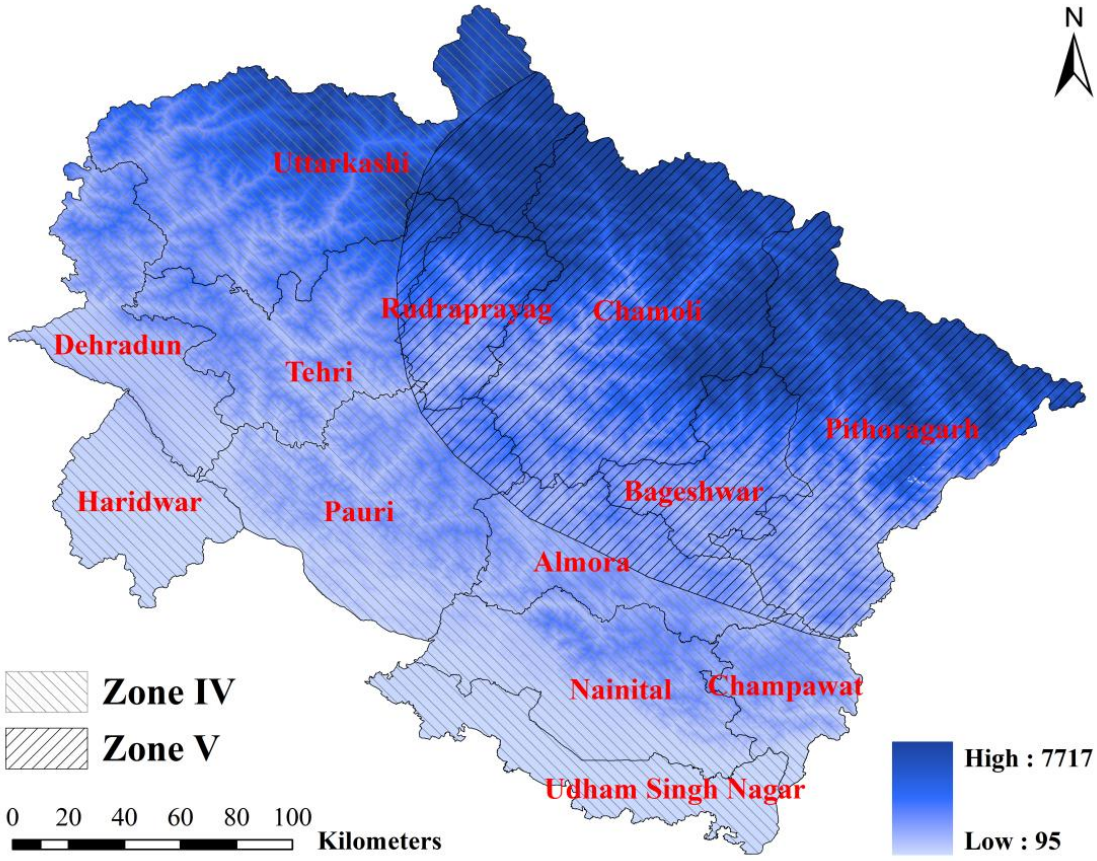

Fig. 3. Earthquake zoning map of Uttarakhand.

Earthquake is however not the sole disaster to which the district is vulnerable. Landslide, cloudburst and flash flood are other disasters common in the area. Geo – tectonic configuration of the rocks makes the area inherently unstable and prone to landslides. In the past the district has been devastated over and again by earthquakes, landslides and flash floods.

Earthquakes of 1803 and 1842 reportedly devastated Rudraprayag region. In 1857 the course of Mandakini river was reportedly blocked

for three days due to landslides. The course of Mandakini was again blocked by landslides in 1976.

Flash floods in Kunjya Gad (tributary of Mandakini) in 1979 inflicted heavy losses in Kontha, Chandranagar and Ajaypur. 29 persons were killed in this incidence and the course of Mandakini was blocked near Chandrapuri.

32 persons were killed in Sirwari landslide in Jakholi tehsil in 1986 and the Uttarkashi Earthquake of 1991 inflicted heavy losses to the residential and other structures in Jakholi, Okhimath and Rudraprayag.

During the monsoons of 1998 major landslides occurred at many places in Madhyamaheshwar and Kali Ganga valleys between 11th and 19th August. Massive landslide at Bheti – Paundar (in the vicinity of Mansuna) blocked the course of Madhyamaheshwar river for more than 24 hours causing serious concern in the downstream areas (Fig. 4). Summary of losses in this event is given in Table 1.

Table 1. Losses incurred by landslides in Madhyamaheshwar and Kali Ganga valleys in August 1998.

Sl. No.	Head	Number
1.	Human lives lost	103
2.	Affected villages	34
3.	Affected families	1,767
4.	Affected population	9,792
5.	Cattle loss	423
6.	Houses damaged	1,276
7.	Agriculture land loss (in ha)	411

Fig. 4. View of Bheti – Paundar landslide of August 1998.

Chamoli Earthquake of 1991 caused significant loss of human lives and property in Rudraprayag district (Figs. 5 and 6). Population of 11,500 in 34 villages was affected by the quake that caused loss of 36 human lives. 176 persons were injured in this incidence that took toll of 140 cattle.

Figs. 5 and 6. View of the devastation at Akhori (left) and Oring (right) villages of Rudraprayag district due to 1999 Chamoli Earthquake.

Landslides amid abnormally heavy precipitation on 15th and 16th July, 2001 in Phata area of Okhimath tehsil caused death of 28 persons (Figs. 7 and 8). Population of 3,924 in 15 villages of the area was affected by this incidence. 52 houses were damaged / destroyed in the incidence that took toll of 62 cattle and 43 hectare agricultural land.

Figs. 7 and 8. View of the Phata landslide of July, 2001.

04 persons were killed in the landslide around Vijaynagar in Agastyamuni on 21st July, 2005. 14 houses were damaged / destroyed in this incidence.

On 26th July, 2006 landslides and flash floods caused massive losses in Ladoli, Devali, Gholtir and Gursyal villages and in 2010 losses were reported from Jaili village of Jakholi tehsil.

The above description makes it amply clear that the areas devastated by the mass movement at present have been inherently vulnerable and have been repeatedly affected by various disasters in the past.

Present disaster event

In the Uttarakhand Himalaya, mass movement is often triggered by high precipitation during monsoon months, destabilization of the toe of the slope material by road construction and other developmental initiatives and undercutting of the banks by streams.

Very heavy rainfall was recorded in the area around Okhimath in Rudraprayag district in the night of 13th September as also in the morning hours of 14th September 2012 (Fig. 9). This triggered landslide and debris flow at many places in the vicinity of Okhimath. It is reported that landslides started around midnight and the dislodged mass continued to move down even till the morning.

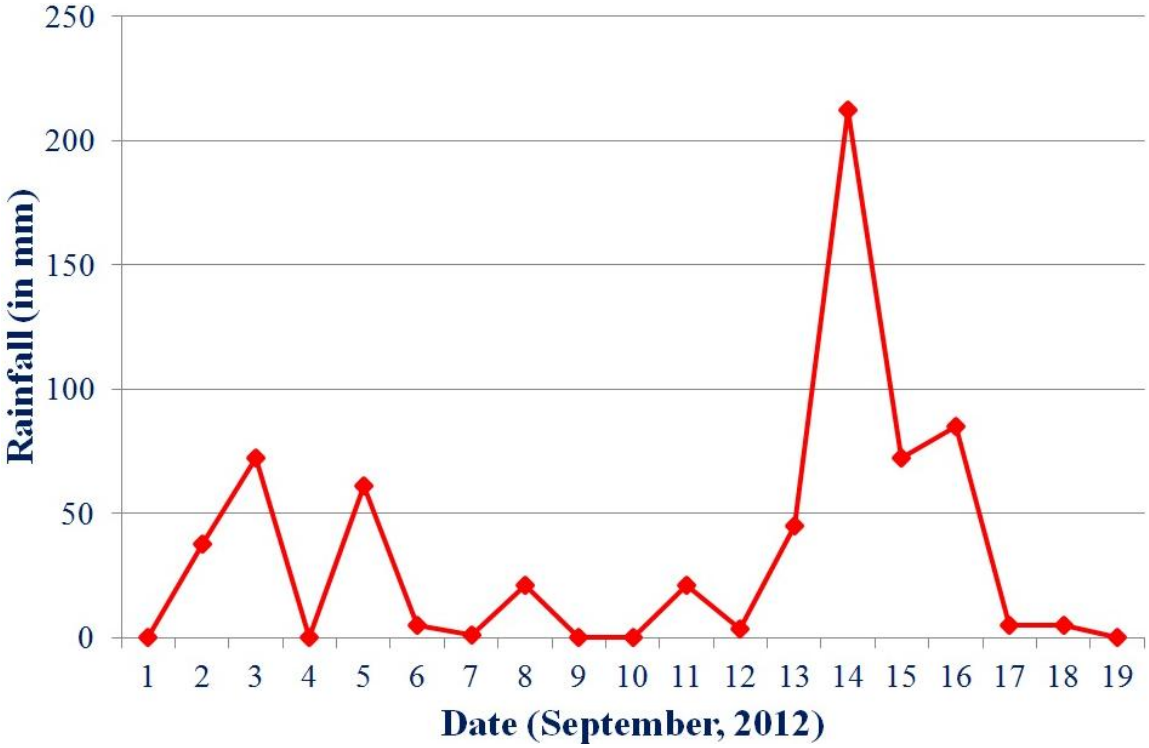

Fig. 9. Daily precipitation received at Okhimath in the month of September, 2012.

These landslides and debris flows devastated Jua, Kimara, Bamankholi, Premnagar, Dangwari, Mangoli, Chunni, Salami and Giriagaon villages. Many houses in these villages were overrun by debris and road connecting Kund to Okhimath was washed away at Kund and Chunni. The other road

connecting Okhimath with Chopta and Gopeshwar was also blocked at Mastura. No vehicular movement to Okhimath was thus possible after this tragedy.

Fig. 10. Damaged houses in Mangoli village.

Fig. 11. Damaged food grain storage facility at Bamankholi.

As if this was not enough Kirora Malla and Timli villages in Jakholi tehsil of Rudraprayag district, that are located in the vicinity of the area affected earlier by landslides, experienced heavy landslides in the morning hours of 16th September, 2012.

These incidences caused loss of 69 human lives and serious injuries were caused to 15 persons. More than 70 residential houses were reported to be destroyed in these incidences that caused heavy loss of other infrastructure and facilities (Figs. 10 and 11).

Administrative response

Even though assess to Okhimath was disrupted and it was raining heavily search and rescue teams of the Department of Disaster Management managed to reach the disaster affected area in the wee hours of 14th September and started search and rescue operations. Officials of the district administration including the District Magistrate and police force also reached the site of the incidence in the morning. By the evening Army and ITBP personnel also reached the site of the disaster and started rescue operations (Figs. 12 and 13).

Figs. 12 and 13. Army and ITBP personnel engaged in search and rescue operations.

Foot paths connecting the villages having been washed off extra effort had to be put in to evacuate the survivors to safer locations (Fig. 14). Injured persons were also quickly evacuated to Base Hospital, Srinagar for advance medical care by helicopter (Fig. 15).

Fig. 14. Survivors being evacuated.

Fig. 15. Air evacuation of the injured.

As the incidence has rendered large number of people without shelter, clothing and other essential items and food relief camp was set up at Government Inter College (GIC), Okhimath and Bharat Sewa Ashram, Okhimath where around 550 persons were accommodated. These persons were provided clothes and bedding together with other necessities. Community kitchen was set up in the relief camp with the help of Shanti Kunj, Haridwar (Figs. 16 and 17).

Fig. 16. Community Kitchen at GIC Okhimath.

Fig. 17. People being provided food at the relief camp.

A temporary medical post was also set up in the relief camps to attend to medical exigencies of any sort (Fig. 18). Apart from this a central store was established at GIC Okhimath for storing the relief material (Fig. 19).

Fig. 18. Medical post at GIC Okhimath.

Fig. 19. Relief material storage facility at GIC Okhimath.

Together with this various logistics related arrangements were also made for the search and rescue personnel, organizations bringing in relief material, media personnel and the VIPs visiting the disaster affected area.

Figs. 20 and 21. Rescue operation in Okhimath by NDRF and rescue team of disaster management, Uttarakhand

In view of fresh incidences in Jakholi tehsil one platoon of PAC was mobilized from Srinagar. One company of NDRF also reached the site of the incidence on 16th September.

Search and rescue teams of the Department of Disaster Management and NDRF were present at the incidence site till the search operations were not called off in the evening of 21st September. Despite best efforts from all quarters only 53 dead bodies could be recovered (Figs. 20 and 21).

Landuse / land cover

Characterization of the landuse was undertaken using satellite imageries of the area (Fig. 22). It shows that 57 percent of the area falls under forest cover and half of this is actually under dense forest cover. 38 percent of the area is observed to be under agricultural operations.

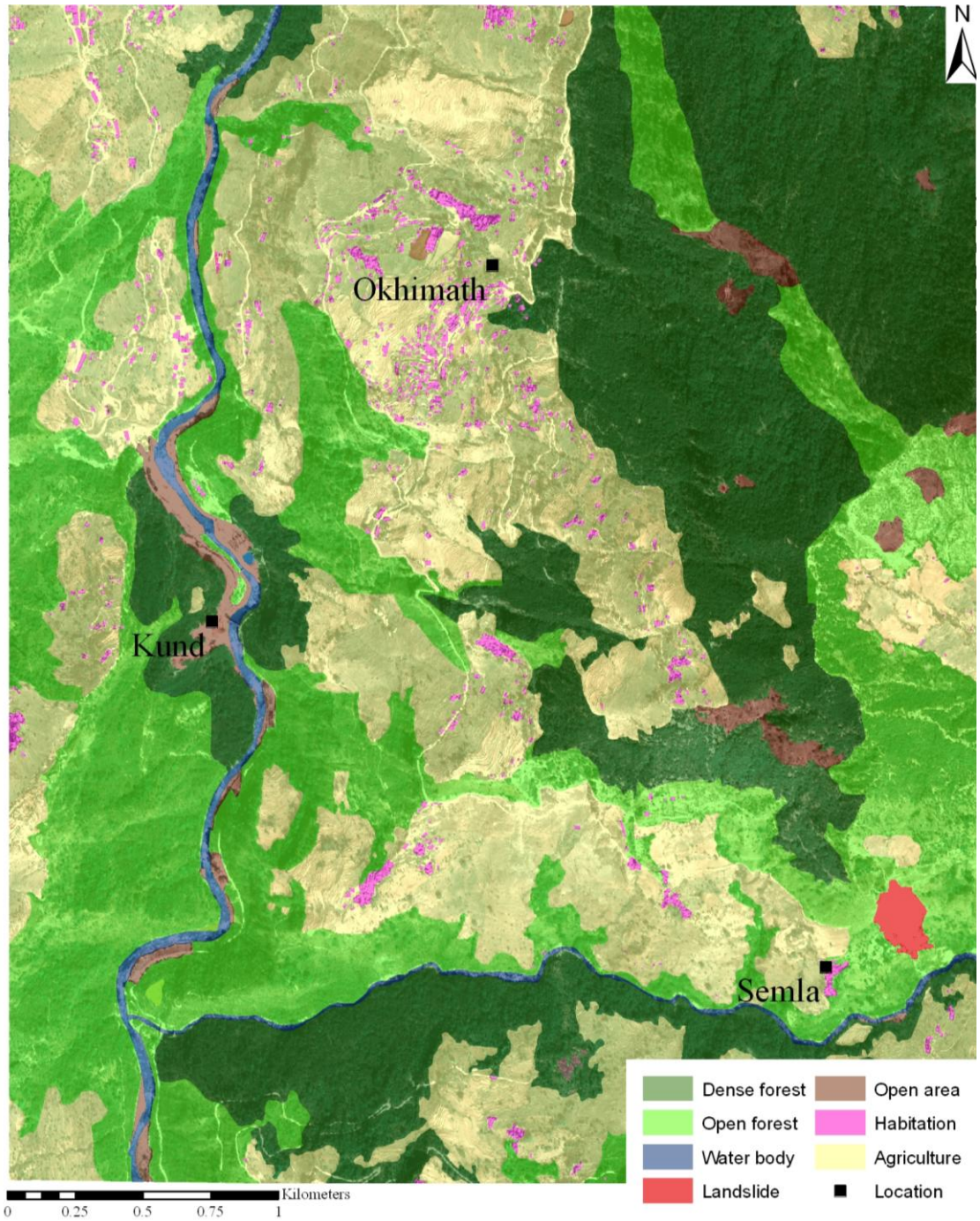

Fig. 22. Landuse map of the area around Okhimath in Rudraprayag district (Satellite imagery of 30th March, 2012).

Comparison of the pre and post disaster satellite imageries clearly shows that more than 0.5 sq km area has been directly affected by landslides (Fig. 23, Table 2).

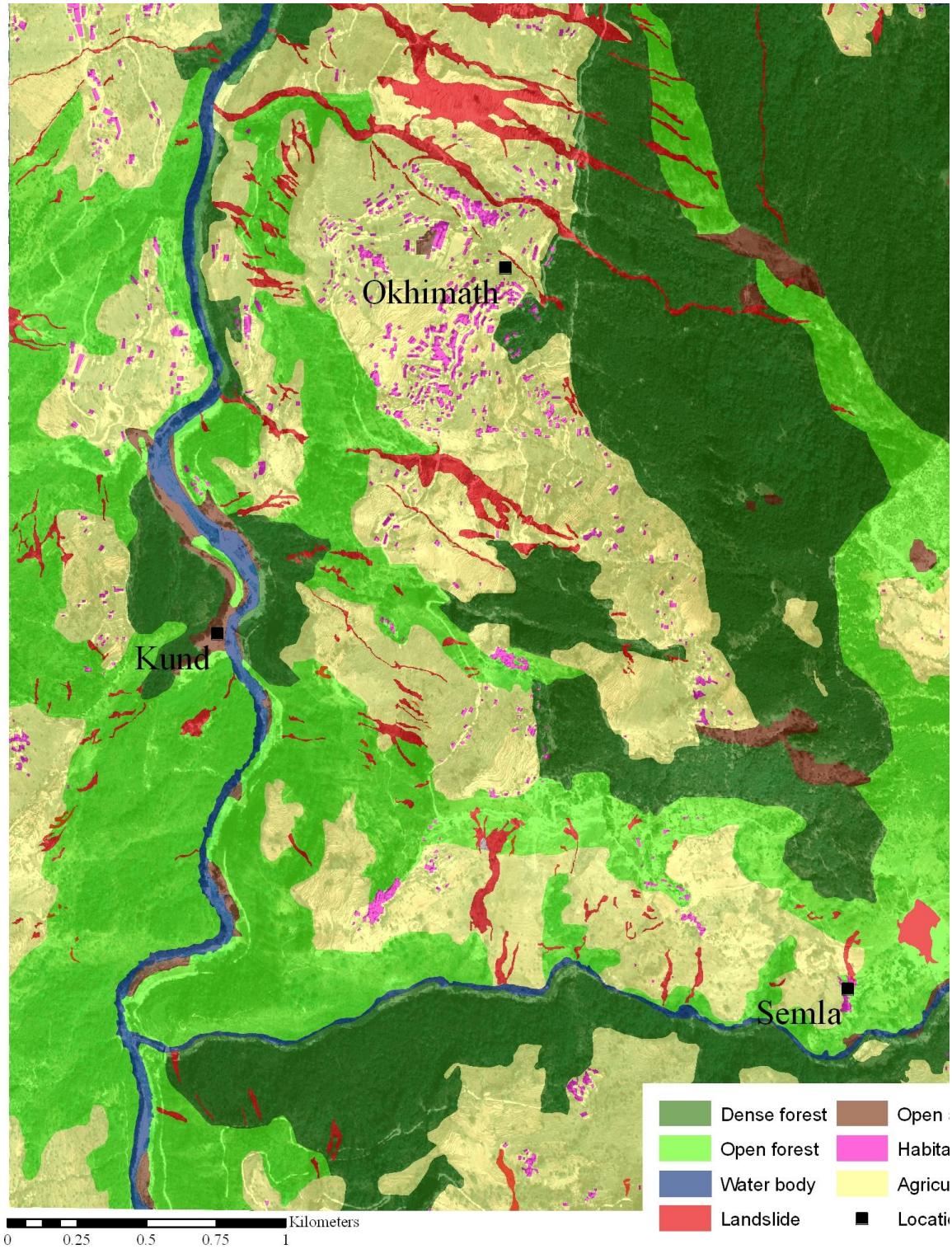

Fig. 23. Post – disaster landuse map of the area around Okhimath in Rudraprayag district (Satellite imagery of 19th September, 2012).

Post – disaster satellite imagery clearly shows that most of the devastating landslides initiated in the higher reaches of the N – S trending steep ridge to the east – northeast of Okhimath. Initiating mostly in forest area these gathered mass and momentum while descending down. This is responsible for the devastating power of these slides.

Most of the habitations were observed to be situated amid agricultural lands with thick cover of overburden material. This added to the devastation and a number of houses were completely swept away by the landslide debris.

Table 2. Statistical details of the landuse / land cover changes brought forth in the area due to the mass movement of September 2012 (Data based upon the satellite imageries of 30th March, 2012 and 19th September, 2012).

Landuse / landcover class	Area (in sq km)			Percent change
	30th March, 2012	19th September, 2012	Change in area	
Dense Forest	4.44	4.56	0.12	2.8
Open Forest	4.49	4.61	0.12	2.7
Agriculture	6.03	5.28	-0.75	-12.4
Open Area	0.30	0.21	-0.08	-27.9
Landslide	0.04	0.55	0.51	1342.1
Water Body	0.22	0.27	0.05	24.1
Habitation	0.28	0.26	-0.02	-7.4

The analysis clearly shows that overwhelming proportion of the area (59 percent) affected by landslides and debris flows was erstwhile under agricultural operations. Of the total area ravazed by landslides 27 percent is accounted for by open forest, 10 percent by dense forest and 4 percent by habitations. This amply highlights the impact the landslides on human interests as 64 percent of the area ravazed by landslides falls under agriculture and habitation.

General geology of the area

The rocks exposed in the Uttarakhand Himalaya range from Archaean to Holocene in age and are grouped into 15 super-sequences whose spatial distribution is often controlled by NW-SE trending tectonic discontinuities that as disposed from south to north are i) Main Frontal Thrust (MFT), ii) Main Boundary Thrust (MBT), iii) south Almora Thrust (SAT), iv) North Almora Thrust (NAT) and vi) Main Central Thrust (MCT).

Super-sequence (litho-package) I (Archaean Central Crystalline) to XI (Late Paleocene to Middle Eocene Subathu Group) are exposed in part of Lesser, Great and Tethyan Himalayan zones. The super-sequence XII (Upper Eocene to Early Miocene Murrees - Dagshai) and XIII (Early Miocene to Lower Pleistocene Siwalik Group) are restricted to the Sub Himalayas. The Super-sequence XIV (Middle to Late Pleistocene older terrace alluvium and lateral moraines) and XV (Holocene newer alluvium and terminal moraines) occur as valley fill deposits.

The Garhwal Group is extensively developed in the Inner Lesser Himalaya from Kali valley in the east to Tons valley and beyond in the west. In the Ganga valley, it is limited by the MCT in the north and North Almora Thrust (NAT) in the south. It represents super-sequence II that comprises of low to medium grade meta-sediments. These include quartzite with penecontemporaneous mafic metavolcanics and carbonates intruded by epidiorite and granite - gneiss. The Garhwal Group is intruded by two types of granites viz. biotite granite and tourmaline granite. The Garhwal Group has been folded into a series of NW-SE trending doubly plunging anticlines and synclines which have been refolded into NE-SW trending cross folds.

Central Crystalline (Super-sequence I) forms a part of a linear belt that can be traced from the Yamuna Valley in the west to the Kali Valley in the east and beyond in the Nepal Himalaya. Main Central Thrust (MCT) forms its southern contact with the Garhwal Group while it forms basement for the deposition for various sequences ranging in age from Meso - Proterozoic to Quaternary. It possibly forms the oldest crystalline basement of the Himalaya. Although, it has witnessed different Precambrian orogenies prior to the strong Himalayan Orogeny, much of the original composition is preserved. The gneisses, migmatites, crystalline schist, thick quartzite with conspicuous horizons of calc-silicates and para-amphibolite with psammite gneisses in the upper part form bulk of the metasediments. Details of lithostratigraphy are given in Table 3.

Table 3: Lithostratigraphy of the Central Crystalline and Garhwal Group (After Agrwal and Kumar 1980, Kumar, 2005).

FORMATIONS	LITHOLOGY	METAMORPHIC GRADE
Central Crystalline Group (Supersequence- I)		
Rilkot	Kyanite, sillimanite-staurolite, biotite schist; banded calcsilicates.	
---------- Unconformity ----------		
Badrinath	Garnet, sillimanite, muscovite and kyanite bearing gneiss, mica schist, migmatite, calc-silicate, leucogranite, pegmatite and garnet mphibolites.	Sillimanite zone
Pandukeshwar	Banded quartzitic gneiss and interbedded quartz mica schist, para-amphibolite.	Kyanite zone
Munsiari (Joshimath)	Garnet mica gneiss, garnet, staurolite and kyanite gneisses, tourmaline-mica gneiss, garnet mphibolites.	Kyanite and Staurolite zone
Bhimgora Quartzite	White quartzite with gneiss and schist.	

Ragsi	Mica schist, gneiss, para-amphibolite.	Kyanite zone
---------- Main Central Thrust (MCT) ----------		
Garhwal Group (Supersequence- II)		
Berinag	Quartzite with/without penecontemporeneous mafic metavolcanic intruded by epidiorite.	
Deoban	Limestone, dolomite and phyllite	
Rautgara	Quartzite with Penecontemporaneous mafic metavolcanic intruded by epidiorite.	
Uttarkashi (= Agastmuni)	Grayish black to grayish blue limestone and dolomite with thinly bedded grey slate. Banded grey, green and slates interbedded with quartzite. White to buff, fine-grained, current bedded quartzite and interbedded slate with minor lenses of limestone.	
---------- Alaknanda Fault ----------		

The exposed rocks in the Mandakini valley mainly belong to Central Crystalline and Garhwal Group that are separated by MCT and the township of Okhimath lies to the north of this tectonic plane.

Most areas affected presently by landslides are observed to show exposures of Central Crystallines.

Observations made around the affected villages

1. Giriyagaon (Pangran tok)

Giriyagaon is located on the left flank of southwesterly flowing Madhyamaheshwar river and can be approached by Okhimath - Mansuna motor road. After travelling for 07 km one however has to leave the vehicle and walk for 2 km from the road head in the upslope direction to reach the village.

The investigations were carried out in the area on 19th September, 2012 and traverses were taken around the site, nala bed, footpath section and upslope to examine the geological setup as also to investigate the causes of instability.

The area was observed to be located amid agricultural fields that are intervened by both rock outcrops and overburden. The rock exposures in area were observed to comprise of gneisses belonging to the Central Crystallines. General trend of the rocks was observed to be NW - SE with moderate dips towards NE. The rocks in the area were observed to be traversed by numerous joints that constitute important structural discontinuities affecting the strength of rock mass and stability of slopes. The foliation planes were observed to dip towards NE at angles varying from 30º to 35º. Other two prominent structural weaknesses (joints) were observed to dip towards WSW at steep angles (75º / 245º) and towards NW at moderately steep angles (45º / 310º).

Reconnaissance geological - geotechnical assessment: Overburden thickness in the area including weathered rock zone was generally observed to be as much as 2.0 meters. The overburden material was observed to comprise of hill wash and debris consisting of grey to grayish brown, fine grained silty matrix with fragments of gneiss.

The slope failure was observed to have occurred on the northern slope of Pangran tok. The area was observed to be prone to instability due to foliation plane dips being parallel to the surface slope.

The width of the failure surface around the crown was observed to be about 12 meters while the height of the crown was about 8 meters from the houses destroyed by the mass movement. The inclination of failure slope was observed to be 35°.

The water laden down slope moving mass was observed to have overrun the houses and cultivated lands in the western side of Pangran tok (Figs. 24 and 25).

Fig. 24. View of the house ravazed by landslide.

Fig. 25. View of the agricultural land overrun by landslide debris.

Saturation by rainwater would have led to increased pore water pressure in the overburden mass on the hill slope and would have significantly reduced the shear resistance of the slope forming materials. This seems the most probable reason for triggering the destructive landslide.

***Mitigation measures*:** Debris accumulated in the back slope of the houses needs to be cleared. After the debris has been removed concrete breast wall with adequate provision of weep holes or perforated pipes for draining out excess water is recommended. This has to be accompanied by provision for safe disposal of rain water through a

network of interconnected drains into the main stream. This would help in stabilizing this site.

2. Salami

Salami village is located on the left flank of southwesterly flowing Madhyamaheshwar river and can be approached by Okhimath - Mansuna link road. After travelling for 3 km one has however to trek for 1.5 km in the upslope direction to reach the village. The area was observed to be drained by three local streams.

The area was investigated on 19th September, 2012 and traverses were taken around the site, nala bed, road section and upslope to examine the geological setup of the area as also to investigate the causes of instability.

The area was observed to be located amid agricultural fields that were interrupted by both outcrops and overburden material. Rock exposures of Central Crystalline gneisses were observed along the road section and as also upslope of the village. The general trend of the rocks was observed to be NW-SE with moderate dips towards NE. The rocks in the area were observed to be traversed by numerous joints that constitute important structural discontinuities affecting the strength of rock mass and stability of the slopes. The foliations were observed to dip towards NE at angles varying from 28º to 33º. The other two weak planes (joints) were observed to dip towards W and NNE (60º / 270º and 75º / 010º).

Reconnaissance geological-geotechnical assessment: General overburden thickness including weathered rock zone in the area was observed to be up to 2.0 meters. The overburden material was observed to comprise of hill wash and debris consisting of grey to grayish brown, fine grained silty matrix with fragments of gneiss.

A number of agricultural fields around the village were observed to be damaged due to shallow water saturated debris flows (Figs. 26 and 27). Water is deduced to be the main driving force of these debris flows.

Fig. 26. Photograph showing slope failure and ensuing damage to a number of agricultureal fields around Salami village.

Fig. 27. View of the houses damaged by water saturated debris in Salami village.

The debris flows were observed to have overrun five residential houses of the village. Amongst these, one house was severely damaged while the others were partially damaged.

Mitigation measures: In this area there exist a number of severely damaged structures that are located on highly vulnerable area falling in close proximity of the course of seasonal drainage channel. These are therefore endangered by bank erosion during coming monsoons. These are required to be removed immediately.

Debris accumulated around the houses needs to be cleared. After this oblique concrete retaining structures of appropriate height would have to be constructed upslope of affected site. Particular caution is required to ensure that these structures are founded on compact rocks and compact soil materials. This would help in protecting the remaining houses.

New constructions and other anthropogenic interventions are required to be avoided in the proximity of seasonal streams.

It is required that anthropogenic intervention of all kinds be strictly regulated in the proximity of both seasonal and perennial streams. Appropriate legislative intervention in this regard is a must and this recommendation applies equally for all the areas under the present focus as also for rest of the state.

3. Chunni, Mangoli, Brahmankholi, Premnagar, Dangwari, Jua and Sansari villages

These villages are located on the Kund – Okhimath - Mansuna motor road and are all located in close proximity of each other. These villages are situated at distances varying between 0.5 to 2.5 km from the bus stand at Okhimath. All these villages are situated on the left flank of south flowing Mandakini river. A number of other local seasonal / perennial streams also drain the area.

The areas were investigated on 18th and 20th September, 2012 and traverses were taken around the site, nala bed, footpath section and upslope to examine the geological setup of the area together with the causes of slope instability.

The areas under present focus were observed to be located in close proximity of the motor road amid agricultural fields that are occupied by outcrops as well as overburden. The upslope area was observed to have very steep rock cut slope with N-S trending ridge.

Exposures of Central Crystalline gneisses were observed along the road section. The general trend of the rocks was observed to be NW-SE with gently to moderately steep dips towards NE. The rocks in the area were observed to be traversed by numerous joints that constitute major structural discontinuities affecting the strength of rock mass and stability of slopes. The foliation planes were observed to dip in northeasterly

direction at angles varying from 20º to 45º. The joint sets were observed to dip at steep angles towards W and S (70º / 270º and 75º / 180º).

Reconnaissance geological-geotechnical assessment: The landslide debris that descended down from the area upslope of the villages was observed to have overrun both agricultural fields and houses (Fig. 28). The thickness of the debris accumulated in the houses was observed to be 1.5 to 2.0 meters. This overburden material is observed to comprise of hill wash and debris consisting of gray to grayish brown, fine grained silty matrix with rare boulders and fragments of metabasics and gneisses.

Fig. 28. View of debris flows around Mangoli, Bamankholi, Premnagar and Dangwari villages.

The disposition of weak planes in the rocks in relation to the direction and amount of slope was observed to be unfavourable while the

crumbled nature of the rocks attributed to jointing and local folding was responsible for low rock mass strength.

The landslide that devastated this area was a huge mass of water saturated debris. While moving down along the steep slope from the uphill area it generated enough momentum to ravage everything that came in its way. High flash-flood discharge of the local streams contributed to the instability of the hill slopes of the area.

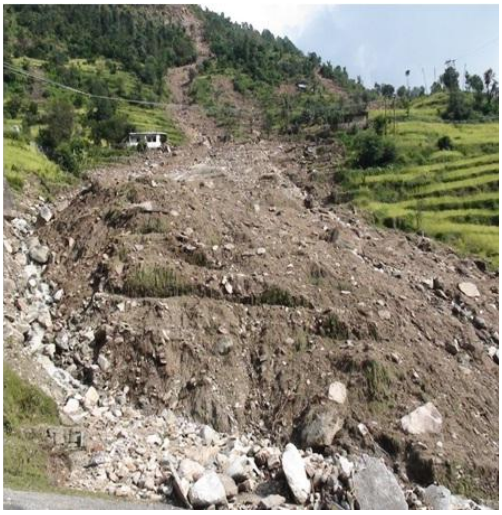

Fig. 29. Photograph dipicting debris flow in Jua Kimana village.

Fig. 30. Photograph showing debris flow around Chunni village.

Number of agricultural fields and houses were damaged due to shallow debris flows in the area (Fig. 29, 30 and 31). Rapidly running water and gravity driven movement induced by lubricating action of ground water were largely responsible for driving the debris down slope at fast pace.

A seasonal stream was observed to flows through Sansari village. The agricultural fields in the vicinity of this stream were observed to show signs of ground subsidence on its left flank. Ground fissures as wide as 1.5 m were also observed around this location (Fig. 32).

Fig. 31. Photograph showing devastation caused by debris flow around Mangoli.

Fig. 32. Photograph depicting subsidence in agricultural lands due to bank eroion by seasonal nala around Sansari.

***Mitigation measures*:** Removal the transported material which is come from the upslope through local streams/gulley's into agricultural lands. After removing the materials local community will be further utilize the agricultural lands.

There should be thorough geotechnical assessment of affected sites of important exists houses whereas infrastructures in the verge of damage and/or partially damaged by destructive debris flows.

Eastern side as well as upslope of villages, all nalas need to be channelizing with cascade form downhill into the main stream. This will help to protect rest of exists houses from excessive rise of water level during the monsoon.

It is suggested that all exists houses near and on specific affected sites along newly developed nalas bed area be immediately removed.

Good lining/gradient/cleaning of road-side drains to prevent further water percolation/stagnation and erosion. These measures focus at preventing development of the harmful saturation, pore pressures and

erosion, and flooding in the weak slopes/zones due to heavy precipitation.

Presently the village Sansari area questioned site is highly susceptible to landslide so the local population is advised not to stay in this highly vulnerable site.

4. Kimana

Kimana vilalge is located above the Okhimath - Chaupta motor road at a distance of 1.0 km from the junction of Mansuna – Okhimath and Chaupta - Okimath motor roads. It is located on the right flank of southwest flowing Kakra Gad, a tributary of Mandakini river.

The affected area was investigated on 20th September, 2012 and traverses were taken around the site, footpath section and upslope to examine the geological setup.

Geology of the area: The village was observed to be located amid agricultural fields and occupied by outcrops as well as overburden material. Upslope side was observed to have very steep rock cut slope with N-S trending ridge. Exposures of Central Crystalline gneisses were observed on the upslope side of the village as also along the road section. The general trend of the rocks was observed to be NW - SE with moderate dips towards NE. The rocks were observed to be traversed by numerous joints that constitute important structural discontinuities affecting the strength of rock mass and stability of slopes. The foliation plane was generally observed to be well developed and dips at angles varying between 30º to 35º towards northeast. The joint sets were observed to have steep dips towards SW and SSE respectively (65º / 240º and 70º / 165º).

Reconnaissance geological-geotechnical assessments: The overburden thickness including weathered rock in the area was observed to be up to 3.0 meters. The overburden material comprised of hill wash and debris consisting of grey to brown, fine grained silty matrix with fragments of gneisses.

The spatial disposition of joint sets was observed to result in the formation of wedges that facilitated detachment of the rock mass (Fig. 33). The same was observed to slide down and overrun the agricultural fields near the Panchayat Ghar (Fig. 34).

Fig. 33. Photograph depicting rocks detached due to wedging.

Fig. 34. View of rock fall zone near Panchyat Ghar in Kimana village.

Mitigation measures: Devastation caused by the down slope moving mass is a direct function of the rock mass and fragmentation of large detached blocks is sure to reduce the impact. It is therefore recommended that the large detached rock mass be broken into small pieces so that the area situated on the down slope direction is safe.

5. Pathali and Semla

These villages are located on the right flank of southwest flowing Kakra Gad, a tributary of Mandakini river and can be approached by Okhimath - Semla link motor road. Pathali and Semla are at a distance of 2.0 and 5.0 km respectively from Okimath.

These areas were investigated on dated 20th September, 2012 and traverses were taken around the site, road section and upslope to examine the geological setup.

Geology of the area: A rock cum debris slide reportedly occurred in Semla village on 15th September, 2012. This affected the agricultural fields located below the road. The agricultural fields were observed to be occupied by both outcrops and overburden material. In the upslope direction the area was observed to have very steep rock cut slope with E-W trending ridge. Exposures of Central Crystalline schists were observed along the road section. The rocks in the area were traversed by numerous joints. The foliation plane is generally observed to be well developed and observed to dip angles varying between 35º to 40º towards northeast. The joint sets were observed to have steep dips towards SW and SSE respectively (65º / 250º and 70º / 170º).

Reconnaissance geological-geotechnical assessment*:* The overburden thicknesses in the area around the villages was observed to be 2.0 m. This overburden material comprised of hill wash and debris that consisted of gray to grayish brown, fine grained silty matrix with rare boulders and fragments of schist.

Intense rain facilitated the slide by providing lubricating effect between the competent rocks that reduced the shear resistance of the slope forming materials together with the overburden material. This triggered

the destructive landslide that inflicted widespread damages in Semla village (Figs. 35 and 36).

Fig. 35. Photograph showing damaged agricultural fields and houses due to rock cum debris slide.

Fig. 36. View of the damaged house.

In the eastern side of the Pathli village number of agricultural fields were observed to be damaged due to shallow debris flows (Fig. 37). Rapidly running water and gravity movement induced by lubricating action of ground water are deduced to be the main driving force causing the debris flows.

Fig. 37. Photograph showing agricultural fields damaged by debris flow around Pathali village.

***Mitigation measures*:** The slope is required to be modified at different level in the area affected by debris slide at Semla village by benching and erection of appropriately designed buttress / retaining walls with suitable provision of weep hole.

Well anchored concrete wall has to be constructed at the toe of the landslide where maximum damage has been inflicted to the houses. It would help in protecting the rest of the houses in case of future instances of slope instability.

Burst wall with appropriate height is required to be constructed on the uphill side of Semla village around the road.

It is recommended that the debris and rock mass accumulated by the slide in the agricultural lands of Pathali village be cleared so as to enable masses to continue with routine agricultural chores.

6. Kirora Malla

A disastrous landslide occurred on 16th September, 2012 at Kirora Malla village in Jakoli tehsil that is located at a distance of 22 km from Augustmuni on Mayali link road (Fig. 38).

Fig. 38. Photograph showing devastation due to landslide in Kirora Malla.

The area was observed to be located just below the road amid agricultural land and occupied by outcrops as well as overburden. The overburden thickness including weathered rock mass around the village was observed to be 3.0 meters. This overburden material comprised of hill wash and debris consisting of gray to grayish brown, fine grained silty matrix with fragments of quartz schist phyllite.

Rock exposures of quartz schist and phyllites belonging to Lesser Himalaya were observed along the road section as also upslope of the village. The rocks in the area were observed to be traversed by numerous joints that constitute important structural discontinuities affecting the strength of rock mass and stability of slopes. The foliation planes were generally observed to be well developed and dipping at angles varying between 35º to 40º towards northeast. The joint sets were observed to have steep dips towards NNW and W respectively (80º / 350º and 55º / 270º).

Fig. 39. Photograph showing debris flow at kirora Malla.

Fig. 40. View of completely damaged house at Kirora Malla.

Reconnaissance geological-geotechnical assessments: A family of five persons was reportedly buried under the debris of the destructive landslides caused by excessive precipitation. Intense rainfall in the area resulted in high stream discharge and soil saturation with reduction of

the coefficient of internal friction of the slope forming materials. This induced massive mass movement that completely destroyed a house that came in its way (Fig. 39 and 40).

Another landslide was observed to be mass of water saturated debris that descended down the steep slope through the nala and ravaged a house that came in its way at Bengar tok (Figs. 41 and 42). Fortunately the flow of water was diverted upslope of the house towards western side and this limited the magnitude of damage.

Fig. 41. Photograph showing slight debris flow at backslope of the house.

Fig. 42. View of debris overrunning a toilet at Bengar tok.

***Mitigation measures*:** In the Bengar *tok* the affected site falls in the course of perennial nala and therefore the population residing in the surrounding area needs to be shifted to alternate safe locations.

Discussion and future strategy

Though often dubbed as being a menace for the mountain areas landslide is a powerful landscape building process. It helps in soil development and often provides good aquifers. Large number of habitations in the hills are therefore located in close proximity of stabilised old landslides.

Our ancestors however very well understood the basic fact that howsoever stabilized the old slide material be it is likely to be reactivated by excessive precipitation and other factors like seismic shaking. They therefore choose not to settle over the stabilized slides. Review of the habitation pattern of the hills brings forth the fact that despite practicing agriculture over stabilised old landslides they deliberately settled down over stable rocks at locations that were in the middle and upper hill slopes. This clearly implied that they had to negotiate long distances daily for both mending fields and fetching water. They thus preferred safety over comfort and this is the simple underlying fact that saved them from the fury of both landslides and flash floods.

Our ancestors could also appreciate the interrelationship between landslides and saturation of soil and other slope forming materials. They therefore devised ways of disposing off excess precipitation in the main stream by a network of drains in the upper reaches of vulnerable slopes. Remnants of these can still be observed in Madhyamaheshwar valley. They at the same time kept the far flung fields outward sloping and unbunded.

Unplanned construction of roads on the vulnerable slopes in the recent times and unscientific disposal of the excavated debris have induced instability in the hill slopes and many areas in the proximity of the roads have became chronically prone to landslides. Detorioration of hill agriculture and concentration of economic opportunities and other facilities in close proximity of the roads encouraged people to settle down by the road side.

Increased inflow of tourist and pilgrim traffic in the area only encouraged this trend.

With the passage of time traditional practices of landslide management were forgotten and more and more people started to settle in areas vulnerable to landslides. This reflects increasing trend of giving priority to comfort over safety in all the spheres of life. This resulted in enhanced landslide risk in the hills.

It needs to be understood very well that landslide is a natural process in the hills and it is not possible to rule out their occurrence. Their impact can however be reduced to a great extent by proper planning and timely implementation of appropriate mitigation schemes.

It is suggested that the following measures be discussed, debated and acted upon, with amendments where required, for making the hills safer from the threat of landslides:

Revival of traditional practices of landslide management: Traditional landslide management practices of the region are required to be studied and documented in detail. These can be suitably amalgamated with the modern technical inputs and put to practice in landslide prone areas.

Ban on the use of explosives: Use of explosives in the fragile Himalayan terrain for infrastructure developmental works introduces instability in the rocks and therefore use of explosives should necessarily be banned.

Limiting construction of roads in the hills: Construction of roads is often highlighted as one of the prime reasons for landslides to occur. Construction of roads is therefore required to be checked and limited. Alternative connectivity options, such as rope-ways would be better suited for the hills.

Discontinuing target driven schemes: Target driven schemes for connecting all the habitations with particular characteristics by road are required to be given a second thought in the hills. These roads, as

constructed under PMGSY, have in no way added to the prosperity of the region but have certainly disturbed its ecological balance. It is required to be clearly understood that attempts to connect every village, tok and house in the mountainous areas are not going to be beneficial in the long run.

Geological studies: It is highly required that detailed geological investigations be carried out before finalizing the alignment of the roads in the hills. This would help in judiciously avoiding the stretches that are likely to become landslide prone.

Debris disposal policy: Unplanned and unscientific disposal of the excavated material along the hill slopes often initiates landslides besides causing loss of forest resources, agricultural land and water sources. A clear cut policy for the disposal of excavated material is immediately required for the hills. The cost of planned disposal of the excavated material would then have to be made part of the routine budget of the developmental initiative. It might sound like additional financial burden but for larger good of the society provision for this would have to be made.

Hazard zonation: At present there exists to mechanism of checking developmental initiatives on the pretext that the area is prone to certain hazard. So long as there is no dispute with regard to the title of the land one is free to use it in the manner he deems appropriate. Areas that have become chronically prone to mass movement and other hazards are therefore required to be identified and officially notified and all anthropogenic interventions in these areas have to be banned by law. This provision would automatically ban habitation in the close proximity of seasonal streams and rivers. In case people are already residing in such areas provision has to be made for their timely relocation. This provision in the long run would encourage people to settle down at safer places due to enhanced awareness

in this regard and differential land pricing and insurance premium depending on its hazard proneness.

Landslide treatment: Landslides have to be scientifically treated in their initial stages. This would ensure that the problem does not become chronic.

Landslide prediction: With establishment of rainfall thresholds for mass movement on different lithologies and slopes it is possible to develop a predictive model for landslides. For this close network of automatic rain gauges would have be established in the region and data would have to be collected on various rock parameters and slope characteristics. To begin with this exercise can be initiated in some of the vulnerable areas and the same can be gradually extended to other areas.

Though put forth plain and simple it all is not going to be easy. Strong lobbying would be required for legislative action and bringing forth policy changes, formation of rules and regulations. Firm executive action in accordance with letter and spirit of the legislative decisions would then be required to ensure compliance of the same.

Annexure A1/9

106 259

Annexure P-3

Annexure P-9

वर्ग बी / Category-B
विवृत फाइल प्रतिवेदन / OPEN FILE REPORT
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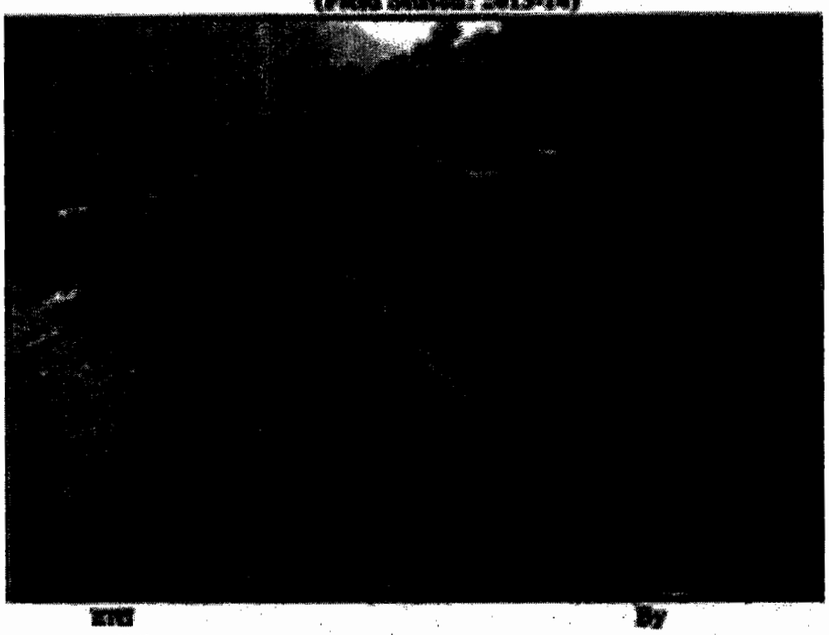
भारतीय भूवैज्ञानिक सर्वेक्षण
GEOLOGICAL SURVEY OF INDIA

उत्तराखण्ड़ के उत्तरकाशी जनपद में नवीन आपदा प्रभावित क्षेत्रों का प्राथमिक ढ़लान स्थायित्व आंकलन।

(मद संख्याः एल एच जेड/एन आर/यू पी यू के/2013/053)
(कार्यसत्रः 2013-14)

PRELIMINARY SLOPE STABILITY ASSESSMENT OF THE RECENT DISASTER AFFECTED AREAS OF UTTARKASHI DISTRICT, UTTARAKHAND

(Item No.: LHZ / NR / UPUK / 2013 / 053)
(Field Season: 2013-14)



डी.पी. डंगवाल, वरिष्ठ भूवैज्ञानिक
नीतू चौहान, भूवैज्ञानिक
मयूखी घोष, भूवैज्ञानिक
एंव
तमघ्नो घोष, भूवैज्ञानिक

D.P. Dangwal, Senior Geologist
Neetu Chauhan, Geologist
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PRELIMINARY SLOPE STABILITY ASSESSMENT OF THE RECENT DISASTER AFFECTED AREAS OF UTTARKASHI DISTRICT, UTTARAKHAND

(Item No.: LHZ/NR/UPUK/2013/053)
(Field Season: 2013 – 14)

By
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VIII. CONCLUSIONS AND RECOMMENDATIONS

I. Uttarkashi district of Uttarakhand experienced an unprecedented high amount of incessant rain fall between 15th and 17th June 2013 that created havoc in the area in the form of landslides and flash floods. The landslides have severely damaged the NH-108 & NH-134 and habitations existing along the river banks. Between 14th and 17th June 2013 discharge and rainfall in the area are showed enormously high figures of 1936.04 cumec and 180mm, respectively. Aanalysis of data shows that it increased manifolds (>7 times) from average discharge and rain fall in the area.

II. A total 60 landslide incidences have been studied in Uttarkashi district. Out of which 37 are debris slide, 22 rocks cum debris and 1 rock slide. Out of the total landslide incidences 61.7% are debris slide, 36.7% rock cum debris slide and 1.6% rock slide and the total volume of debris/ rocks displaced or moved due to mass movement is approximately 31,80,711m^3

III. Landslide studies carried out in the area reveals that most of the slope failure incidences have been recorded either on river terraces or in slope wash / slope debris material resting on steep slopes. The badly affected towns/ villages in Uttarkashi district are Joshiyara, Tiloth, New Dedsari and Kharadi mostly located on T_0 and T_1 Level River/ *nala* terraces. However, Singoti, Banderkot, Raturisera, Pipalmandi etc., are located either on T_1 or T_2 level terraces. Many Central and State government buildings, have been constructed on T_0 level terraces resulting in loss of government property.

IV. The main factor responsible for triggering of the landslides are abnormal downpour causing flash floods, toe cutting, saturation of slope forming material. Also, anthropogenic activities like road cutting, encroachment of human in the river/ *nala* bank and unplanned urbanization, etc have aggravated the situation.

V. Based on the type of slide and the factors responsible for triggering of landslide, short term (temporary) and long term (permanent) remedial measures were suggested.

Short term measures

a. Slope failures have mainly occurred due to over saturation of debris material after incessant rains (180mm in 12hrs). The slopes occupied with unconsolidated slope wash, river borne material (terrace), jointed, weathered and shattered rock mass should, in general, be protected from water charging water logging and surface runoff should be channelized by constructing contour drains, catch drains and linned toe drain with proper gradient depending on site geology and topography (Gangnani slide, Jyoti slide, Hanumanchatti landslide and Wariya landslide).

b. Modification of the slope by giving stable slope angle and provision of berms in between the slope. The slope with gentle slope angle and occupied with highly weathered rock mass can be stabilized by giving biodegradable treatment like geo-jute / geo-net along with mulching of local species of

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grass and bushes, e.g. Naitala landslide, Aungi landslide, Dharasu power house landslide and Dharasu bridge landslide, etc.

c. Construction of breast wall/ retaining wall along with adequate number of weep holes/perforated pipes for draining out water thereby reducing the pore water pressure is recommended.

d. For landslides caused due to toe cutting/erosion by the river, proper toe protection measures have to be adopted like constructing RCC/ retaining wall with deep foundation either on the sound bed rock or it should be lowered down below the scouring depth of river/ nala as per site geological or topographical conditions. Construction of gabion/crate wall with deflectors for energy dissipation and to protect the structures from its impact.

e. As most of the damage occurred due to toe cutting of the structures located at or near river bed level (T_0-T_1 level), it is advisable that such practices should be prohibited. Construction of roads in such areas be planned carefully and excavation and stabilization work should be done concurrently, backfilling of the constructed wall should be done with proper compaction and providing lined toe drains, etc. Drainage system improves life of structure because water is the main culprit as happened at Dharasu landslide and Kharadi landslide.

f. During construction of roads particularly on the soft rock/ overburden, the material should be well compacted stability measures must be adopted simultaneously with the construction. Also, road constructed over terrace material should be adequately compacted.

g. The consequences from nala discharge can be minimized by channelization, constructing check bunds, construction of breast wall/ retaining wall along with provision of sizeable culvert to pass the seasonal discharge, restoration of the damaged road, provision for lined toe drain with proper gradient away from the affected zone and dredging the nala course. Construction activities should be banned on nala course and in proximal as suggested for Asnol landslide zone. Shifting of the electricity transmission lines should be done, away from the nala section to a safer place.

h. Landslides caused due to disposition of unfavorable discontinuity planes, measures like rock bolting, chain linking/ wiremesh, shortcreting may be adopted depending on the study of local/site geological conditions. During construction of road, in jointed rocks (Laldang and Bishanpur) controlled blasting should be done to avoid further deterioration of rock mass. It is advised that construction of road in hilly terrain especially in jointed rockmass, cutting of strata should be done carefully taking into account geological conditions

i. It has also been noticed that between Yamnotri and Kharadi, along NH-134, the restoration work of road is being carried out by BRO but the stability measures being taken up appeared to be inadequate. Most of the weep holes, culverts and hume pipes are silted / clogged up. Many of the breast walls are without drainage holes or inadequate number of weep holes. Due to increased pour

water pressure the concrete walls are showing signs of bulging, gaping cracks, etc. Restoration/ repair work be initiated to avoid further deterioration.

Long term measures

Few stretches of the NH and landslide affected villages have been suggested for detailed investigation (1:5000/2000) so that long term stability measures could be suggested.

a. 'Dharasu bend landslide' is of prime importance and it is a "chronic slide". Detailed geological mapping (1:5000) scale is required for deciding long term treatment or realignment of the road through tunneling.

b. Sukhi top landslide' also needs detailed geotechnical evaluation as this is problematic in every monsoon due to excess discharge along the *nala* and it intersects highway at five locations, therefore, to bye-pass this stretch of road, proposal of tunnel along river level on right bank or left bank may be considered after detailed geological mapping of the area.

c. About 2 km road stretch of NH between Lata and Malla village is continuously sinking/sliding, therefore, planning for long term stability measures detailed study is required on 1:5000 scale.

d. Detailed geotechnical evaluation/ mapping on 1:5000/1:1000 scale of Barsu village is required for suggesting long term measures.

e. Initial 100m stretch of the road near Singoti village is steep and it can be realigned by cutting carefully the steep terrace deposit whereas, rest of the area is flat and being used for cultivation. Realignment of the road towards hill side leaving about 50m as buffer zone towards river side may be considered for further feasibility.

f. Detailed geotechnical investigations are recommended to work out site specific slope stability measures for a 1.5km stretch of NH-108 from Chadethi upto Papar *gad.*

g. It is worth mentioning that detailed geotechnical investigations for Bhatwari landslide have already been carried out by GSI during FS: 2010-12 and recommendations made by GSI should be implemented accordingly.

Apart from this, following are some general suggestions for minimizing the impact of the slides in the district.

i. Town planning should be adhered to low landslide potential zones.

ii. In hilly region landslide related hazards can be reduced/ minimized by avoiding unplanned excavation and if cutting is essential sustainable measures may be adopted immediately.

iii. Increasing public awareness and training programs related to disasters depicting the harmful effects of hill cutting, improper land use and associated legal restrictions be emphasised.

iv. Real time monitoring and early warning be strongly developed. The monitoring of the rainfall (rainfall threshold) in the area can be used to forecast the slide events.

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v. Involvement of geologist in every stage of construction activities such as hydro electric projects, traffic tunnels, bridges, highways, city planning etc where intervention with the nature is involved, may be made mandatory.

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- Guidelines & Best Practices

Annexure P-10

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Rationale...

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G-SHE

- The sustainable development of this region is a challenging endeavor
  - Need to innovate to ensure that good practices are adopted after suitable adaptation to local conditions
  - In parallel, there is a need for clear guidelines for sustainable management and governance of the Himalayan ecosystem

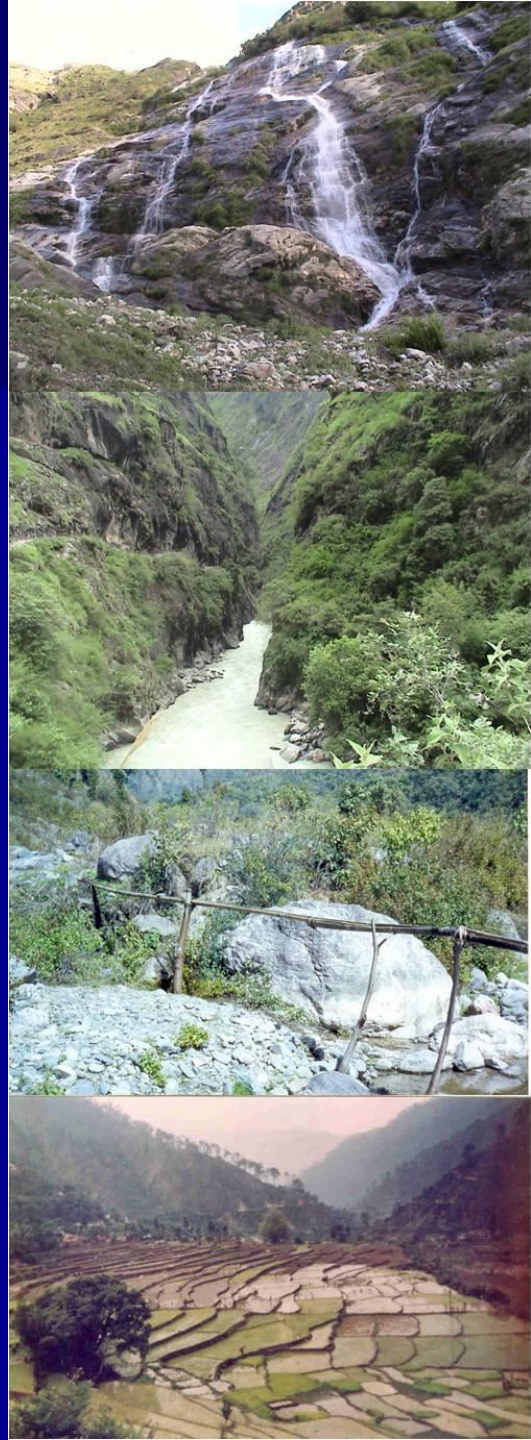
G-SHE...

- Forms a part of broader climate change adaptation strategy
- Collation of key learning from existing best practices
- Exercise towards mainstreaming the valuable lessons

A working document, meant to provide the basis on which new approaches and practices can be adopted

Major Issues

- Sustainable Urbanization
- Tourism and Ecotourism (Regulated tourism)
- Rejuvenation of Springs and River Basin (Water scarcity)
- Building Environmental Awareness
- Green Energy Solutions (Energy options)
- Conservation Areas and Forest Zone Management
- Monitoring Networks
- Infrastructure Development: Integration of New Approaches (Infrastructure development)
- Disaster Risk Reduction



Issues and Best practices

- **Sustainable Development of Hill Towns**
  - **Smart City Mission (2015)**
  - **Guidelines for Hill Town Planning and Architectural Norms**
- **Solid Waste Management**
  - **Swatch Bharat Abhiyan (2014)**
  - **Ban on Plastic (HP, UK, Sikkim, Tripura)**
  - **Door to Door Garbage Collection (HP, UK)**
  - **Applicable Guidelines and Rules:**

    (Municipal Solid Waste (Management and Handling) Rules, 2000; Hazardous Waste (Management and Handling) Rules, 2000; Plastic Waste (Management and Handing) Rules, 2011; E-Waste (Management and Handing) Rules, 2011; JNNURM SWM Toolkit 2012)
  - **Guidelines for scientific solid-waste management plans suggested**

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Issues and Best practices

Tourism and Ecotourism

- **Tourism and Pilgrimage in Sensitive Areas**
  - Harnessing Religious Sentiments for Conservation
  - Regulation of tourism in Rohtang pass
- ***Ecotourism and Regulation of Commercial Tourism***
  - Community based ecotourism in NE states
  - Development of ecotourism in Sikkim
  - Encouraging homestays for local communities
  - Linking of tourism with Rural Business Hubs in NE region

Rejuvenation of Springs & River Basins (Water Security)

- **Springshed Development**
  - Dhara Vikas Program in Sikkim
  - Spring Recharge through VEAP, GBPIHED
  - Springshed management, Meghalaya
  - Spring of Hope, HP
  - Minimum flow policy for Hydropower, HP

Issues and Best practices

Building Environmental Awareness

- Environmental Education, Awareness and Training (EEAT), MoEF&CC
- Green Haat, MoEF&CC
- Science Express: Biodiversity Special (SEBS), DST & MoEF &CC

Sikkim Government

- Eco Clubs and Green Fund instituted for schools and colleges
- National Green Corps Programme
- National Environmental Awareness Campaign
- Green School Programme

Green Energy

- Supportive measures by IHR states for energy generation and conservation, Himachal Pradesh, Tripura
- Efficient Use of Energy, Uttarakhand
- Biomass energy from Pine Needle at village level, Uttarakhand

Issues and Best practices

Conservation Areas and Forest Zone Management for Community Development

- **Forest Conservation and Management**
  - Maintenance of Forest Cover, Finance Commission
  - Green India Mission and CAMPA & National Afforestation Programme (NAP), MoEF&CC
  - Renting colonies of honey bees by Apple growers, Himachal Pradesh
- **Community based Conservation and Management**
  - Joint Forest Management (JFM) Programme- J&K, Manipur, Mizoram, UK, Assam
  - Van Panchayat System, Uttarakhand
  - Community conserved area approach, AP
- **Payment for ecosystem services, HP**

G-SHE...

Issues and Best practices

Monitoring Networks

- Himalayan Glaciology Programme (HGP), DST
- Integrated Himalayan Meteorology Programme (IHMP), IMD
- Weather and Glacier monitoring, GBPIHED & CSIR-C-MMACS,
- Centre for Glaciology, DST-WIHG

Infrastructure Development – integration of new approaches

- Ideal Himalayan Habitats, GBPIHED
- Ecologically safer roads – green road, Assam
- Green Highways Plantation and Maintenance policy 2015, GOI
- Comprehensive EIA of Developmental projects
  - Carrying capacity assessment at basin level, MoEF&CC

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Issues and Best practices

Disaster Risk Reduction

- **Institutional structure is in place**
  - National Disaster Management Authority (NDMA), GoI
  - State Disaster Management Authority (SDMA), IHR States
- **Other Initiatives**
  - Vulnerability Framework, SDC
  - Poverty Vulnerability Framework, ICIMOD
  - National School Safety Project, IHR States & NDMA
  - Hazard Safe Building Codes and Norms, Sikkim

Suggested Guidelines and Road Map

- Solid Waste Management
- Hill Town planning and Architectural Norms
- Regulating Tourists and Pilgrimage to Sensitive Areas
- Promoting Ecotourism and Regulation of Commercial Tourism
- Rejuvenation of Springs and Degraded Catchments
- Rain Water Harvesting
- Ecologically Safer Roads
- Community Based Disaster Risk Reduction
- Road Map for Implementation of the G-SHE

Solid Waste Management

- Guidelines/prescriptions disallowing indiscriminate disposal of garbage, particularly the non-degradable waste, caused by accumulation of plastic bottles and polythene bags in hill towns in the Himalayas should be immediately put in place.
- Good quality potable water may be made available at various locations in hill towns so that people can fill their bottles, on payment basis.
- Preventive and management steps for solid waste management need to be initiated at the point of origin itself i.e. households in the urban/rural localities, trekking routes and camps, and expedition tops.
- Documentation about the different composition of waste from the hill towns to the expedition tops is essential. The nature and extent of solid waste will be able to identify the sources in terms of the factory make as well as type of individuals.
- Energy driven techniques such as conversion of biodegradable waste into biocompost, or vermicompost should be promoted in place of land filling open dumping or burning.
- The four `R's principle' should be applied for waste management problem: Refuse waste prone commodities, Reuse once discarded commodities for other uses, Reduce through segregation into broad categories—biodegradable and non-biodegradables at household/ individual level, and Re-manufacturing once fully used or completely unusable commodities/items from factories such as ruptured plastic into plastic noodles for new products. Such practices would also help generate income.
- Awakening and capacity building of the stakeholders like urban/rural dwellers, municipalities, tourists, trekkers, expedition members in promoting the suggested management plan in a particular geographic region would help a lot in managing the waste in the Himalaya.

Hill Town planning and Architectural Norms

- Fragmentation of habitat in hill areas should be prevented. The habitats in hill/mountain areas should be consolidated in order to avoid demands for creation of additional infrastructure.

- Specific areas for rural/urban development should be designated beyond which construction may not be permitted.
  - No construction should be undertaken in areas having slope above 30^0 on areas which fall in hazard zones or areas falling on the spring lines and first order streams identified by the State Governments on the basis of available scientific evidence
  - Construction should be permitted in areas with slope between 10^0 to 30^0 or spring recharge areas or old landslide zones with such restrictions as competent local authority may decide

- Architectural and aesthetic norms for construction of buildings in mountain/hill areas should be enforced

- Tourist resorts, commercial complexes and institutional buildings should be located in areas with surplus water and electricity so as not to affect the rights of existing users without their prior consultation

- Where cutting in an area causes ecological damage and slope instability in adjacent areas, such cuttings shall not be undertaken unless appropriate measures are taken to avoid such damages

- An integrated development plan may be prepared taking into consideration environmental and other relevant factors including ecologically sensitive areas, hazard zones, drainage channels, steep slopes and fertile lands. Areas rich in ground water may not be diverted for construction activities

- In highly seismic areas like Himalaya, all construction should incorporate earthquake resistant features as prescribed in building codes, guidelines, manuals and other bye-laws

- Location-specific technologies should be deployed for construction of buildings (including use of hollow blocks for better insulation of buildings, and making use of passive solar heating)

- Regulation of sale/purchase of land and residential/commercial buildings may be considered in order to prevent violation of land use planning norms

Regulating Tourists and Pilgrimage to Sensitive Areas

- Pilgrimage tourism in the Himalaya requires both development and regulation so as to reduce congestion and resultant pollution
- The accommodation and road transport infrastructure needs to be developed in pilgrimage sites. Existing accommodations in the pilgrimage sites need to be improved with adequate amenities and facilities throughout the region wherever it has potential
- All existing sites should have adequate provision of garbage disposal and management
- Sacred groves in the Himalayas, particularly the NE region, have been proving to be the best means of conservation for natural resources such as forests; emphasis should thus be placed on spreading the idea in other parts of Himalaya with a provision for the villagers for some earnings from the visitors.
- An inventory of historical, sensitive and sacred sites including sacred groves should be prepared and their vulnerability should be assessed.
- The number of tourists to vulnerable sites should be regulated and limited
- The pilgrimage tourism is a kind of "economy class" tourism in the Indian Himalayan Region since most pilgrims generally belong to middle income group and prefer to stay in Dharamshalas and moderately priced accommodation. Suitable accommodation and other facilities need to be made available accordingly. This will also help in identifying carrying capacity of the area in accommodating the inflow of tourists.
- The access to such (and other) sites of incomparable value through vehicles needs to be restricted beyond a certain zone.

Promoting Ecotourism and Regulation of Commercial Tourism

- 5-Star approach in respect of hospitality industry should be replaced by homestead approach to promote mountain tourism. Eco-tourism villages, parks, sanctuaries and other areas should be identified to establish a primary base for ecotourism. Village communities, especially youths, and rural women should be involved in Ecotourism
- Restriction should be placed in terms of visitors/ vehicles per day/ per group to the eco-tourist sites in order to minimise impact and maintain the sustainability of the eco-tourist destination. Economic instruments and product diversification can also be used for regulation of tourist numbers
- Fund raised should be used for base resource, eco-tourism element conservation, and education and awareness campaigns for visitor/ host community sensitization
- Incentive structures should be developed by according specific roles to the locals in management of tourism and allied industries. Their capacity in different segments of the enterprise should be built so that they feel involved and react in a responsible manner
- Local art, crafts, cuisines, and dishes should be promoted and made an integral part of tourist experience in order to ensure that most of benefits go to locals and, at the same time, their cultural integrity/ entity is not lost in the face of acculturation and cultural drift
- It should be mandatory for expedition to remove and take out the garbage, refuse and particularly the non-degradable materials. Expeditions should be asked to leave a deposit as security with an appropriate authority to ensure that the regulation is met. Penalties on the use of wood should be imposed
- Best practices on commercial trekking should be imposed on a mandatory basis in consultation with institutions having the necessary expertise and Government approval
- Interactive websites relating to mountain access, trails, availability of facilities should be set up which should also provide the facility of online request, approval for visit to parks, restricted sites and payment of fees etc.
- Creation of soft infrastructure like log/bamboo huts should be promoted in busy mountain areas

Rejuvenation of Springs and Degraded Catchments

- Special attention should be paid to recharge of ground water and improvement of hydrology and quality of mountain lakes/wetlands through restoration of forests
- Detailed geological mapping should be conducted to identify the spring recharge zone and locate structures such as, joints, faults, shear zone fractures and cleavage etc.
- Nuclear water prospecting technologies available with Institute of Hydrology and BARC should be used to map the water sources and prevent the location of construction activities that could damage or adversely affect such sources
- There should be engineering measures to protect recharge zone from biotic interferences such as, grazing, felling of trees and cutting of grasses and other vegetation, mining, wildfire etc. in form of barbed wire/stone wall fencing
- Social fencing measures, e.g. (i) digging shallow infiltration trenches (1-1.5 ft. deep) along contours and small percolation ditches on sites showing open joints, fractured or sheared rocks and providing stone gravel mulch in these trenches to reduce evaporation losses and soil erosion; (ii) construction of stone-mud check dams in gullies to store rainwater and check soil erosion; and (iii) land leveling, maintenance of crop field bunds to allow stagnation of rainwater should be enhanced.
- Vegetative measures include clothing the recharge zone with grasses, shrubs and broadleaf trees at suitable distances with the aim to enhance rainwater infiltration and reduce rainwater runoff. The selection of plants should be made from the local flora and after consultation with the local people. Shallow-rooted plants are most desirable for this purpose. Leaf litter and weed mulching at barren spots would induce rainwater infiltration and reduce evaporation loss of soil moisture
- Involvement of stakeholder community should be ensured at every step of the Spring Sanctuary Development. The maintenance and aftercare of the interventions have to be ensured through their involvement.

Rain Water Harvesting

- All buildings to be constructed in future in urban areas should have provision for roof-top rain water harvesting commensurate with its plinth area with minimum capacity of 5 KL for plinth area above 200 sq. m., 2 KL for plinth area of 200 sq. m. or below in case of residential buildings and minimum capacity of 0.01 cum per sq. m. of plinth area in case of commercial and institutional buildings such as tourist complexes, hotels, shopping complexes and Government buildings
- Provided that minimum standards for commercial and institutional buildings shall also apply to such buildings in areas not covered within the limits of urban areas, where minimum standards have already been laid down by the State Government such standards shall take precedence
- The institutional and commercial buildings should not draw water from existing water supply schemes which adversely affect water supply to local villages or settlements
- In rural areas rain water harvesting should be undertaken through such structures as percolation tanks and storage tanks and any other means;
- Spring sanctuary development should be undertaken in the spring recharge zones to augment spring water discharge
- Rain water collected through storm water drains should be used to clean the waste disposal drains and sewers
- Ground water aquifer recharge structures should be constructed wherever such structures do not lead to slope instabilities.

Ecologically Safer Roads

- For construction of any road in the Himalayan region of more than 5 km (including extension/widening of existing roads) length where the same may not be tarred roads and environmental impact assessment is otherwise not required, environmental impact assessment should be carried out in accordance with the instructions to be issued for this purpose by the State Governments
- Provision should be made in the design of the road for treatment of hill slope instabilities resulting from road cutting, cross drainage works and culverts using bio-engineering and other appropriate techniques by including the cost of such measures in the cost estimate of the proposed road
- Provisions should also be made for disposal of debris from construction sites in appropriate manner at suitable and identified locations so as not to affect the ecology of the area adversely; further, the dumped material should be treated using bio-engineering and other appropriate techniques and the cost of such measures should be included in the cost estimate of the proposed road
- Wherever hot mix plants are used, they should be set up at least 2 km away from settlements and a minimum area of 200 sq. m. surrounding the site should be devoid of vegetation
- No stone quarrying should be carried out without proper overall management and treatment plan including rehabilitation plan and financial provision for rehabilitation of the site should be included in the cost of the management plan;
- All hill roads should be provided with adequate number of road side drains and these drains shall be kept free from blockage for runoff disposal; in the event that this is not done and this fact leads to damages that could otherwise have been prevented, the persons responsible should be liable for prosecution/damages; further, the cross drains shall be treated suitably using bio-engineering and other appropriate technologies so as to minimise slope instability
- The runoff from the road side drains should be connected with the natural drainage system in the area
- Fault zones and historically land slide prone zones should be avoided during alignment of a road, where for any reason it is not possible to do so, notice should be given providing full justification and the construction should be carried out only after sufficient measures have been taken to minimize the associated risks
- Notice should be given about all fault zones and land slide zones along the roads indicating the beginning and the end of such areas;
- Ridge alignment should be preferred to valley alignment. Alignment should be selected so as to minimise loss of vegetal cover; South or South-west alignment should be preferred to avoid moist areas
- Appropriate design standards should be followed while designing the roads including mass balancing of cut and fill and avoidance of unnecessary cutting; Encouragement should be provided for use of debris material for local development.

G-SHE... Suggested Guidelines

Community Based Disaster Risk Management

- Undertaking groundwork within government agencies working at village, block and district levels and to explore possibilities for CBDRM to occur and flourish, this includes the analyses administrative and financial environments within national, state and local governments.
- Selection of communities through risk assessment by identification of vulnerable community and venue of risk reduction actions.
- Building rapport and understanding community priorities to gain trust and confidence of the community to understand their needs and capacities.
- Participatory disaster risk management planning to evolve and plan a risk management strategy through constructive dialogue with selected community.
- Community managed implementation of risk reduction measures for implementing a CDBRM programme within a selected community/ communities
- Community based participatory monitoring and evaluation (usually community devised) to measure progress with risk reduction to take actions to improve the actions.
- Ensuring of establishment, strengthening, and sustenance of community level organization mechanism for implementation of CBDRM by involving the local residents in the community.
- Preparation of community hazard vulnerability capacity map (HVCM) to form basis for community based disaster risk reduction and community learning.

G-SHE... way forward

- Coordination Committee for G-SHE at central level comprising MoEF&CC and DST and other line Ministries in which Secretary/Additional Secretary level officers from MoEF&CC and DST may chair the committee with DST Secretary/Additional Secretary as Co- Chair and the Directors of the Agencies anchoring Task Forces of NMSHE

- Nodal officers at the level of Joint Secretaries from other Central Ministries and equivalent level from all IHR States may be identified as members. The committee may co-opt any other members

- The coordination committee would suggest the road map for implementation of G-SHE guidelines under NMSHE with engagement and ownership of state governments for effective implementation of G-SHE guidelines. The meetings of the Coordination Committee for G-SHE may be organized once in six months

- After constituting the Central Coordination Committee and finalization of TOR, similar coordination committees/mirror image may be constituted in all the IHR states under the Chairmanship of identified State Nodal Officer

- A parallel expert group chaired by an eminent Scientist and consisting of subject matter specialists and relevant institutions such as ICIMOD may be constituted to address relevant scientific issues in different sectors identified for implementation under G-SHE guidelines

- The Mountain Division at MoEF&CC, and GBPIHED shall take measures to initiate updating of G-SHE document

G-SHE...

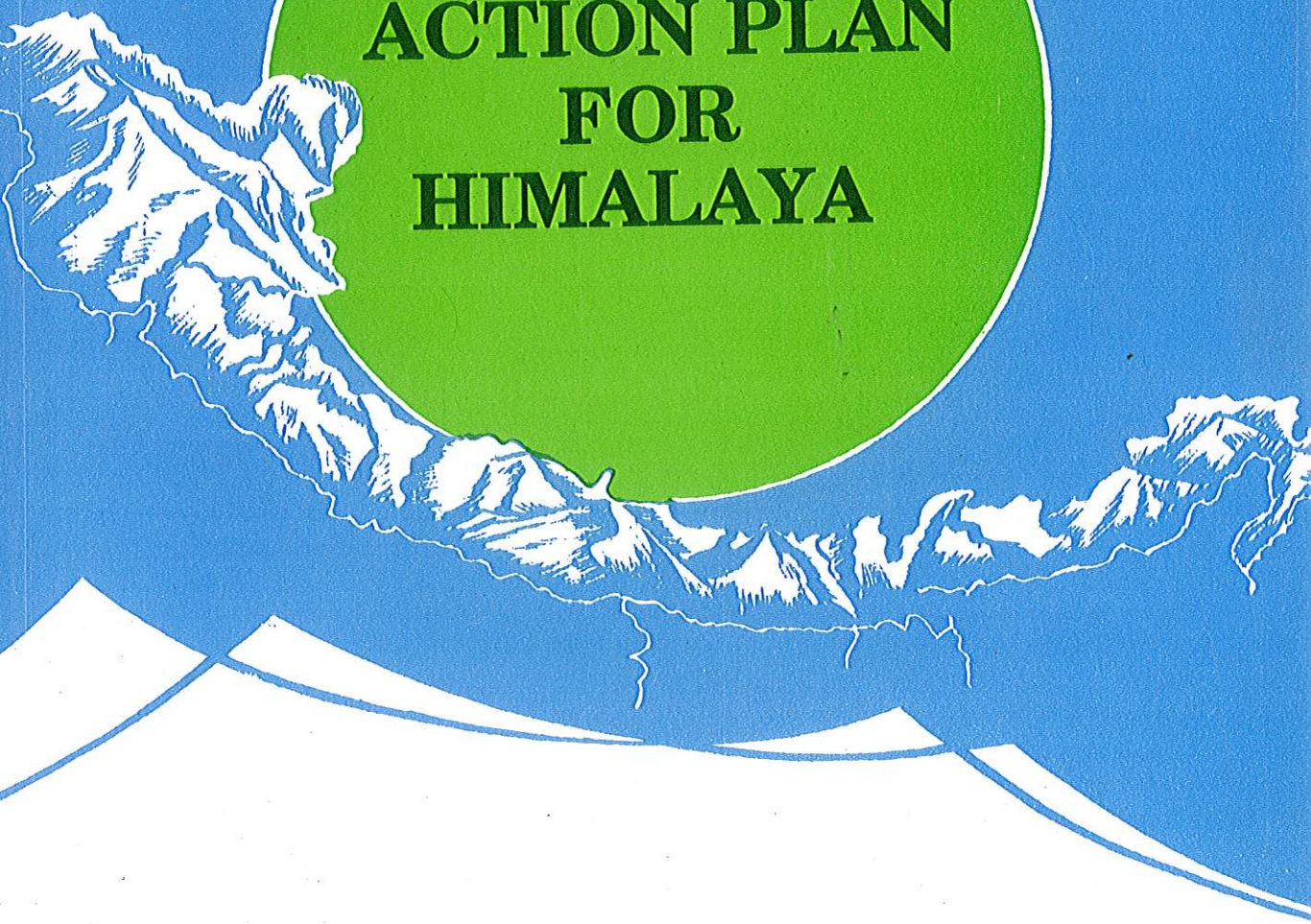
Striking a balance among development and the fragile ecosystem components - *forest, land & soil & snow, water*

Thanks...

Himavikas *Occasional Publication No. 2*

Annexure P-11

ACTION PLAN FOR HIMALAYA



G.B. Pant Institute of Himalayan Environment & Development
(An Autonomous Institute of Ministry of Environment & Forests, Government of India)
Kosi, Almora 263643
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790

Action Plan For Himalaya

G.B. Pant Institute of Himalayan Environment and Development

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FOREWORD

The Himalaya is vast, gigantic, diverse and youngest mountain system in the world. It is the glory of India on several planes, spiritual and philosophical as well as materialistic, economic and ecological.

It occupies 18% of the geographical area of our country, and regulates climate of the entire Indian sub-continent. There are several valuable plant and animal species, minerals and human societies exclusive to the region, with rare or no alternate options elsewhere. The Himalaya feeds the major river systems of the Indian sub-continent. The difficult terrain and inhospitable climatic extremes coupled with many other factors, seem to impede the pace of development of the region. While there are several pockets subjected to severe environmental degradation, many resource rich pockets still exist.

The Himalaya, on account of its vastness and distinct entity, biological, social and ethical diversity and problems of the region having far reaching local, regional and even global consequences, deserves priority for action - action planned in ways radically different from those being adopted elsewhere.

The magnitude of problems directly or indirectly related to environmental and developmental issues vary from place to place. Much is known about the origin and consequences of these problems but what remains to be done is to find out workable solutions to them.

All are concerned as to how to overcome the undesirable trends of deterioration of environmental quality and unsustainable development, yet preservation of environmental quality and long-term sustainability in development remain to be achieved. In order to negate the possibility of further aggravation, the emphasis should necessarily be shifted from mere 'concern' or 'thinking' to the 'concrete and quick actions' for environmentally sound and economically viable development. Often emphasis is laid more on theoretical aspects of the course of action rather than the much needed specific actions.

It was to fill-in this gap that the G.B. Pant Institute of Himalayan Environment and Development decided to prepare a comprehensive document, "Action Plan for Himalaya", to strengthen the mechanism of ecologically sound economic development of the Himalaya.

We are appreciative of the efforts put in by the Director of the Institute and his team in accomplishing this task within record time. This document, I am sure, will give an integrated flavour to the sectoral development actions to be carried out by various organizations.

In my capacity as President of the Society, as well as the Minister for Environment & Forests, I take pleasure in presenting this Action Plan to the general public for their information. We would be happy to receive suggestions on the subject, which can be followed up by the Institute in its research and extensive effort of working in this magnificent terrain of ours.

(KAMAL NATH)

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   - 4.5. Biodiversity and conservation
   - 4.6. Transport and communication
   - 4.7. Tourism
   - 4.8. Industrialization
   - 4.9. Health and nutrition
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PREFACE

G.B. Pant Society of Himalayan Environment and Development, presided over by Honourable Minister of Environment & Forests, Government of India, Shri Kamal Nath, at its first meeting in March, 1992 assigned the task of preparing an "Action Plan for Himalaya" to this Institute. This document is the outcome of this decision.

Usually seminars and symposia are organised to gather ideas for preparation of such documents. Departing from the beaten path, the scientists of the Institute preferred to follow a different route. Letters were sent to eminent and knowledgeable persons in the country working in or thinking about the Indian Himalaya, seeking their views on the actions needed for an environmentally sound development of the region. Simultaneously, scientists of the Institute conducted a rapid survey of the rural areas in each of the states in the region so as to know about the perceptions of and priorities for development among different sections of the society. In addition, Institute's earlier publication "Himalayan Environment and Development - Problems and Perspectives" was a great help in preparing this document.

It is rightly stated in Shantiparva of Mahabharata (190.9) that इह खल्वमुष्मिंश्च लोके वस्तुप्रवृत्तयः सुखार्थमभिधीयन्ते। *i.e.,* "In this world or elsewhere, all attitudes to obtain the things are aimed at happiness". Therefore, the Action Plan has to be to improve the ways and means to obtain the happiness, which vary with time and space. To obtain happiness, demand for the roads is the top priority in remote and non-accessible areas. Scarcity of food is the most common in areas of limited agricultural land. Priorities include income generating sectors like tourism in the list of elites, issues relating to conservation in the list of scholars, and industries in the list of unemployed youths. In such a scenario, to prepare the Action Plan in accordance with the priorities was found to be an uphill task. However, water and soil conservation followed by forests and energy have been identified as the priority sectors for achieving sustainable development of the region.

The document only enumerates the sector wise priority actions covering research and developmental activities as well as management aspects required for increasing the pace of environmentally sound development in the region. The methodology and financial outlays to execute the actions will vary from sector to sector as well as from one region to another but these aspects have not been included in the document.

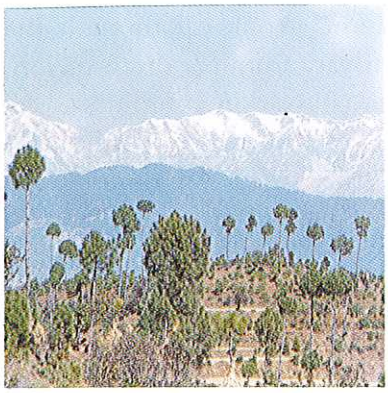
It is relevant to add that during our surveys it was felt that a general perception has grown among the public that development and environmental management are the responsibilities solely of the Government and of its personnel. The fruitful outcome of any Action Plan depends on the worldly morality of all; Government is only an instrument for management of the activities, which should work as 'catalyst' and not as 'fuel'.

The document owes a lot to all my colleagues at the Institute specially, Drs. R. Swarup, K.G. Saxena and K.S. Rao. Special appreciation is extended to Miss Sarita Aswal and Miss Hema Pant for their tireless and devoted efforts in typing the manuscript. The help of Mr. R.C. Prasad and Mr. C.B.S. Mehra in preparing the graphics and data compilation is duly acknowledged.

Kosi
December 15, 1992

A.N. Purohit
Director

1. HIMALAYA - A PRIORITY AREA



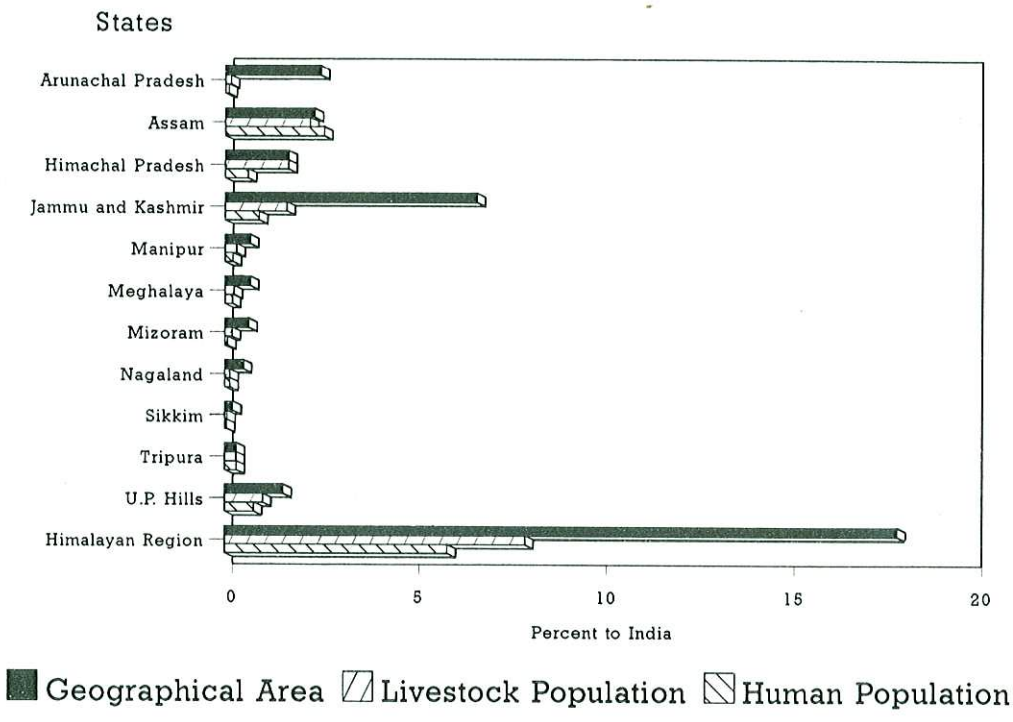
Ecological Diversity

Himalaya constitutes a unique geographical and geological entity comprising a diverse social, cultural and environmental set up. On account of its being the youngest mountain chain on the planet, the region is believed to be still evolving and thereby not having stabilised from geomorphological and geological considerations. Geological instability interacting with a complex of problems including population pressure, deforestation, landslides, erosion, water scarcity, out migration and poverty manifest fragility to the Himalayan ecosystem. Despite all these problems apparent as degradation of Himalayan environment and poor level of living of its people, the region encompasses several 'resource rich spots'. Alterations in environment and patterns of development in the Himalaya in future are considered crucial not only for the indigenous people but also to those elsewhere. Himalaya influences even the climatic changes in the continent. Himalaya controls monsoonic climate and ensures adequate water flow in major rivers in a part of South Asia. Agriculture potential of Indo-Gangetic plains, the bread-basket of India, depends very much on the Himalayan environment which regulates the water supply to the plains.

More than 2,800 kms in length and 220 to 300 kms wide, the Indian Himalayan region is spread over the states of Jammu & Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya and a part of Assam, alongwith eight districts of Uttar Pradesh and one district of West Bengal. It has a total geographical area of approximately 591 thousand sq.km (18% of India)inhabited by 51 million persons (6% of India). The region is characterised by sparse population, undulating terrain, farflung small villages difficult to approach, tiny and scattered land holdings more so on slopes with shallow and gravely soil, agro-pastoral economy, scanty irrigation, little use of modern technology and inputs, low productivity, *etc., etc.* These coupled with almost no industrial development and

thereby low employment potential, stimulate the local youngmen to seek employment away from their homes. The problem of youth moving away gets aggravated in the areas where an inhospitable climate outweighs the sentimental attachment of people with the native land. Agriculture is the primary occupation of the people all through the region but the agricultural land use patterns vary from region to region. While in the north-eastern region, shifting cultivation continues to be the general practice on slopes, settled agriculture on terraced slopes dominates in the central and north-western region. All through the region valleys are characterized by settled agriculture and intensive cropping.

BROAD FEATURES OF HIMALAYAN STATES



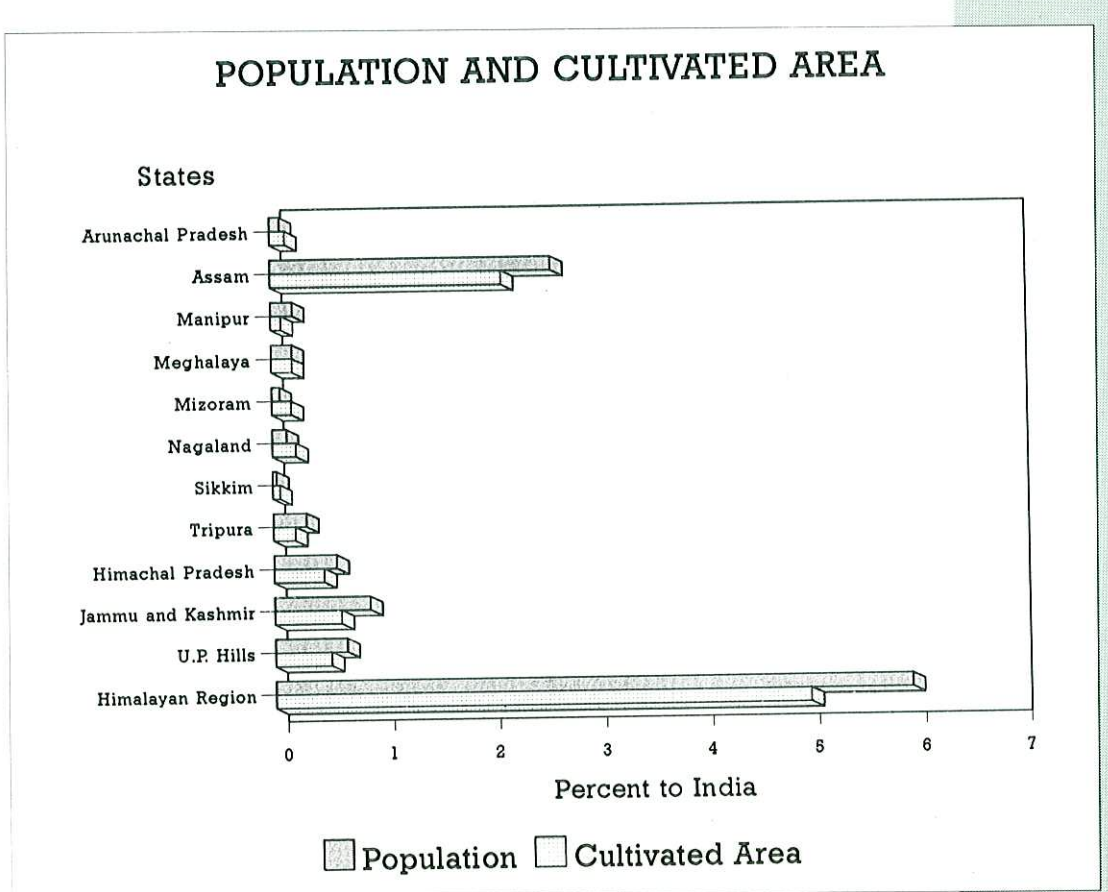
The natural resources of any country or region, and so of the Himalaya too, can be grouped under two broad categories:

I. Geophysical:
   - Land
   - Water
   - Climate

II. Biological:

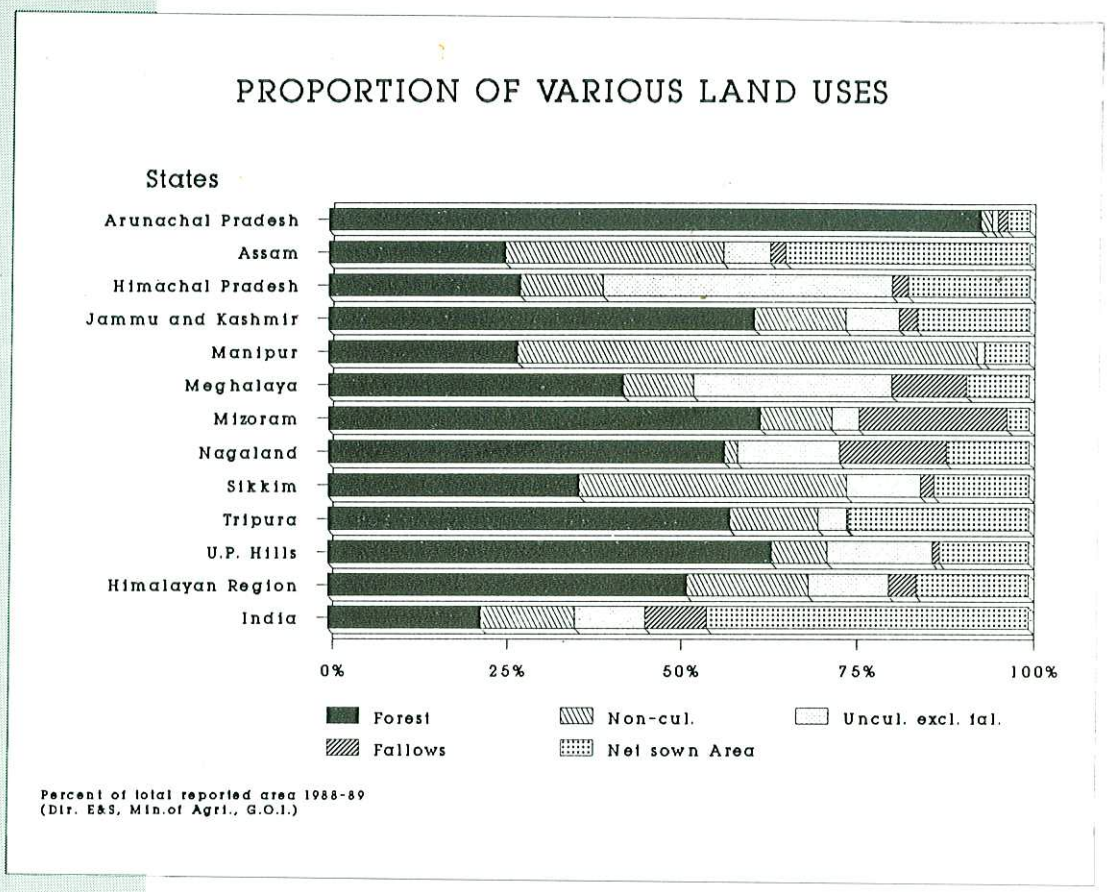
People
Livestock
Flora and Fauna

Amongst these, people are the most important one, as apart from they constituting 'human resource', their actions set the values and use of other resources. Also, it is the welfare of human beings which constitutes the goal of development planning - whatever be the scale - regional or global. The density of population is highest in Assam (284) closely followed by Tripura (262) while Arunachal Pradesh (10) stands at the other extreme in this matter. However, very high population density in Assam is probably due to inclusion of floodplain of Brahamputra and in case of Tripura because of exceedingly large influx of population from East Pakistan (now Bangladesh). Himachal Pradesh (8.7 % of population in urban centres) followed by Sikkim (9.1 % of population in urban centres) are the least urbanised while Mizoram is reported to be the most (46.2 % of population in urban centres). In the matter of sex ratio, barring the rural areas of hill districts of Uttar



Pradesh and Himachal Pradesh, males out-number females, the difference in the sex-wise relative position is narrower among urban populace. Like elsewhere in the country, the proportion of literates is more in urban areas than in the rural. Literacy is more in eastern states of Himalaya compared to that in the western.

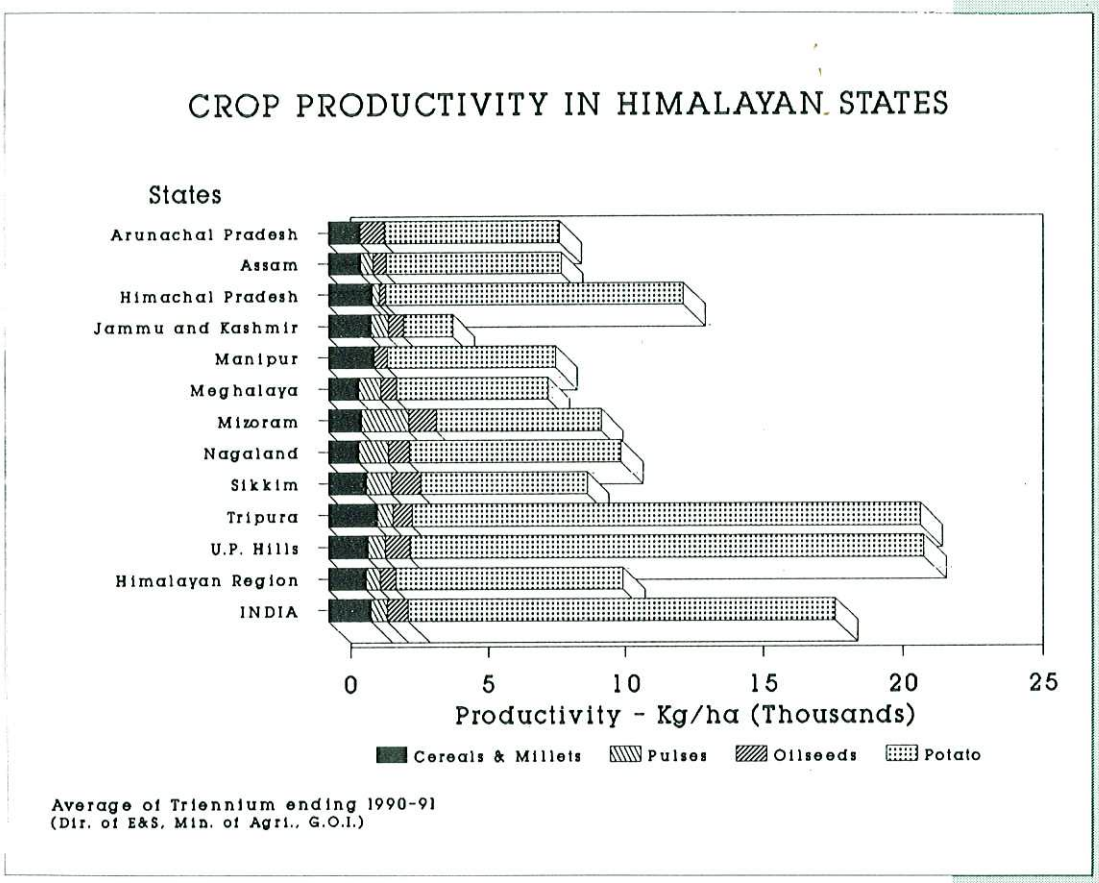
The figures for decadal population growth rates calculated for each of



the Himalayan States for the period 1901 to 1991 indicate that the rate of increase has slowed down, though marginally in most of the cases. However, it is still above the national average in all sub-regions excepting Himachal Pradesh and Hill Districts of Uttar Pradesh.

Excepting in Tripura, the proportion of women cultivators is more than that of men. In Tripura, more women are reported to be engaged as agricultural labourers and in other works. This, by and large, supports the general view that in the hills women work more than the menfolk.

The entire Himalayan region accounts for 6.22 per cent of the land holdings covering 4.95 per cent of the area in the country. Thus the average size of holding in Himalaya is smaller than elsewhere and that of the country as a whole. This is so as a large chunk of land is either seized for non-agricultural use, *e.g.*, forest or is not suitable for agriculture, *e.g.*, uncultivable, covered with water or old fallows. All these together pull down the figures of net sown area in all parts of the Himalaya. Despite the poorer irrigational facilities and other modern agricultural technology impacts, the region, except for the states of Mizoram and Tripura, exhibits cropping intensity better than the national average.



Wheat, maize, ragi, rice, and potato are the most important crops grown all over the region. State averages of yields of these crops are lower than the respective national averages. The region does enjoy monopoly in the production of virus-free potato tubers, temperate fruits particularly apples, and several other high value, cultivated as well as wild, crops which provide scope for designing alternatives or

complements to traditional agriculture as an instrument for development in the region.

The causes and consequences underlying the increased deficits in resource demand-supply potential are many and varied. The consequences, social, economic or ecological, apparent at local, regional or global level, are challenges to scientists, planners and administrators. Himalaya, on account of being highly diverse when characterized in terms of physical, biological and socio-economic parameters and far-reaching consequences of the problems in the region, demands a priority for actions for development planning distinct from other regions of the country. The specificities of Himalaya deserve to be made use of and not looked down.

2. THE SYNDROME OF PROBLEMS AND FUTURE OUTLOOK

Land Degradation

Trends reflecting exploitation of natural resources at rates much higher than those at which these resources get replenished, are presently evident all through the world. The reasons and consequences of these trends are also well known. While dramatic increase in per capita resource demand is identified to be the basic cause of widening the gap between resource exploitation and replenishment in the affluent regions, population explosion is argued to be the strongest determinant of such trends in the developing and underdeveloped regions. Consequences of these trends appear as deterioration in environmental quality in terms of deforestation, poor biological productivity and utility potential, soil erosion, hydrological imbalances, flood and other natural hazards and socio-economic inequities. With increasing altitude, the "mountain - syndrome" is characterised by: (1) lower rates of abiotic, biotic and cultural exchanges, (2) slower rate of growth, (3) slower aging and late maturity, (4) poorer reproductive efficiency, and (5) higher resistance. Therefore, in such a syndrome the visible impact of environmental problems are less prominent at higher elevations. However, the impact of natural hazards increases with increasing altitude.

In the present day scenario deforestation is considered to be the primary problem paving way for a chain of secondary problems including erosion, land slide and poor crop production. Conflicting views on the causes of deforestation and associated environmental degradation have been expressed. While the governmental agencies invariably argue for excessive extraction and conversion of forests by the rural poor to meet the fuelwood, fodder and food demands, others accuse the forest management policy for giving emphasis to maximizing the revenue returns. There are indications that population growth (human as well as animal) alone was not responsible for the observed

extent of deforestation. Forest area and human population data of states in the Himalayan region indicate that though the increasing trend of population growth and decreasing trend of forest area are evident, there seems to be no statistically significant relationship between the two parameters. Nagaland, a state where the rate of population increase is observed to be the highest, shows the lowest extent of deforestation. Manipur, Meghalaya and Tripura exhibit more or less similar rates of population growth but differ considerably with respect to the loss of forest cover during the same period. Data on forest cover and population merely at two points of time are indeed inadequate for drawing any precise trends or relationships. Further, demands on forests by the increasing population may not necessarily get expressed as deforestation in a true sense. While there are deficiencies in the methodology adopted for deducing these statistics, the observations do provide substance indicating that (a) population explosion alone is not responsible for the current scenario of forest degradation, (b) unrealistic picture may emerge if attempts are made to predict the future scenario based upon the available data.

Expansion of pine forest at the expense of broadleaf tree species is the biggest problem in the region which is going to lead to an alarming decrease in recharge of ground water and diminishing discharge of springs. Other consequences are the extensive forest fires leading to warming of micro-environment, loss of vegetational diversity and wildlife.

Agriculture is the primary occupation of the people in India. In the Himalayan region, agricultural systems and resource use patterns which could sustain the mankind under climatic constraints, difficult terrain and poor communication, evolved in the process of advancement of civilization. Although the habit of hunting and food gathering as an exclusive way of sustenance vanished long back, its remnants in various forms are still observed. A number of wildly growing plant species are even presently supplementing the food requirements of some tribes in the Himalaya. Shifting agriculture wherein the resource impoverished as a result of crop domestication, is recovered through the natural process of vegetational succession, continues to be the way of life of majority of tribals in the north-eastern India. Ecosystem stresses induced as a result of repeated crop harvests in terraced agroecosystems in the central Himalaya are still alleviated largely through the organic inputs derived directly or indirectly from the forests. Despite the

apparent differences in the organization of these diverse systems, all have a commonality in that all are dependent upon forest based inputs to sustain crop production. In one situation outputs to man through crop domestication and inputs through forest vegetation are separated in time (*e.g.*, cropping phase alternating with fallow phase in shifting agriculture) while in the other the outputs and inputs are separated in space (settled agriculture on terraces of the sloppy land). The critical separation of input and output sources in space or time needed for the optimal functioning of these systems has been threatened as a result of increasing pressure on land. This in turn has set in the trend of declining agricultural productivity and efficiency of production. Pastoral systems and nomadism representing an elegant example of resource use in favour of the mankind realizing the spatio-temporal variations of climatic constraints does exist. A close association of man, forests and environment observed all across the Himalaya implies a strong perception of ecological principles in the traditional management systems. These systems, however, are getting weak and also diminishing in critical areas. Deforestation appears to be the cause as well as the consequence of this collapse.

Historically, forests had been treated as a common property resource and thereby freely accessible to those inhabiting the region. Restrictions or denial to the rights and concessions pertaining to the forest use by the people through land tenure or ownership regulations are obvious to aggravate pressures on whatever forests are left accessible to the people. This in turn is likely to lead to complete loss of trees *i.e.*, deforestation than what perhaps would have been if the use pressure was diffused in the absence of such controls. Industrial exploitation of forests since the last century till a couple of decades back cannot be denied as a cause of deforestation in the hills.

Poor infrastructure and difficult terrain impede industrial development of the area and thereby low employment potential for the local people. Thus, though the region is rich with a primary production potential, concentration of processing of the primary produce elsewhere debars the Himalayan dwellers in getting a significant share in the accrued benefits. Reduction in productive capacity of the land alongwith many other factors accompanied mass migration, more so of males in many areas. There are instances in Garhwal Himalaya where more than 3/4th of the families migrated out of a village and an equal proportion of cropped land was abandoned during the period 1972-88. It is for the

salaried jobs for which males migrate but ownership of native land is retained. Management of land in such situations becomes the exclusive responsibility of women. Enormous expenditure of energy and time in collecting fuelwood, fodder and drinking water have made the life miserable specifically of the rural women.

Hydrological imbalances currently observed in the Himalaya are considered to be linked to the loss of vegetation cover. Further these two factors under the influence of the geomorphological forces in geologically active belts exacerbate the process of landslides and erosion. These phenomena apart from directly deteriorating the local environment, have significant implications for the adjoining regions too. Devastating floods in the Indo-Gangetic plains are considered to be the consequence of deforestation in the Himalaya. However, it is also perceived that deforestation is inadequate as a generalised cause of floods. Run-off from chir-pine forests is far greater than from broad-leaved forests in good condition. Grass cover in good condition is as effective (if not more so) as broad-leaved forests as a check of run-off, and gives a clear run-off, *i.e.,* less silt. The forests are not in good condition specially because of over-grazing which prevents regeneration. Soil erosion is a natural process and gets accelerated under the influence of man induced disturbances beyond a critical disturbance regime. The disturbances are likely to have additive effects on erosion rates in the hills because of topography and geological processes. The observed consequences are thus the resultant outcome of natural and man-induced erosive forces. Most of the data on regional extent or intensity of problems like denudation, siltation, hydrological imbalances and floods suffer from the drawbacks including generalized surveys and tremendous extrapolation of site specific observations to large heterogeneous areas. Precision of the regional quantifications is found to be quite low. Similarly, while decline in agricultural production is realized and also attributed as a consequence of deforestation in many instances, the upper and lower limits of soil fertility in relation to crop yields for a given soil type have yet to be defined. There are serious limitations of using the available data to resolve whether the declining yields are due to decrease in productive land area or due to decline in yield rates or if due to both, their relative contribution. Thus it remains a challenge to the researchers as to what extent a given cause, by itself or in interaction with others, contributes to the degradational process. Pressure on government owned forest land and 'government policy - rural interests' conflicts are likely to aggravate with increase in

population density as long as alternative provisions for the sustenance and developmental needs of the people are not provided.

The entire Himalaya suffers from the natural disasters of mass movement and earthquakes, some regions being more sensitive than the others. These disasters would remain in times to come and one has to find out ways not of evading these disasters but to combat or at least reduce their disastrous consequences.

An appraisal of information available for the Himalayan region suggests that management considerations argued to have emanated from scientific studies are already inherent in the traditional systems. In Central Himalaya inter-cropping of 2-6 crops in a single field and crop rotations coupled with fallowing are common. Fallow length ranges from 3-4 months on irrigated fields in lower elevations to 8-9 years in rainfed areas at high altitudes. Material inputs in these production systems are exclusively the locally available ones. Irrigation is provided by diverting water flows along the gravitational force while minerals depleted as a result of crop harvest are replenished through input of organic manure. Crop production system practised in the fertile valley lands is of more intensive nature when compared with terraces.

Another example of traditional knowledge pertains to the shifting agricultural system, still a predominant land use in the north-eastern Himalaya. The number of crops sown together but harvested sequentially may vary from 4 to 35 depending upon the ethnic group involved and climatic conditions. A diverse crop cover is found to prevent losses through erosive forces and helps in optimizing resource use for diverse subsistence needs. The empirical ability of tribal farmers to identify crop composition as suited to prevailing conditions is also reflected. Cereals which are less vigorous and exhibit slow growth in the conditions of poor soil fertility are grown under longer cultivation cycles when nutrients are available in sufficient quantities. On the other hand, under short cycles where nutrient stresses are effective and weeds also increase to serious levels, tuberous and perennial crops which are more stress tolerant and vigorous, are emphasized. The system with sub-regional variations also provides an insight into the linkages of social and cultural values with resource production and use practices. What is needed is to appreciate the positive points of traditional resource production and use systems and strengthen them through science and technology inputs for further improvement in their values

and efficiency instead of advocating abrupt changes involving replacement of traditional systems by the new ones found suitable elsewhere and carrying a big question mark in the context of hills.

Development programmes in the past, due to economic, social and political constraints, have affected the food-fodder-energy links. Despite the ambiguity and inconsistency of land use data, reduction in forest cover cannot be denied. Since subsistence systems are dependent upon forest based inputs, yields are likely to be lowered, if not so far, then definitely in the future. As an ameliorative measure, promotion of agroforestry is often advocated to achieve the dual objective of promoting cash economy and environmental conservation. The former objective, in the present scenario, is as important as the latter, but is hard to achieve on account of long gestation periods before the planted trees yield marketable goods. Further, there are strong reservations of the people towards planting trees because of tiny and fragmented crop fields. The knowledge of tree culture ensuring the existing levels of crop production or possible improvements therein with such management itself, is quite inadequate in the hill areas. The ineffectiveness of the afforestation/reforestation programmes is clearly felt, though not quantified precisely. However, the facts that mountain trees are more productive than others, the existence of a rich tree germplasm useful to man for his present needs and the capability of many indigenous trees to improve rather than exhaust the soil fertility must be recognised and realized for future research and development in the Himalaya. Cultivation of medicinal plants has the possibility of getting ready acceptance by the people as it would help in strengthening the economy over short periods. This is an area which should be given priority in the development planning of the region. Promoting the earlier practice of collecting fruits and other useful products from the wild could be another option for benefiting people without any adverse consequences. This would however, necessitate framing an institutional mechanism by which the economic benefits directly reach the people in a wholesome way. There is, thus, immense scope for making use of the existing production systems to improve the well-being of the people inhabiting harsh hill environments. In the present circumstances when ecology and economy of the region have deteriorated to serious levels, development programmes ought to be framed for both short term and long term gains.

Since land and water resources have already been degraded to an alarming extent, restoration of the degraded ecosystems has to be the

core thrust of all development policies. The conceptual course of action in the research and development programmes in this context must attempt on:

- A thorough and objective quantification of resource base and problems;
- knowledge and application of in-hand Science & Technology to rejuvenate the degraded areas;
- undertaking research to refine the science/ technology relevant to restoration; and
- ways and means to motivate people to understand the problems, their far-reaching consequences and to seek their participation towards the problem solution.

3. DEVELOPMENT PLANNING

3.1. Past Scenario

Marker of Development

Development is a continuous process; even the most developed countries strive to develop further. Therefore, distinction of 'developed', 'underdeveloped' or 'developing', in a true sense is an illusion. Level of development is measured in relative and not in absolute terms. Further, perhaps with no exceptions, all the indices of development pertain to well-being and comforts of human-beings at varied spatial or geographical scale. Hence, the term denotes position of a region or country in comparison to others. In this sense, the hill areas of our country are the least developed and considerable efforts have certainly been made to elevate them to the national average. Though the desired has generally not been achieved, but at the same time, the seven Five Year Plans did have their impacts, the important ones worth listing are:

- A realization of special consideration of the peculiarities of hilly terrains and hill societies in development policy formulation and planning process;
- an appreciation of the values of hills in the maintenance of ecological balance, alongwith their long term economic values;
- preference to development programmes relying more on indigenous/local rather than external resources;
- emphasis on the area specific development programmes compatible to ecological and social specificities of an area, rather than a blanket plan for all hills;
- a need for hastening the process of technology transfer;

- importance of long term studies for ecological and economic changes in time and interactions in space for a realistic understanding of the hill ecosystems;
- relevance of integrated management of natural resources and programme implementation in ecological units (say watershed) instead of administrative units (Block/District); and
- over and above, all feel that drastic changes in the strategies so far adopted for development of Himalaya, are needed urgently.

3.2. Gaps in Efforts

The glaring gaps are:

- Poor use and performance of the available technologies in spheres like road construction, water supply, soil conservation, processing of fruits, vegetables and wool, *etc.;*
- lack of improvements in the age old designs of farm implements and thereby their efficiency;
- poor provisions and perceptions for linkages, complementaries, infrastructural and organisational support so essential for these areas;
- limited specific researches, technology development and transfer in the areas like varietal improvement in crops and fruits, restoration of degraded lands, water resource management, *etc.;*
- lack of complimentary and coordinated efforts for research and development with end-uses pertaining to progress of societies in the region;
- compromise on short term studies and ignorance for creating long term data base on geophysical, social, economic, and ecological aspects of the region;
- competetive and often antagonistic effects among the endeavours of governmental and non-governmental agencies on dissemination of science and technology;
- discontinuation of programmes like handicrafts; agricultural extension started in 1950s without providing alternative options to their end-users;

- presumptions of inherent inefficiency of traditional systems and thereby emphasis on search of new systems or imposing new systems in the hills without visualizing their irreversible negative impacts; and
- callous attitude of educational institutions towards necessary modification in their curricular and educational mechanisms taking care of the needs of the region.

3.3. Constraints

At this stage, it becomes pertinent to question ourselves as to why, in spite of considerable know-how and repeated recommendations of the Planning Commission, gaps in development planning exist and still worse is that instead of narrowing, the gaps are perhaps widening. The following factors have been observed to be generally responsible for such a grim situation:

- low investment per unit of area (one sq. km. on orthogonal projection in map may be twice or more depending upon the slope of land in mountain systems), though due to sparseness of population, the per capita figures appear impressive;
- introduction of technology without assessing the needs and priorities of the people having diverse socio-economic, cultural and ecological settings as well as problems;
- developmental efforts put in a particular direction in isolation and with no consideration to its effect in other related fields;
- technology developed for plains pushed into the hills without necessary and appropriate modifications;
- predetermined norms of development based on experience in the plains applied to the mountains as well;
- lack of extension education programmes appropriate to the needs of women and menfolk in the mountains;
- small, isolated and fragmented holdings;
- principle of 'more incompetent' persons to 'more difficult and undeveloped areas' restricting the hills from getting benefitted from efficient public servants;

- assertions by and privilege to 'pseudo-scientists' and politicians capable of impressively high thinking and propounding new ideas but lacking exposure to the realities in the hills and thereby emergence of local feuds and undesirable changes in programme formulation and implementation process;
- allurement towards comforts and glare of urban centers among the local elites and qualified youth in hill areas;
- political priorities for tertiary activities manifesting in 'abrupt changes' over the primary and secondary activities; and
- absence of government mechanisms to ensure contingencies in the event of natural risks and uncertainities for primary activities, and thereby attraction for salaried jobs rather than self-employment.

The perceptions towards development vary. The people are not satisfied with the pace of development and are less conscious towards the sustainability of development in a long term perspective. Policy framers, programme executors and the scientific community are now concerned more for the sustainability component and perhaps less for the pace of development.

Development in many sectors seems unsustainable for a variety of reasons. In the Himalaya, geophysical constraints and ecological imperatives of preserving the environment often lead one to conclude that whatever development has been possible, is *ad hoc* and merely an eyewash. Though such an extreme conclusion is certainly not true, it is felt that a long lasting strategy of development must be evolved keeping in view the terrain, agro-climatic conditions, background and needs of the local people, as well as their aspirations and the resources. While it is true that Himalayan environment has already deteriorated to an alarming extent and there are many gaps in our knowledge to design appropriate solutions, it is also true that ecologically rich areas and low input production systems (though they are not conceived to be developed on economic criteria), are surviving in the Himalaya to a much greater extent than elsewhere in the country. This appreciation for the environmental values blended with the essentiality of purposeful alterations in the natural resources as well as processes, an integral component of culture and social system of Himalayan man, has been suppressed by the documented knowledge on the 'miracles' of modern science and technology. Strategic approaches of developing new

technologies or thrusting those which proved successful elsewhere, must be replaced by looking into the indigenous repository of knowledge and technology followed by necessary refinements therein. Major components of such a strategy would be:

- Preparation of resource inventories and studies on levels of living of the people highlighting their needs in the context of their habits, traditions, experience, and resources ;
- identification of improved technologies that are simple in adoption, proven efficient under the socio-economic and physical conditions, specific to the problem or to the area;
- imparting extension education to the womenfolk alongwith the men in the target area;
- incentives for primary production activities and interventions for economic benefits of primary production directly to the rural poor;
- creating awareness towards the elements of sustainability in conjunction with the present trends of development so as to contain the unrealistic aspirations of the common mass and, an aspiration for development of society and not of the individuals;
- impact studies focusing on the acceptance or otherwise of the newly introduced technology and further needs in that direction. This would lead to a two-way traffic between the people and the technologists; and
- last but not the least, political willingness free from interference, and dedication of public servants without which nothing would succeed in our system.

It is not easy, though not impossible, to act on the above lines. At the same time, it would never hit the development targets in the real sense of the word unless these are followed. All development efforts aim towards fulfillment of human needs as well as their desires. Further, development has to be sustainable so that the posterity does not have to suffer because of the present mistakes. Therefore development without sustainability amounts to narrowness of thinking and action. Hence hard decisions on the matter would be unavoidable for the upliftment of the hill people who have continued to be hoodwinked so far at each level and by all concerned. The success of strategy depends, apart from many other factors, on the available finances to implement the tasks.

Finances are and will always be limited. Instead of the general development all across the Himalaya which has been attempted so far, it would be prudent to target selective remote pockets in each state in the first phase and then diffusing the strategies to other areas.

3.4. Institutional Facilities

Institutional capabilities, in terms of numbers, for generating and transferring the scientific information and technology have been developed to a considerable extent during the past Plan periods. The Snow and Avalanche Study Establishment at Manali is concentrating on avalanche control measures through civil and geo-technological engineering. The role and charter of the Institute include many other aspects of glacier and snowfed catchment basins in the entire Himalayan zone which might be taken up in the Eighth and subsequent Plans. The Defence Research Development Organisation is doing valuable work on high altitude crops and vegetables. In addition to these, Botanical Survey of India, Zoological Survey of India, Geological Survey of India, Forest Survey of India, Indian Council of Forestry Research and Education and Survey of India since their inception are also engaged in generating scientific knowledge and technological know-how about the hill areas in their respective fields. The Indian Council of Agricultural Research Institutions/ Agricultural Universities have been established in hill zones of the country. North-East Council has been established to look after research and development problems in the north-eastern region. In addition to the government departments representing various disciplines, general universities have also been established in most of the areas with the aim to generate and spread the knowledge and technology specific to the areas in which these institutions are located. In recent past, a healthy trend of the growth of non-governmental organizations is also observed. One of the basic philosophies behind the working of such organisations/ Institutions is to form a link for transfer of technology to the rural areas.

All the aforesaid institutions or bodies can be grouped under three categories namely, academic, managerial and voluntary. A perceptive review indicates that technological know-how for many problems is available but it is not getting transferred to the users as fast as it should have been. Remoteness of these areas, lack of communication and transport, lack of incentives to serve these difficult areas, are the reasons put forward for weak delivery systems. More than these, is the lack of

commitment and dedication at all levels. One of the dilemmas being faced is the inevitable fact of the administrators (managerial staff) and the scientists (academic staff) working differently. It is, however, vital that they work as a team. At present this concept of partnership between the two types of institutions is completely lacking and this has further been aggravated by the prolific rise of the third Institution of a recent origin, the non-government organizations, which should have been the 'customers' of new technologies rather than becoming the 'creators' of technology and 'critics' of the government infrastructure. Their deviation from the main role of spreading the technology is creating an independency instead of inter-dependency.

The environment and development related issues are mainly due to increasing conflicts of interests over resources. It is being realised that in spite of all our efforts, the environmental conservation is going at a slow speed. There is now need for a new paradigm or pattern of behaviour to put our knowledge into practice. It is in this connection, that all the partners in the development process review their presently common role and change it in the direction of desirability.

4. ACTIONS - DESIRABLE AND FEASIBLE

It is evident that problems of the Himalayan region are well known by now. The consequences of the problems are also realized. Knowledge gaps exist in the quantification of specific problems and their likely consequences. Multitude of problems demand immediate actions which are economically viable and ecologically sound and, at the same time, appeal to the people. Since there are many problems which are interlinked, integrated development rather than sectoral development oriented actions are needed. The problem in executing desirable actions is as to how sectoral development approaches could be readily transformed into integrated development approaches. Integrated watershed management approach sounds well when the objects of integrated management for development in the region are considered. However, as at present, watershed management programme implementation appears to be dominated by forest management. Further, there also appear problems for people as well as for the development agencies accustomed to consider Block or District as a unit of development planning, to orient themselves to watershed as a unit of planning.

There are significant gaps in the knowledge on designing appropriate solutions to the problems and limitation in finances are invariably felt to ensure effective application of solutions already known. Application of in-hand science and technology for restoration of degraded environments coupled with economic upliftment of the Himalayan people is required with parallel efforts on strengthening the science and technology knowledge system itself. The developmental activities in the region should be based on the carrying capacity of the individual areas.

This section enumerates priority actions covering both immediate applications for development in the region and research/development studies for increasing the pace of development in the future. A brief rationale on identification of the actions and the core themes of actions are given separately for the recognised sectors of development. As

financial and manpower resources are also limited, relative importance of and weightage to different sectors will be governed by the national development policy and regional priorities. The environmental consciousness at all levels is a prerequisite for the success. Our education system, in the past has been totally economy oriented. Therefore, it is difficult for the people to come to terms with the ecological approach immediately until we change the educational pattern. All states in the Himalayan region need to give top priority for the environmental education at various levels, only then any action plan will be possible to implement in the real sense.

The task of identification of 'right actions' must receive attention due to it but should not be emphasized to an extent that execution of identified actions is relegated to a secondary and isolated status. Future research and development must be tied up with the timely testing and replication of integrated development packages. It is high time to realize and accept that present environmental-economic-social problem complex in the Himalaya is not solely because of lack of 'technological know-how' but perhaps equally because of neglect of available knowledge while deciding priorities and specificities of actions for development in the region. This document provides a broad framework of actions desired for environmentally sound development in the Himalaya. Issues and actions pertaining to environment and development in broad terms are similar all across the region but the specificities and priorities would indeed vary depending upon a whole range of issues like current economic status, social conditions and organization, state machinery, local and regional concerns and so on. These specificities and priorities alongwith functional responsibilities of different agencies and associated financial requirements could be crystallized for each state by undertaking pilot projects.

The actions outlined here imply three courses *viz.*, research, technology development and extension. The agencies/institutions involved with these actions and whose efforts need to be coordinated from environmental considerations have been indicated broadly for each sector. There are already many existing institutions looking at the three courses independently or with some degree of overlap but are not interlinked to the desired levels. Strengthening the knowledge base by undertaking academic exercises are the priorities of the Universities. A mix of pure and applied research often tagged with experimental demonstrations are the priorities of agricultural and allied Universities

ROLE OF PARTNERS IN DEVELOPMENT

Actual	*Desirable*
THE PEOPLE	
Blame government for all failures and expect government to provide all resources for every bit of developmental activity with zero contribution from their own.	Strengthen the governmental efforts for development both by healthy criticisms and actual supports through peoples' participation particularly.
POLITICIANS	
Create 'illusory impressions' about development without much care for accomplishments.	Ensure development all over and in accordance with needs of the people and potentiality of the area.
BUREAUCRATS	
Conscious of the uncertainty of political process, take *a priori* decisions as per the political directions and give, *ex post facto* justifications.	Set the stage for continuously rational decisions and their implementation in letter and spirit.
SCIENTISTS	
Apprehensive of the premium put on publications resulting in arm-chair research, remote contact with people and field, and neglecting problem-solving research.	Direct contact with people and study area, examine peoples' needs, aspirations and problems, regional potentiality and viability of options, act as conveyer-belt between people and other partners in development.
TECHNOLOGISTS	
Claim to be providing instant technological solutions to problems posed to them and blame the extension agencies for their non-acceptability.	Assess problems and needs of the people through scientists as well as directly from the field and provide workable technologies.
GOVT. EXT. AGENCIES	
Kept busy with miscellaneous jobs *e.g.*, local arrangements for visiting dignitories, *etc.*, and more paper work leaving little time for extension work.	Should be aggressive partners in programmes like 'lab to land' and vice versa, help people in improving their know-how and do-how, and guidance for actions.
NGOs	
Fault-finding with the above groups and blaming them for all gaps and mistakes in development; depend on public funds for development activities, and too ambitious for public prominence.	Close contact with people and the area to have grass-root knowledge, make people aware of the solutions within their means, and arrange two-way traffic between people, technologists and government agencies.

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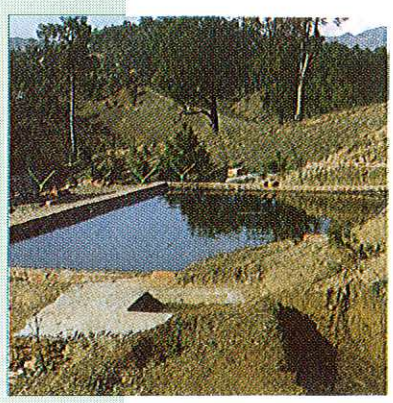
and scientific, technological and industrial Laboratories/Centres/ Institutes of State or Central Government. Extension presently is the major responsibility of State Governments. During the past couple of decades, quite a large number of non-governmental organizations have also come forward and often complement to the extension network. Thus, creating new institutions and establishments is not as important as strengthening collaboration and cooperation among the existing set-ups. G.B. Pant Institute of Himalayan Environment and Development, as per its mandate, is charged with the responsibility of imparting coherence to the development efforts in the Himalaya. The Institute is to serve as central node of network of all organizations concerned with environment and development in the Himalayan region. The networking has to ensure that available human resource and infrastructure is optimally utilized to progress towards the goal of environmentally sound economic development. The Institute itself is a satellite network with its programme centres/units located in different parts of the Himalaya (as at present Himachal, Garhwal, Kumaon, Sikkim and the north-east) in order to facilitate linkages and coordination in the vast and diverse Himalaya. Ministry of Environment & Forests, Government of India has set up 'Environmental Information System for the Himalaya' in the Institute which would ensure centralized storage of information and its accessibility/flow to the research, technology development and extension agencies - the users and partners in the Action Plan. The G.B. Pant Society of Himalayan Environment and Development consisting of decision makers, policy planners, scientific expertise and peoples' representatives from different States as well as Central Government could serve as forum of formulating guidelines for institutional networking.

4.1. Water Management and Soil Conservation



Water Harvesting

Water as a natural resource and fundamental basis of existence of life is abundant in Himalayan ranges. Its uneven distribution both in space and time comes in the way of development needs of the region. Often there is too much water when and where it is not needed or too little of it when and where it is needed most. Flow of water as a result of

gravitational force provides immense scope for power generation and improving upon the efficiency of agricultural systems in the region. At the same time, a short sighted approach of harnessing this renewable resource may accompany social problems, waste of financial resources and hazards engulfing the plains too. The common perception reveals that water during late summers and monsoon is in abundance and scarce during the rest of the year. The intense rainfall during the rainy season causes soil erosion, specially in highlands, deteriorating agricultural productivity, causing instability of hillslopes and landslides locally, and floods and associated catastrophic losses in the adjoining plains. When monsoon is late or weak, water shortage causes serious disruptions of all productive activities. However, Himalayan rivers are considered to be a key to economic prosperity and environmental salvation not only of this area but of the whole country. The limitation is the lack of hydrological information (such as distribution, variability, quality, flow rates and regeneration potential) and technology for designing suitable intake structures and water harvesting and supply systems in the unstable hill regions. It is for this reason that despite the abundance of water resources, a large number of villages do not have even the drinking water facility. Drinking water supply being the most basic need puts water management as the top-most priority. Although numerous small scale water supply projects have been undertaken in many areas, these no longer operate because of faulty pipe lines, joints and/or pumping sets. Such types of lapses indicate poor management of such a necessity.

At present, in all hill areas, excluding river valleys, the main source of sustenance are the sub-surface and surface water flows which need adequate recharging to meet the demand. The recharging depends on vegetational cover in addition to the geological and geomorphological controls. The impact of dwindled vegetational cover and type of vegetation around hill-springs is well documented. Therefore, the recharge of aquifers and conservation of water through appropriate technology is perceived as the first priority. Following are considered of immediate importance in this regard:

- Water harvest through storage in all the streams and development of spring sanctuaries near the village;
- large scale mapping and recharge and discharge capacity measurements of natural perennial springs;

- long term hydrometeorological data along an altitudinal gradient across the latitudinal zones to address: rainfall, water run-off generation and its route through protected and disturbed lands; effect of different types of sediment delivery to rivers, soil porosity, rate of evaporation/transpiration on different slopes, and net water balance;
- evaluation of economic viability of traditionally known methods of water management systems, identification of constraints in their continuation/replication and their remedial measures;
- major technical research needs to find out low cost material(s) increasing infiltration of rain water in recharging areas;
- widespread field trials to test and compare the effectiveness of identified materials in containing the seepage of water in canals;
- identification of species which can help in reducing water loss due to evapo-transpiration and augmenting recharge of ground water;
- identification of tree/ food crop species/varieties with high water use efficiency;
- introduction of centralised water storage and decentralised safe water supply system in the villages helping to stop misuse of water and improve conditions in restructuring the village settlements;
- consolidation of land holdings so as to economise on water requirement for irrigation;
- effective protection of identified perennial springs with barbed wire or deep rooted vegetation; and
- selection of tree species in plantation based not exclusively for economic benefits but also considering their high values in water recharge and conservation.

River water as a resource, far exceeds the quantity required for development needs of the region and so deserves special attention for having implications for both regional economic development and national power and irrigation needs. For a consistent and effective planning in this sphere, following inputs not listed above are essential:

- Data on temporal trends - seasonal as well as daily snow accumulation, snow and glacier-melt-water-flow and evaporation to improve the designs and operational efficiency of the proposed hydroelectric and irrigation projects (at present Snow and

Avalanche Study Establishment of the Department of Defence Research & Development Organisation, Manali, is collecting some data but its main focus is on avalanche control);

- creation of a sampling station network for computerised measurements of water flow rates, sediment yield and soil load in major rivers. (Although there are more than 1,5000 sites for recording the river flow in India, only a few are located in the Himalaya. This limited data with unknown precision are used to extrapolate the flow rates of ungauged sites);
- emphasis on a large number of small run-of-the-river projects, involving low investments, simultaneously with executing major dam projects on appropriate sites to meet national demands selected on the basis of authentic data base; and

Research	*Technology Development and Demonstration*	*Extension/Execution*

- Central Soil and Water Conservation Research & Training Institute	- ICAR Centres/stations in the Himalayan region	- State Government Deptt. of
		  - Agriculture
		  - Forest
		  - Public Works
		  - Rural development
		  - Irrigation
		  - Hill Development
		  - Mining

- Universities in the Himalayan Region	- Universities of Agriculture and allied subjects in Himalaya	- Planning Wings of District Administration
- All India Soil & Landuse Survey Organisation	- Integrated Watershed Management Projects in Himalaya	- Non Governmental Organisations
- National Bureau of Soil Survey & Landuse Planning		
- Wadia Institute of Himalayan Geology		
- National Institute of Hydrology		
- Water Resource Development & Training Centre		
- Central Road Research Institute		
- Indian Council of Agricultural Research and its Institutes		
- Indian Council of Forestry Research & Education		
- Geological Survey of India		

- identification and execution of institutional mechanisms which ensure that benefits accrued as a result of water resource use in the region meet the local essential needs (drinking water, irrigation and power) first and the excess for needs elsewhere (water resource as a natural asset of the region should be harnessed for national needs following the local needs instead of maintaining a competition between the two).

Water resource management and soil conservation in mountains are closely linked issues. In fact, inputs listed above will also be essential for soil conservation. However, the success of soil conservation programmes mainly depends on the active involvement of farmers. Promoting tree crops in agricultural land, improvement in terrace construction, drainage and irrigation could greatly reduce surface erosion and slope failure. Soil conservation, as conceived by the local people and the methods traditionally practised for the purpose, should be investigated and recorded for an in-depth understanding of their rationale.

4.2. Forests and Forestry

Forests Supporting Agriculture

Amongst a variety of resources in the Himalaya, forests have received perhaps maximum attention, but more as a subject of administration than of management in a true sense. Deforestation is known to aggravate soil erosion, floods, reservoir sedimentation, drying up of wells and springs, droughts, desertification alongwith many other adverse impacts. However, an impression that a poor vegetational cover is a cause or a consequence of these degradative processes still remains uncertain. But the fact remains that forests are being used at a rate faster than their regeneration. While it is accepted by all that tree cover is continually declining, the rate and extent of decline are not confidently known. Even more confusing is as to whether the reasons for loss in forest cover are rooted in the rural hillmen or elsewhere. Although the exploitation of forests for fuel, fodder and other domestic needs of hill people are commonly argued as causes of deforestation, yet there are evidences of poorly stocked forests in well managed government owned forest lands suggestive of some fundamental and

serious lapses in the forest management system itself. Forests, being among the basic resources for development, have to be provided necessary protection and inputs to make them more productive so as to meet the developmental as well as environmental demands. In connection with forest productivity, it has to be recognised that with an increasing demand for food, urbanization and industrialization the competition for 'favourable' sites is growing steadily. Additional inputs like, irrigation (which are hardly available even for the crop production) in forestry sector in the hilly areas of the country will be hypothetical for some decades to come. Therefore forests have to remain confined to marginal sites. Historically, forests were open to the hill people to meet their forest based domestic needs while ownership of forest land and revenue therefrom were the objects of the rulers. Therefore, forests, whatever restrictions are framed for accessibility to them, will continue to be treated by the local people as a 'free natural resource' as long as suitable alternatives are not provided. It is logical to keep 2/3rd of land area under forest for maintaining ecological balance in mountains but illogical to anticipate that people will let this policy succeed even in the absence of appropriate alternatives.

The forest based demand structure and trends in hill areas should form the basis for the types of forests to be raised. Villagers' priorities affiliated with forests are fodder, twigs for fuel, forked poles, fruits *etc.* These should be considered while selecting the species for plantation. Another important factor which needs to be taken into consideration in the forestry programmes for the mountains is that the man-made forests should be as close as possible to the natural one. The productivity of this resource has to be increased to a level higher than the demand of the people so that it could supplement the cash requirement of the community. The spectacular standardized pine or eucalyptus plantations do not meet the villagers' priorities. In a subsistence economy, if their basic needs are not met, people are forced to meet them at all costs and risks, legal, economic or environmental. Following are suggested on this subject based on the interviews with rural people:

- The local needs of fuel, fodder, small timber, grazing and the like have to be met from the forests. Therefore, if wasteful uses can be reduced through extension education, it will do a lot good;
- needs of the people be estimated scientifically, there is twenty-fold variation in figures worked out for fuelwood consumption;

- likewise, to give the local people a sense of belongingness, the forest land could be given to the people on perpetual lease to individuals for production of under-canopy cash crops, collection of grass, *etc.*, with no rights of cutting the trees. Such a practice, it is understood, in some form exists in Sikkim and Himachal Pradesh. However, such provisions, may necessitate modifications in existing Laws and Acts;

- it is observed that the forest areas are put to fires to burn the fallen leaves and dry grass cover. This practice is believed to help in healthy growth and improved palatability of grass with the onset of monsoon. If the fallen leaves (pine needles) are purchased and utilised in manufacturing boards, that would be of great benefit in several ways - avoid lot of damage, provide employment and income to people who might collect and sell, and a good substitute to wooden planks;

- efforts for rural electrification not only for lighting purposes but also for cooking and heating requirements would reduce pressure on forests automatically;

- to make villagers feel that this resource should be used judiciously, needs to be protected, and should be allowed to regenerate, it would be useful to establish wild edible fruit and seed collection centres, purchase and processing units in different areas. Further, industries operating on the basis of raw inputs from Himalayan forests (*e.g.*, paper and resin industries) should be located in the hills, *i.e.*, close to the source of availability. The mountain constraints will certainly permit a large number of small industries and not big enterprises at many locations;

- legislations have been framed for compensation of loss in tree cover as a result of developmental activities. However, the spirit of these legislations as far as the object of conservation of Himalayan environment is concerned, is often not met. Compensatory afforestation elsewhere in the plains, whatever the reasons may be, in lieu of forest land in the Himalaya, though important, does not serve the purpose of maintaining the quality of environment in the Himalaya. Further, development agencies assign the task of compensatory afforestation or catchment area treatment to other agencies, invariably the government owned, thereby part away with their responsibility except for diverting the funds. It should be ensured that compensatory afforestation is carried out by the concerned developmental agencies within the

Himalayan region. The success of these remedial measures must be ensured and made apparent by the development agencies before they start production process;

- proper understanding of seed physiology, nursery practices, growth of nursery stocks and transplanting is the basic requirement for successful plantations. Unfortunately, very little work on Indian tree species has been done to cover these aspects. Since direct seeding in forestry is yet to get accepted and practised in management of hill forests, afforestation programmes have to depend on nursery stocks. Technology should be developed for raising containerised stocks so as to ensure least damage and transport costs;

- finding a way to maintain favourable internal water balances of forest trees at the time of transplanting is a problem of paramount importance and should be vigorously researched. It will be rewarding to find out some cheap anti-transpirants which will reduce transpiration without affecting photosynthesis;

- any massive plantation programme should be launched on the basis of long-range environmental compatibility of species and acceptability of their values to the local people;

- while introducing a species in agroforestry, its effects on associated crops/vegetation should also be worked out in advance;

- it is a scientifically established fact that fast growing species will use higher amount of water as compared to the slow growing ones. Plantation of species imposing higher demands of water under canopy radiation loads should be avoided in the areas with perennial water resources like wells and springs;

- water and organic matter being limiting factors on marginal lands, species with higher water use efficiency and fast rate of leaf decomposition should be selected. The nitrogen fixing trees should be preferred over others;

- study of root-systems of various forest species needs immediate attention for agroforestry as well as for raising the plantation on denuded areas. There are many tree species like *Celtis* sps., *Grevia* sps., *Sapium* sps., *Ficus* spp. in agroecosystem in Central Himalaya but a comparative account of their contribution in maintaining or improving soil fertility and crop yield have not been

investigated. It is better that the species already known are researched before recommending for alien introduction;

- genetic improvement of selected species should form a priority item in forestry to get species with combination of low transpiration rates, higher photosynthesis, high calorific value, and desirable shade and shelter effects;

- it is a general perception that tree-line (upper elevation limit of tree growth) all over the world is descending and at the same time the regeneration rate under Himalayan climate is relatively poor. This means that in the near future the sub-alpine forest will also decline. Technology need to be developed to mitigate this situation. In this connection, a detailed understanding of sub-alpine ecosystem has to be developed and technology should be evolved for plantation in sub-alpine areas;

- one of our most serious deficiencies is the lack of understanding of reproductive biology of Indian tree species. The reproductive growth of many tree species is disturbingly irregular. A detailed knowledge of reproductive biology to overcome this irregularity is essential;

- cultivation practices for medicinal and aromatic plants should be developed so that these could be grown beneath tree crops in the social forestry programmes;

- grassland management should receive priority and taken-up on a scientific basis. For this purpose, integrated approach of developing grazing lands inside and outside the forests, frequent reseeding of these areas with desirable species of grasses and legumes is needed. May be, the grass and legume seed banks have to be established for different localities. Depending upon the area and the conditions of habitat, improved strains of grasses should be produced and introduced. The soil macro and micro-nutrient conditions are also to be taken care of. While introducing legumes, the application of phosphorus or lime in high rainfall zones might be necessary;

- with increasing elevation, leguminous elements in the flora decrease. Therefore, high altitude-stress-tolerant strains of Rhizobium as well as leguminous species need to be developed; and

- alpine pastures and semi-arid and arid cold deserts need special attention in connection with grassland development. A wild type

of lucerne is another species which is relished by domestic animals and has resistance to high altitude stress. Such species need to be explored on scientific lines.

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Forest Survey of India	- Indian Council of Forestry Research & Education at its various Institutions	- State Government Department of Forests in the region
- Indian Council of Forest Research & Education and its Institutes/Centres	- Universities of Forestry and of Agriculture in the region	- Universities of Agriculture and of Forestry in Himalaya
- Department of Space at -NNRMS, Bangalore -SAC, Ahmedabad -NRSA, Hyderabad	- Forest Department of concerned States	- Non Governmental Organisations
- Universities of Forestry and of Agriculture in Himalaya		

4.3. Energy

Age-old Energy Source

If per capita consumption of energy is considered to reflect the level of development, hill areas have been considerably neglected. Legislative restriction on the traditional uses have been framed but delivery of alternate energy sources have not been ensured. The Sixth and the Seventh Five Year Plans laid emphasis on the introduction as well as popularisation of non-conventional sources of energy but not much is observed to have been done in this direction. Following actions are listed for overcoming this situation:

- Mini and micro-hydroelectric projects should be established at suitable sites throughout the Himalayan region. In order to hasten the process of transfer of this technology, these projects should form part of Watershed Management Plans which are suggested to be area specific. Direct involvement of locals should

be ensured before execution of project in order to avoid conflicts during execution of the project. Training to local people and institutional mechanisms to ensure their adequate participation in installation and operation of the project should be given due care in the project planning phase;

- there are certain areas where the conventional methods of extending power supply by construction of transmission and distribution lines may not be feasible due to topographical conditions. Energy supply in such areas should be attempted through alternate technologies like diesel sets supplemented with biomass gassifier. Certain perennial biomass of obnoxious weeds like, *Lantana* should be used for this purpose. The technological know-how already generated in this direction should be utilised. Further, this programme too should form a part of Watershed Management Authorities in different localities;
- other technology which could use forest weeds like, *Lantana* is Hot Air Engine (10 KW). Technical know-how should be generated to use this technology in the rural areas of the hills;
- biogas plants have been installed at several places and these are reported to be working successfully upto 1200 meter altitude. Identification of proper catalysts to increase fermentation even at lower temperatures will help in extending this technology significantly;
- the use of pressure cookers is accepted to be markedly reducing consumption of energy. This equipment should be provided at highly subsidised rates not in hills only, but all over the country;
- the technical know-how to harvest the wind energy as well as solar energy is now fully established. However, round the year data on wind profile of selective sites across the region should be collected for proper designing of wind generators;
- although some photovoltic systems have been installed at several places but due to lack of technical and financial back-up required for their maintenance in the remote areas, these have yet to become successful. Technological inputs are required to minimise the bottlenecks of the installation and maintenance; and
- use of high carbohydrate accumulating plants starchy-annuals which grow abundantly on marginal sites in mountains is another source of renewable energy. Ethyl alcohol from these can be produced by simple fermentation. However, this option should

be used only if there is no risk of inducing the social evil of alcoholism in the hills where the evil already exists in a big way.

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Tata Energy Research Institute, New Delhi	- Department of Non-Conventional Energy G.O.I. through its Institutions and Organisations	- Voluntary Organisations - Extension Agencies of State Governments
- Department of Non-Conventional Energy, New Delhi	- Institutions of Engineering Education and Research	
- Central Power Research Institute, Bangalore	- Council for Advancement of Rural Technology (CART)	

4.4. Farming Systems

Fertile Valley Land

The agroclimatic conditions of the Himalayan region render agricultural production quite uncertain. Though there is a wide spectrum of diversity in the farming systems operating in the region, yet there are quite a few commonalities *viz.* crop diversity involving mixed cropping as well as crop rotations, subsistence rather than commercial values of agriculture, maintenance of soil fertility through natural processes (alternating crop-fallow phases in shifting agriculture or addition of organic manure consisting of animal dung and litter from forests in other systems) and strong linkages between crop husbandry, animal husbandry and forests. Climatic conditions optimal for growth of many food crops occur in the mountains and the need is to exploit these opportunities for economic upliftment of the region without degradation of environment. Introduction of horticultural crops is a more recent phenomenon and has penetrated the traditional farming systems in a few pockets such as Himachal Pradesh, Jammu & Kashmir. Invariably, horticultural crops are given importance more for their commercial benefits than for local consumption.

4.4.1. Crop husbandry

As much as 84 per cent of the net sown area in the Himalayan Region depends on rains - the range being 97 per cent in Arunachal Pradesh and Mizoram to 65 per cent in Assam. Mixed and multiple cropping with crop rotations involving a large number of annual and perennial crops have been in practice in these areas for ages. The basic aim behind this practice probably was to grow all that was needed and harvest whatever could be possible under unpredictable situations. This is literally true in higher hills where it is not possible to have more than one crop in any year. Multiple cropping increases total production per unit of area, raises farm output, increases the range of products available to diversify the diet, make efficient use of available nutrients and water, and enhances soil fertility. Mixed cropping also avoids to some extent the possibility of pest problems. These traditional systems conceived earlier as weak on account of involving low external inputs and economic gains, are now being considered to represent an "Advance Sustainable Technology" in crop husbandry sector. Thus, the blends of this traditional technology and modern scientific know-how offer a great potential to make the present crop husbandry commercially viable in addition to meeting the food requirement in the region. A strategy for the development of hill areas is possible provided the following constraints are mitigated on priority basis:

(i) **Consolidation of Holdings**: Economic advantages of this are too well known and those hold true no where more than in the hills. This is so because of the terrain and long distances. Fragmented holdings make crop husbandry uneconomic and cause all types of hinderances in making use of the productive potential of land. Governmental efforts should be strengthened to take up the task of land consolidation on priority. Such tasks are difficult to accomplish. Strong public opposition coupled with technical difficulties faced by the officers in the land measurements led to failure of the efforts made in areas like Kumaon and Garhwal. However, success stories do exist, *e.g.*, Himachal Pradesh indicating that consolidation in mountains is difficult to carry out but certainly not impossible. Public awareness of the various advantages of such a step should be developed.

(ii) **Land Abandonment:** As a consequence of the uneconomic production from inconveniently located plots and attraction for outside employment, a significant portion of agricultural land

gets abandoned. Such a situation is an expression of out-migration from the rural areas in hills and, at the same time, unwillingness of the absentee owners(non-resident) to part away with the land. Land abandonment under these conditions is observed to accompany perpetual loss in the productive potential of land. This issue needs immediate intervention on the part of the government as well as that of the people so that legal provisions of private ownership do not restrict land use for the benefit of people.

(iii) **Irrigation**: The importance of this input is well accepted. As already suggested, in hills there is no scarcity of water as such and the only problem is in its management and distribution. Till recently the hillmen used to manage this entire thing themselves but for some unknown reasons (perhaps to inflate the figures of providing employment), the irrigation 'gools' or 'kuhls' have been taken over by the State Irrigation Department (in U.P. hills). Since then, all sorts of problems have come up in the system. The traditional system has been discarded while the new system doesn't work because the persons at the helm of affairs have neither the knowledge nor the willingness for obvious reasons. Traditional systems should not be disrupted unless government interventions are found superior to the indigenous technologies based upon a rigorous performance assessment in mountainous areas. Therefore, it will be necessary to consider all aspects of this subject and tackle it on war-footing.

(iv) **Marketing**: With these steps, the hill areas too will have some marketable surplus. At that stage, an efficient marketing system will be needed. At the same time, the farmers may be advised to diversify their production pattern and go in for high value crops like amaranthus, buckwheat *etc.*, and off-season vegetables which could be grown exclusively in the region and thereby bring larger income. An Institution like 'public purchase system' or cooperative marketing would be more useful for promoting trade in inaccessible areas of high hills.

(v) **Diversion of Prime Lands to Non-Agricultural Uses:** There is no dearth of barren and uncultivable land in any part of the Himalaya. This is confirmed by the official figures. Yet, the construction activities whether it is residential colony or dam or laying of roads, the fertile agricultural land, which is generally irrigated also, is the first victim of development. This is equally, if not more, true for non-agricultural activities of the government.

This practice should be arrested by non diversion of agricultural land to such uses. This may have to be done through legislation.

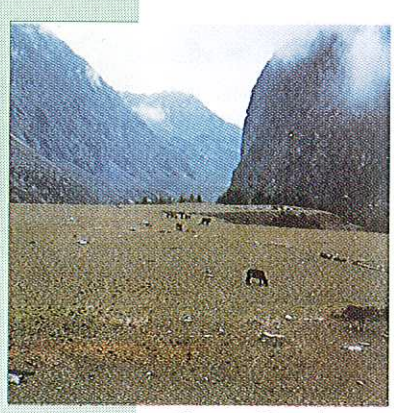
(vi) **Others:**

- Science and technology can help in a big way by devising and suggesting appropriate engineering measures for better terracing;
- high yielding varieties of field crops should be thoroughly tested for their performance under the local farming/cropping system before releasing to the farmers. Recommendation for their introduction should be based not merely on the basis of crop yield, but also considering the quantum of inputs required to maintain higher yields in long term in mountain perspective;
- one of the reasons for ineffective use of chemical fertilizers in the hills (alongwith all those applicable in the plain areas) is the inconvenient size of the bag. Carrying the currently used large sized heavy weight bags, on human backs is problematic. Further, since majority of farmers have small land holdings, large packages far exceed the requirement and capacity of individual farmers. Therefore, in these undulating areas, it would be helpful if smaller bags of 10 kgs. each are provided;
- the use of chemical fertilizers should be kept to minimum so as to avoid the downstream pollution problem and residual effects. Thrust should be not on fertilizer use to obtain 'maximum possible yields' but to hasten organic recycling to obtain 'improved yields'. Chemical fertilizers are needed to strengthen and to improve the efficiency of the traditional organic manuring systems rather than their replacements;
- another important barrier to transfer of technology is the fact that it is the women who carry on almost all operations in crop production (excepting ploughing and construction of retaining walls for terraces), but not only the agricultural extension workers are males, these are the male members too who are given training in farm activities. This situation needs to be corrected so as to ensure effective transfer of technology;
- efforts should be to introduce new/modern technology after exhaustive testing and gradually, rather than aiming a revolution. Effect of field demonstrations is reported to be the most appropriate in all such situations. Cases are not lacking where poor farmers have become poorer because all aspects of the technology were not considered/tested before its introduction;

- cultivation of medicinal plants would prove to be an effective practice particularly in the high elevations. Apart from meeting the national needs, it would strengthen the rural economy and would not involve drastic changes in the land use. Further, many medicinal plants could be raised under forest canopy for which appropriate changes in the land tenure measures would be essential;
- action oriented researches for long term benefits of perennial crops in reducing soil erosion and maintaining water balance should be undertaken on mass scale in agricultural land dominated by annual crop farming *e.g.*, in Central Himalaya; and
- a network of demonstration plots for practices like drip irrigation, strip cropping, relay cropping, alley cropping, not known in the region, should be laid so that farmers themselves evaluate the advantages of such practices over the traditional ones. Local knowledge and traditional practices should not be discarded without going deep into their rationale. This would necessitate thorough investigations, recording, analysis and drawing of inferences thereafter.

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Agricultural Universities and Institutes in Himalayan Region	- Agricultural Universities and Institutes through their their Departments and Regional Centres in Himalayan region	- State Government Deptts. of - Agriculture - Horticulture - Rural Development - Hill Development - Community Development
- ICAR through its various Institutions and Regional Centres	- Central Potato Research Institute, Shimla	- Universities in Himalaya
- Agro-Economic Research Centres at Delhi, Shimla, and Jorhat	- ICAR Research complex, Shillong	- Youth Wings
	- IARI Regional Stations at Shimla, Katrain and Sikkim	- Non Governmental Organisations
	- Vivekananda Parvatiya Krishi Anusandhanshala, Almora	

4.4.2. *Animal Husbandry*



Open Grazing

Livestock being an integral part of hill life and hill farming, the economy in all parts of Himalaya is basically agro-pastoral. This is so for several reasons. The land holdings being very small, livestock supplement the income and are considered to constitute capital asset. The animal dung and bedding material is the only manure for the crops. Almost the entire energy requirement of hill agriculture is met either from bullock power or human power. This scenario is not likely to change much in the future also for reasons of the terrain. Of the 449 million domestic animals in the country, nearly 9 per cent are in the Himalayan region whereas geographical area of the Indian Himalaya is 18 % of the country. Of the various types of livestock cattle are the most important (47.5 %), followed by buffalo (12.3 %), goats (15.8 %) and sheep (10.4 %). Generally, cattle, goats and sheep constitute an important livestock wealth in Western and Central Himalaya, pig and poultry in Eastern Himalaya, and ovine in alpine zones. Yaks are also reared in alpine areas. Equines are essential for transportation.

Open grazing by livestock in all these areas is an age old practice and probably will continue even if the laws to restrict grazing are strictly enforced, unless workable alternatives are provided to the people. Planners concerned with protection and development of forests and range ecosystem consider open grazing as a problem. Stall feeding, although not as common as in the plains, does exist in some area of Sikkim. Effective community action for avoiding over exploitation and open grazing does exist in an area like Himachal Pradesh where rangelands, specifically those dispersed in the habitated zone and under community ownership, are divided into temporary plots- one each for a farmer.

Any programme of developing Himalayan region has to necessarily include the development of livestock, and for which, the following steps deserve consideration:

- Some potential solutions to reconciling the conflicting interests of forestry, agriculture and animal husbandry: These three sectors

should be looked not in isolation and competitive but in conjunction with one another in an integrated perspective. A concern for ownership of land (*e.g.*, government ownership of forest land) should have an additional dimension for the optimal use of land based resources. Such an approach is reflected in traditional management systems and thereby their rejuvenation could be one possibility *e.g.*, "Gharpal System" (a system of backyard feed-lot raising) still in practice. In group of villages situated in compact and continuous areas in upper as well as lower foot-hills, this system could be taken up as "Pilot Scheme". This system will be more suitable for sheep and goat husbandry. The kids and lambs introduced at the age of 3-4 months are reared for 3-5 months and sold thereafter;

- spatial separation of forests and pastures: clear separation of forestry and pastoral land use seems to be the best solution for avoiding conflicts. This has been the most successful approach taken in many parts of the temperate zone. This can be achieved by separation of forestry and pastoralism by fencing. Such methods could be applied particularly for protecting important or sensitive forest areas and environmentally fragile zones by fences or by guards so that grazing takes place only after a defined period. More effective management combined with increased productivity would, however, be facilitated if such activities could be concentrated on the most suitable sites. This would imply a reduction of the total area under forest management but an increase of high yield forestry, without the risk of permanent encroachment. On the other hand, intensive pastoral management could be performed, eventually supplemented by the cultivation of fodder crops;

- secondary utilization of forests by regulated grazing: The present open grazing practice should be replaced by controlled grazing so that both forestry and pastoralism could mutually benefit. Some known promising methods are:

  (a) partial substitution of animals in incompatible situations: Under this concept goats are partly replaced by similar animals causing less damage. Damage in a high forest is likely to be less severe than in a selection forest or in shrub plantations;

  (b) reduction of the number of animals per unit area through introduction of better breeds, upgrading of local breeds, and culling of uneconomic animals. It will be useful to encourage

production of dual purpose mutton and wool sheep and also small to medium size backyard feed lot system by villagers;

- forage production as a forest management goal would mean:
  (a) plantations for the protection and improvement of pastures;
  (b) enrichment of natural forests with fodder plants;
  (c) establishment of special fodder plantations; and
  (d) alpine pasture improvement.
- mechanical methods of shearing and ginning of wool should be introduced. Incentives be given for the use of improved wool spinning wheels; and
- cottage industries utilising wool, skins, horns and other animal by-products should be encouraged. Training in the crafts be imparted for self-employment, not for salaried jobs. Improved technology, new designs and products should be introduced alongwith adequate market outlets and facilities.

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Agricultural Universities in Himalayan region	- National Dairy Research Institute, Karnal	- State Government Deptts. of - Animal Husbandry - Rural/Community Development
- ICAR and its regional Centres/Stations	- Indian Veterinary Research Institute, Izatnagar and its Centres	- Universities
- Indian Veterinary Research Institute	- Central Institute for Research on Goats, Mathura	- Voluntary Organisations
	- Central Sheep and Wool Research Station, Dehra Dun	
	- Indian Grassland & Fodder Research Institute, Jhansi	
	- National Research Centre for Yak, Nikmadung, Arunachal	

4.4.3. *Horticulture*

Untapped Potential

The Himalayan region is now known to be producing several types of fresh fruits, dry fruits, vegetables, flowers, seeds of vegetables and flowers, mushrooms, *etc.* Crab apples and other wild species of temperate fruits are reported to have been grown in the Himalaya for hundreds of years. Production of fruits on commercial scale is only a recent phenomenon and has picked up well, the best example being apple production in Himachal Pradesh. Following suggestions are listed for a sustainable development of horticulture in the region:

A long-term horticultural development plan should be prepared, incorporating a crop diversification programme and indicating what crops should ideally be grown where in the future, and at what scale. Based on the diversification programme long term planning of all facets of the industry can be done from nursery requirements to research/extension, and processing and marketing, and the appropriate roles of public and private sectors determined;

- planting material be improved and made available to growers through: (a) introduction and testing of new varieties; (b) establishment of a Himalayan repository of all commercially grown varieties in the region; and (c) development of the private sector nurseries to utilize improved scion wood produced from the repository;
- availability of credit to fruit growers through adoption of improved branch level banking methods identified by ongoing Credit Delivery Pilot Project;
- boosting of research and development into alternative fruit storage, packaging and transport, including cardboard cartons and wire bound wooden boxes; and into on-farm cool storage and bulk transport of perishables;
- expanding use of existing cold stores by private sector for medium and long term storage of fruit, and precooling of direct marketed fruit. This should be done using the cold stores

currently owned by agencies like the Horticultural Corporations of hill states;

- initiating long term planning for a phased establishment of cold storage and fruit processing plants both in production and consumption areas, matched to increasing demand for these facilities. Developing incentives to encourage the maximum private sector involvement would be an important facet of this planning;

- improving technology availability to farmers through reorganization of extension services. Two additional aspects are important: (a) the need to convert existing government nurseries into demonstration farms/orchards, and (b) the establishment of a large training and technical assistance component necessary to facilitate adoption of overseas technology which is available today and directly applicable to horticulture in the region;

- initiating studies on the production of different fruit crops, marketing for apples and other crops and the financial incentives to intermediaries at different stages of the marketing and processing chain;

- developing common grade standards of fruits for efficient marketing and introduction of these into the industry;

- continuing the development of research capabilities of agricultural and horticultural Universities in the region. Both facilities and research programmes should be reviewed by experts taking the region as a whole, to avoid duplication of efforts, and to develop the concept of lead institution in temperate fruit research;

- off-season vegetable cultivation needs special attention. There are as many as 20 species of cucurbits which are grown or grow naturally in hilly areas and many of them have high potential market in the plains. These need to be improved and their agronomical requirements worked out in detail. In addition to cucurbits, about 26 types of vegetables, 15 greens, and 17 species of spices and condiments are cultivated by the farmers. All of them can form a sound base for cash returns. The eco-physiological requirement for obtaining high yields and genetic improvement in crops need to be researched;

- processing of culled and lower grade fruits at household level be encouraged with quality control and necessary marketing arrangements; and

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Universities, Institutes and Colleges of Agriculture/ Horticulture in the Himalaya	- Indian Institute of Horticultural Research, Bangalore	- State Government Deptts. of - Horticulture - Rural/Community Development - Agricultural Marketing
- ICAR Institutions and Regional Centres in Himalaya	- National Mushroom Research and Training Centre, Solan	- Universities
- Agro-Economic Research Centres Delhi, Shimla and Jorhat	- Horticultural Experiment and Training Centre, Chaubatia	- Non Governmental Organisations
- Indian Institute of Horticultural Research,Bangalore		

- finally, before launching any massive campaign of extending horticultural activities, facilities needed for efficient marketing of the produce must be ensured.

4.5. Biodiversity and Conservation

Crop Genetic Diversity

Conservation is important both for the development of the present generation and that of the following ones. The need of conserving the available resources is felt by the planners and administrators, but the strategies for conservation have yet to penetrate to grass-root level. In Himalaya, as also elsewhere, creation of sanctuaries and national parks has been adopted as the major task of achieving the objects of conservation. Restricting human interference to conserve biological diversity, is an act repealed by the rural masses of hill areas already facing a complex of problems including small land holdings, meager employment opportunities and, over and above, natural hazards and environmental uncertainities. Conservation strategies must address to the needs of conservation for posterity but, at the same time, should not neglect the present needs of the people.

Further, the current strategy involves conservation of wilderness areas of the forest land. Conservation of cultivated crops is a neglected subject. A variety of food and medicinal crops exist in the region, many of which are not much known outside the region and may have a potential of providing food alternatives in the region and elsewhere as well. Such crops are also known to be insect resistant and stand long storages. Arbitrary distinction of 'coarse' and 'fine' grains and other recent socio-economic changes are among the factors discouraging the cultivation of these crops. These aspects should also be given due consideration in the conservation policies and planning. There are many facets of 'conservation' on which relevant research and development inputs are altogether lacking.

The Botanical and Zoological Surveys of India have prepared provisional lists of threatened flora and fauna. There is however neither any biological information nor the adequate knowledge of causal factors that have led to the rarity of these plants and animals in their habitats. It has also been stated that many more are on their way to extinction. In addition, in the present situation of intense competition among alternative land uses, minimal area required to achieve the objects of conservation ought to be worked out. Following inputs will be required for the sustainable utilization, management and multiplication of the endangered genetic resources of the region:

- Educational institutions from primary to University level in the region deserve special attention both for incorporating an environmental conservation course and action oriented work in their curricula. Financial assistance for developing a piece of land through afforestation/ reforestation within or adjacent to the campus should be provided. Further, the successful demonstrations must be distinguished by instituting awards. This will infuse an 'ethos of conservation' in the coming generations apart from increasing the forest cover with no land ownership problem, in the Himalaya;
- survey of endangered species on regional basis;
- behavioural and reproductive biology, development of technology for propagation of flora and captive breeding of fauna in natural habitats;
- domestication and development of tissue culture techniques for mass multiplication of medicinal plants;

- establishment of alpine/temperate botanical garden/zoological parks to conserve specimens of alpine/temperate flora and fauna;
- development of management plans aiming to avoid conflicts between conservation goals and people's needs for Sanctuaries and National Parks;
- research and development on indigenous food and medicinal crops much less known elsewhere in the plains; and
- long term quantification of ecological benefits emanating from Parks and Sanctuaries.

In addition to plant and animal resources some past human cultural resources of Himalaya are either unknown or are endangered. For a better understanding and conservation of these the following inputs are needed:

Research	*Technology Development and Demonstration*	*Extension/Execution*

- Botanical Survey of India	- Concerned State Government Department of
	  - Forest
	  - Agriculture
		- World Wildlife Fund (India)

- Zoological Survey of India		- Rural Development Agencies
- Forest Survey of India	- Rural Development Agencies	- Voluntary Organisations

- Anthropological Survey of India	- Institutions and Centres of
	  - ICAR
	  - CSIR
	  - ICMR
		- Department of Bio-Sciences at Universities of Himalaya

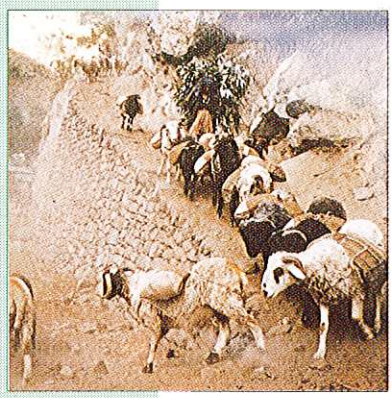
- Tribal Research Institute, Shillong		- Universities of Agriculture and of allied subjects in Himalaya

- National Bureau of Plant Genetic Resources	- National Botanical Research Institute, Lucknow	- State Government Deptts. of
		  - Forestry
		  - Agriculture
		  - Animal Husbandry

- Indian Council of Agricultural Research	- Universities in Himalaya	
- Indian Council of Forest Research & Education		
- Wildlife Institute of India		
- CSIR Institutes in the region		
- Concerned Departments of Universities in Himalaya		

- Investigation-cum-study of the material-culture, biotic and food residue remains from archaeological sites to develop the understanding of past human ecology in these areas;
- conservation of monuments of cultural heritage. This will also give a great fillip to tourism industry in the Himalaya; and
- technology based documentation of the gradually vanishing material-culture and pattern of life sustenance of the ancient societies of the mountain areas.

4.6. Transport and Communication



Traditional Modes of Transport

Primary goods and commodities, agricultural or industrial are generally of very little help unless those are provided place utility and/or time utility and/or form utility. This, in turn requires that the primary outputs are subjected to transportation, storage and processing. Each of these and a few more components of marketing are important but transport is the essential one. Any amount of production is of no use to the farmer unless he can exchange his products with the goods he needs. This is possible only after his produce is sold and which, if carried to the place of consumption, would bring him higher returns generally.

Hilly areas being sparsely populated, have fewer roads which are accepted as the nerves of development. It is also claimed that wherever roads have been laid, the rate of deforestation and landslides get aggravated. Therefore a workable compromise deserves to be accomplished so that the benefits are harvested with least damages. Any planning in this regard must take into account the fragility and perishability of the fruits and vegetables which shall remain the major commodities produced throughout the Himalayan region.

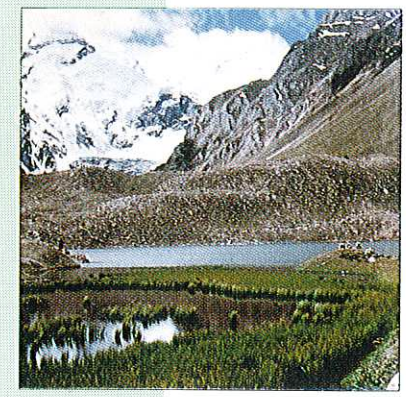
Projects of expanding the road network should be carefully formulated. Road alignments should be worked out on the basis of geotechnical

feasibility instead of the desire of the people, which is more often put forward and emphasized to serve political motives. Broadening and metalling of existing foot paths or bridle paths or cart roads should be restricted. Instead, necessary changes in the design of vehicles for transport in the hills should be given priority.

It is most surprising that the matter of constructing ropeways or cable transport has not been given the attention it deserves. This is an excellent alternative to roads in steep and remote areas for the transportation of humans as well as goods. These are much cheaper in the long run and environmentally more benign than long stretches of winding mountain roads. Therefore, it is suggested that ropeways, several times more than what has been proposed in the Eighth Plan, be constructed all over the Himalayan region. Modern technology of satellite communication should be expanded and utilized to overcome the difficulties of accessibility.

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Central Road Research Institute, New Delhi	- Engineers India Limited	- Public Works Department of concerned States
- Telecommunication Research Wing of G.O.I.	- Indian Institutes of Technology	- Telecommunication Department
- Indian Institute of Technology at New Delhi, Kharagpur, Madras, Kanpur, Bombay, and Varanasi	- Institutes and Colleges of Engineering and of Technology in Himalayan States	- Border Roads Organisations
- Jawaharlal Nehru Technological University, Hyderabad	- Telecommunication Department of G.O.I.	- Engineers India Limited
- State Engineering Colleges in Himalayan region		- Non Governmental Voluntary Organisations
- Road Research Institute, New Delhi		

4.7. Tourism



Potential of Adventure Tourism

The region offers all sorts of attractions to tourists; the problem is to ensure that the benefits of tourism industry are disseminated for development of the region without any adverse impacts on the environment and culture. The region offers opportunities for developing "Ecotourism" as well.

Tourism generates lot of local employment particularly for traders, craftsmen, transporters, hoteliers and to those who have the knowledge of the local places and would like to work as guides. In this direction, following would be of great use:

- New places of tourists' attraction should be explored, developed and given proper publicity;
- tourism be declared an industry throughout the Himalayan region so that various benefits of establishing an industry in the industrially backward area can be reaped by those who may like to invest in this venture. This, it is learnt, has been done in Himachal Pradesh where this step has been welcomed and utilized by the locals. However, at present this model does not reflect the concept of eco-tourism;
- rest houses, hotels and restaurants managed by government do not enjoy good reputation amongst visitors in general. Therefore private parties should be offered incentives so that a healthy competition is created between the public and the private sector in offering better services to the visitors. A general policy should be to promote use of indigenous resources;
- government intervention to give tourist a taste of local identity rather than creating same type of facilities as existing elsewhere in the plains. Multistoried building complexes should be avoided on grounds of seismological sensitivity;
- while it is more paying to attract visitors from high income groups, those of middle and even of the lower income group should not be neglected. It is a matter of common knowledge that a very large bulk of our people fall in the middle class. The facilities created for the people of this category will cross the break-even stage much earlier as the investment will be lesser and utilization rate would be higher; and

- local people should be educated to view long-term gains of tourism and should therefore 'not kill the goose that lays golden eggs.'

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Department of Tourism in Himalayan Universities	- Professional Trackers and Mountaineers	- Tourism Departments of G.O.I and of Himalayan States
- Amateur Clubs	- Manufacturers of Mountaineering equipments	- Hoteliers and Travel Agents
- Nature Clubs	- Local Peoples	- Airlines and Organisations operating Buses, Taxis *etc.*
		- Voluntary Organisations
		- National Cadet Corps

4.8. Industrialization

Agave-Potential for Cottage Industries

Planning for establishing industries utilizing locally produced raw materials for marketable production is likely to follow multiple benefits like employment generation and trade expansion with concomitant strengthening of primary production activities already existing in the region. Keeping in view the available resources, socio-economic and topographical conditions of these areas, labour-intensive and capital-saving technology should be prioritized in these areas.

Constraints on industrial development in the hill areas have been felt. Recommendations for establishing of some footloose industries which would produce high value and low-weight products like pharmaceuticals, thermometers, watches, precision instruments and electronics have been made. Some units of such type have been established but their number should be increased further. However, such industries are capital intensive and are possible only through

government patronage. These require fine technology which cannot so easily be learnt without some level of prior industrial training or experience. Unfortunately, as soon as training is imparted in such technologies, the trained persons migrate to the places which provide them more comforts with the same income that they might earn while working in hills.

At present many cost as well as labour-intensive industries are being established in the foot-hills. These are providing very good employment. However, such set-ups are going to cause depopulation and abandonment of lands in the villages as well as in small urban units of the hill areas. Point centred growth adjacent to urban centres must be avoided in any attempt for industrial development in the mountains.

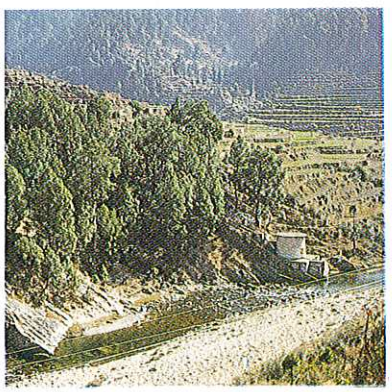
The alternatives are available in the form of setting up of small scale industries in large number. The Science and Technology know-how is already available for establishing such units and it is now simply a matter of transfer of technology on priority. Swaminathan Committee on Eco-development of Hill Areas recommended establishment of units such as the wild and cultivated fruit processing units, pine needle hard-board plants, small turpentine factories, oil presses, carding machines, saw mills, wood-wool, chip boards, traditional handicrafts, and many others. Some of these have been given incentives and others need the same. Cultivation of fruits has gone up in many areas but at present these are being sold unprocessed and a sizable quantity is not utilised at all. Similarly wool is harvested in good amount but is supplied as raw-material to the markets in plains and then comes back in finished form to be consumed in hills. Such a system can be changed for better if the processing of wool, (as suggested under animal husbandry component) can be arranged locally. Goat and yak hairs have received little attention but offer indigenous resource potential to fetch more income to the local people. The marketing facilities still continue to be a big constraint, specially in "Hill Areas". Meat, wool, and potato chips are a few more to add to the list which will be highly economical and where Science and Technology know-how is well established. However, alongwith incentives to local craftsmen marketing facilities should be created to encourage these activities. Also the time and money consuming processes of administrative clearance for micro level and rural industrial units should be simplified.

There are several 'wild fruits' traditionally used to supplement diets but remain unexploited for their economic values. Technology for the

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Department of Mining Engineering, Institute of Technology, BHU	- Regional Engineering Colleges - I.I.T.s	- Departments of Industry of concerned State Governments
- Geological Survey of India		- NGOs
- Wadia Institute of Himalayan Geology, Dehra Dun		
- National Hydro Power Electric Cooperation, New Delhi		
- Department of Non-Conventional Energy (DNES) Sources		
- Industrial Corporations/ Boards/Departments of State Governments		

extraction of their active component and preservation should be developed. Small scale industries need to be established in the appropriate pockets of the region.

4.9. Health and Nutrition



Water and Sanitation

Deficiencies in the areas of housing, water supply, sanitation, health and nutrition are often visible in villages as well as in urban centers. Improving health is basic to improving the quality of life, which is one of the main goals of hill area development. Storage and supply of drinking water for large areas currently being practised by public agencies suffer from several drawbacks. To achieve the physical and financial targets and to expose the governmental efforts on creating the basic amenities, costly technologies involving pumping of water against gravitation force are adopted. Undulating terrain and damaging processes of landslides and erosion render a short life span to the expensive piped supply systems. For all these drawbacks, decentralized schemes of water storage and supply targeting small areas and managing flow of water along and not against the gravitational force should be emphasized.

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Almost the whole population in hills consumes unsafe water, disposes human excreta recklessly and are constantly exposed to insects and rodents. These are the major causes of several predominant communicable diseases. If adequate and safe water and disposal of wastes could be provided to all the hilly areas, most health problems will disappear automatically. Following efforts will supplement the planning to reduce the health hazards:

- The basic principles of hygiene should form a compulsory part of primary and secondary education, as well as of family welfare programme;
- very often it is claimed that people in rural areas do not have balanced nutrition resulting into poor health. Since the nutritional requirements vary with the climate, it is essential to undertake studies on the nutritional requirements and intake of the people at different altitudes and its relationship with various disorders;
- traditional medicine systems should be encouraged to continue alongwith the new or modern ones;
- comprehensive studies on levels of living including cooking and eating habits, practice of cleaning, washing and bathing *etc.* should be on a continuous basis. This would indicate the gaps and the changes therein;
- studies should also be undertaken on thermoregulatory mechanisms, physical and mental performance, endocrinology and reproduction;
- the raw water supply in the villages/urban areas should be through sand filters or some other appropriate purification reservoirs constructed with local material and manpower inputs;
- the water supply through pipes in the villages should be decentralised;
- the water supply in the villages should be coupled with appropriate arrangements for disposal of waste water;
- appropriate low-cost technology should be introduced for the disposal of human excreta;
- some of the important medical problems relating to higher altitudes like, cold acclimatization, pulmonary oedema, ophthalmic problems, should receive high priority;

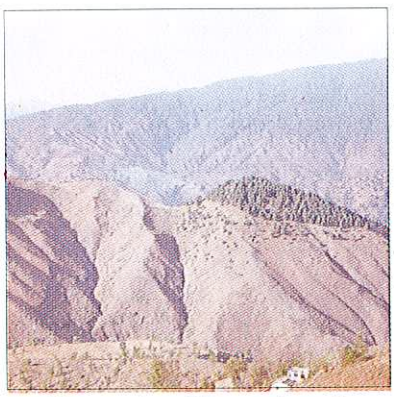
Research	*Technology Development and Demonstration*	*Extension/Execution*

- Agricultural and allied Universities of Himalayan region through their Departments/Faculties of Home Science and of Nutrition	- Institute of Research in Indian Systems of Medicine, Joginder Nagar
	- Regional Centres for Ayurveda, Jammu
		- State Departments of
		  - Health and Welfare
		  - Community Development
		  - Hill Development
		  - Rural development

- Central Food and Technological Research Institute, Mysore		- Voluntary Organisations
- Indian Council of Medical Research		- Philanthropists
- Central Council for Research in Homeopathy, New Delhi		
- Central Council for Research in Unani Medicine, New Delhi		

- smokeless 'Chulhas' should be introduced, reasons for their non-acceptance recorded and carried to technologists for the needed improvements;
- dark glasses should be distributed at nominal costs to people in high altitudes to guard against snow blindness; and
- similarly, for sun-burn also, some effective way should be found out to help the people escape it.

4.10. Management of Natural Hazards



Hazards—Natural and Man Made

Earthquakes, hail storms, lightning and avalanches are common in Himalayan region. Our ability to mitigate these hazards is limited at present. These natural events affect the life through the variations in their magnitude, frequency, duration and temporal spacing. Therefore, the impact of these hazards on the developmental attempts are only mitigated through some minor adjustments which we can make within

our socio-economic frame work. At present the scientific knowledge is limited to forecast about these events. In case of earthquake, sensitive zones in Himalaya are well known. However, in case of hail storms, lightning, avalanches and other natural hazards even the prediction about the areas is difficult at present. It is, therefore, time for us to strengthen our R & D efforts in this direction. Following suggestions are put forth in this connection:

- Methodology to predict the possible earthquakes;
- design of earthquake stable shelters;
- development of forecast systems for hail storms, lightning and avalanches;
- methodology to suppress hail storms and lightning by cloud seeding; and
- biological and physical methods for avalanche control.

Since all these studies need detail investigations, concerned R & D agencies should be issued directions to take up studies on these aspects on priority.

Research	*Technology Development and Demonstration*	*Extension/Execution*
- Department of Earthquake Engineering, Roorkee University	- Central Building Research Institute, Roorkee	- Central and State Government Department of
- Central Mining Research Station, Dhanbad	- River Research Station, Guwahati	- Planning & Development
- Central Building Research Institute, Roorkee	- Indian Institute of Meteorology, Pune	- Hill Development
- National Environmental Engineering Research Institute, Nagpur	- Snow and Avalanche Study Center, Manali	- Voluntary Organisations
- National Geophysical Research Institute, Hyderabad		- Philanthropists
- Defence Research & Development Organisation		
- Directorate/Departments of Geology and Mining of concerned State Governments		
- Indian Meteorological Department, New Delhi		

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Further Information:

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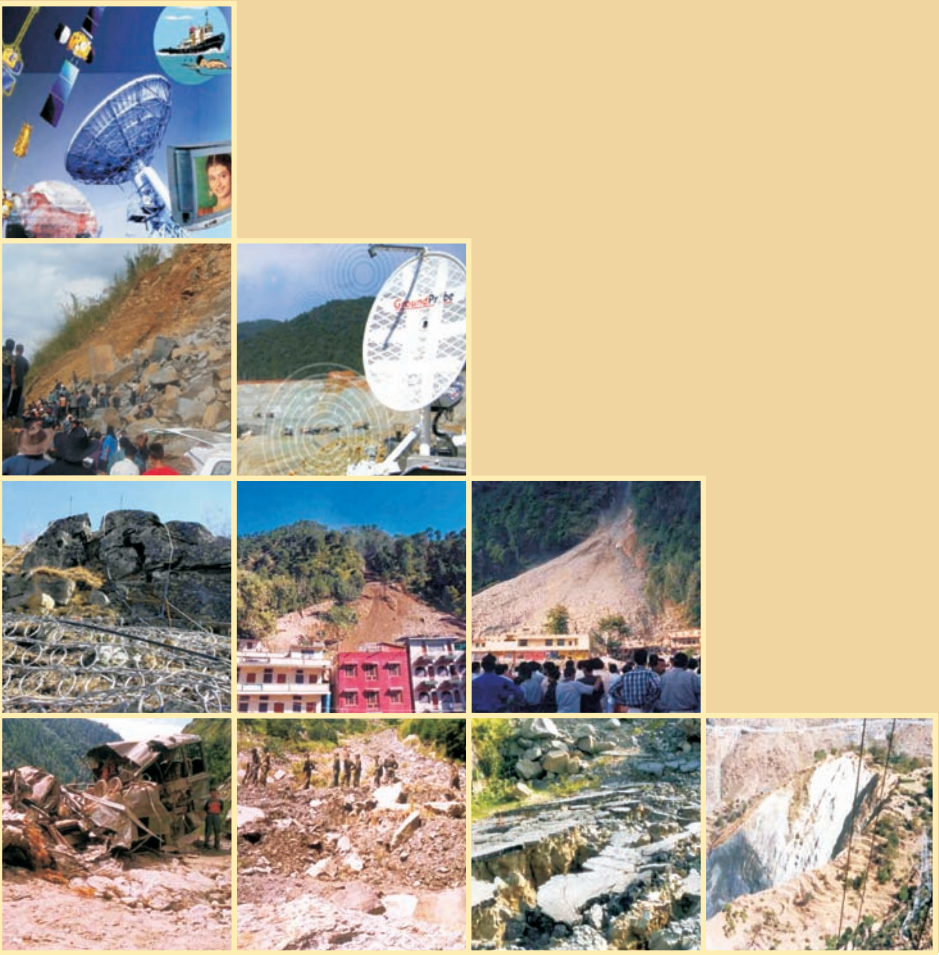
Annexure P-12

Training Module on

COMPREHENSIVE LANDSLIDES RISK MANAGEMENT



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NATIONAL INSTITUTE OF DISASTER MANAGEMENT
MINISTRY OF HOME AFFAIRS, GOVERNMENT OF INDIA

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सत्यमेव जयते

Training Module on

COMPREHENSIVE LANDSLIDES RISK MANAGEMENT

Impacts of Landslides on Society & Environment

Author :
Surya Parkash

nidm
Towards a disaster free India

National Institute of Disaster Management

(Ministry of Home Affairs, Govt. of India)
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Dr. SATENDRA, IFS
Executive Director

Foreword

The module on "Comprehensive Landslides Risk Management" is developed for five day training course focusing on imparting basic and requisite knowledge / skills needed by different stakeholders at various levels in the field of Landslide Management.

The module has been divided into sub-modules, each targeting specific learning units to enable certain learning events through well-designed course sessions with the support of a good trainer in the particular field.

The module has been prepared by Dr. Surya Parkash, Associate Professor, NIDM, based on his experience gained from more than 25 training programmes on landslides, all over the country over the past five years. In addition, inputs for preparation of the training module have also been provided by different eological Survey of India (GSI), Border Roads Organization (BRO), Central Road Research Institute (CRRI), Advanced Technical Engineering Services (ATES), Central Building Research Institute (CBRI), Defence Terrain Research Laboratory (DTRL), Snow and Avalanches Studies Establishment (SASE), Wadia Institute of Himalayan Geology (WIHG) and NGOs like Save The Hills, Community Based Disaster Risk Management Society (CBDRMS) and Sphere India. The module has been designed with multi-hazards risk management approach and briefly discusses all types of vulnerabilities for all stakeholders in an integrated holistic manner.

NIDM acknowledges the valuable support from all resource persons and institutes, especially GSI, BRO, ATES and CRRI for providing technical inputs on the module and reviewing the same at various stages of preparation and publication. This training module is developed for use in different training Institutions/centres for capacity in enhancement in the field of Landslides Risk Management.

(Satendra, IFS)
Executive Director,
National Institute of Disaster Management
New Delhi, India

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Preface

The Malpa landslide tragedy in August 1998 that killed more than 200 persons on trek to Kailash Mansarovar brought the attention of the Central Government to the problem of landslides. Department of Science & Technology constituted 3 national level task forces to look into different aspects of landslide problems. After the enactment of disaster management act in 2005, National Disaster Management Authority was established under the chairmanship of Hon'ble Prime Minister. The Authority issued national guidelines for management of different types of disasters including landslides and avalanches. The author had assisted NDMA as part of the Core Group and Drafting Committee for the Landslide Guidelines at the national level. He is presently involved with NDMA as part of the National Task Force on Landslides Management and Working Committee of Experts on Landslides.

National Institute of Disaster Management (NIDM), New Delhi has been mandated by the DM Act 2005 to organize training programmes, seminars, workshops and conferences on disaster management including the field of landslides and other mass movements. The experiences gained by the author from the above-said activities have been gathered and used to compile this module for enhancing the knowledge and information related to landslides and disaster management among the different stakeholders.

NIDM has been recently recognized as **World Centre of Excellence on Landslide Disaster Reduction (WCoE-LDR)** by the Global Promotion Committee of the International Consortium on Landslides (ICL) and International Progarmme on Landslides by International Strategy for Disaster Reduction (IPL-ISDR), for its contributions in the field of training and capacity development for landslide risk reduction. The author, who in Leader of the WCoE-LDR at NIDM, has also been made Coordinator for the ICL's Thematic Network on Landslide Risk Management and approved as Project Leader for IPL-172 project on *"Training, Documentation and Capacity Development for Landslides Risk Management"* under the International Programme on Landslides. He is presently engaged in developing teaching tools for landslide risk reduction with ICL as one of the expert members.

It is hoped that the module will provide an insight to the trainees in the basic understanding about landslides and measures required for reducing the risks at different levels. The trainees are encouraged to interact with field experts and resources persons in this field to prepare themselves better for landslides risk reduction.

(Surya Parkash)
Author

Acknowledgement

At the outset, I would like to express sincere thanks to Dr. Satendra, Executive Director, National Institute of Disaster Management, New Delhi for his kind encouragement for writing this module. I would like to place on record the significant contributions made by different resource persons in compiling the information, database and maps related to landslides in the country. I am particularly thankful to Dr. R.K. Bhandari, Prof. Yudhbir, Dr. Y.P. Sharda, Dr. R.N. Ghosh, Shri M. Raju, Shri Joyesh Bagchi, Shri Sanjiv Sharma, Dr. P.C. Nawani, Shri U.S. Rawat, Dr. R.K. Avasthy, Dr. Saibal Ghosh, Dr. Pankaj Jaiswal, Shri P.P. Srivastava, Shri Ishwar Singh Duhan, Shri Jog Singh Bhatia, Dr. Tapas Martha, Shri Yadvendra Pandey, Shri Om Prakash Sahu etc. for for their fruitful discussions and contributions in preparing the manuscript of this module. I am grateful to the reviewers Dr. V.M. Sharma, Director AIMIL Ltd. and Shri Sanjiv Sharma, Director, LHIM & EPE, Geological Survey of India, for the useful comments on the draft of this Module has helped us improve the quality and standard of its content.

I am sincerely thankful to the international experts like Prof. Kyoji Sasssa, Executive Director, International Consortium on Landslides, Dr. Peter Bobrowsky from Canada, Ms. Lynn Highland from USGS, Prof. Dwikorita Karnawati and Dr. Faisal Fathani from Indonesia, Prof. Alexander Strom from Russia, Dr. S.H. Tabatabei from Iran, Dr. He Bin and Dr. Hiroshi Fukuoka from Japan and so on, who have encouraged me in undertaking challenging tasks related to landslides risk reduction.

I am happy to acknowledge the support and cooperation from my colleagues and supporting staff at NIDM, without which it would not have been possible for the document to be completed. I would like to place on record my thanks to Dr. Chandan Ghosh, Professor and Head, Geohazards Risk Management Division, NIDM and Dr. Ritu Raj for extending necessary help in preparing the module. I would also like to express my sincere gratitude to faculty members and staff of disaster management centres in the different states in the country who have helped in various manners by sharing their experiences, resources, database etc. and made valuable contributions to this effort. Particular thanks are due to Dr. Om Prakash, Shri J.C. Dhondiyal, Shri Ashok Kumar Sharma, Dr. Hovithal Sothu, Dr. Lal Rokima, Dr. R. Dharmaraju and so on.

Last but not the least, I would like to thank my wife Reeta and my daughter Rasika, without whose consistent moral and logistic support, I would not have been able to give due attention and time to this work. I am indebted for their tolerance to bear with me when I was busy with work related to the module and could not give due attention and care to them.

Finally, I am grateful to the Almighty God without whose grace and kindness, I would not have been capable to carry this task successfully.

(Surya Parkash)
suryanidm@gmail.com
Author

Module at a Glance

- Name: Training Module on Comprehensive Landslides Risk Management
- Developed by: Dr. Surya Parkash, Associate Professor, National Institute of Disaster Management (NIDM), New Delhi
- Technical Support: Geological Survey of India (GSI), Border Roads Organization (BRO) Central Road Research Institute (CRRI), Advanced Technical Engineering Services (ATES), Central Building Research Institute (CBRI), Snow and Avalanches Studies Establishment (SASE), Wadia Institute of Himalayan Geology (WIHG), Community Based Disaster Risk Management society (CBDRMS)
- Total Number of sub-modules: 14
- Target Audience: Stakeholders in various sectors at different levels, particularly geologists, engineers (civil, mining and hydel), administrators, planners, NGOs, civil defence, environment agencies etc.
- Training programme on the basis of this module requires:
  - Duration of Training: 5 working days (~38-40 working hours)
  - Number of Trainers : 2 or more
  - Training Hall with movable chairs and tables
  - Training Materials as mentioned inside
- Total Pages: 278 (excluding annexures/handouts)
- Photo Courtesy: Dr. Surya Parkash, NIDM
- Maps : Dr. Surya Parkash, NIDM

Who Shall Use This Module

This module shall be used by a trainer involved in conducting courses on landslides risk management. The following individuals / organizations are the potential users of this module.

- Geologists, Civil/Mining/Hydel Engineers, Field Professionals, Architects/ Planners, Developers, Environmentalists (in Hilly Terrains)
- NDMA, SDMA, DDMAs. Geological Survey of India, State Departments of Geology and Mines, Academicians, Researchers and Professionals working on landslides
- Disaster Management Centres at State ATIs & SIRDs
- NGOs, CBOs, SHGs, Social Volunteers, Public Representatives
- NDRF, SDRF, QRTs, RRFs, paramilitary and military
- Administration, Local Bodies like Municipality and Panchayats
- NSS, NYKS, NCC, Scouts and Guides, Home Gaurds, civil defense and Fire Fighters
- Field Agencies like Border Roads, PWD, NHAI, PGCL, NHPC, THDC, NTPC, Irrigation and Flood Control etc.
- Stakeholders in Insurance, Finance, Planning, Policy, Development and Legal Sectors

How to Use this Module

The training design brief will provide users the objectives of the course, target audience, structure, training methodologies and resource materials etc.

The chapters on pre and post training assessment will guide on how to carry out the evaluation and impact assessment of the training course along with a set of questionnaires and necessary instructions. The actual training sessions will start with the sub-modules provided in the contents. However, elaborate instruction and guidelines are given for the session in every sub-module.

Trainer's Guide

The Trainer/Facilitator/Course Director may find the following tips useful for smooth conduct of the training.

General

- In the inauguration / introduction session, trainees should be asked to put their mobiles / cell phones on silent mode and to attend the urgent calls only, that too outside the training hall during the sessions.
- Participants list with names, addresses, contact numbers, email IDs etc. should be circulated for verification by the trainees for necessary corrections.
- All training materials and equipment should be kept ready and re-checked before the training.
- Clear information about lunch hours and tea breaks should be given to trainees to avert any delay. They should be informed about exact time of start of sessions and next day plans.
- Care should be taken for proper logistic arrangements for the trainees to make their stay during the training, comfortable.

Training Specific

Following aspects should be taken care of.

- Each day shall start with a recapitulation session of about 15 minutes except the first day. At the end of each day, summary of the day's proceedings shall be shared by the participants for 10 minutes after the last session.
- Group composition shall change for every activity/exercise through different methods.

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ABBREVIATIONS/ACRONYMS USED

ATES -	Advanced Technical Engineering Services
ATI -	Administrative Training Institute
BIS -	Bureau of Indian Standards
BRO -	Border Roads Organization
CBDP -	Community Based Disaster Planning
CBLRM -	Community Based Landslides Risk Management
CBDRM -	Community Based Disaster Risk Management
CBO -	Community Based Organizations
CBRI -	Central Building Research Institute
CLRM -	Comprehensive Landslides Risk Management
CRED-	Centre for Research on Epidemiology of Disasters
CRF -	Calamity Relief Fund
CRRI -	Central Roads Research Institute
DDMA -	District Disaster Management Authority
DGBR -	Director General Border Roads
DGCD -	Director General civil Defence
DGM -	Department of Geology and Mines
DMA -	Disaster Management Act
DMMG -	Department of Mines, Minerals and Geology
DoS -	Department of Space
DST -	Department of Science & Technology
ESF -	Emergency Support Function
GSI -	Geological Survey of India
GFDRR -	Global Facility for Disaster Reduction and Recovery
HVCR -	Hazard, Vulnerability, Capacity and Risk
ICL -	International Consortium on Landslides
ILC -	International Landslide Centre
IMD -	Indian Meteorology Department
IIRS -	Indian Institute of Remote Sensing
IPL -	International Programme on Landslides
ISDR -	International Strategy for Disaster Reduction
ISRO -	Indian Space Research Organization
ITBP -	Indo Tibetan Border Police
LHZ -	Landslides Hazard Zonation
LMP -	Landslides Management Plan
LRM -	Landslides Risk Management
LSN -	Landslides Schools Network
LSZ -	Landslides Susceptibility Zonation

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Abbreviations / Acronyms Used

MHA -	Ministry of Home Affairs
MoM -	Ministry of Mines
MoES -	Ministry of Earth Sciences
NCCF -	National Calamity Contingent Fund
NDMA -	National Disaster Management Authority
NDMRC -	National Disaster Mitigation Resource Centre
NDRF -	National Disaster Response Force
NDRF -	National Disaster Response Fund
NGO -	Non Governmental Organization
NHAI -	National Highways Authority of India
NHPC -	National Hydro Power Corporation
NIDM -	National Institute of Disaster Management
NTPC -	National Thermal Power Corporation
NRSC -	National Remote Sensing Centre
PGCL -	Power Grid Corporation (I) Limited
PWD -	Public Works Department
QRT -	Quick Response Team
SASE -	Snow and Avalanches Studies Establishment
SDMA -	State Disaster Management Authority
SDRF -	State Disaster Response Fund
SDRF -	State Disaster Response Force
SOP -	Standard Operating Procedures
THDC -	Tehri Hydro Development Corporation
UNDP -	United Nations Development Programme
UNESCO -	United Nations Educational Scientific and Cultural Organisation
UNHCR -	United Nations High Commission for Refugees
UNICEF	United Nations Children's Fund
U.N. OCHA	UN Office for Coordination of Humanitarian Affairs
UNDAC	United Nations Disaster Assessment and Coordination
UNITAR	United Nations Institute for Training and Research
UNU	United Nations University
USD -	United States Dollars
USGS -	United States Geological Survey
UT-	Union Territories
VOs -	Voluntary Organizations
WBI -	World Bank Institute
WIHG -	Wadia Institute of Himalayan Geology

Glossary / Terminology related to Landslides

Acceptable Risk - A risk for which we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.

Cloud Burst: Clouds are formed when water vapors reach a height where temperature is low. Water vapors condense to form small water droplets. When nucleation of such clouds takes place, water droplets grow in size to form raindrops, depending on the thickness of clouds and low temperature, the rain is light or heavy. In case of cloud bursts, cyclonic winds virtually compress the clouds and forced nucleation amounting to sudden precipitation takes place where all the water from the clouds is poured out. This is called cloud burst.

Sudden rainfall with great velocity is called a cloud burst. It results from the condensation of stratus clouds. It does not last very long. Heavy rains on the other hand are caused by nimbus clouds which are black in color and suspended at a lower height

Controlling (Perpetuating) Factors which dictate the condition of movement as it takes place; i.e. factors which control the form, rate and duration of movement.

Hazard - A condition with the potential for causing an undesirable consequence. Alternatively, the hazard is the probability a particular landslide occurs within a given time and space.

Individual Risk - The risk of fatality and/or injury to any identifiable (named) individual who lives within the zone exposed to the landslide, or who follows a particular pattern of life that might subject him/her to consequence of the landslide.

Landslides are simply defined as down slope movement of rock, debris and/or earth under the influence of gravity. This sudden movement of material causes extensive damage to life, economy and environment. **Landslide** is the most common and universally accepted collective term for most slope movements of the mass movement type. The term has sometimes been considered unsuitable as the active part of the word denotes sliding.

Mass Movement is outward or downward gravitational movement of earth material without the aid of running water as a transporting agent. It does not deny the importance of water in either its solid or liquid state as a destabilising factor nor does it excludes subsidence and other movements on flat ground.

Mass Wasting is a broader term commonly used in conjunction with the erosion cycle to refer to the mass reduction of the interfluves as opposed to the degradation by streams. In effect it must include the action of all non-linear erosional processes working on the slopes between streams.

Preparatory Factors which dispose the slope to movement; i.e. the factors which make the slope susceptible to movement without actually initiating it and thereby tending to place the slope in a marginally stable state.

Risk - A measure of the probability and severity of an adverse effect to individuals or populations, property or the environment.

Risk Management - The complete process of risk assessment and risk control.

Slope Failure refers to the process of rupture or shearing in materials rather than to a particular ground feature. Terzaghi (1950) advocated this term for slope movements on engineered slopes.

Slope Instability refers to the predisposition of a slope to mass movement. The condition may be recognised by analysis of stress within the slope, by various slope characteristics or by analysis of historical records of slope development.

Slope Movements restricts to mass movements on slopes.

Societal Risk - The risk of multiple injuries or deaths to society whole: one where society would have to carry the burden of a landslide accident causing a number of deaths, injuries, financial, environmental and other losses.

Stability Factors - All forces determining stability are controlled or influenced by identifiable phenomena are referred as Stability factors. When these operate to induce instability, they are called destabilsing or causative factors. e.g. climate, slope strength, vegetation etc. Indeed there are many components of the slope system which can change independently to destablise the slope but the significance of any change is dependent on the aggregated effect of all the components. An examination of the *temporal variability* of factors identifies some as being **passive** (slow or gradually changing) e.g weathering, and **transient or active** (fast changing).

Triggering Factors which initiate movement; i.e those factors which shift the slope from a marg

Tolerable Risk - A risk that society is willing to live with so as to secure certain net benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible.

CONTEXT

Context

Landslides occur in hills / mountains in response to a wide variety of terrain conditions and triggering processes like heavy rainstorms, cloudbursts, earthquakes, floods and unsafe developmental activities. As per an assessment, more than 5000 people are buried alive under landslides and economic losses of >4 bn USD occur every year, globally (ICL, 2010). Continent-wise, Asia suffers the maximum damages / losses due to landslides in general and the south Asian nations, in particular, are the worst sufferers. Further, among south Asian countries, India is one of the most affected by landslides.

In our country, nearly 15% of its territory is prone to various degrees of landslide hazard (GSI, 2001), frequently affecting the human life, livelihood, livestock, living places, structures, infrastructure, and natural resources in a big way. In addition to direct and indirect losses, landslides cause significant environmental damages, societal disruption and strategic concern. Landslides are spread over 22 states and 2 Union Territories including Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal, Assam, Meghalaya, Mizoram, Manipur, Nagaland, Sikkim, Tripura, Kerala, Karnataka, Tamilnadu, Andhra Pradesh, Goa, Maharashtra, Madhya Pradesh, Chhatisgarh, Andaman & Nicobar Islands and Puducherry (NDMA Guidelines, 2009). The most sensitive areas are the Himalayan belt, the Nilgiris, the Western and Eastern Ghats. Landslides constitute a serious hazard that causes substantial human and financial losses in the country. It is estimated that annually on an average about 300 human lives are lost and approximately Rs.300 Crores are lost every year. *Bansal and Mathur (1976) reported that a*nnually **Rs.350 million** are lost due to failure of transport and communication caused by the landslides*. Bartarya and Valdiya, 1989 estimated that a*lmost **50% of the landslides** occur along the roads*. Valdiya, (1987) reported that the i*ncidences of landslides increase by **25 to 345 times** due to road construction activities whereas *Gupta (1990) estimated that e*ach kilometer of road in hills require displacement of **40 to 80 thousand cubic meter** debris.

Landslides can happen not only in isolation but also along with or as a consequence of other disasters like earthquakes, floods, cyclones, lightning, cloudburst, forest fires, dam / lake bursts etc. In such cases, landslide losses are normally included within the primary disaster and hence, are not dealt separately. Thus, most of the reported estimates on landslides losses are found to be quite lower than the actual impacts of landslides on the society as a whole.

Context

With growing population, urbanization and human interventions in terms of developmental activities over unstable slopes, landslides pose increasing risk to human lives, buildings, structures, infra-structures and environment. Changing climatic conditions manifested in the form of global warming, glacial melting, erratic and uneven rains, extreme temperature conditions etc. are also extending these risks to even unexpected areas. Large scale deforestation along with faulty management have led to increased vulnerability to landslides in many regions of the country. Human activities relating to expansion on unsafe locations, unscientific mining, unsafe construction of roads, dams and river training works ignoring natural features contribute to increased intensity of landslides. The absence of large scale landslide hazard maps leads to people being caught unaware especially when the first time landslides strike. This could have been avoided if large scale landslide hazard maps were available and people made aware about the potential hazards.

As a single landslide usually affects limited area and people, damage resulting from landslide hazards are not recognized as a problem of national importance and are not addressed on a national basis. The absence of coordinated national approach to mitigating the detrimental effects of landslides result in a reduced ability of the states and local government agencies to apply the important lessons learnt, often at enhanced expense.

As a result, the need for a national strategy was strongly felt and worked upon by the National Disaster Management Authority through National Disaster Policy and Guidelines on Management of Landslides and Avalanches. Being cognizant of the diversity of issues associated with national landslide problem that arise from both regional considerations and considerable variations in the institutional capability and responsibility at regional and local levels, inputs from a wide variety of stakeholders are essential. Hence, strengthening the process of landslide assessment, investigation, mapping and management is sure to have far reaching effects in reducing landslide losses.

The aim of this training programme is to work in the following directions to make the hilly terrains and coastal areas free of landslide disasters.

- To promote the use of landslide risk analysis techniques to guide loss reduction efforts at the state and local levels.
- To play a vital role in evaluating methods, setting standards, and advancing procedures and guidelines for landslide hazard maps and assessments.
- To provide tools for landslide hazards mitigation and promote basic research on monitoring techniques and on aspects of landslide process mechanics.

- To impart education, training and awareness of landslide hazards and mitigation options to decision makers, professionals, and the general public.
- To integrate and mainstream landslide risk management with development and climate change in a multi-hazard perspective involving interdisciplinary cross-sectoral partnership approach
- To produce implementation and management plans that will provide the practical basis for an effective national strategy that can be applied at local levels.
- To support advocacy, policy, guidelines and plans for landslides risk management at different levels among various stakeholders
- To develop workable partnerships with states, district and local level governments and non-governmental organizations as well as professional and other stakeholders.

Aim of the Course

To enhance knowledge and skills related to landslides risk management of a multi-stakeholder target group which is expected to play an important role in reducing landslide incidences and impacts through various kinds of activities involving social, technical, legal, financial, environmental, administrative and other relevant issues, aspects and dimensions at different levels/scales.

Course Objectives

At the end of the training program, the participants will be able to

- Define the terms/concepts in landslides risk management and become aware of basic information about landslides
- Describe landslide scenario and mitigation strategy with multi-hazard perspective
- Characterize/identify landslide indicators/precursors and relate factors affecting landslide occurrence and its extents
- Identify the needs, gaps and strategies in landslide databases, inventory & mapping
- Understand the Mechanism for Landslide Hazards, Vulnerability and Risk Assessment, Zonation, Prioritization and Communication for Landslide Risk Reduction

- Learn options for minimizing landslides risks – avoidance, prevention, mitigation (including structural and non-structural measures), preparedness, and response to the disaster
- Assess landslides damages and losses in a systematic way
- Inform about planning, policy and guidelines on landslide risk management as well as roles/responsibilities/SOPs to stakeholders
- Understand cross-sectoral issues like administrative, technical, legal, financial, social etc.
- Enlist and use Indian Standards and Codes related to landslides
- Discuss about the possible applications of technology, local resources/ skills, and traditional wisdom in landslides management – Community Based La-ndslides Risk Management
- Demonstrate through an exercise the process of landslide risk management
- Carry out mock drills for public safety against landslides
- Integrate and mainstream landslide risk management with development and climate change in a multi-hazard perspective with interdisciplinary cross-sectoral partnership approach
- Provide a forum for networking, linkage and coordination among different stakeholders for exchange of ideas, information, knowledge, experiences and resources on landslides risk management

Target Group

The target group for this programme would be senior officers from departments of Revenue, Disaster Management, Geology and Mines, Geological Survey of India, Town Planning, Public Works Department, Border Roads Organization, Irrigation and Flood Control, Rural and Urban Development, Hydropower Sector, Building and Housing Department, State and District Development Authorities, NDRF, Police and Civil Defence, Fire Services, Environment & Forest, Roads and Bridges, Watershed Management, State Science and Technology Council, State Remote Sensing Application Centres, Professional, Research, Academic and Community organizations/Public Representatives etc.

The participants are expected to have varied responsibilities, academic backgrounds & experience. But all of them are required to be equipped with minimal level of knowledge, skills, information and experience related to landslides for doing their tasks in their organizations effectively. They are

expected to deal with disaster management during planning and implementation of developmental activities. The programme is intended to provide a comprehensive knowledge and skills in the field of landslide risk management to these participants.

Assumptions about Trainees

It is assumed that the age of trainees varies as they are associated with different sectors. The academic qualifications and level of degrees will also be dissimilar. They may or may not have experience / exposure to disasters prior to the training.

Why This Training?

Lack of adequate knowledge, skills and information about landslide disasters have aggravated the losses and prolonged the recovery process. Informed, skilled and trained human resources can play a significant role in landslides risk management and loss reduction. The training aims to fill this gap in a proactive mode by imparting skills, knowledge and information related to landslides management.

Training Needs

An interaction with the various concerned organizations over the years has made us believe that landslides incidences and impacts are rising due to lack of adequate number of trained human resources with these organizations besides that fact that affected communities are also unaware, uninformed, unprepared and unequipped. Different stakeholders as well as the affected communities need to be sensitized, aware, informed, prepared and made capable to assess the potential / impending landslides risks, minimize them and gear themselves up against the remnant risk.

Relevance of Objectives to Training Needs

The objectives of the training programme are so formulated to cater to the training needs of the different stakeholders for carrying out their tasks more effectively and efficiently in order to reduce landslides risks and manage their impacts on life, economy and environment.

Time Constraint

There will be time constraint for holding training course due to the fact that most of landslides happen during monsoon periods and the concerned officials would be busy in managing them. Hence, relevant participants shall be available

only in pre and post monsoon seasons. Thus, timings for the training should preferably be fixed in pre and post monsoon period to enable to attend the training without stress of the field work.

Trainers

Senior officers from GSI, BRO and faculty members of NIDM, ATIs, research and academic institutions who have expertise in different aspects of landslide risk management

Logistics

Boarding and lodging arrangements for 20-25 trainees / participants.

Number of trainees / participants

20 to 25 trainees / participants belonging to various departments / agencies

Venue(s) for Training

NIDM, State ATIs and GSI /DMMG training centres

Entry Behavior

Geologists, Engineers (civil, mining, irrigation) and concerned field level officers involved in landslide studies and management. Field officers preferably with academic background of geology/ geophysics/ geotechnical engineering/ mining engineering/highway engineering/ irrigation/watershed management/ remote sensing. People with and experience / involvement in landslide risk management will be given preferrence.

Content defined in relation to objectives

- Terms and Concepts in Landslides Risk Management
- Landslide definitions, types, causes, factors, impacts
- Landslide Database, Inventory, and Zonation
- Institutional Mechanism for Landslide Management
- Policy, Guidelines and Plans for Landslides Risk Management
- Landside Identification, Investigation, Instrumentation and Monitoring,
- Early Warnings, Alerts and Communication Systems
- Search, Rescue and Relief Operations for Landslide victims
- Landslides Preparedness for pre, during and post landslide conditions (Do's and Don'ts)
- Survival Skills for Disastrous Situations

- Prevention, Mitigation and Management of Landslide
- Response to Landslides
- Damage and Loss Assessment
- Cross cutting issues – Administrative, Legal, Financial, Technical, Social etc.
- Mainstreaming Landslide Risk Reduction with Development and Climate Change Adaptation in Hilly Regions
- Community Based Landslides Risk Management
- Standards, Codes, Regulations, Acts, Byelaws related to Landslides
- Case Studies and Best Practices
- Handouts/Exercises/Orientation Notes for Group Tasks, Guided Field Exercises, Role Plays and Mock Drills
- Resources, Links & Networks

Language

Medium of instruction is English. Further, all the presentations/ Demonstrations/ Drills/Exercises have been prepared in English but these can be translated into any local languages for understanding by layman. Interactions can also be in Hindi or any other vernacular languages.

Time Frame

Training shall be held for 5 days.

Training Methods

Lectures/Interactive Discussions, Power Point Presentations/slide shows, Brainstorming discussions / panel discussions / experience sharing / participatory learning, Needs Assessment, case studies, guided group exercises (table-top and simulation), hands on exercises/practicals, skill transfer, mock-drills, demonstration and exposure visit/guided field work.

Media and equipments

Computers, LCD Projector, Screen, Laser pointer, Overhead Projectors, White board, Flip Charts and a Stand, Markers, mike and speakers (PA system), Camera, GPS.

Performance Aids

Flip charts, lecture notes/hand-outs of presentations, questionnaires, check list, formats for data collection / templates, Exercises for Case studies.

Training Materials

Note pad, Pen, Folder/bag, CD, Sketch Pens, Flip Charts

Measures for Transfer of Learning

Each trainee shall submit an action plan to implement and impart training skills at his/ her organization. Trainees will be asked to submit a short term project with in one month to demonstrate their level of learning from the course and their efficacy in using the skills.

Assessment, Feedback and Validation Measures

During the course, questionnaires will be distributed to assess the level of learning of the participants. Daily session-wise evaluation will be done through recapitulation of learning of the previous day. Trainer / facilitator will also evaluate transfer of skills during role plays, exercises and mock drills by the participants. At the end of the course, the participants would be required to fill feedback form for their observations and comments. External validation shall be done through short term projects and feed back from the head of the sponsoring agency.

Benefits

1. Pool of trained human resources who can cater to the needs for assessing landslides risks and help in managing them or reducing their risks at district, state and national levels.
2. Reliable and credible system for landslide risk management would be developed.
3. Networking and co-ordination among various stakeholders will become stronger.

Cost of Training (per Course)

It includes TA/DA for Resource Persons, Training Kit, Stationery Cost, Expenditure on Field Visit, boarding and lodging charges for the participants, Transportation Charges, Photography, Xeroxing/Binding of Reading Material/Hand Notes, Hospitality Charges for Resource Persons, Communication Charges (mobile/ telephone/postage), Tutor Expenses, Miscellaneous/Contingent Charges, Administrative / Overhead Charges

Approximate Budget

Rs.63,000/- per training course

Day 1 - Learning Event for Learning Unit -1:

Landslide History, Morphology and Diagnostic Features

Topic 1-0: Registration

Enabling Objectives:

- Personal & Organizational Information about trainees
- Expectations from the Course
- Experience of participant

Contents

- Filling of Registration Form
- Compilation of registration record
- Profile of trainees/organizations

Time: 0930-1000 hrs. (30 min.)

Method : Proforma for registration

Facilitator: Training Assistant

Topic 1-2: Introduction and Inauguration

Enabling Objectives:

- Mutual Introduction of participants
- Experience sharing
- Course Introduction
- Significance of Programme & Paradigm shift

Contents

- Welcome to participants
- Experience sharing and Expectations
- Entry Behaviour
- Ground Rules
- Course Introduction
- Inaugural Address

Time: 1000-1130 hrs (90 min.)

Method: Mutual Interaction

Resource Person(s): Course Director and Guest Speaker

Learning Event for Learning Unit- 1:

Basic Information on Landslides, History and Landslide Scenario

Training Objective:

(i) Basic Information about Landslides and Understanding about Landslides

(ii) Understanding history and scenario of landslide disasters – global, national add state-wise

Objectives: At the end of this session, participants would be able to

1. Define landslides
2. Study the landslides features / morphology
3. Characterize different types of landslides
4. Inform about landslides scenario in the State/UT

Contents:

- Introduction to Terms/Concepts in CLRM
- Definition & Types of Landslides
- Landslide Features / Morphology

Time: 1145-1300 hrs (75 min.)

Method: Lecture, Presentation and Discussions with field examples

Topic – Landslide History and Scenario

Enabling Objectives: Learning about past landslide disasters and their impacts

Landslides Distribution Scenario of the State/UT

Contents:

- History and Distribution of Landslides
- Lessons learnt from past landslides disasters

Time: 1400 -1530 hrs (90 min.)

Method: Lecture, Presentation and Discussions with field examples

Topic – Landslide Morphology and Diagnostic Features

Enabling Objectives: Learning about parts of landslides

Diagnostic features of potential and relict landslides

Contents:

- History and Distribution of Landslides
- Lessons learnt from past landslides disasters

Time: 1545 -11715 hrs (90 min.)

Method: Lecture, Presentation and Discussions with field examples

Summary of the Day-1: Recalling Day-1's deliberations

Time: 1715-1730 hrs (15 min.)

Method - Mutual Interaction

End of Day - 1

Day 2 - Learning Event for Learning Unit- 2:

Factors affecting Landslides and Landslides Hazard Zonation

Training Objective:

(i) Landslides Indicators/precursors, Factors & Causes,

(ii) Landslides Database, Inventory and Hazard Zonation

(iii) Landslide Risk Assessment and Treatment

Session 2-1:

Topic 2-1 - Recapitulation of Day-1

Enabling Objectives: Recalling the learnings from last day

Contents:

- Recapitulation by participants
- Reference to the reading material

Method: Oral / Flip Chart

Time: 930-1000 hrs. (30 min.)

Session 2-2:

Topic 22- Identification of Landslide Indicators and Precursors

Enabling Objectives: Understanding

- Field Indicators for slope Movements
- Precursors of Landslides

Contents:

- Enumeration of potential indicators for landslides
- Observations and interpretation of indicators
- Case examples from the field sites
- Experiences with landslide precursors
- Scope and limitation of landslide indicators and precursors for safety

against landslides

Method:

Presentation and Discussion with field examples and sketches

Time: 1000-1100 hrs (60 min.)

Session 2-3:

Topic 2-3: Factors affecting occurrence of landslides

Enabling Objectives: Understanding

Factors & their types

Role and relation of different factors with the landslides

Content:

- Recognizing the factors affecting landslides
- Classifying factors as preparatory, controlling and triggering factors
- Discussing their relation with landslides using a case study

Method: Lecture, Presentation and Discussions with a Case Study

Time: 1115-1215 hrs (60 min.)

Session 2-4:

Topic 24- Factors and Causes of landslide

Enabling Objectives: Understanding factors and causes affecting

Dimensions of landslides (LxWxD)

Velocity of Landslides & Run-out distance

Time and duration of landslide activity

Contents:

Factors, causes and consequences of landslides

Method: Lecture and Discussions

Time & Duration: 1215-1300 hrs (45 min.)

Session 2-5:

Topic 25- Landslides Database and Inventory

Enabling Objectives: Understanding

Need, Status, Gaps and Strategy for Landslides Database and Inventories

Collection and Compilation of Data

Contents:

- Existing Landslides Database and Inventory

- Needs, Status, Gaps and Strategy to generate and update database - NDSS
- Template for Landslide Database
- Template for Landslide Inventory

Method: Lecture, Presentation and Discussions with Case Studies and Templates

Time and duration: 1400-1530 hrs. (90 min.)

Session 2-6:

Topic 26- Landslide Hazard Zonation, Risk Assessment and Treatment

Enabling Objectives: Information about LHZ

Landslide Risk Assessment

Options for Landslides Risk Treatment

Contents:

- Landslide Hazard Zonation
- BIS Code for LHZ
- A case study on LHZ
- Landslide Risk Assessment and Treatment

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 1545-1715 hrs. (90 min.)

Summary of the Day-2

Recalling Day-2's deliberations

Mutual Interaction

1715-1730 hrs (15 min.)

End of Day-2

Day 3 - Learning Event for Learning Unit 3 :

Landslide Investigation, Monitoring and Remediation; Table-top Exercises

Training Objective:

(i) Landslide Investigation and Instrumentation

(ii) Landslide Monitoring and Warning system

(iii) Landslide Remediation

(iv) Table-top Exercises

Session 3-1

Topic 3-1: Recapitulation of Day-2

Enabling Objectives: Recalling the learnings from last day

Contents:

- Recapitulation by participants
- Reference to the reading material

Method: Oral / Flip Chart

Time and Duration: 930-1000 hrs. (30 min.)

Session 3-2:

Topic 32- Landslide Investigation and Monitoring

Enabling Objectives: Understanding

Preliminary Investigation and Monitoring

Detailed Investigation Planning

Instrumentation and Monitoring

Contents:

- Geological Investigations
- Geophysical Investigations
- Geotechnical Investigations
- Landslide Instrumentation

Method: Lecture, Presentation and Brainstorming Discussions

Time and Duration: 1000-1100 hrs (60 min.)

Session 3-3:

T 33- Options for Landslide Remediation

Enabling Objectives: Understanding

Landslide Remediation Practices

Options for Landslide Remediation

Mitigation methods for different types of landslides

Relevant standards and codes for landslide mitigation

Contents:

- Remedial Measures
- Landslides Management Practices in India

- Mitigation methods for different types of landslides
- Biotechnical and bioengineering measures

Method: Lecture, Presentation and Panel Discussions

Time and Duration: 1115-1300 hrs, (105 min.)

Session 3-4:

Topic 34- Orientation for Case Study on Landslides Management

Enabling Objectives: Understanding

Critical Issues related LRM activities

Contents:

(i) Orientation of participants to conduct TTE

(ii) Information about landslide

(ii) Grouping of participants – Team building

(ii) Rules for Conduct of TTE

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 1400-1430 hrs. (30 min.)

Session 3-5:

Topic- Table Top Exercise on Landslide Management

Enabling Objectives: Conduct of TTE

Facilitation, Observation and Monitoring

Contents:

- Understanding and utilization of information
- Interactions by individuals and discussion among the group
- Facilitation, Observation & Monitoring of TTE
- Action plan and implementation strategy for pre, during and post landslide risk management by the team

Method: Group Exercise (Table-top)

Time and Duration: 1430-1630 hrs (120 min.)

Session 3-6:

Topic- Presentation and Feedback of TTE

Enabling Objectives- Comments on Technical/managerial content

Observations on attitudinal aspects and team spirit

Contents:

- Group Presentations
- Comments and feedback

Method: Group Presentation

Time and Duration: 1630-1715 hrs (45 min.)

Summary of Day-3 activities and learnings

Instructions for Field Visit on next day

1715-1730 hrs (15 min.)

End of Day-3

Day 4 - Learning Event for Learning Unit- 4:

Field Exposure/Exercises, Mock drill and Videos/Documentary shows

Training Objective:

Field Visit to Landslide, Conduct of Simulation Exercise/Mock Drill, Videos on Evacuation and SRR, Demonstration of S&R techniques, first-aid and survival-skills

Session 4-1:

Topic - Recapitulation of Day-3

Enabling Objectives: Recalling the learnings from last day

Contents:

- Recapitulation by participants
- Reference to the reading material & discussions

Method: Oral / Flip Chart

Time and Duration: 930-1000 hrs. (30 min.)

Session 4-2:

Topic 42- Field Exposure to Landslide

Enabling Objectives: Understanding

Field Identification of Landslides

Studying landslide features/morphology

Observations & Data collection

Assessing factors & causes affecting landslide occurrence

Hazard, Vulnerability & Risk Assessment

Options for Risk Minimization

Contents:

- Features for landslide identification
- Landslide Morphology
- Landslide Characteristics & behaviour
- Elements at Risk & their degree of Vulnerability
- Risk Estimation, Classification, Prioritization and Communication
- Mock Drill / Simulation Exercise

Method: Exposure Visit / Guided Field Work / Simulation Exercise / Mock drill

Time and Duration: 1000-1530 hrs, (330 min.)

Session 4-3:

Topic- Presentation and Feedback of Field Visit and Simulation Exercise

Enabling Objectives- Comments on Technical/managerial content

Observations on attitudinal aspects and Team spirit

Contents:

- Group Presentations
- Comments and feedback
- Recommendations

Method: Flip Charts, Power Point Group Presentation

Time and Duration: 1630-1715 hrs

Summary of Day-4 activities and learnings

Next day plan

1715-1730 hrs (15 min.)

End of Day-4

Day 5 - Learning Event for Learning Unit 5 :

Community Based Disaster Risk Management, Mainstreaming Landslide Risk Reduction, Capacity Development and Emerging issues

Training Objective:

(i) Community Involvement in Disaster Risk Management

(ii) Mainstreaming Landslide Risk Reduction

(iii) Capacity Development

Session 5-1:

Topic- Recapitulation of Day-4

Enabling Objectives: Recalling the learnings from last day

Contents:

- Recapitulation by participants
- Reference to the reading material, field discussions and presentations

Method: Oral / Flip Chart

Time and Duration: 930-1000 hrs. (30 min.)

Session 5-2:

Topic- Community Based Disaster Risk Management

Enabling Objectives: Understanding

Role of community in disaster risk management

Tools and Technique for CBDRM

Case Study on CBDRM

Contents:

Methodology for CBDRM

Application to a locality

Case Example

Method: Video/slide show on community involvement in disaster risk reduction

Time and Duration: 1000-1030 hrs (30 min.)

Session 5-3:

Topic - Mainstreaming Landslides Risk Reduction

Enabling Objectives: Understanding

Inter-relation between disasters and development

Integrating disaster risk reduction with development

Contents:

- Relation between disasters and development
- Mainstreaming disaster risk reduction
- Issues and Strategies

Method: Video/slide Show on mainstreaming DRR with development

Time and Duration: 1030-1100 hrs, (30 min.)

Session 5-4:

Topic- Capacity Development and Emerging Issues

Enabling Objectives: Landslide Education and Training

Landslide Awareness and Preparedness

Capacity Development

Emerging Issue

Contents:

Training and Capacity Development for Landslides Risk Reduction

Emerging Issues

Method: Slide show

Time and Duration: 1115-1215 hrs (60 min.)

Session 5-5:

Topic - Networking, Linkage and Coordination

Enabling Objectives: Landslide Networks and Links

Coordination between different stakeholders

Contents:

- Information Landslide Knowledge Networks
- Information about Landslide Resources Networks
- Linkage and coordination activities

Method: Practical Demonstration on First Aid and survival Skills

Time and Duration: 1215-1300 hrs (45 min.)

Session 5-6:

Topic- A Case Study on Community Based Landslides Risk Management & LMP

Enabling Objectives: Understanding

Community Involvement in LRM

Format for LRMP

Contents:

- Aims and Objectives of CBLRM

- Methodology for field operation
- RRA/PRA/PLA Tools
- Context specific issues
- Template for LMP

Method: Lecture, Presentation and Discussions

Time and Duration: 1400-1500 hrs. (60 min.)

Session 5-7:

Topic- Cross cutting Issues and Mainstreaming DRR with Development & Climate Change

Enabling Objectives: Issues related to discipline, sectors, levels, boundaries, policies etc.

Contents:

- Inter-disciplinary studies
- Cross-sectoral and multi-level approach
- Transboundary Issues
- Advocacy, Policy, Planning & guidelines

Method: Group Discussions

Time and Duration: 1500-1600 hrs (60 min.)

Session 5-8:

Topic- Landslide Quiz

Enabling Objectives- Knowledge Check

Contents: Knowledge Check

Method: Slide Show, Question-Answers

Time and Duration: 1600-1645 hrs

Session 5-9:

Evaluation, feedback, certification and valediction

Contents:

Feedback from participant

Post-training assignment

Method: Follow-up Strategy

Time and Duration: 1645-1730 hrs (45 min.)

End of the Course

Comprehensive Landslides Risk Management

Module

A. Introduction

Landslides occur in all hilly terrains in response to a wide variety of conditions and triggering processes like heavy rainstorms, cloudbursts, earthquakes, floods, cyclones and haphazard human activities. CRED data indicates 8,658 human casualties due to landslides and avalanches between 1990 and 1999 but it appears to be significantly under-estimated. As landslides are frequent and widespread, the annual cumulative losses worldwide amount to tens of billions of USD in terms of lost property, environmental damage, repair works, and the maintenance of defence measures *(source: Page 61, World Atlas of Natural Hazards by Bill McGuire, Paul Burton, Christopher Kilburn and Oliver Willets).* The frequency of landslides is strongly influenced by the return periods of triggering events like rainfall and earthquakes.

More than 5000 people are buried alive under landslides and economic losses of >4 bn USD are suffered every year globally. Continent-wise, Asia suffers the maximum damages / losses due to landslides and among the Asian countries, South Asian nations are the worst sufferers and even among South Asian countries, India is one of the worse affected by landslides.

In India, nearly 15% of its territory (covering about 0.49 million sq.km) is prone to various degrees of landslide hazard *(GSI, 2001)*, frequently affecting the human life, livelihood, livestock, living places, structures, infrastructure, and natural resources in a big way. In addition to direct and indirect losses, landslides cause significant environmental damage, societal disruption and strategic concern. Landslides are spread over 22 States and 2 UTs including J&K, Himachal, Uttarakhand, Arunachal, Assam, Meghalaya, Mizoram, Manipur, Nagaland, Sikkim, Tripura, Kerala, Karnataka, Tamilnadu, Andhra Pradesh, Goa, Maharashtra, Madhya Pradesh, Chhatisgarh, Andeman & Nicobar and Puducherry. The most sensitive areas are Himalayan belt, Nilgiris, Western and Eastern Ghats. Landslides constitute a serious hazard that causes substantial human and financial losses in the country. It is estimated that on an average about 500 lives are lost and costs approximately Rs.300 crores annually.

Landslides can happen not only in isolation but also along with or as a consequence of other disasters like earthquakes, floods, lightning, cloud-burst, forest fires, dam / lake bursts etc. In such cases, landslide losses are normally included within the primary disaster and are not dealt separately. Hence, most of the reported estimates on landslides losses are found to be quite lower than the actual impacts of landslides on the society as a whole.

With growing population and human interventions in terms of developmental activities over unstable slopes, landslides pose increasing risk to human life, buildings, structures, infra-structures and environment. Large scale deforestation along with faulty management practices have led to high vulnerability to landslides in many regions of the country. Human activities relating to expansion on unsafe locations, unscientific mining, haphazard construction of roads, dams and river training works ignoring natural features contribute to increased intensity of landslides. The absence of awareness and non-availability of large scale landslide hazard maps may catch people unaware especially when the first time landslides strike.

As individual landslides usually affect limited local areas and residents, damage resulting from landslide hazards was not recognized as a problem of national importance and were not addressed on a national basis. The absence of coordinated national approach to mitigating the detrimental effects of landslides resulted in a reduced ability of the States and Local Government agencies to apply the important lessons learnt, often at considerable expense, in other parts of the country.

As a result, the need for a national strategy has been strongly felt and worked upon now by the National Disaster Management Authority through National Disaster Policy and Guidelines on Landslides. Being cognizant of the diversity of issues associated with national landslides problem that arise from both regional considerations and considerable variations in the institutional capability and responsibility at regional and local levels, inputs from a wide variety of stakeholders are essential. Strengthening the process of landslide assessment, investigation, mapping and management will have far reaching effects in reducing landslide losses. NIDM, the nodal institute dealing with disasters is planning to undertake such projects in order to stimulate necessary activities across the country and create a nodal platform to deliver trainings on various aspects of landslides risk management and also create a network of resources persons / experts who can contribute in this activity. It would pave way for effective decision making and planning

micro level mapping for various developmental and regulatory activities in hilly terrains.

NIDM, thus, aims to work in the following directions to make the hilly terrains and coastal areas free from landslide disasters.

- To promote the use of landslide risk analysis techniques to guide loss reduction efforts at the State and Local Levels.
- To play a vital role in evaluating methods, setting standards, and advancing procedures and guidelines for landslide hazard maps and assessments.
- To provide tools for landslide hazards mitigation and promote basic research on monitoring techniques and on aspects of landslide process mechanics.
- To improve education, training and awareness of landslide hazards and mitigation options for decision makers, professionals, and the general public.
- To integrate and mainstream landslide risk management with development and climate change in a multi-hazard perspective involving interdisciplinary and cross-sectoral partnership approach
- To produce the implementation and management plans that will provide the practical basis for an effective national strategy that can be applied at local levels.
- To support advocacy, policy, guidelines and plans for landslides risk management at different levels among various stakeholders
- To develop workable partnerships with States, District and Local Level Governments and Non-Governmental Organizations as well as professional and other stakeholders.

B. Landslide Scenario in India

Landslides are a threat to our settlements and infrastructure, farms and fields, vast stretches of border roads and railway lines, hydro-electric, water supply, and transmission line projects, aerial ropeways, open cast mines, tunnels, heritage buildings and worshipping / holy places, pilgrim routes and tourist spots.

The vulnerability to landslides can be reduced by spreading mass awareness and culture of safety through careful land-use planning, timely and appropriate engineering intervention, conscientious maintenance of slope

and connected utilities, early warning, public awareness, and preparedness. There is a need to develop the culture of quick response to manage disasters and reduce the impacts.

The Ambutia landslide, located on the tea garden clad picturesque hill slopes around the Kurseong town in the Darjeeling district, West Bengal is probably the largest landslide in Asia. As the pressure of population rapidly grew, more and more of human settlements, roads, dams, tunnels, water reservoirs, towers and other public utilities have to come up. The network of roads in the Himalayan region today is well over 50,000 km. A large number of dams have been built in the Himalaya. For example, the dam projects over the Ganga and its tributaries in the hills alone exceed two dozen. A number of tunnels, microwave, TV, transmission and communication towers also dot the hilly areas. Quarrying and mining, for example, in the Doon valley lead to deforestation and bare lands, Jhiroli (Almora) and Chandhak (Pithoragarh) have inflicted heavy damages to slopes and the associated environment.

Landslides have been occurring along NH-1A and NH-1B in Jammu & Kashmir, Rishikesh- Badrinath pilgrimage route in Uttarakhand Himalaya, many areas in Darjeeling & Sikkim Himalaya, Dimapur-Imphal and Shillong-Silchar National Highways in north-eastern region. These have been disastrous and have caused enormous economic losses and affected the social fabric of the region for a long time.

Recent landslides that have catastrophic effects in terms of life, economy and environment include Kapkot Landslide (2010), Leh Debris Flow (2010), Nilgiri Landslide (2009) and La-Jhekla Debris Flow (2009), Karwar Landslide (2009), Ghanvi village Landslide (2007), Sakinaka Landslide in Mumbai, Konkan landslides (2005), Varunavat Landslide (2003), Budha Kedar Debris Flows (2001), Malpa Landslide (1998), Kaliasaur Landslide (1984), Zubza and Mao Seng-Song Landslides along Dimapur- Imphal National Highway, Sonapur Landslide along Shillong- Silchar National Highway. Other examples of devastating landslides include Amboori landslide in Thiruvanantapuram district, Kerala; Runnymede, Hospital, Glenmore, Coonoor and Karadipallam Landslides in Nilgiris district, Tamil Nadu

Instances of co-seismic landslides particularly in the Himalayan terrain and North-eastern part of the country are not uncommon. Shillong earthquake (1897), Kangra earthquake (1905), Bihar-Nepal Earthquake (1934), Assam earthquake (1950), Uttarkashi earthquake (1991) and Chamoli earthquake (1999) generated numerous co-seismic landslides over vast areas. Similarly,

October 2005 Kashmir earthquake generated numerous landslides both in Pakistan territory as well as in Indian territory. More recently, the Sikkim-East Nepal earthquake on 18 September 2011, triggered numerous landslides in the Sikkim state.

Some of the landslides block the drainage courses and form natural dams known as landslide dams. A few important ones are the Gohana Gad landslide dam that blocked Birehiganga in 1893, landslide blockage on river Patalganga in 1970 which led to Alaknanda tragedy, Naptha-Jhakhri landslide on Satluj that caused huge losses to the Nathpa-Jhakhri hydroelectric project, and the devastating landslide that blocked the river Parechhu in Tibet that caused large scale floods in Himachal Pradesh in 2005 when this natural dam breached.

C. Impact of Landslide Disasters

The landslide disasters have both short term and long term impacts on society and environment. The former account for the loss of life and property at the site and the latter include landscape changes that can be permanent, including loss of cultivable land and environmental impact in terms of erosion and soil loss, leading to population shift and relocation of establishments.

Like in any other disaster, the most affected are the socio-economically weaker sections of the society who inhabit the vulnerable areas. They have a meager source of livelihood, which when wiped out by a hazard, leaves them without any food and shelter. Apart from this, the injury and the casualties add to the woes of the affected families. The biggest loss is that of properties of individuals and of the government as well as damage/destruction of heritage structures.

The frequent obstructions caused to the movement of traffic by numerous landslides during rainy season for days together, particularly in the Himalayan terrain and north-eastern region of the country, brings untold miseries to the people inhibiting the villages and townships in the landslide prone hilly terrains.

The landslides also reduce the capacity and effective life of hydroelectric and multipurpose projects by adding enormous amount of silt load to the reservoirs.

Landslide dams result in flooding of large upstream areas. Further, if the dam fails, it causes flooding and large scale devastation in downstream areas. Also,

solid landslide debris can "bulk" or add volume and density to otherwise normal stream flow or cause channel blockages and diversions creating flood conditions or localized erosion. Landslides can also cause overtopping of dams resulting in flash floods and/or reduced capacity of reservoirs to store water, for examples are Gohna and Parechhu Lake bursts.

D. Landslide Hazard Management in India

Landslide hazard management in India had so far been confined to adhoc solutions of the site specific problems and implementation of immediate remedial measures including debris removal and dumping them either down slope or into the river. The aim of the present training is to manage the landslide hazard through an institutional mechanism and following a systematic approach that includes both short term and long term planning and treatment of landslide problems involving hazard, vulnerability and risk assessment approaches.

Landslide hazard management involves the measures to avoid or mitigate the risk posed by the landslide hazard. The most important role in this process is played by the local government machinery. Once this body receives the information about the probability of landslide occurrence within its jurisdiction, it initiates steps to warn the communities living in the area about the risk involved and tries to convince landowners and building occupiers to shift to safer places. Moreover, further development should be avoided in such high risk zones. The mitigation strategies might not be possible in every landslide hazard prone area both due high cost of the land there and indifferent attitude of the public. The efforts to reduce the risk are also made by road construction and maintenance agencies by implementing the treatment measures.

There is, however, a need to pre-empt the disaster by disseminating information available before it strikes and same should be emphasized by all states specially those routinely affected by multi-hazards.

E. Landsides in other countries

In Japan alone, an average of **90 lives are lost annually** from debris flows *(Takahashi, 1981).* In 1970, a debris avalanche (a rapidly moving form of debris flow) triggered by an earthquake, completely destroyed the city of Yungay, Peru, **killing an estimated 17,000 people** and burying the whole **city under 5m of mud and debris** *(Plafker and Erickson, 1978).* **Other countries** with chronic losses from debris flows are USA, Indonesia, Tanzania, Norway, Sweden, Denmark, Costa Rica, China, Brazil, Ireland, Romania, Japan, Bangladesh, New Zealand, Russia etc.

Landslides have caused over 600 deaths across Canada since the middle of the 19th century. In addition, communities have been damaged, lines of communication have been severed, and the resource base has been significantly impacted. Recent studies of the geographic distribution of the impact of landslides in Canada has indicated that the Canadian Cordillera, comprising about one-fifth of Canada's land mass, is the region most prone to damaging landslides.

The southeastern Cordillera (roughly defined by the Trans-Canada Highway to the north, the Foothills to the east and the Okanagan Valley to the west) has been the site of a number of catastrophic landslides including the 1903 Frank Slide, Canada's worst landslide disaster. The region is crossed by national strategic transportation corridors, has important natural resources, and has extensive areas of designated natural heritage. The record of damaging landslide events in historical time has been compiled from existing case history documents, archival information, and information supplied by transportation companies and government agencies. The record has been assembled in a relational database. Some damaging landslide types have been identified as follows; rock avalanches, rockfalls, rainfall-triggered debris flows and debris avalanches, landslides in built slopes, and landslides in slopes consisting of glacio-lacustrine deposits. Deforming rock slopes, however, constitute a hazard that is difficult to assess.

F. Benefits of Good Landslide Management Practices

Several countries like Japan, Hong Kong, Switzerland and USA have made good attempts in prevention and management of landslide risk through various measures such as landuse, construction and development controls. *Slosson and Krohen (1977)* have demonstrated the benefits of good landslide management practices with the following example from California as given in the Table 1 below.

Table 1: Landslide & Flood Damages to Hillside Homes in Los Angeles County, California

Construction Dates and Legal Requirements	Number of Homes built on Hillside sites	Damaged Homes			Average Cost Prorated for Total Number of Homes Built
		Number	Percent of Total	Total Damage	
Pre-1952: No Legal requirements for soils engineering or engineering geological studies	10,000	1,040	10	$3,300,000	$300
1952-1963: Soils engineering studies required. minimum engineering geology studies	27,000	350	1.3	$2,767,000	$100
1963-1969: Extensive engineering geology and soils engineering studies required	11,000	17	0.15	$80,000	$7

SUB-MODULE 1: LANDSLIDES – INTRODUCTION

1.1 Introduction

Landslides are simply defined as down slope movement of rock, debris and/or earth under the influence of gravity. This sudden movement of material causes extensive damage to life, economy and environment. It is the most common and universally accepted collective term for most slope movements of the massive nature. The term has sometimes been considered unsuitable as the active part of the word denotes sliding, whereas it connotes even movements without sliding like fall, topple, flow etc.

Other terms which have been used by different stakeholders in place of landslides are mass wasting, mass movements, slope failures etc. Similarly the slope materials are also classified differently by various researchers. For example, *Sharpe (1938)* defined landslides as the perceptible downward sliding or falling of a relatively dry mass of earth, rock or a mixture of the two. *Varnes (1978)* preferred the term 'Slope Movements' as it does indicate process and defined it as a downward and outward movement of slope forming materials under the influence of gravity. *Brunsden (1984)* preferred the term 'mass movement' and distinguished this from mass transport as being a process which did not require a transporting medium such as air, water or ice etc. *Cruden (1991)* defined landslides as a movement of mass of rock, earth or debris down a slope. However, the classification of slope processes and slope materials as proposed by cruden and *Varnes (1996)* has been widely accepted and is given below for the reader's reference.

Table 1.1: Classification of slope processes and materials *(after cruden and Varnes, 1996)*

Type of Movement	Type of Material			
		Bedrock	Coarse Grained Soil or Debris	Fine Grained Soil
Falls		Rock Fall	Debris Fall	Earth Fall
Topples		Rock Topple	Debris Topple	Earth Topple
Slides	Rotational	Rock Slump	Debris Slump	Earth Slump
	Translational / Wedge	Rock Slide	Debris Slide	Earth Slide

Lateral Spreads		Rock Spread	Debris Spread	Earth Spread
Flows		Rock Flow	Debris Flow	Earth Flow
Complex	Nature of movement varies with time			
Composite	Nature of movement varies in different parts of the failed slopes			

It is important to distinguish among the different types of landslides to be able to understand how to deal with each of them. The ways to identify and mitigate different types of landslides are often different.

1.2 Morphology of Landslides

Before we discuss about different types of landslides, it would be good to learn about the morphology of landslides and its various features/parts as given below.

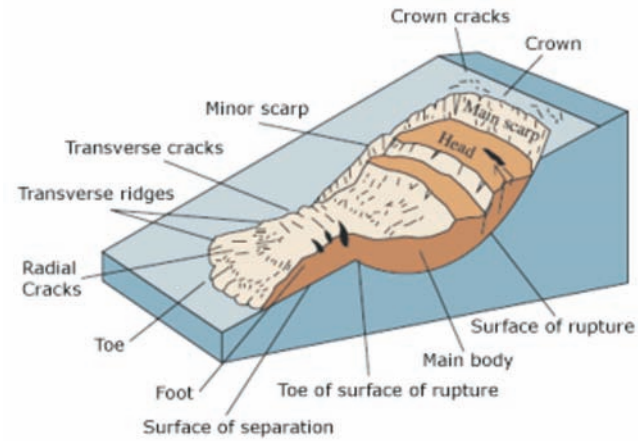


Figure 1.1: An idealized slump-earth flow showing commonly used nomenclature for labeling the parts of a landslide (Source: USGS)

1.2.1 Parts of Landslides – Description of Features

Accumulation - The volume of the displaced material, which lies above the original ground surface

Crown – The practically undisplaced material still in place and adjacent to the highest parts of the main scarp

Depletion – The volume bounded by the main scarp, the depleted mass and the original ground surface

Depleted mass – The volume of the displaced material, which overlies the rupture surface but underlies the original ground surface

Displaced material – Material displaced from its original position on the slope by movement in the landslide. It forms both the depleted mass and the accumulation.

Flank – The undisplaced material adjacent to the sides of the rupture surface. Compass directions are preferable in describing the flanks, but if left and right are used, they refer to the flanks as viewed from the crown.

Foot – The portion of the landslide that has moved beyond the toe of the surface of rupture and overlies the original ground surface.

Head – The upper parts of the landslide along the contact between the displaced material and the main scarp.

Main body – The part of the displaced material of the landslide that overlies the surface of rupture between the main scarp and toe of the surface of rupture.

Main scarp – A steep surface on the undisturbed ground at the upper edge of the landslide, caused by movement of the displaced material away from undisturbed ground. It is the visible part of the surface of rupture.

Minor scarp – A steep surface on the displaced material of the landslide produced by the differential movement within the displaced material.

Original ground surface – the surface of the slope that existed before the landslide took place.

Surface of separation – The part of the original ground surface overlain by the foot of the landslide

Surface of rupture – The surface that forms the lower boundary of the displaced material below the original ground surface.

Tip – The point of toe farthest from the top of the landslide.

Toe – The lower, usually curved margin of the displaced material of a landslide, it is the most distant part from the main scarp.

Top – The highest point of contact between the displaced material and the main scarp.

Toe of surface of rupture – The intersection (usually buried) between the lower part of the surface of rupture of a landslide and the original ground surface.

Zone of accumulation – The area of landslide within which the displaced material lies above the original ground surface.

Zone of depletion – The area of the landslide within which the displaced material lies below the original ground surface.

1.3 Landslide types based on process of failure

Based on process types, there are five types of landslides i.e. Fall, Topple, Slide, Spread, Flow and Subsidence.

1.3.1 Fall: is a very rapid to extremely rapid movement which starts with detachment of material from steep slopes such as cliffs, along a surface on which little or no shear displacement takes place (Figures 1.2 and 1.3). The material then descends through the air by free falling, bouncing or rolling onto the slopes below.

- The detachment of soil or rock from a steep slope along a surface on which little or no shear displacement takes place.
- Movement very rapid to extremely rapid.
- Free fall if slope angle exceeds 76 degrees and rolling at or below 45 degrees.

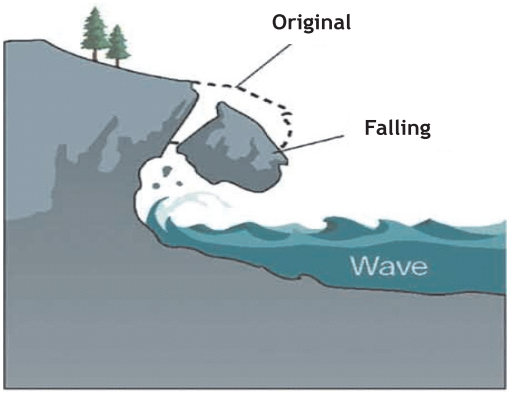


Fig. 1.2 Sketch showing mode of failure in fall

Fig. 1.3: Field photograph of a rock fall site

Landslide types - Fall (Material free falls)

However, in order to identify the potential falls and relict falls, Table 1.2 may be referred.

Table 1.2: Diagnostic features of falls

	Potential Falls	Relict Falls
1	Steep to vertical slopes, overhanging; undercut; open cracks close to slope face	Where rockfalls have taken place these may be curved hollows, beams, bridges of rock on buttresses.
2	Dip of discontinuities dip or open towards the free slope face are vulnerable	Look for piles of debris, loose rock, scree slopes, open-work rock textures in colluvium, detached boulders, massive debris in valley floors, valley dams.
3	Discontinuities with gouge or other soft infillings and interbedded materials are common locations	If the fall source is mainly debris, then the relict form may be boulders set in a redistributed matrix or colluvium
4	Falls occur where high water pressures are possible. Melting permafrost or seasonally frozen faces are vulnerable areas	
5	Any eroded slope in debris or soil is vulnerable . Such slopes rapidly unload or weather so that boulders fall in heavy rains or similar disturbances.	

1.3.2 Topple : involves *overturning* of material. It is *forward rotation* of the slope mass about a *point or axis below the centre of gravity* of the displaced mass. Topples range from *extremely slow to extremely rapid* movements (Figs. 1.4 to 1.6).

- The forward rotation out of the slope of a mass or a rock about a point or axis below the centre of gravity of the displaced mass.
- Movement varies from extremely slow to extremely rapid.
- Driven by gravity and sometimes by water or ice in cracks in mass.

Fig. 1.4: Sketch showing the end-over-end motion of rock down a slope during toppling

Fig. 1.5: Field photo showing topple failure

Fig. 1.6: Toppling Failure in Rocks

However, in order to distinguish between potential and relict topples, some of the diagnostic features as referred in Table 1.3 can be used.

Table 1.3: Diagnostic features of topples

	Potential	Relict
1	A free face, steep slopes or cliff with sufficient unloading potential	Cliff top may be marked by residual, unemployed tension cracks, partially detached columns.
2	Sufficient height (weight) relative to the width of base to provide disturbing force	Rock face will show open vertical cracks. Cracks may have chaotic infill from overlying material
3	Sufficient rock strength to allow a column to stand. Usually hard or coherent rock layer overlying a weaker stratum	Base of cliff shows disturbed strata or bulging material
4	Strong vertical joint development which divides face into columnar units; Strong jointing or unloading tension cracks parallel to face	Where a column has fall the weathering detail on the face may be less well developed. Very fresh scars will be smooth.
5	Critical dip in basal materials	Debris will be very chaotic. Huge boulders or partially broken columns will be scattered across the lower slopes. The texture will be coarse with open works and extensive voids.

1.3.3 Slide: movement of material along a recognizable shear surface e.g. translational and rotational slides (Figs. 1.7 to 1.10).

- Downslope movement of a soil or mass occurring dominantly on surfaces of or on relatively thin zones of intense shear strain.
- The sign of ground movement are cracks of the original ground.

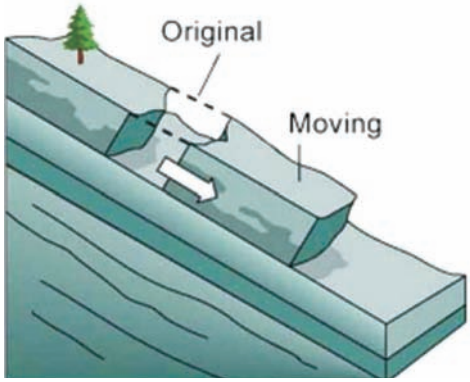


Fig. 1.7: Sktech showing movement parallel to planes of weakness and occasionally parallel to slope.

Modes of Sliding:

- Translational / planar slides
- Wedge slides
- Rotational slide

Fig. 1.8: Planar rockslide

Fig. 1.9: Wedge rockslide due to intersection of two joint planes hading towards valley

Table 1.4: Diagnostic features of rotational slides

	Potential	Relict
1	Single rotational slides require steep slopes, undercut areas, erosion by streams and the sea	Hummocky ground
2	Rise in piezometric surface or changes in water regime	Toe area recognisable as a pronounced lobe with a steep front
3	Usually, unconsolidated clays and uniform clay outcrops	Crown will have a back-tilted or horizontal surface.
4	Multiple slides commonly occur where permeable rocks overly impermeable rocks	Hollows infilled with washed debris and organic material common at head
5	A weak layer is usually required to allow development of a common shear surface for multiple slides	All irregularities will be smoothed out and infilled in time. Form may be completely erased to a smooth slope, but the structure and shear surface will remain beneath the ground
6	Retrogressive unloading could generate new slides	Tension cracks may be visible at the head

Fig. 1.10: Example of a Rotational Landslide at Chilla Tal-Valley

1.3.4 Flow: is a landslide in which the individual particles travel separately within a moving mass (Figs. 1.11 to 1.13).

- Spatially continuous movement, in which surfaces of shear are short-lived, closely spaced and usually not preserved.
- Flows are differentiated from slides, on the basis of water content, mobility and evolution of movement.

Features for recognition of flows are

i. Crown may have few cracks.

ii. The main scarp typically has serrated or funnel shaped upper part; is long and narrow, bare and commonly striated.

iii. Flanks are steep and irregular in the upper part; may have levees built up in the middle and lower parts.

iv. The body has flowlines, follow drainage ways, is sinuous, and is very long compared to width.

v. The toe spreads laterally in lobes; if dry, may have steep front.

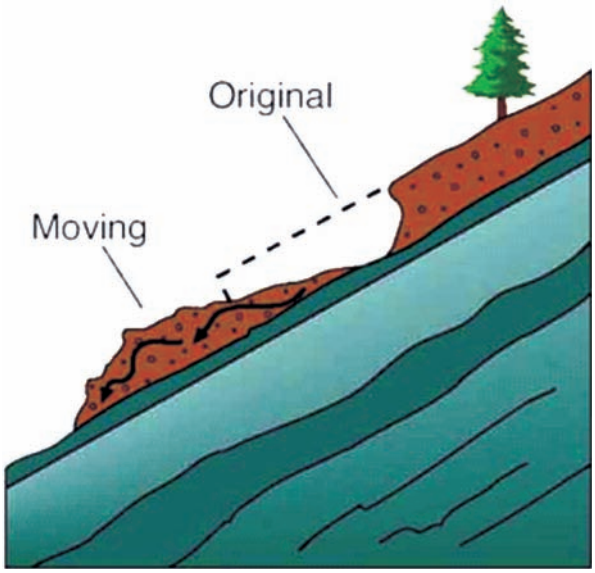


Fig. 1.11: Sketch showing Viscous to fluid-like motion of debris, often channeled

Modes of Flow

- Open-slope debris flow
- Channeled flow

Fig. 1.12: Debris flow after a cloudburst at Balta, Uttarakhand

Fig.1.13: Debris Flow near Sikkim Supreme Factory on NH-31 A, Sikkim

1.3.5 Spread

- Sudden movement on water- bearing seams of sand or silt overlain by homogeneous clays or loaded by fills.
- May result from liquefaction or flow of softer material.

Modes of Spreading:

- Block Spreads
- Liquefaction spreads
- Complex spreads
    - Lateral Spreading: is usually used to describe the lateral extension of a cohesive rock or soil mass over a deforming mass of softer underlying material in which the controlling basal shear surface is often not well defined.
    - Rock Spreading: is the result of deep seated, plastic deformation in a rock mass, leading to extension at the surface. e.g. cambering, horsts and grabens and valley bulging.
    - Soil Spreading: takes place as a result of plastic deformation in the soil mass, only it occurs generally in response to a loss of strength, and by the application of stresses over a long period of time.

1.3.6 Slump

It is a type of rotational failure on slopes. The trees bends or fall backwards on towards the slope, as shown in the figure 1.14.

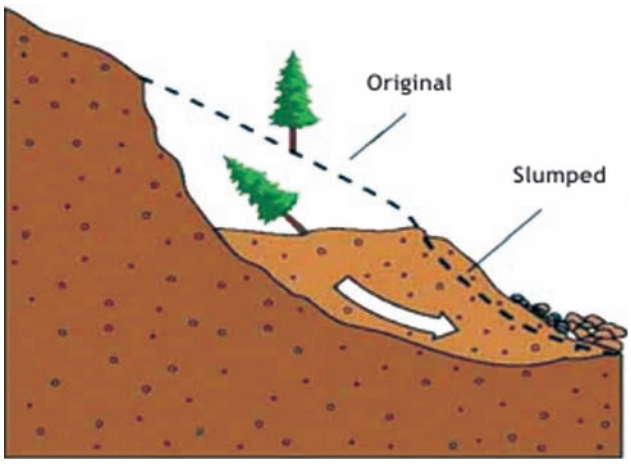


Fig. 1.14: Sketch showing slump type failure

1.3.7 Creep

Very slow rates of slope movements, usually a few millimeter per year, that is imperceptible in nature) are covered under this category (Fig. 1.15).

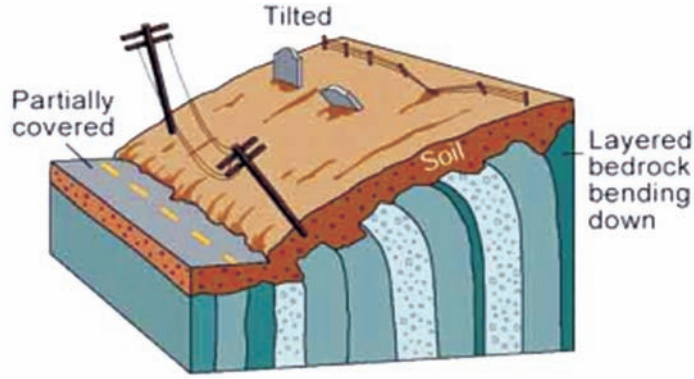


Fig. 1.15: Gradual movement of slope material during creep

However, one may find landslides that do not fall directly under any of these typical singular types of slope failures. Such landslides may be composite, complex or multi-tier. The following examples indicate some mixed processes

1.3.8 Multi-tier / Multi-rotational landslides – When more than one main scars appear in a landslide site and slope mass has more than one slip surface along which movement takes place (Fig.1.16).

Fig. 1.16: Multi-tier Rotational Landslide at Sataun, H.P.

1.3.9 Complex Landslides – Those landslides where the nature of failure process is not consistent but changes with time (Fig.1.17). For example, a landslide that begins with rock sliding changes its nature to a rock-fall due to steepening of slopes during a failure, may again result into a debris flow due to formation of a channel during the process of past failures. Thus, it becomes, often very difficult to prevent and control such complex landslides. It requires a persistent study to understand the causes of such landslides properly. These landslides are also found to be chronic and recurring in nature. For example, Kaliasaur landslide in Alaknanda valley, Uttarakhand has displayed complex failure.

Fig.1.17: Complex Landslide at Kaliasaur, Alaknanda Valley, Uttarakhand

1.3.10 **Composite Landslides –** The slopes which fail in different manners simultaneously at the same site are termed as composite landslides (Fig.1.18). These landslides display a composite nature as different parts of the landslide indicate a different process type. The types of failure vary due to changes in slope aspect, gradient, heterogeneity in slope mass, landcover, structural / tectonic controls etc. For example, Matli landslide in Bhagirathi valley, Uttarakhand is an example of composite landslide.

Fig. 1.18: Matli landslide exhibiting composite landslide failure

In addition to the classification based on process types and their combination, the landslides can be classified in more different ways. Some examples of such landslide classifications proposed by different researchers, are given here for better understanding of the slope failures.

According to age (Huang, 1983), slope movements are classified into contemporary, dormant and fossil movements. Contemporary movements are generally active and relatively easily recognizable by their configuration (the surface forms produced by mass movements are expressive) and not affected by rainwash and erosion. Dormant movements are usually covered by vegetation or disturbed by erosion so that the traces of their last movement are not easily discernible. However, the causes of their origin do not die down and the movement may be renewed. Fossil movements generally developed in the Pleistocene or earlier periods, under different morphological and climatic conditions, cannot be repeated.

According to stage (Huang, 1983), slope movements can be divided into initial, advanced and exhausted movements. At the initial stage, the first signs of the disturbance of stability (equilibrium) appear and cracks in the upper part of the slope develop. In advanced stage, the loosened mass is propelled into motion and slides downslope. In the exhausted stage, the accumulation of the slide mass creates temporary stabilization (equilibrium) conditions.

The degree of activity of landslides enables an assessment of the possibility of future movement. Erskine (1973) provided the following definitions on various degrees of activity. Active slopes represent those moving at the present time or within last cycle of seasons. Whereas Inactive slopes have not moved within the

last cycle of seasons and are therefore, dormant. They may later renew their activity or remain dormant for so long that their features become degraded. The following table outlines the major differences between active and inactive landslides.

Table 1.5: Features indicating Active and Inactive Landslides

	Active	Inactive
1	Scarps, terraces and crevices with *sharp edges*	Scarps, terraces and crevices with *rounded edges*
2	Crevices and depressions *without secondary infilling*	Crevices and depressions infilled with *secondary deposits*
3	*Secondary mass movement* on scarp faces	*No secondary mass movement* on scarp faces
4	Surface of rupture and marginal shear planes show *fresh slickensides and striations*	Surface of rupture and marginal shear planes show *old or no slickensides and striations*
5	*Fresh fractured surfaces* on blocks	*Weathering* on fractured surfaces of blocks
6	*Disarranged drainage system*; many ponds and undrained depressions	I*ntegrated* drainage system
7	*Pressure ridges in contact with slide margins*	*Marginal fissures and abandoned levees*
8	*No soil development* on exposed surface of rupture	*Soil development* on exposed surface of rupture
9	Presence of *fast growing vegetation* species	Presence of *slow growing vegetation* species
10	*Distinct vegetation differences* `on' and `off' slide	*No distinction* between vegetation `on' and `off' slide
11	Tilted trees with *no new vertical growth*	Tilted trees with *new vertical growth above inclined trunk*
12	*No new* supportive, secondary *tissue* on trunks	*New* supportive, secondary tissue on *trunks*

1.4 Other Classifications

Besides the process based classification, the landslides have also been categorized based on velocity of landslides (Table 1.6), depth of landslides (Table 1.7) and area affected by landslides (Table 1.8) etc.

Table 1.6: Proposed Landslide Velocity Scale *(Varnes, 1996)*

Class	Description	Velocity (mm/sec)	Typical Velocity	Probable Destructive Significance
7	**Extremely Rapid**	≥5 x 10^{3}	≥5 m/sec	Catastrophe of major violence; buildings destroyed by the impact of displaced material; many deaths; escape unlikely
6	**Very Rapid**	≥5 x 10^{1}	≥3 m/sec	Some lives lost; velocity too great to permit all persons to escape
5	**Rapid**	≥ 5x 10^{-1}	≥1.8 m/hr	Escape evacuation possible; structures, possessions and equipment destroyed
4	**Moderate**	≥5 x 10^{-3}	≥13 m/month	Some temporary and insensitive structures can be temporarily maintained
3	**Slow**	≥5 x 10^{-5}	≥1.6 m/year	Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
2	**Very Slow**	≥5 x 10^{-7}	≥16mm/year	Some permanent structures undamaged by movement
1	**Extremely Slow**	<5 x 10^{-7}	<16mm/year	Imperceptible without instruments; construction possible with precautions

Speed of a running man is ~5 m/sec (It matches approximately with velocity of extremely rapid and rapid landslides)

Fig. 1.19: Field example of a fast moving landslide / rock fall

Table 1.7: Classification of Landslides on the basis of its depth

	Depth of slide below surface	Class Name
1	<1.5 m	Surficial Slide
2	1.5 m - <5 m	Shallow Slide
3	5 m - <20 m	Deep Slide
4	>20 m	Very Deep Slide

Table 1.8: Classification of Landslides on the basis of its magnitude *(after USSR State Committee on Construction, 1981)*

	Scale of Landslides and Mudflows	Volume of Landslides and Mudflows in m^3
1	Small	Hundreds
2	Fairly Large	Thousands
3	Large	Tens of thousands
4	Very Large	Hundreds of thousands
5	Enormous	Millions
6	Collosal	Tens and hundreds of millions

1.5 Causal Factors for Landslides – There can be several different causative factors for the occurrence of landslides which may work individually or collectively to cause a landslide. Broadly these factors can categorized into ground conditions, geomorphological processes, physical processes and man-made processes. A brief list of these causal factors is given in the table below.

Table 1.9: A brief list of landslide causal factors

A	**GROUND CONDITIONS**
•	Plastic weak material
•	Sensitive material
•	Collapsible material
•	Weathered material
•	Sheared material (Fig. 1.31)
•	Jointed or fissured material
•	Adversely oriented structural discontinuities including faults, unconformities, flexural shears, sedimentary contacts (Figs.1.29 & 1.31)
•	Adversely oriented mass discontinuities (including bedding, schistosity, cleavage)
•	Contrasts in permeability and its effects on ground water (Figs.1.26 & 1.27)
•	Contrasts in stiffness (stiff, dense material over plastic material)
B	**GEOMORPHOLOGICAL PROCESSES**
•	Tectonic uplift
•	Volcanic uplift
•	Glacial Rebound
•	Fluvial erosion of the slope toe
•	Wave erosion of the slope toe
•	Glacial erosion of the slope toe
•	Erosion of the lateral margin
•	Subterranean erosion (solution, piping)
•	Deposition loading of slope at its crest
•	Vegetation removal (by erosion, forest fire, drought)
•	Ground Cracks (Fig.1.30)
•	Subsidence (Fig.1.49)
C	**PHYSICAL PROCESSES**
•	Intense rainfall over a short period
•	Rapid melt of deep snow
•	Prolonged heavy precipitation
•	Rapid drawdown following floods, high tides or breaching of natural dam (Fig.1.22)

- Earthquake
- Volcanic eruption
- Breaching of crater lake
- Thawing of permafrost
- Freeze and thaw weathering
- Shrink and swell weathering of expansive soils

D MAN-MADE PROCESSES

- Excavation of the slope or its toe
- Loading of the slope or its crest
- Drawdown of reservoir (Fig.1.22)
- Irrigation (Fig.1.23)
- Defective maintenance of drainage system (Fig.1.24)
- Water leakage from services like water supplies, sewage, storm water drains (Fig.1.25)
- Vegetation removal (deforestation)
- Mining and quarrying in open pits or underground galleries (Fig.1.21)
- Creation of dumps of very loose waste
- Artificial vibration including traffic, pile driving, heavy machinery, blasting and explosion (Fig.1.20)
- Poor maintenance of remedial measures (Figs.1.60 & 1.61)

1.6 Classification of Conditions/Factors responsible for Landslides

Some slopes are susceptible to landslides whereas others are not so. Many factors contribute to the instability of slopes but the main factors indicating stability conditions are relief, drainage, bedrock, regolith, vegetation, climate, earthquake, paleo-features and man-made conditions. The conditions/factors governing landslides can be classified as inherent (terrain) and external factors as given below.

1.6.1 Inherent or basic conditions

Geology

Lithology

Structure

Hydrologic conditions and climate

Vegetation

1.6.2 External Factors/conditions include precipitation, vibrations induced by earthquake / blasting / explosion, loading or unloading of slopes etc.

These factors may actually produce two different types of changes, i.e. changes in stress conditions and changes in strength of materials. The different factors producing different changes are given below for illustration.

1.6.3 Factors producing unfavorable changes in conditions

Those that change stress conditions

- Erosion or deposition
- Fluctuation in water level
- Seismic vibrations
- Construction activity
- Cuttings
- Reservoir fluctuations
- Landuse practices

Those that change strength of materials

- Progressive softening of fissured clays
- Disintegration of granular rocks (freeze & thaw)
- Hydration of clay minerals
- Drying and cracking of clays
- Loss of cementitious material from coherent material by solution

1.6.4 Landslide's Driving Force

The principal driving force for any landslide is the gravitational force and the tendency to move of this mass will be proportional to the hill slope angle. The resisting forces preventing the mass from sliding down the slope are inversely proportional to the same hill slope angle and proportional to the friction angle of the material. Stability of the material resting on a slope will be reduced with an increased slope angle. In addition, the resisting forces can be significantly reduced in case of rain or earthquake vibrations.

1.7 Identifying Landslide Areas – The identification and prediction of a landslide is essential to minimize or control the hazard. Usually this is done using costly procedures as surveying, monitoring or soil testing, which are not affordable or feasible in rural regions with almost no resources. Therefore, simpler but still effective methods have to be used to assess the stability of slopes and decide if a given location is safe for construction. The following features may be used to identify probable landslide prone areas.

- Existing or old landslides or places of historic landslides
- Areas at the base of slopes
- Within or at the base of minor drainage hollows
- At the base or top of a fill slope
- At the base or top of a cut slope
- Any sloping ground in an area known to have a landslide problem
- V-shaped valleys, canyon bottoms, and steep stream channels
- Fan shaped areas of sediments and boulders accumulation at the outlet of canyons
- Areas with large boulders (2 to 20 feet diameter) perched on soil near fans or adjacent to creeks
- Steep hill slopes above a home or hamlet
- Logjams in streams above a home or hamlet
- Steepened road cuts, sunken or down-dropped road beds
- Areas that have been extensively disturbed by excavation into steep slopes
- Moderately steep slopes that are exposed to high water flow
- Burn areas, intensively irrigated agricultural field, canyon, hillside, mountain and other steep areas are vulnerable to landslides

1.8 Potential landslide risk indicators - The following simple observations and inspection by community, municipal officials and property owners, may assist in assessing potential landslide hazards. It is important to note that some of these features can also be due to causes other than landslides, such as swelling clays.

- Saturated ground or seeps in areas that are not typically wet
- New cracks and scarps or unusual bulges in the ground, roads or pavements (Fig.1.36)
- Movement of ancillary structures such as decks and patios in relation to a house (Fig.1.42)
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb (Figs.1.32, 1.33, 1.34 & 1.37)
- Soil moving away from foundations
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences

- Offset fence lines or retaining walls (Fig.1.28)
- Sunken or displaced road surfaces (Fig.1.49)
- Rapid increase in creek water levels, possibly accompanied by increase in turbidity (soil content)
- Sudden decrease in creek water levels though rain is still pouring or just recently stopped
- Springs, seeps or saturated ground in areas that are not typically wet
- Thorough cracks in walls, gaps between roof and wall etc. (Fig.1.33 & 1.35)
- Damage to building elements (Fig.1.38)

In most cases in the field, one may find the presence of combination of landslide risk indicators.

It is important that local bodies provide a means of keeping records, preferably in written format, about the occurrence of landslides, with photographs and / or diagrams where-ever possible. This will provide a means to sustain landslide knowledge through time and it is important that such landslide information be made available, in some manner, to general public.

1.9 Effects and Consequences of Landslides

Landslide effects can be classified as direct and/or indirect.
Direct effects - are those first order consequences which occur immediately after an event, such as deaths and damage caused by landslides directly
Indirect effects – may emerge after the landslide event and may be much less easy to attribute directly to landslides. This includes psycho-social impacts, bereavement and evacuation.
Similarly the effects may be classified as tangible and/or intangible.
Tangible effects – are those to which it is possible to assign reasonable reliable monetary values, such as replacement of a damaged property.
Intangible – can not be satisfactorily assessed in monetary terms; for example, loss of human life, has proved difficult to assess financially
Landslides effects occur in 2 basic environments – built environment and the natural environment. Sometimes there is intersection between the two; for example agricultural lands and forest lands that are logged.

- Physical Injuries and Loss of human lives.
- Property / Infrastructural damages and economic losses
- Affect a variety of resources like water supplies, fisheries, sewage disposal systems, forest, dams and reservoirs etc.

1.9.1 Effects of Landslides on Built Environment

Landslides affect manmade structures whether these are directly on or near a landslide. Residential buildings on unstable slopes may experience partial damage to complete destruction as landslides destabilize or destroy foundations, walls, floors, surrounding property, utilities such as water pipelines, power lines, communication lines, transport routes etc. Commercial structures may also face similar consequences as the residential buildings but the consequences may be greater due to disruption in business due to damage of access routes.

Fast moving landslide such as debris flows and rock falls/topples are more destructive and life-taking as they often occur without precursors or warnings, move too quickly for any safety measures to be taken, with high momentum due its mass and velocity that can destroy anything that comes in its way; whereas slow moving landslide may only cause slight damage and its slow pace may allow implementation of mitigation measures as well. However, left unchecked, even slow landslides can completely destroy the structures over time *(USGS Circular 1325)*. The nature of landslide movement and the fact that they may continue after days, weeks, or months preclude rebuilding on the affected area, unless mitigation measures are taken appropriately.

As the world population grows, they are increasingly vulnerable to landslides. People tend move on to new lands that might have been deemed too hazardous in the past but are now the only areas that remain for the growing population. Poor or non-existent landuse policies allow building and other constructions to take place on the land that might better be left to agriculture, parks or other such uses. Communities are not geareded to regulate unsafe buildings practices and may not have legitimate or adequate means / expertise to do so,

1.9.2 Impacts on buildings (including residential, commercial, private, public and government)

Landslides result in development of cracks in the buildings in case of slow moving / creeping landslides but may cause collapse or complete damage / burial of buildings in cases of sudden massive and fast moving landslides (Figs.1.38, 1.45 & 1.47). Figure 1.62 depicts the impact of Varunawat Landslide in Uttarkashi City of Garhwal Himalaya, Uttarakhand State, where nearly 400 houses were affected by the massive landslide.

Fig. 1.62: Landslide buries both commercial and residential buildings besides blocking the highway

1.9.3 Impact on highways, roads and railways

One of the greatest consequences of landslides is its impacts on transportation system (roads and railways) which indirectly affects large number of people in any locality (Figs.1.39, 1.40, 1.48, 1.49, 1.51, 1.54, 1.58 & 1.59). Blockages of highways by landslides occur very commonly around the world, and many can simply be cleared by bull dozer or shoveled away. Others may require temporary diversion of traffic or even closure of road traffic or a major excavation. National / State highways and connecting roads are also very vulnerable to the impacts of landslides. A large number of landslide that occur along the roads and highway result in damage / destruction of transportation / access routes as well as pose risk to the vehicles and passengers / passers-by on the road-side. Figure 1.48 depicts the destruction of national highway to Badrinath due to Lambagar Landslide in Uttarakhand state and Figure 1.40 show the impacts of a rock-fall on a bus parked close to a landslide spot near Sukhi on Bhatwari-Gangotri National Highway in Uttarkashi district, Uttarakhand state.

1.9.4 Impact on essential services like power, communication, water supply etc.

Besides the buildings and roads, the landslide affect our essential services like power, communication and water supply etc. Particularly the rigid pipelines and structures are more badly affected compared to flexible / elastic pipes and structures. The photograph (a) below shows the inundation of a power tunnel in

a hydel project (Sanjay Jal Vidyut Yozna in Satluj Valley) due to blockade of river by a landslide on the downstream side, thus, hindering the operations for power generation. The photograph (b) reveals the problems of power transmission due to their location just close to the crown of retrogressive landslide, thereby endangering its stability and functionality.

1.9.5 Impacts on health and education sectors

Entire population in landslide prone areas is at risk; the most vulnerable are patients, pregnant ladies, and school children, especially the young ones. In a devastating landslide incidence of 18 August 2011 in Uttarakhand state, 18 school children aged between 5 and 11 years, were buried alive while attending the school. Similarly, there were instances when hospital buildings at Shimla and Rampur in Himachal Pradesh were damaged by the landslides. Thus, safety from landslides in educational and health buildings has prime importance as the people in them are dependent on others.

1.9.6 Effects on natural environment

Landslides may have the following impacts on natural environment

- The morphology of earth's surface - mountain valley system, both on continents and beneath oceans, are most significantly affected by landslide due to morphological changes
- The forest and grassland cover changes
- The native wildlife, its rivers, lakes and seas.

The following landslides may occur in natural environment.

(a) Submarine Landslide is general term used to describe downslope mass movement of geologic materials from shallower to deeper regions of the oceans. Such events may produce major effects to the depth of shorelines. These types of landslide can occur in rivers, lakes and oceans. Large submarine landslides triggered by every intense arthquakes can cause deadly tsunamis.

(b) Coastal cliff retreat or cliff erosion – Falling rocks from eroding cliffs can be especially dangerous to anyone occupying areas at the base of cliffs, or on the beaches near cliffs. Large amount of landslide material can also be destructive to aquatic life such as fish.

(c) Landslide dams can naturally occur when a large landslide blocks the flow of river, causing a lake to form behind the blockage. Most

of these dams are short-lived as the water will eventually erode the dam. If the dam is not destroyed, it creates a lake. Lakes created by landslide dams can last a long time, or they may suddenly be released and cause massive flooding downstream.

1.9.7 Impacts on natural resources and cultural heritage

During Varunawat landslide at Uttarkashi, more than 300 pine trees got uprooted and about 300 tress were cut for treating the landslide. Besides the pine trees, numerous other varieties of trees and shrubs were also affected. Therefore, it can be surmised that a huge loss to the natural resources occur due to such landslides. Figures 1.56 and 1.57 depict the impacts of landslides at heritage structures in Uttarakhand.

1.9.8 Strategic Impact on National / Border Security

The occurrence of landslide can lead to security problems if it happens and blocks roads in international border areas. The movement of army vehicles and troupes on the ground can get hurdled by the landslides (Fig.1.43). The photograph below is depicting the situation of army movement when a landslide happened on a border road to Bhaironghati in Uttarakhand state. The insurgency by terrorists and anti-social elements also rises when the army movement is restrained by landslides in border areas.

1.9.9 Economic effects of landslides

- Cost of repair.
- Loss of property value
- Disruption of transportation routes
- Medical costs (injury)
- Water availability, quality and quantity

Direct Losses – are the most visible consequences of landslides. They may be comparatively easy to measure but they are not always the most significant outcome. They are caused by the immediate damage done to humans, resources and environment.

Indirect Losses – rise mainly through the second order consequences of landslides, such as disruption of economic and social activities in a community or onset of ill-health amongst disaster victims. These effects often outlast those of direct losses by months or even years and can be highly intangible.

1.10 Inter-relationship of landslides with other natural hazards The Multiple Hazard Effect

Natural Hazards such as floods, earthquakes, volcanic eruptions and the landslides can occur simultaneously, or one or more of these hazards can trigger one or more of the others. Landslides are often the result of earthquakes, floods, and volcanic activity and may in turn cause subsequent hazards; for example an earthquake induced landslide can cause a deadly tsunami if sufficient landslide material goes into a body of water to displace a large volume of water. Another example would be a volcanic eruption induced or earthquake induced landslide that blocks a river, causing water to back up behind the mass and flood the upstream area. Should the dam fail, the impounded water will be suddenly unleashed to cause flooding downstream. The flooding can then add to riverbank and coastal erosion and destabilization through rapid saturation of slopes and undercutting of cliffs and banks. It is therefore, imperative, when evaluating an area's vulnerability to landslides, to examine all other possible hazards. Thus, a multiple hazard susceptibility should be produced for showing all multi-hazard events involving landslides.

1.11 Communicating Landslide Hazard

The successful translation of natural hazard information into a form useful for non-technical users conveys the following 3 elements in one form or another.

- Likelihood of the occurrence of an event of a size and in a location that would cause casualties, damage, or disruption to an existing standard of safety
- Expected location and extent of the effects of the event on the ground, structures or socio-economic activity
- Estimated severity of the effects on the ground, structures or socio-economic activity

The non-technical user must be able to perceive likelihood, location and severity of the hazard so that they become aware of the danger, can convey the risk to others, and can use the translated information directly to reduce the risk.

1.12 Landslide Warning Signs

Some simple warning signs can be placed in hazardous areas along with some information that can be used in emergency management. Some basic information about safety tips for landslide prone areas may be posted and distributed among the public in such places.

1.13 Minimizing the effects of Landslides

Planners and Decision Makers should learn from past tragic events and should impose stringent planning and design requirements in landslide-prone and unstable areas. These may include:

- Implementation of regional hazard and risk assessments into land planning policies. This ensures that appropriate processes are in place whereby new development applications are assessed with respect to slope stability issues and zoning for future development is directed towards areas with a low or very low risk of slope instability.
- Engineering and geotechnical investigation that define the landslide hazard and risk at site specific levels of investigation.
- Mapping of landslide vulnerability that can help with the development of emergency response scenarios.

The following photographs exhibit some of the above features noticed in the field.

Fig. 1.20: Blasting in road construction leads to landslides

Fig. 1.21: Improper open cast mining causes landslide

Fig. 1.22: Sudden and fast drawdown results in subsidence / landslides

Fig. 1.23: Inappropriate irrigation practices cause slope stability problems

Fig. 1.24: Ill-maintenance and clogging of drainage culverts results in damages

Fig. 1.25: Rigid pipelines and joints get ruptured during landslide and water leakage further aggravates the instability

Fig. 1.26:Seepage and leaching at junction between sand & clay beds

Fig. 1.27: Permeabilities contrasts in rocks leads to percolation and development of pore pressures

Fig. 1.28: Retaining walls get de-aligned due to landsliding

Fig. 1.29: Faults are weak zones susceptible to landsliding

Fig. 1.30: Ground cracks indicating incipient slope failures

Fig. 1.31: Fold axis is the weakest plane along which movement can occur

Fig. 1.32: Landslides create gap between door frame and floor

Fig. 1.33: Opening between wall and roof due to differential settlement

Fig. 1.34: Cracks appear close to doors and windows in a building

Fig. 1.35: Monitoring wall cracks using paper slips with markings

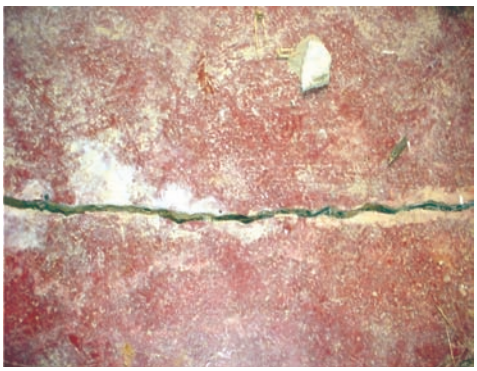


Fig. 1.36: cracks appear in pavement / ground in a house

Fig. 1.37: Cracks extend from floor to walls during landslides

Fig. 1.38: Building gets damaged posing risk to residents

Fig. 1.39: Extensive damages to roads from landsliding

Fig. 1.40: Bus damaged due to boulder fall; it was parked close to slide spot

Fig. 1.41: Stability of towers affected due to its proximity with slide

Fig. 1.42: Differential settlement in pavement / floors in houses

Fig. 1.43: Army personnel facing problems of access after a landslide on a border road

Fig. 1.44: Transit lake created due to river damming by landslide

Fig. 1.45: Residents protect houses by using polythene sheets to prevent seepage

Fig. 1.46: Tunnel in a hydel project filled with muddy water after a landslide dam on a river

Fig. 1.47: Earthquake induced landslide causing damages to a cluster of houses

Fig. 1.48: Complete road washed off after bursting of transient landslide dam

Fig. 1.49: Subsidence causing differential settlement and damage to road

Fig. 1.50: Petrol pump damaged leading to fuel shortage

Fig. 1.51: Bridge washed off due to landsliding

Fig. 1.52: Landslide affects cluster of houses at foothill slopes

Fig. 1.53: Post-earthquake landslide affects UNESCO heritage toy train track adversely

Fig. 1.54: Landslide causes damage to railway track and road

Fig. 1.55: Net barriers to reduce the impacts of debris flow, need proper maintenance

Fig. 1.56: Heritage building at risk from landslides

Fig. 1.57: Historical pilgrimage sites at risk from landslides

Fig. 1.58: Passengers and traffic stranded due to landslides

Fig. 1.59: Railway track damaged due to landslides

Fig. 1.60: Ill-maintained culverts get damaged and cracked

Fig. 1.61: Poor maintenance of mitigation measures causes failures

SUB-MODULE 2: LANDSLIDES INVENTORY AND HAZARD ZONATION

2.1 Landslide Inventory

The main purpose of preparation of a landslide inventory map and database is documentation of all the known landslide incidences including stabilized, dormant, reactivated and most recent slides. The documentation includes location, date of occurrence, triggering factors like rainfall and seismicity during the event, dimension and type of slide, volume of material dislodged, nature and extent of damages caused/may be caused by further sliding, type of triggering factor (earthquake, cloudburst, anthropogenic interference, toe erosion by streams or rivers etc.), probable causes and run-out distance. A colour photograph and sketch plan of the landslide on the date of investigation will be an additional input. Another important parameter is the collection of historical record of each slide which will give an idea about the approximate return period of the slide. All such information paves the foundation for LHZ mapping, vulnerability assessment and risk zonation mapping.

A landslide inventory map not only shows the time and date of occurrence but approaches, ranging from digital stereo image interpretation to automatic classification based either on spectral or altitude differences, or a combination of both. The multi temporal images can be used to prepare a landslide activity map. The stereo-images are not only useful for the derivation of height information but also for landslide inventory mapping as it provides a 3-dimensional visualisation opportunity

Very high resolution imaging technique (QuickBird, IKONOS, CARTOSAT-1 and 2) has become the best option now for landslide mapping through remote sensing, and the number of operational sensors with similar characteristics is growing year by year. Other remote sensing approaches of landslide inventory mapping include shaded relief images produced from Light Detection and Ranging (LiDAR) DEM and Synthetic Aperture Radar (SAR) interferometry. Lidar is an active sensor and the signal from the sensor from onboard aircraft has the capability in most case, of penetrating the tree crowns and thus provides data about subtle elevation variation of the bare ground. Lidar data has been used to prepare landslide inventory in forest areas in hilly regions and to refine the

boundaries of landslides marked during field investigations. This data is not only useful for mapping old landslides but also is a tool to improve field survey based investigation in regions with subdued morphology. SAR images are useful in identifying critical terrain elements such as faults and slope characteristics. Also subtle movement due to landslides can be picked up from interferograms generated from SAR image pairs. Another advantage of SAR over optical sensor is its all weather monitoring ability. So, combination of SAR imagery with high resolution optical multispectral imagery is useful for monitoring debris hazard in mountainous areas. However the problems such as foreshortening and layover effects associated with SAR data in mountainous areas have to be addressed carefully.

Preparation of a comprehensive and user-friendly national landslide inventory database will be taken up, thus paving way for continuous updating of the landslide map of India. This will be achieved by nation-wide networking of the agencies engaged in the task and would be aided by the latest tools of geomatics and followed by field checks.

2.2 Landslide Database

A. Location of the Slide Site

i. Name of Road

ii. Motorable Road or bridle road

iii. Nearest village or town and direction and distance of the slide from it

iv. Slide developed at km (From ---- to -----)

B. General Description of the Area

i. Elevation (Height above M.S.L.)

ii. Slope on Uphill side

iii. Slope on downhill side

iv. State of erosion on slope

v. Density of vegetation (low, medium, high); give details of trees and vegetation.

vi. Are trees tilted?

vii. Are there cultivated fields?

viii. Monthly data for average rainfall for last 3 years. Annual rainfall for last 10 years or as many years as available.

ix. Name of the nearest observatory.

C. Geological Features of the Area

i. Type of rock exposed or below the ground (thinly/thickly bedded or massive).

ii. Dip and strike

iii Joints, their dip and spacing. State of joint planes - favorable/ unfavorable.

iv. Structural features (folds, faults, conformity)

v. Stratigraphic position.

vi. Lithological characteristics of the rock with sequence of formation

vii. Texture of rocks

viii. If not rocky to which following types it belongs:

Debris (soil to rock pieces)

Soil (almost no rock pieces)

D. Drainage Features

i. Is there any nala or river flowing at toe of the slide, if so indicate whether it was eroding the toe of the slope.

ii. Give the position of water accumulation, place of spring water, position of snow accumulation with respect to position of road.

iii. Is any water body (pond or lake) present on hill slope?

iv. Any other remark regarding nature of hill slope affecting the stability of hill slope.

E. History & Description of the Slide during its Development

a Sketch of the Slide

(Please sketch the slide showing its relationship with road and/or other land marks, take photographs from appropriate angles and sufficient in number to be able to generate a panoramic view of the area by making mosaic photographs.

The sketch should show approximate dimensions, boundaries of the slide, position of notable cracks, position of the road, nala and river if any, water path, places of water percolation, spring water, position of road outcrops, big boulders, trees, retaining walls and other prominent structures, position of sinking areas, if any.

i. Date of Occurrence of slide.

ii Number of times the slide has taken place in the known past

iii. Duration of the road blockage due to slide

iv. Number of casualties or persons injured, if any.

v. Damages to the property due to slide (houses, road, fields etc.)

a. Number of houses completely damaged

b. Number of houses partially damaged

c. Number of livestock lost

d. Nature of Damage

e. Occurrence of damage

f. Progressive nature of damage - Yes/No

g. If extension of damage has any relation with season - Yes/No

h. If yes, whom and how observed and their details.

i. Period of extension of damage.

vi. Method of clearance of slide mass by manually/by machine or by both.

vii. Time taken for clearance.

viii. Condition before occurrence of slide (dry, heavy rains etc.)

ix. Was road sinking noticed ?

x. Slope angle.

xi. Height of crown of the slide from road level.

xii. Depth of toe of the slide from road level

xiii. Any other remarkable point observed during or before slide.

xiv. Rate of movement (cm per day)

F. Causes of Slide

What you consider the cause of slide to be?

i. Whether it was human action (such as back cutting, blasting, excavation, changes in nature / artificial drainage etc.)

ii. Natural cause (such as river erosion, nala erosion, saturation of hill slope mass, cloud burst, unfavourable nature of hill slope mass, earthquake, deforestation, disruption of drainage etc.)

iii. Any other cause visualized at the site.

Note: Generally more than one cause develop the slide but one cause may be dominant

G. Remedial Measures

i. Whether applied - Yes/No. If yes, please state the measures, viz. :

a. Sealing of cracks.
b. Provision of retaining structures.
c. Improvement in drainage.
d. Measures for protecting river erosion
e. Chemical treatment
f. Grouting
g. Plantation etc.

What is their outcome?

ii. Has the slide area been studied for adopting remedial measures by any competent investigator? If so, give the name of organisation and the summary of major recommendations.

iii. Indicate what measures were followed and their outcome.

H. **Notes:**

i. Please complete separate sheet for important slide site of your region. Mark the location of all slides of your region on the district map.

ii. Your active input of the information is required and will help the investigator in suggesting corrective measures to pertinent landslides and similar ones.

iii. If you feel problem in providing information, the respective column may be left blank, but should be followed up later. Some of the information as e.g. in para (3) may be left for geologist, in case the field engineers are not able to fill it.

Date:----------

Signature (Name) of Reporting Officer

Designation

2.3 Landslide Hazard Zonation Mapping

The aim of LHZ, a pre-requisite for risk assessment, is to determine spatial and temporal extent of landslide hazard. In general the LHZ map divides the landslide prone hilly terrain into different zones according to their relative degree of susceptibility to landslides. It requires identification of those areas that are, or could be, affected by landslides and assessing the probability of such landslides occurring within a specific period of time. Commenting on the time domain of landslide occurrences through zonation mapping is a difficult

task. Due to conceptual and operational limitations, landslide hazard zonation is conceptually stated as landslide susceptibility zonation (LSZ). Spatial prediction of landslide is termed as landslide susceptibility, which is a function of landslide and landslide related internal factors (i.e., ground characteristics). The aim is to identify places of landslide occurrence over a region on the basis of a set of physical parameters. The LSZ can formally be defined as the division of land surface into near-homogeneous zones and then ranking these according to the degrees of actual or potential hazard due to landslides. The LSZ maps do not directly incorporate time and magnitude of landslide occurrences. Since LSZ is conceptually accepted as LHZ, it is popularly used as LHZ all over India. A Landslide Risk Zonation Map integrates landslide hazard, landslide vulnerability and degree of risk.

LHZ map requires dividing an area into several zones indicating progressive levels of landslide hazard. The number of zones into which the territory is divided is generally arbitrary. Landslide hazard zoning entails mapping all possible landslides and landslide-induced hazards to the required detail. The hazard maps are designed to limit information to the users' requirements, and present it in a form comprehensible to them. Indeed, the users' maps ought to be different from those prepared by or for specialists. Graded landslide hazard maps are required by, among others, developmental planners as tools for efficient management of land and its resources. Landslide hazard maps are also essential for assessment of damage potential, and for quantification of risks. Scientific forecasting of a landslide for early warning finds its first clue in the landslide hazard map of the area.

It is necessary to understand the conditions and processes that control landslides and determine existing landslide hazard if future landslide occurrences are to be estimated. A map of existing landslides serves as the basic data resource for understanding these conditions and processes. Existing landslides and their relationship with other key parameters – nature of slope forming material, slope inclination and aspect, land cover, landuse, climate and hydrology – form the basis for hazard assessment.

An all-inclusive approach for mapping slides, starting with the assessment of regional geologic and geomorphic setting, then focusing on detailed scale is recommended. A comprehensive view of the terrain is needed to identify all possible problems associated with slope condition, including existing and potential instability. It is necessary to review the impact of geological features located beyond the boundaries of the site that could influence the status of hazard in future. There may be vital evidence of instability processes outside

the area to be developed that may not be evident on the site itself, but could have a future impact on the site.

The available geological and geomorphological maps form the basic inputs for LHZ mapping. It is not at all possible to prepare all thematic maps covering vast areas by field work. This problem can be solved with the help of aerial photographs or satellite imageries followed by limited field checks.

Preparation of maps showing landslide hazard includes:

- Generation of thematic maps by compiling and collating the observations on geology, geomorphology, landuse, land cover and distribution of landslide processes including use of local records, interpretation of aerial photographs and high-resolution imageries.
- Collection of relevant information on the existing landslide hazard and analysis of potential landslide hazard including first times.
- Identification of areas that could be affected by landslide hazard in future.
- Transformation of process maps into hazard maps identifying the potential for spatial impact and probability of occurrence of hazard.

2.4 Selection of Scales

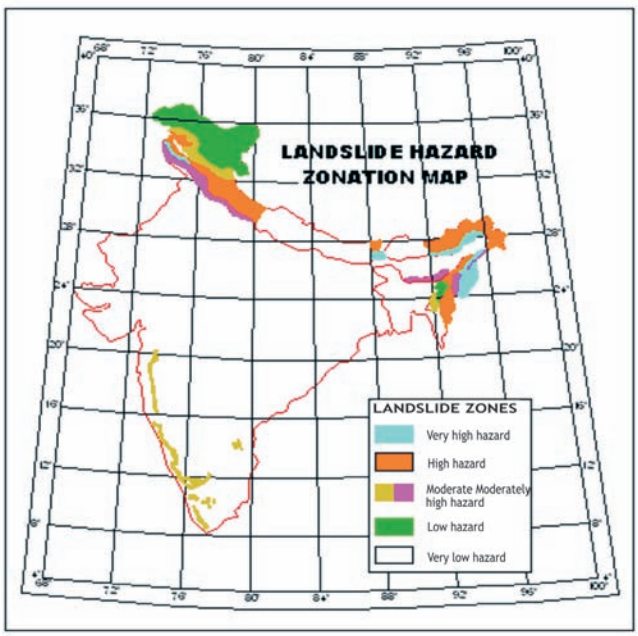
Landslides related data and information have to be mapped on a scale that is suitable for end-use purposes to enable planners to make decisions about future landuse on or close to landslides or landslide-affected areas. At present, only a few local authorities have access to landslide maps on appropriate planning-level scale (say 1:10,000). Most of them are ignorant even about 1:50,000 scale maps. While these or smaller scale maps are appropriate for regional studies, they do not provide adequate detail for planning at local level which requires detailed information at least up to municipal ward level. At present, very little area of the country has been mapped even on 1:50,000 or 1:25,000 scales on the landslide theme. It is important that a landslide hazard map be on a scale not markedly different from the data maps used to produce it otherwise estimation of hazard might be misleading.

Considering the importance of landslide hazard and its mapping, GoI constituted a Task Force on LHZ Mapping in March 1999. Keeping in view the availability of topographic and geological maps in the country at present and recommendations of the Task Force, different scales suggested for preparation of LHZ maps for different purposes are given below.

MAP SCALE FOR LANDSLIDES

- National or Regional (1:100,000 to 1:1,000,000)
- Macro- scales (1:25,000 to 1:50,000) – River basins, communication routes etc.
- Meso-scales (1:5,000 to 1:10,000) municipalities, localities etc.
- Mapping on scales larger than those on meso- scales should be carried out for site-specific studies and not for zonation.

However, it is not appropriate to carry out zonation on scales larger than 1:5000. Landslide studies are being carried out on 1:5000 and larger scales for detailed studies. A nation-wide consensus on the rationale of selection of uniform mapping scales should be developed.



Figur 2.1 Landslide Hazard Zonation Map of India (source: GSI)

2.5 Seismic Landslide Hazard Zonation

The principal triggers for landslides are rainfall, earthquake and anthropogenic activities. Since landslides in most areas can co-occur with other hazardous events like earthquakes, intense rainfall or cloudburst, these areas can suffer from more than one hazard at a time. Therefore, it is required that risk emanating from all hazards should be considered for assessing the total risk. It implies that it is necessary to integrate the landslide hazard into multi hazard concept.

The landslides triggered or induced by earthquakes are known as co-seismic landslides. Earthquake triggered slides occur when existing landslides are activated by an earthquake and earthquake induced are fresh or first time generated slides caused by an earthquake. Earthquake induced first time landslides are few but earthquake-triggered landslides are many. In a great majority of cases, landslides take place with the earthquake shock, and a few of them may also occur hours and days after the shock. It is observed that the extent of the area within which landsliding is generated tends to increase with the shock magnitude. Seismically generated landslides occur suddenly and in more widespread area. Example: Eastern Nepal – Sikkim earthquake (M-6.9 on Richter Scale, 18 September 2011) induced widespread landslides in Sikkim, West Bengal, Bihar and Nepal.

The most abundant types of earthquake-induced landslides are rock falls and slides of the slope forming material resting on steep slopes. However, almost every other type of landslide can occur due to an earthquake but landslides resulting from liquefaction are caused by a seismic event only. Other types of mass movements that can be generally related with seismic activity are:

- Rock avalanches on over-steepened slopes in weak rocks
- Mud flows, rapidly moving wet earth flows that can be initiated by earthquake shaking

Comprehensive research, development and field oriented studies on instrumented problematic slopes would be undertaken to improve our understanding of earthquake induced landslides. Multi-hazard and seismic micro-zonation programmes will be enriched by added focus on hither to neglected subject of earthquake induced site affected in hilly areas and their effect on slope instability.

2.6 Earthquake-Induced Landslides

A clear distinction is essential between the earthquake-triggered and earthquake induced landslides. Earthquake events are usually known to serve as a trigger for pre existing but dormant landslides to create what may be called as earthquake-triggered landslides. Strong tremors, however, hold the potential to induce new slides especially by rupture along unfavorable discontinuities and shear zones. Such slides are designated as earthquake-induced landslides. It should also be recognized that the commonest classes of the best-understood problems are flow slides due to liquefaction. The other possibilities are (a) reactivation of old, dormant or previously inactive landslides (b) acceleration of known landslides (c) triggering of rock falls (d) development of fresh, first time landslides, and

(e) onset of slumping and breaking up of the ground. The understanding of whole process presupposes understanding of (a) topographic and hydrological controls, (b) geological and geotechnical controls (c) seismological controls and (d) anthropogenic controls.

- Ground surface acceleration alone is a poor measure of the effect of shaking on slope stability. Intensity is even more so. The indicators such as ground velocity, experiences on past earthquake events, and duration of shaking are considered to be better indicators of landslide susceptibility under seismic conditions. Critical acceleration of a slope is also an important factor in deciding seismic safety of a slope. The factor of safety during an earthquake may drop below one (limit equilibrium state) for a short time, but the effect of failure on the slope may perhaps be negligible, and needs to be determined.
- The observation that catastrophic landslide events are a post-seismic phenomena rather than a co-seismic happening needs to be investigated. While the earthquake provides the trigger, the development of a landslide is seldom sudden, and it usually occurs after the earthquake and its after-shocks.

2.7 Government Policies and Initiatives

- The devastating Malpa tragedy resulting from a landslide that occurred along Kailash- Mansarovar route in the Kumaon Himalayans in August 1998 acted as an eye-opener for the GoI as far as landslide hazard is concerned. It decided to set up 3 different Task Forces for LHZ; Geotechnical Investigations and landuse zonation and regulation. Geological Survey of India (GSI) was identified as the nodal agency for LHZ while Department of Science & Technology (DST) and Ministry of Environment & Forest (MoEF) were identified as nodal agencies for the other two Task Forces, respectively. Consequently, Department of Mines (DoM) constituted a Task Force for LHZ in order to review the existing methodologies for LHZ study; to prioritise areas/belts for LHZ study and to recommend a plan for preparation of macro/meso/micro LHZ maps. The report of the Task Force on LHZ was submitted to the Government in September 2000.
- There are many government departments and organizations engaged in landslide hazard studies and hazard management in the country. These include GSI, Central Road Research Institute (CRRI), Central Building Research Institute (CBRI), Indian Institute of Technology-Roorkee (IIT-R), Wadia Institute of Himalayan Geology (WIHG), Department of Space (DoS), National Remote Sensing Centre (NRSC), Defence Terrain Analysis

and Research Laboratory (DTRL),Bureau of Indian Standards (BIS), some academic institutions and individual experts to name a few. Snow and Avalanches Studies Establishment (SASE) under Ministry of Defence (MoD) is engaged in studying snow avalanches. In addition, Border Roads Organisation (BRO) is the principal agency responsible for construction and maintenance of roads in almost all hilly regions of the country and Department of Science and Technology (DST) has been funding the R&D activities that include that include different types of landslide investigations.

- The earliest works in the field of landslides in the country were carried out by the GSI. These include study of Nainital landslide by Sir *R.D. Oldham in 1880 and C.S. Middlemiss in 1890,* study of *Gohana slide in 1893* in erstwhile UP Himalaya that resulted in formation of 350m high landslide dam across Birehiganga. Till date the Department has carried out studies on more than 1500 incidences of landslides. In case of LHZ mapping, GSI has prepared LHZ maps on 1:50,000/25,000 scale covering about 45,000 km^2 area in the landslide prone hilly tracts. Landslide Hazard Zonation has also been carried out on the same scale covering about 4000 line km along the important National & State Highways. Besides, GSI has also prepared detailed LHZ maps of around five landslide affected townships in different parts of the country on 1:5000/10,000.
- The facet based LHZ methodology was initiated at University of Roorkee, (now Indian Institute of Technology) in mid eighties and the work is still continuing over different parts of Uttarakhand Himalaya incorporating progressive improvements. Several workers and Institutes later adopted the facet based LHZ mapping.
- Major areas of activity of CRRI include geological and geotechnical investigations of landslides, landslide hazard potential and risk analysis, instrumentation, monitoring and prevention of landslides. CRRI has published reports on landslide correction techniques, application of geo-textiles, deep trench drains and promotion of jute based geo-textiles etc. CRRI has also prepared a partial database of over 200 landslides of different parts of the country.
- CBRI has prepared LHZ maps in parts of Garhwal (Uttarakhand), Sikkim and Darjeeling Himalaya (West Bengal) using different techniques; it has also carried out monitoring of some landslides. The Institute has also implemented the control measures at Mussoorie bye-pass and Kaliasaur landslides in the state of Uttarakhand.

- Central Scientific Instrumentation Organization (CSIO), a national Laboratory of instrumentation, has installed an instrumentation network for landslide monitoring at Mansa Devi, Haridwar in 2006.
- WIHG carried out LHZ mapping in parts of Satluj valley. The institution has also monitored a few landslides.
- BIS has the responsibility of developing zoning codes and guidelines related to landslide practices. It has issued guidelines related to LHZ mapping on macro-scales, construction of retaining walls and landslide controls. BIS is developing guidelines of LHZ mapping on meso and macro scale, risk evaluation, detailed investigations etc. so that standard practices are followed in landslide studies.
- Initial landslide hazard Atlas of India on small scale was jointly published by Building Materials Technology Promotion Council (BMTPC) and Anna University in 2004.
- NRSA had undertaken a specific project of preparation of landslide hazard Zonation (LHZ) maps on 1:25000 scale along various pilgrimage routes and important highways in Uttarakhand and Himachal Himalaya. Utilization of latest available remote sensing techniques and synthesisation of data on GIS platform were highlights of the work. The NRSA published two volumes (I&II) of Atlas on LHZ in 2004. The NRSA has also carried out high resolution aerial survey for Varunawat landslide and provided detail maps on the contour, slope etc. The NRSA, GSI and ITC are collaborating on developing landslide risk assessment model for NW & NE Himalayas and also Western Ghats. A collaborative project on LHZ for NH-17 (Mumbai to Goa) by the GSI and NRSA is in progress.
- With the availability of high resolution images, it is possible for the NRSA to monitor the slides through these techniques and also keep an eye on occurrence of new slides as well as on formation of landslide dams in highly inaccessible areas.
- National Institute of Disaster Management (NIDM), which works under the control of NDMA, has the capability to develop training modules, formulate and implement human resources development plans, organize training programmes covering disaster management of natural hazards including landslides, develop education material for disaster management and provide assistance to State Governments and State Training Institutes in formulation of State level policies and plans for disaster management.
- DST has been carrying out a number of activities related to Landslide Management for the past 15 years. It carried out landslide hazard mapping

in parts of Sutlej Valley in Himachal Pradesh, Kumaon and Garhwal areas in Uttarakhand, Konkan Railway Region from Panvel to Ratnagiri, Nilgiris and North-eastern States of Manipur, Nagaland, Mizoram, Sikkim and Arunachal Pradesh. The data/maps are in digital form and can be shared for DM activities. DST has also developed Software/Brochures for Land Slide Safe Route Finder to provide safe navigation while constructing new communication lines/roads in hilly areas.

- DST has brought out many publications on landsides and related issues like coordinated national programme on "Landslide Hazard Mitigation"; A field Manual for landslide investigations etc. It also periodically organizes awareness programmes / courses / workshops amongst the Government agencies / NGO and communities.
- In collaboration with International Centre for Geo-hazards and Norwegian Geo technical Institute, DST is establishing a National Geo-technical facility (NGF) in Dehradun. NGF aims to have the state-of-the-art in Geo-technical Sciences and provide platform for building capacities in Geo-technical investigations and research. This will also help in networking the institutions within the country which have facilities and technical man-power. It is expected that NGF will provide inputs for DM related activities in designing / retrofitting the under-ground / over-ground structures.
- Central Water Commission (CWC) has been a lead agency to assess the hazard potential of landslide dams in the country and its vicinity.

2.8 Measures to reduce landslides hazards and/or risks

If unacceptable levels of landslide safety are identified, it may be appropriate and necessary, that the professionals provide recommendations for measures to reduce landslide hazards and/or risks. Measures can be passive such as covenants or relocation of proposed buildings, or active such as stabilization or protective works. Residual risks, or those that remain should the recommendations be implemented, should be estimated and clearly explained.

Typically, a landslide assessment report should include the following:

- Legal description of the property
- Location map or description of property relative to well known geographic features
- Objectives, method of landslide hazard or landslide risk analysis, and the level of effort

- List of background information available, collected and reviewed, and its relevance
- Terrain or physical description of the study area
- Map or plan of the property including topography, natural features, existing structures, roads, infrastructure and surface drainage
- Description of proposed residential development
- Methods and intensity of field work
- Observations of topography, geology, landslide processes and elements at risk
- If applicable, adopted level of landslide safety used for comparison
- Results of landslide assessment
- Conclusions, accompanied by supporting rationale
- Recommendations, if requested and as required, to reduce the landslide hazards and/or risks
- An estimate of the associated residual risks if the recommendations are implemented
- If required, recommendations for further work and requirements for future inspections, and by whom
- Definitions of qualitative terms, technical terms, concepts and variables
- Other information as specified in the agreement with client, or as required jurisdictional guidelines
- References, including maps and photographs
- Limitations and qualifications of the assessment and report, assumptions, error limits and uncertainties

Reports should be accompanied by drawings, figures, sketches, photos, test reports/logs, tables and other supporting information/data. Graphic information should be consistent with the information in the text. Maps or plans should delineate the areas of landslide hazards and risks in relation to existing and proposed residential development. The report should be written clearly to allow reviewers to understand the methods, information used and supporting rationale for the conclusions and recommendations, without necessarily visiting the site. A peer review of landslide assessment report, prior to its submission to the client and / or authority, is strongly encouraged as part of quality assurance/ control programme.

2.9 Limitations and Qualifications of Landslides Assessment

The limitations and qualifications of a landslide assessment depend on the objectives, method of landslide hazard or risk analysis, level of effort, size of the study area, stability and geological and geotechnical complexity of the terrain, type of residential development, elements at risk, availability, quality and reliability of background information and field data, intensity of field work, experience and local experience of the professional, and whether or not a defined level of landslide safety has been adopted by the approving authority.

Although field work associated with a landslide assessment can provide reasonable coverage of the study area, field work may not cover the entire study area or all areas potentially affected by residential development. The extent of field work should be described in the report.

Many aspects of landslide assessment are qualitative and subjective based on observed, inferred and assumed conditions. Only some landslide assessments include subsurface investigations, sampling, instrumentation, monitoring and laboratory testing.

Conclusions and recommendations are based on the assumption that standard methods of residential development will be followed. Non-standard development, design and / or constructions recommendations should be clearly described. Substandard practices of construction may render the conclusions and recommendations invalid and sometimes damaging.

The life of landslide assessment report depends on the occurrence of subsequent landslides, changes in landuse, site development, neglect or discovery of previously unknown information.

Limitations and qualifications, including those associated with background information, assumptions, sources of error and range of values, should be clearly described in the report.

Levels of landslide safety are determined by society, not individuals. Therefore, for residential development, the levels must be established and adopted by the local and provincial government after consideration of a range of societal values. For example, factor of safety of a slope under static conditions must be significantly greater than one to accommodate earthquake loads. Acceptable factor of safety depends on the uncertainty in the analysis, the soil parameters and the magnitude and duration of seismic excitation, in addition to the potential consequences of slope failure.

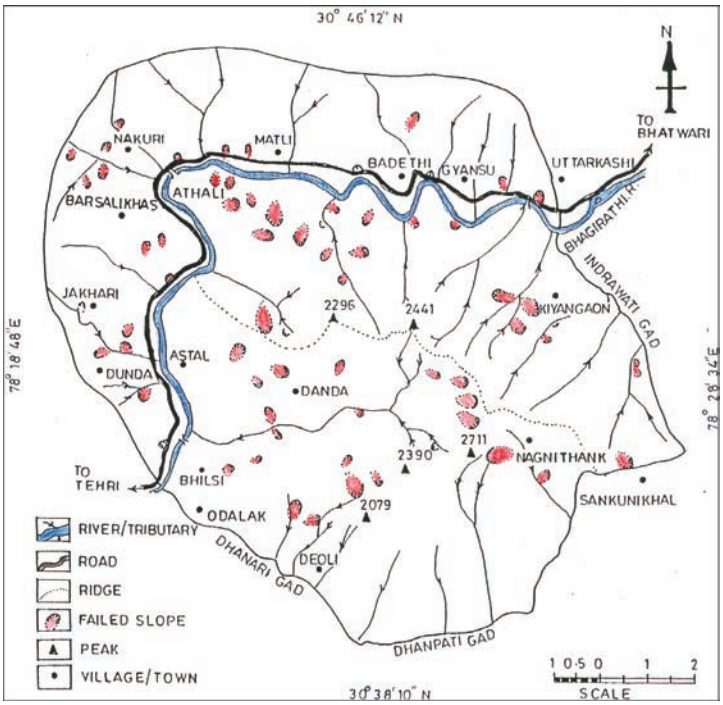


Fig 2.2 Map Showing Distribution of Failed Slopes in Dunda Uttarkashi

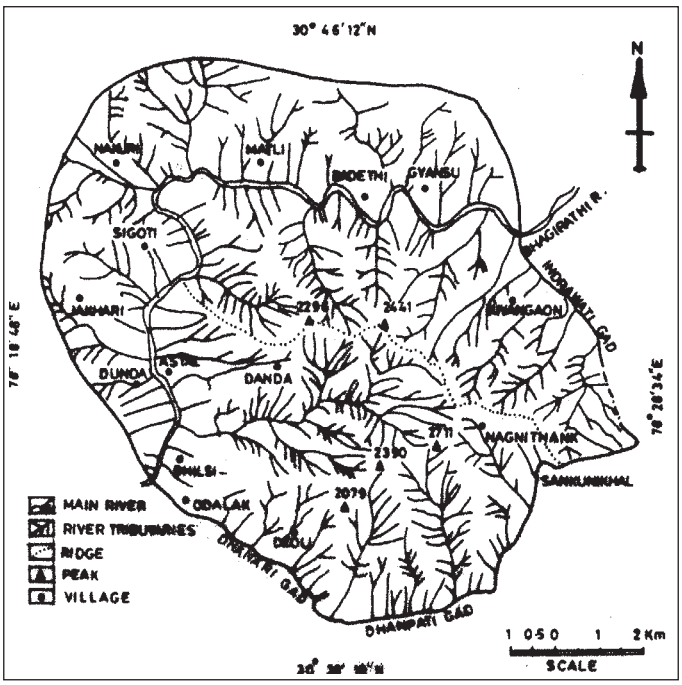


Fig 2.3 Drainage Map of the Dunda Uttarkashi Area

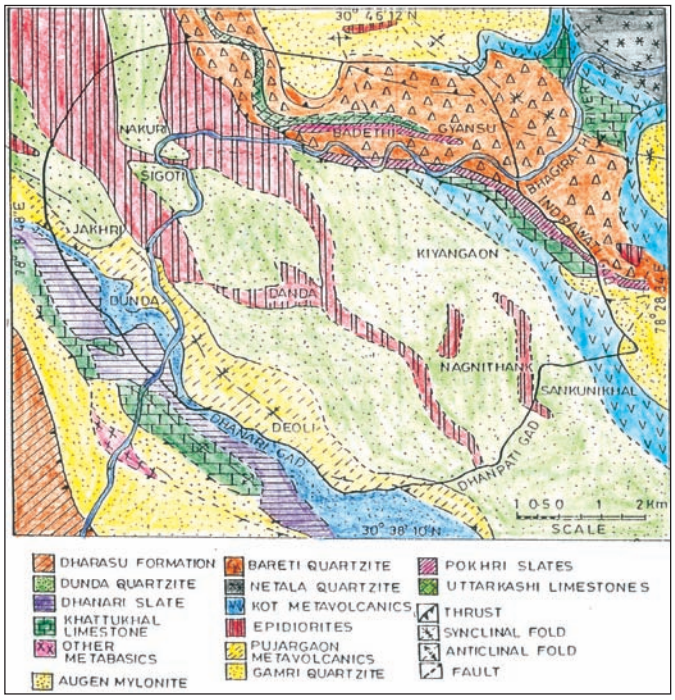


Fig 2.4 Geology Map of Dunda, Uttarkashi Area

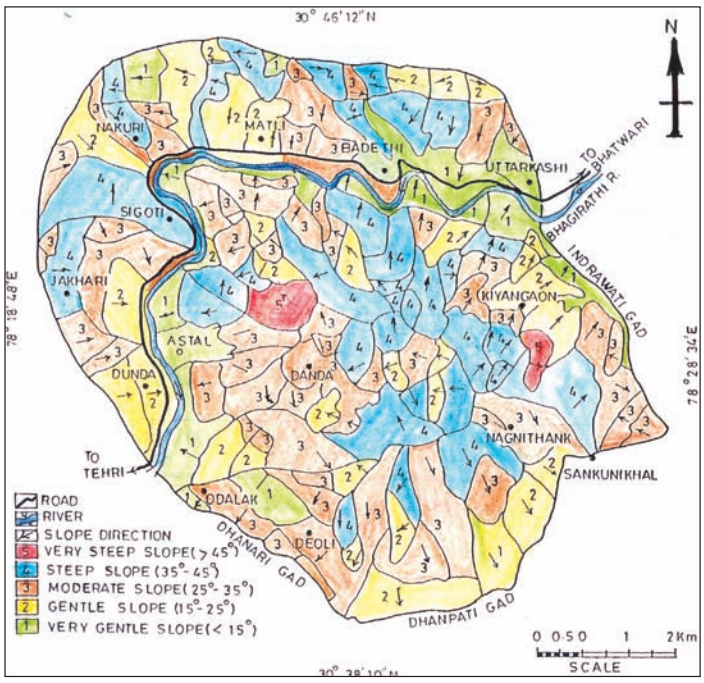


Fig. 2.5 Slope Map of the Dunda, Uttarkashi Area

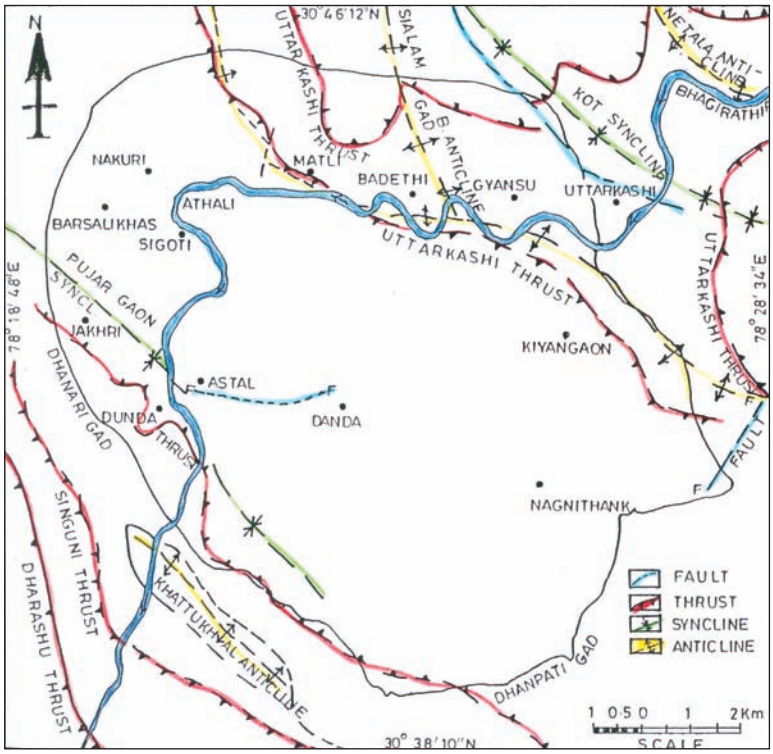


Fig. 2.6 Structure & Tectonic Map of the Dunda, Uttarkashi

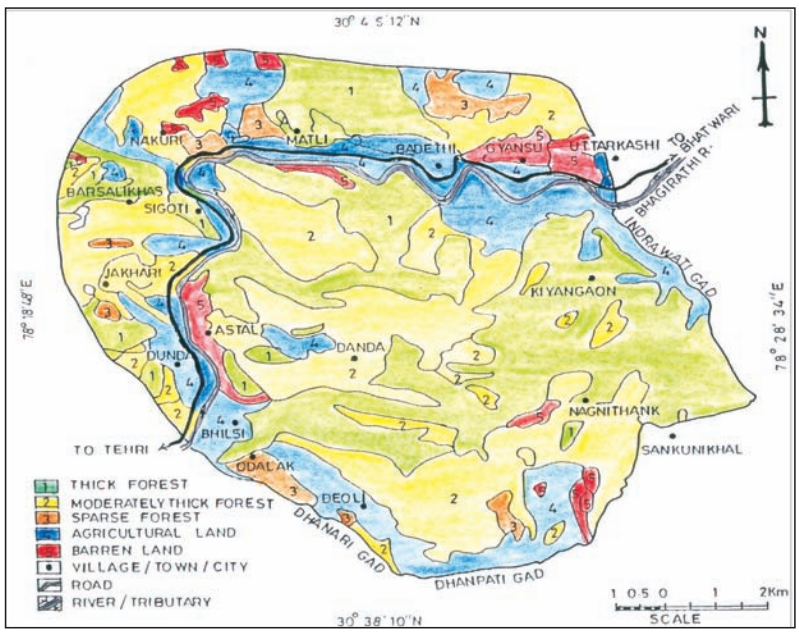


Fig. 2.7 Landuse Map of Dunda, Uttarkashi

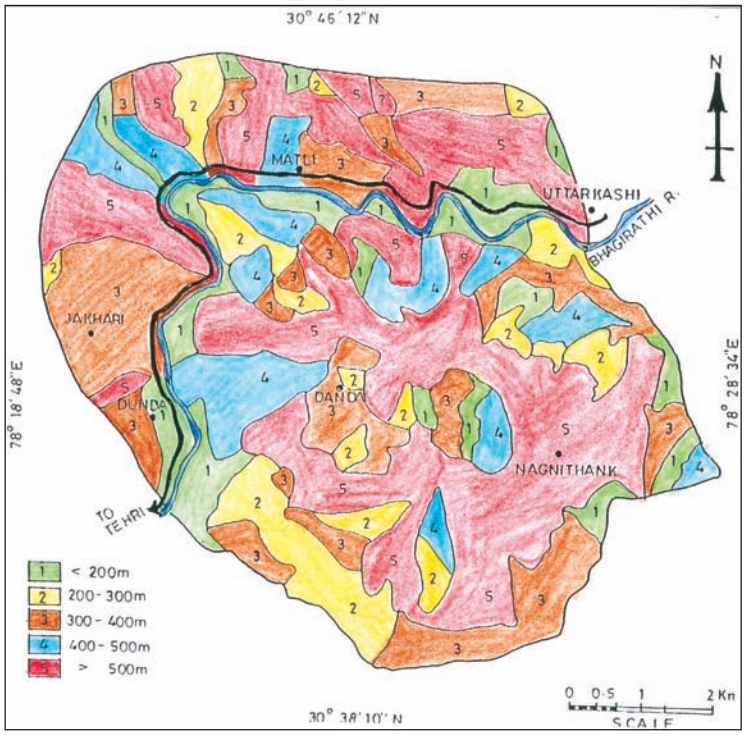


Fig. 2.8 Relative Relief Map of the Dunda, Uttarkashi

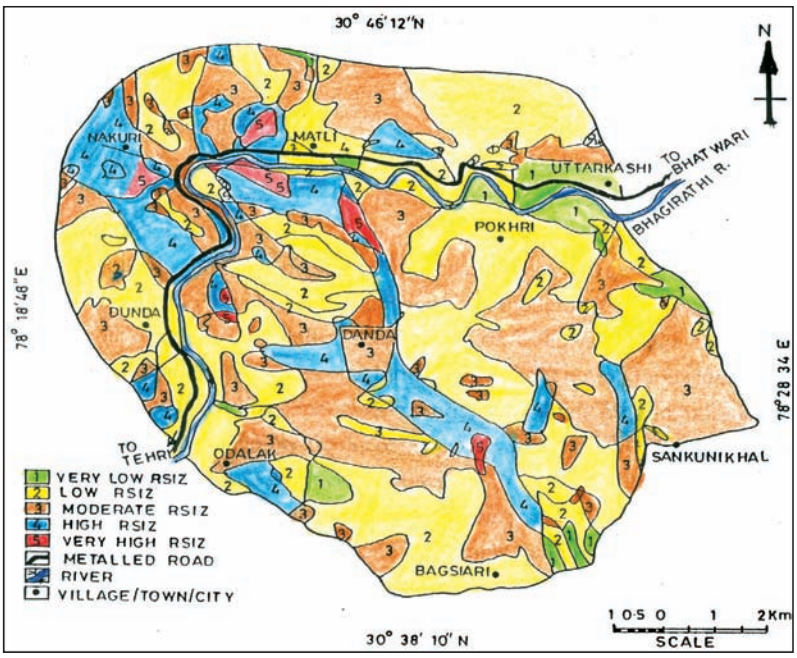


Fig. 2.9 Relative Slope Instability Zonation (RSIZ) Map of the Dunda, Uttarkashi

SUB-MODULE 3: LANDSLIDES RISK ASSESSMENT

3.1 Introduction

Landslide is a natural process, which occurs and recurs in certain geologic settings under certain conditions. The rising costs of landslide damages are a direct consequence of the increasing vulnerability of the people, structures and resources to the hazard. The vulnerability of people to the natural hazard is determined by the relationship between the occurrence of extreme events, the proximity of people to these occurrences, and the degree to which the people are prepared to cope with these extremes of nature.

$$Rt = (E) * (Rs) = (E) * (H \times V)$$

where Rt is Total Risk,

E - Elements at risk,

Rs - Specific Risk,

H - Natural Hazard,

V - Vulnerability

3.2 Principles

- The past and present are key to the future.
- The main conditions that cause landslide, can be identified.
- Degree of hazard can be estimated.

3.3 Landslide Risk Assessment

Natural hazard is a condition that expresses the probability of a damaging event occurring with a specified magnitude within a defined time period and area. Risk is a measure of the probability and severity of the damaging event.

Landslide risk can be defined as the potential for adverse consequences, loss, harm or detriment to population and resources. Hence, landslide risk is a combination of the probability of occurrence of landslides and the consequences due to landslides.

Management of risk involves the complete process of risk assessment and risk control. Risk assessment, the process of risk analysis and evaluation, is the initial and the most important step of risk management. Conducting a risk assessment can provide information on location of hazard, value of existing

land and property, an analysis of risk to life, property and the environment that may result from natural hazard events. The complete Risk Management process comprises three components:

- Risk analysis
- Risk evaluation, and
- Risk treatment

3.3.1 Risk Analysis: Risk analysis involves the use of available information to estimate the risk to individuals or populations, property or the environment from hazard. The effects of landslide may not be limited to property damage and injury/loss of life. Other consequences may include public outrage, political effects, and loss of business confidence, social upheaval and consequential costs, such as litigation. It is important to define the site, geographic limits that may be involved in the processes that affect the site, scope of analysis, the extent and nature of the investigations that will be carried out, types of analyses that will be conducted and basis for assessment of acceptable and tolerable risks. Subsequent to hazard identification, risk estimation must be carried out.

Risk estimation may be carried out quantitatively, semi quantitatively or qualitatively. Wherever possible, the Risk Estimate should be based on a quantitative analysis, even though the results may be summarized in a qualitative terminology.

A complete risk analysis involves consideration of all landslide hazards for the site (e.g. large, deep seated landslide, smaller slides, boulder falls, debris flows) and all elements at risk. For computation of total risk, the risk for each hazard for each element is summed up. Most of the approaches applied for assessing Landslides Risk Analysis have inherent limitations but the risk analysis has the benefit of encouraging a systematic approach to assessing the problem and promoting a greater understanding of consequences. The risk analysis, assessment and evaluation can be done through detailed analysis employing multi disciplinary approach. In this effort the geological and geotechnical investigations play an important role.

Landslide Risk Analysis (LRA) can be made at different stages in the decision-making process, starting from developmental planning on a regional scale to a particular site evaluation at large scale. Landslide risk assessment on a regional scale leads to demarcation of areas with different levels of threat to risk elements. This information can be used to establish landuse plans, developmental activities and patterns of building regulations. LRA on regional

scale depends on two factors: (i) the spatial probability of landslide occurrences in a region and (ii) the vulnerability of resources at risk.

The spatial probability of landslide occurrences depends on the causative factors. Hence, the LHZ maps may be used to define the landslide potential in a region.

Vulnerability may be defined as the level of potential damage, or degree of loss of resources at risk, subjected to a landslide occurrence of a given intensity. Vulnerability assessment involves the understanding of the interaction between a given landslide and the affected resources. Generally, the vulnerability to a particular landslide may depend on the volume and velocity of sliding, the distance of transported sliding material, the resources at risk, their nature and proximity to the landslide. The assessment of vulnerability is somewhat subjective and may largely be based on the historical data of the region. However, in case of a regional scale vulnerability assessment, the resources at risk and their nature and proximity to landslide hazard zones may be considered. The appropriate vulnerability factor may be assessed systematically based on the opinions of experts and can be expressed at a scale of 0 to 1.

In the present context of regional risk analysis on regional/macro/meso scales, the LRA can be considered as a function of landslide potential (LP) and resource damage potential (RDP). The LP and RDP can be characterized by LHZ map and resource map (i.e., landuse and land cover map) of the area respectively. The LRA map can be obtained by integrating landslide susceptibility and resource damage potential at spatial level. This map can be categorized into areas of different risk zones. Therefore, risk maps essentially include landslide hazard map and elements at risk map. Landslide hazard map is generated by the integration of thematic maps, landslide incidence maps and vulnerability maps.

For site specific LRA, run-out effect analysis due to specific landslides based on travel distance analysis method can be implemented.

In risk analysis, the role of remote sensing is of utmost importance in providing necessary inputs for identifying the element at risk. The large coverage of satellite data with its temporal capability is useful for mapping the landuse / land cover, infrastructure, settlements which are vital input for landslide risk assessments.

3.3.2 Risk Evaluation: Risk Evaluation is the final step in the Risk Assessment process. The main objectives of risk evaluation are usually to decide whether to accept or treat the risks and identify priorities. Risk evaluation involves

making judgments about the significance and acceptability of the estimated risk. Evaluation may involve comparison of the assessed risks with other risks or with risk acceptance criteria related to financial aspects, loss of life or other parameters. Risk evaluation may include consideration of issues such as environmental effects, politics, business or public confidence and reaction. While evaluating risk, it is important to distinguish between acceptable risk which society is prepared to face as such without considering its management and tolerable risk that they have confidence that it is being properly controlled and monitored. This applies to both property and loss of life.

3.4 Risk Assessment Framework

3.4.1 Sliding

What is the probability of sliding?

- Rain/snow/reservoir seepage induced
- Earthquake induced
- Earthquake induced liquefaction
- Reservoir drawdown induced
- Combination of the above

If landslide occurs, how large will it be?

- Which mechanisms induced sliding?
- How deep is the slide (i.e. surface of rupture)?
- How long along the river?
- How long normal to the river ?

How far will the displaced material move?

What will the reservoir level be?

What quantity of the displaced material will reach the reservoir and how quickly?

What will be volume of water displaced? Will it generate a wave?

What are the expected losses?

Will these be acceptable?

What is the probability of secondary movement? Subsequent landslide?

3.4.2 Rock Fall

Rockfall from cutting present several hazards to users:

a. Moving highway traffic obstructed by rockfall

b. Stationary vehicle hit by rockfall
c. Moving vehicle hits a fallen rock
d. Rockfall could block traffic causing costly delays and diversion of traffic
e. Damage to highway
f. Pedestrians, cyclists, highway maintenance workers impacted by rockfall

What is the probability of rockfall?

How big will the rockfall be?

Where will be the impact of rockfall?

What is the number and characteristics of vehicles (speed and length of vehicle etc.) using the highway?

What is the probability of a moving vehicle being hit by a falling rock?

What is the probability of a stationary vehicle being hit by a falling rock?

What is the probability of a moving vehicle hitting a fallen rock?

In the event that a rock impacts a vehicle, what is the probability of fatality?

What are the acceptable risk criteria?

3.4.3 Debris Flows

The main hazard due to debris flow in a settlement area may cause:

a. Damage to houses in the debris flow path and its deposition
b. Damage to urban infrastructure, e.g. roads, power and telephone lines, and drainage
c. Potential for fatalities and injuries to persons in the houses
d. Potential for fatalities and injury to persons on the roads.

What is the probability of a debris flow?

How big will the debris slide be?

How far will the debris slide flow and what will be their flow path?

What is the probability of a property or person being hit by a debris slide?

What is the vulnerability of property and persons?

What are the risks to property and persons?

What are the acceptable criteria for evaluating risk?

SUB-MODULE 4: LANDSLIDES RISK TREATMENT

4.1 Introduction

Risk Treatment is the ultimate aim of Risk Management and provides the tactic of mitigating the effect of the natural hazard. Once the risk has been analysed, the strategy is to identify the options and methods for minimizing it. Some typical options would be to accept the risk, avoid the risk, reduce the likelihood, reduce the consequences, install monitoring and warning systems, transfer the risk, or, if there is sufficient uncertainty from the available data, postpone the decision. The relative costs and benefits of the options are required to be considered so that the most economic solutions, consistent with the overall needs can be identified. Combination of options or alternatives may be appropriate, particularly where relatively large reduction in risk can be achieved at relatively small cost. A treatment plan for each option may be used to delineate how the option will be implemented. Each plan also needs to identify responsibilities for each stakeholder during and after implementation, the extent of work required, cost estimates and programme, performance of measures and the expected outcome. Monitoring of the treatment plan and risks is needed to ensure that the plan is effective and changes in circumstances do not alter risks. It is essential to reconsider all stages of the analysis, assessment and prioritisation as the treatment plan evolves and is implemented. The results of monitoring may enable feedback for reassessment of the risks.

Landslide risk can be mitigated by five approaches used individually or in combination, to reduce or eliminate losses.

Restricting Development in Landslide-Prone Areas: Landuse planning is one of the most effective and economical ways to reduce landslide losses by avoiding the hazard and minimizing the risk. This is accomplished by removing or converting existing development or discouraging or regulating new development in unstable areas. However, in many States in our country, there are no widely accepted procedures or regulations for landslides

Codes for Excavation, Construction and Grading: Excavation, construction and grading codes have been developed in many countries for construction in landslide-prone areas. There is no uniform code to ensure standardization in the country

Protecting Existing Developments: Control of surface and subsurface drainage is the most widely used, and generally the most successful, slope-stabilization

methods. Stability of a slope can be increased by removing all or part of a landslide mass, or by adding earth buttresses placed at the toes of potential slope failures. Retaining / Restraining walls, piles, caissons, or rock anchors, soil nailing are commonly used to prevent or control slope movement. In most cases, combinations of these measures are used.

Monitoring and Warning Systems: Monitoring and warning systems help to protect lives and property, these cannot to prevent landslides. However, these often result in issuing warning of slope movement in time to allow the construction of physical measures that will reduce the immediate or long-term hazard. Site-specific monitoring techniques include field observation and the use of various ground motion measuring instruments, trip wires, radar, laser beams, and vibration meters. Data from these devices can be telemetered for real-time warning.

Landslide Insurance and Compensation for Losses: Landslide insurance would be a logical means to provide compensation and incentive to avoid or mitigate the hazard. Landslide insurance coverage could be made a requirement for mortgage loans. Controls on building byelaws, development, and property maintenance would be needed for mandatory insurance. Insurance and appropriate government intervention can work together, each complementing the other in reducing losses and compensating victims.

4.2 Mitigation Measures

4.2.1 Structural measures:

Adopt remedial techniques (i.e., buttresses, shear keys, sub-drains, soil reinforcement, retaining walls, etc.) of existing landslides that are in close proximity to public structures.

4.2.1.1 Drainage Corrections:

The most important triggering mechanism for mass movements is the water infiltrating into the overburden during heavy rains and consequent increase in pore pressure in the overburden**.** Hence the natural way of preventing this situation is by reducing infiltration and allowing excess water to move down without hindrance. As such, the first and foremost mitigation measure is drainage correction. This involves maintenance of natural drainage channels, both micro and macro, in vulnerable slopes.

4.2.2 Non-structural Measures

4.2.2.1 Proper landuse measures: Adopt effective landuse regulations and building codes based on scientific research. Through landuse planning,

discourage new construction or development in identified hazard areas without first implementing appropriate remedial measures.

4.2.2.2 Afforestation: The afforestation programme should be properly planned so the little slope modification is done in the process. Bounding of any sort using boulders etc. has to be avoided. The selection of suitable plant species should be such that can withstand the existing stress conditions of the terrain.

4.2.2.3 Awareness generation: Educate the public about signs that a landslide is imminent so that personal safety measures may be taken.

Some of the signs include:

(i) Springs, seeps, or saturated ground in areas that have not typically been wet before

(ii) New cracks or unusual bulges in the ground, street pavements or sidewalks

(iii) Soil moving away from foundations, and ancillary structures such as decks and patios tilting and/or moving relative to the house

(iv) Sticking doors and windows, and visible open spaces

(v) Broken water lines and other underground utilities

(vi) Leaning telephone poles, trees, retaining walls or fences

(vii) Sunken or dropped-down road beds

(viii) Rapid increase in a stream or creek water levels, possibly accompanied by increased turbidity (soil content)

(iX) Sudden decrease in creek water levels even though rain is still falling or just recently stopped

4.3 Three elements for translating technical information to users

i. Likelihood of the occurrence of an event of a size and location that would cause casualties, damage or disruption

ii. Location and extent of the effects of the event on the ground, structures or socio-economic activity

iii. Estimated severity of the effects on the ground, structures or socio-economic activity

Translate hazard information so that nontechnical users are also able to perceive likelihood, location and severity of the hazard.

Mitigation includes any activity that prevents an emergency, reduce the chance of an emergency happening, or lessens the damaging effects of unavoidable emergencies. Investing in preventive mitigation steps now such as planting

ground cover (low growing plants) on slopes, or installing flexible pipe fitting to avoid gas or water leaks, will help reduce the impact of landslides and mudflows in future. For more information on mitigation, contact your local emergency management office.

4.4 Techniques For Reducing Landslide Hazards

Discouraging new developments in hazardous areas by:

- Disclosing the hazard to real estate buyers
- Posting warnings of potential hazards
- Adopting utility and public facility service-area policies
- Informing and educating the public
- Making a public record of hazards

Removing or converting existing development through:

- Acquiring or exchanging hazardous properties
- Discouraging non-conforming uses
- Reconstructing damaged areas after landslides
- Removing unsafe structures
- Clearing and redeveloping blighted areas before landslides

Providing financial incentives or disincentives

- Conditioning financial assistance by the state or by central government
- Clarifying the legal liability of property owners
- Adopting leading policies that reflect risk of loss
- Requiring insurance related to the level of hazard

Relating to new developments in hazardous areas by:

- Enacting grading ordinances
- Adopting hillside development regulations
- Amending landuse zoning districts and regulations
- Enacting sanitary ordinances

Protecting existing developments by:

- Controlling landslides and slumps
- Controlling mudflows and debris flows
- Controlling rockfalls
- Operating monitoring, warning and evacuating systems
- Emergency plans (life-saving, evacuation and facility specific)

SUB-MODULE 5: LANDSLIDES INVESTIGATIONS

Investigation of Landslides

The investigation of landslides should be carried out in the following sequence

5.1 Preliminary Investigations

5.1.1 Collection and Review of Existing Data,

Landslides often occur at specific locations under certain topographic and geologic conditions. Therefore, it is important to utilize existing data (history of the problem, records of restoration work, and data review) along with the topography, geology, and properties of similar landslides. It is also important to understand their relationship with meteorologic factors such as rainfall, period of activity, existence of any warning sign, ground water conditions, chronology of topographic change or erosion by rivers, earthquakes, and other factors which may have a relationship with the slope deformation/displacement surrounding the investigation site area prior to the detailed investigation.

5.1.2 Topographic Investigations

It is necessary to identify any changes in the site topography. That can be accomplished by recognizing;

a) the overall topographic feature of the site;
b) understanding the topographic characteristics of the site slopes; and
c) estimating the regional geologic structure of the site.

Such methods include comparing the aerial photographs of the site and vicinity taken prior to and after the sliding, and interpreting the topographic maps and aerial photographs. The latter can be used to understand the chronologic and topographic changes over a period of time. By utilizing aerial photographs, it is possible to interpret landslide phenomena and warning signs, geology and geologic structure, topography and distribution of vegetation types. For landslide investigations, it is useful to identify and interpret the distribution and continuity of knick points, gentle slopes, gullies and cracks in the photos to aid in preparing a photo interpretation map which can then be utilized during field investigation.

Remote sensing using satellite imageries has been particularly useful for estimating the distribution of slide areas and ground water, and vegetation at

regional levels. Remote sensing can also be used for analysis of topographic characteristics in terrain susceptible to landslides

5.1.3 Field Investigations

With an assessment of the overall topographic features and knowledge of the distinctions of movement and areal extent of the sliding blocks (viewed from the opposite hillside), a detailed field investigation plan can be developed to delineate the areal extent and a general direction of movement of the landslide zone, assess the lithologies and geologic structures, estimate the causes of the sliding, and predict future movement. The field investigation should not include just the actual landslide area, but also extend to slope limits or local drainage basin area. The field investigation should also include areas where aerial photographic interpretation is difficult or unclear, and in areas that could aid in the understanding of particular topographic features and characteristics.

5.2 Preparing a Detailed Investigation Plan

A detailed investigation which will satisfy the following objectives, should be planned.

(i) areal extent of the slide, differentiation of moving blocks and identification of the type, direction and extent of movement; if possible, the time and duration of movement as well

(ii) location and shape of slide planes

(iii) nature of landslide blocks

(vi) possibility of further or future movement on slopes above the existing slide

(v) possibility of further, future or accelerated sliding

(vi) distribution of ground water and heterogeneity of slope mass

5.2.1 Survey lines can be established on each moving block on the ground where the slide mass is expected to be thickest and where the stability analysis and plan for control works will be emphasized.

5.2.2 Exploratory borings : At least three borings should be drilled along the main survey line with one going at least 5 to 10 m below the slide plane. During the early stage of investigation, it is particularly important to have an accurate estimate of the configuration and location of slide plane(s) for planning an adequate boring depth (Figs.5.11 & 5.12).

5.2.3 Geophysical survey : Seismic survey should be conducted along the main survey line as well as along the longitudinal survey lines that cross the main survey line and subsidiary survey lines. For the seismic survey, the survey points should be established at 5-10m intervals, and for electrical surveys, 20-50m. Furthermore, to verify the results of the geophysical surveys, it is important to drill at the survey line intersections.

5.3 Geological Investigations

Landslide investigation and mitigation, requires mapping landslide hazards and creating a knowledge /database with the fullest appreciation of the scale and degree of reliability of the information gathered. For estimation of destructive potential of a landslide, one needs to know its expanse/spatial extent and also time scale of landslide activity, mechanism, run out distance, elements at risk and recurrence history. For prediction of a landslide, one needs to find out where and when will it occur and how far and how fast will it move. For design of control measures to manage landslides, one needs to know what the landslide type is (its classification) , what could be different possible modes of failure, where are the slide boundaries, what the operating shear strength characteristics of boundary shears and how will the pore pressures vary on slide boundaries with time. For measuring the efficacy of control measures, one would need to know the actual performance of the slope measured vis-a-vis the design performance. The plan of geotechnical investigation should clearly state its purpose.

The term geological investigation covers both surface and subsurface explorations to be carried out for determination of the extent of the landslide in all the dimensions, nature and disposition of geological formations, structures in the area, physical and geotechnical characteristics of the material involved in the landslide process and factors responsible for activating the slide and severity of hazard. The extent of geological investigations should be planned keeping the above factors in view.

5.3.1 Preliminary Stage Geological Investigations

The preliminary stage investigations involve collection of available information, desk studies as well as initial recognoitory traverses in field to collect regional as well as local information and data. Extensive use of remote sensing products including high resolution CARTOSAT-1 & 2 should be made to demarcate the area likely to be affected further to understand the dynamic behaviour of slide, delineate modified slope conditions by preparing DEM etc.

Field Surveys and Investigations: The first task to be taken in the field after finishing the desk work is to verify and validate the data collected during desk studies and plan further course of work. The preliminary field surveys in the slide area should be carried out with a view to assess:

i) The dimensions, geometry and nature of the landslide and status of sliding activity.

ii) The condition of the ground beyond the boundaries of landslide.

iii) Record orientation, spacing and openings of all cracks.

iv) Disposition of zones of accumulation, depletion and scarp faces and distribution pattern of different size fractions in debris.

v) Disposition, attitude of bedding, foliation and all other planar structures, lithological variation of rocks, state of weathering, joint/fracture spacing, openness, roughness, continuity, joint/fracture wall alteration etc.

vi) Locations of seepage, spring, natural drainage courses and slushy ground.

vii) Recording the movement of different parts of slide during period of investigation

viii) Location of human habitation, communication corridors and other civil engineering structures.

ix) Weathering profile, nature of slope forming material, study of overburden and rock contact, nature of drainage, springs, scarps etc.

x) Demarcation of Buffer zone based on the trajectory of the falling rock blocks, between the toe of the hill and the human settlements or other structures to avoid any risk factor during treatment of the slide.

5.3.2 Detailed Geological Investigations

The detailed geological investigations, both surface and subsurface, which are required to be carried out at this stage are further to the studies already carried out. The extent of area to be covered by geological mapping and the extent of subsurface geological investigations required are guided by the geological complexity of the site. Detailed investigations at this stage should be planned and executed in close cooperation and interaction between engineering geologist and geotechnical engineers.

After completion of surface geological mapping, the behaviour of surface material and other features in depth are required to be explored. The subsurface explorations required for this should aim to establish:

- Depth to bedrock or thickness of overburden and weathering limit. Lithological characters of various rock units and their significance, limit of slump joints and glide cracks, if any.
- Nature, condition, opening, spacing and continuity of prominent joints, slip surface, minor and major shear zones. etc.
- Depth of ground water table.
- Permeability of strata and
- If possible, the depth and disposition of plane along which failure has taken place.

The above parameters can be determined by employing non- destructive geophysical techniques that are easily available. Geophysical exploration should be done especially in the areas covered by debris or river-borne material/terrace deposits. Geophysical surveys including, resistivity surveys, seismic refraction surveys have been found helpful in determination of above parameters. With developments in electronic and software technologies, the results are becoming more and more precise, accurate and dependable.

Ground Penetrating Radar (GPR) can be initially employed in such surveys for evaluating depth and nature of bedrock and also ground water conditions. GPR surveys are very quick and provide results quickly. These can be followed by seismic (reflection) and resistivity surveys.

The preliminary and detailed geological investigations of landslides constitute the bedrock on which sound geotechnical investigations must be built. Detailed guidelines will be developed on diverse aspects of slope engineering for ensuring systematic geological investigations and mapping.

5.4 Geotechnical Investigations

These include mapping of problematic slopes on an appropriate scale, scientific understanding of its kinetics, elucidation of landslide boundaries, determination of representative shear strength parameters, pore pressure variations on the slide boundaries and finally evaluation of factor of safety. It is important to understand the distinction between the first time and the reactivated slides. The boundaries of the former are not known in advance and also the investigation needs and mitigation measures for imminent landslide of this kind may be different.

Geotechnical Investigation for mass movements like rapid motion landslides, multi-tier landslides, rock falls, debris flows and avalanches may throw

up many other investigational requirements. There could also be cases of landslides changing their character. For instance, in its wetter manifestation, a landslide may partake the character of a flow and acquire rapid motion. In such cases, laws of fluid dynamics may take over from the laws of classical soil mechanics.

A good geotechnical slope investigation is usually driven by the leads thrown up by the large scale geomorphological map of the area. It should always begin with careful study of field evidences that can be closely observed by a trained landslide investigator. For instance, study of the slide boundaries, surface geology, discontinuities, shear zones; water springs, aquifers, slope subsidence, heave, cracks and behaviour of buildings/walls/floors etc., provide a sense of direction to the nature and quantum of ensuing detailed sub slope geotechnical investigations. A vigilant eye can express much more by looking at an exposed roadside cutting than the whole gamut of geotechnical investigation made after huge expense of time and money. No amount of drilling can ever replace the practice of observing and careful characterising the fissures, slip surfaces and shear zones, joint fillings, the erratic nature of soil profiles, the sand and the silt lenses, the solution cavities, the evidences of underground erosion and more, visually seen in the open exposures and cuttings.

No matter how thorough is the geotechnical investigation, uncertainties involved would always call for making design assumptions based on engineering judgment. Every geotechnical report must clearly state the assumptions made and the basis there of. It would, therefore, be a big mistake to prescribe a rigid programme of soil investigation at the outset. The best soil investigation programmes are those which advance and get modulated with every new shred of investigational information.

A geotechnical investigation often tends to get expensive and even wasteful if it does not relate closely to the slope information to be gathered and answer the specific questions. For instance, it has become a common practice to prescribe an extensive programme of drilling to locate basal boundary shear of a landslide even without a site visit. One must remember that even with extensive drilling, the basal boundary of a landslide may defy attention in the core logs. Imagine the savings and time effectiveness in investigation that will accrue if one were to succeed in locating traces of basal boundary shears in, for example, a road side cutting.

Selection of equipment for slope investigation, drilling and in situ testing and decision on scale, scope and type of undisturbed sampling and laboratory testing are highly specialized matters. The present tendency of making divergent uninformed choices without adequate scientific reasoning must end. There is a need to develop guidelines on this, especially for the training of geotechnical engineers engaged on landslide projects as also for the benefit of those responsible for building institutional capacities.

Deterministic analyses of slopes can be either two or three dimensional. The former under-estimate the factor of safety and are, therefore, done where either side resistance to landsliding is negligible or uncertainties are large and quick conservative designs are required for further planning. For important projects where high quality investigation is mandatory, a three dimensional analyses should be done for ensuring economy in design. Since there are uncertainties involved at various steps of investigation and design, and it is not always possible to justify single value inputs, the need and merit of probabilistic analyses of slope must also be considered.

Deterministic analyses could either be in terms of effective stress or as total stress. The unhealthy practice of ignoring this essential requirement must stop. There is a need to develop guidelines for scientific analyses of slopes and landslides in terms of total and effective stresses as the ground situation demands. Every report will specifically point out assumptions made and limitation of the data used in slope analyses and design. The efforts must clearly focus on neglected but vital aspects such as techniques of undisturbed sampling of shear zones and boundary shears and evaluation of shear strength parameters using appropriate stress path. It is often meaningless to spend money doing tests such as SPT and DCPT in drill holes or unconfined compression tests in a laboratory, since shear strength is not a unique property of a soil sample. Laboratory tests without obtaining representative high quality undisturbed samples and without picking the right type of test could also be misleading. Besides, one must remember that soils are non-homogeneous and anisotropic and their non-linear behaviour is greatly influenced by their stress-strain history and structure.

Most landslides being the result of poor slope and sub-slope drainage, detailed hydrological studies of the catchments associated with landslides are essential. In the areas of complex landforms with water streams, springs and ill defined overland flow; radioisotope studies are often useful to map subterranean water flow while investigating the causative factors of a landslide.

For achieving the objectives of an investigation, the coupling between study of landslides through remote sensing and ground surveys should be logical and strong. Landslide investigation without remote sensing is often blind. By the same logic, landslide investigation without ground studies and validation is lame.

Landslides in meta-stable deposits of granular (sandy) nature, especially in the high rainfall areas, tends to liquefy due to seismic shock or external vibration. Similarly earthquake-induced landslides could be co-seismic or post-seismic.

Reference to geotechnical reports prepared for different civil and infrastructure development projects at or close to the location of a landslide will serve the triple purpose of consolidating the available body of geotechnical information, pinpointing the inconsistencies, inadequacies and gap areas and provide a cost-effective and sound basis for deciding the geotechnical scope of a landslide investigation.

Fig. 5.1: Triaxial Test apparatus for evaluating strength parameters

Fig. 5.2: Stress Path Triaxial Test System

Fig.5.3: Computer Controlled Consolidometer

Fig. 5.4: Laser Particle Size Analyser

Fig. 5.5: Computer Controlled Triaxial Test Equipment

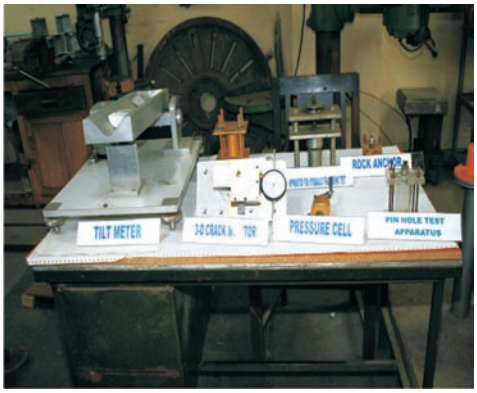


Fig. 5.6: Indigenous instruments (Tiltmeter, Crackmeter, Pressure Cells) for slope monitoring

Fig. 5.7: Triaxial Testing equipment for strength parameters of rocks

Fig. 5.8: Compressive strength test equipment for rocks

Fig. 5.9: Indigenous Open stand-pipe type piezometer

Fig. 5.10: Electrical Strain Gauge Equipment

Fig. 5.11: Use of bore hole camera to study bore wall

Fig. 5.12: Core logs used to identify and grade subsurface materials

SUB-MODULE 6: INSTRUMENTATION, MONITORING AND WARNING FOR LANDSLIDES

6.1 Slope Instrumentation, Monitoring and Landslide Prediction

Slope instrumentation for monitoring and prediction of landslide has so far not been a general practice in our country. A few attempts have been made by some institutions but the methodology and techniques as well as the results are not uniform. Thus, the efficacy of slope monitoring through instrumentation has remained a non starter**.** The detailed slope stability analysis and modeling of a landslide are almost impossible without instrumentation. Monitoring indicates acceleration of movement and development of pore pressures at different locations within the slide mass. Interpretation of data is difficult as critical values are unknown unless there is documented history of previous events. It is not practicable to monitor all the landslides by the installation of instruments considering the prohibitive cost and infinite landslide incidences in the country. The monitoring system of landslide can also be used for alerting the people about impending disaster.

6.2 Early Warning of Landslides

The Early Warning Systems elsewhere in the world have been developed by Real Time Automated Monitoring of landslide parameters. These include monitoring the movements, development of stresses, and pore pressures or hydrostatic pressures continuously and transmission of instrumental generated data through telemetric system at regular time intervals. At the initiation of an event, the radio signals are transmitted and alarm signals sent to the relevant authority regarding the probable time of occurrence and impending danger of the landslide. However, generating awareness and involvement of local communities is vital component of an early warning system. Therefore, for an early warning system to be successful it is necessary that local people are associated with it. In certain cases they, if properly trained and adequately motivated can observe the movement indicators on hill slopes and issue necessary warnings.

The Real Time Automated Monitoring for the development of an Early Warning System may be undertaken for a few devastating, large dimension and recurring types of slides or rock falls which are very difficult to stabilize

and pose high risk. Since the ultimate goal is to find out a permanent solution to stabilize the slide, the development of Early Warning System is not the ultimate answer to this natural hazard, but it is a part of the effort to mitigate its impact.

Considering the probable danger of loosing the instruments due to recurrent nature of some of the conspicuous landslides and prohibitively high cost of them, an effort may be made to develop the early warning system for those devastating landslides where instrumentation would be proposed as it will serve the twin purpose i.e. detailed slope stability analysis for suggesting the most appropriate remedial measures or development of an early warning system by real time monitoring of landslides. The experience gained from this type of exercise will be immensely helpful for studying other landslides.

6.2.1 Monitoring of Landslides

Monitoring of landslides movements consists of:

- Selection of specific location depending upon the type of movement, location and hazard and risk value of slope failure.
- Selection of monitoring methods and frequency of data collection.
- Data processing and methods of presentation / communication of results.

Methods generally used for monitoring landslide can be divided into surface and subsurface measurements of the landslide activity and total regime measurements.

6.2.1.1 Surface Measurements of Landslide Activity

Simple method of monitoring is installation of a few survey pillars within a landslide zone and on its periphery and linked with a few reference pillars installed on undisturbed and stable ground. Periodic observations of the relative position and top level of survey pillars particularly in pre, during and post-monsoon periods give a fairly good idea about the extent and rate of surface movement of the slide, amount of subsidence and also surface stress variations. The rainfall data, particularly the intensity of rainfall should be collected from the nearby rain gauge station and an effort may be made to correlate the intensity of rainfall data with time of initiation of the mobilization event. Measurement of cracks on surface of the slope and their development provides very useful input to slope stability analyses.

6.2.1.2 Subsurface Measurements of Landslide Activity

Subsurface measurements of landslide activity are carried out by installing different types of instruments in boreholes drilled at various identified locations. The shallow subsurface movements including creep are measured by installing flexible casings in boreholes and observing their behaviour; SGI rod Inclinometers; Kirby's T- pegs and Strain Probes. The movements at deeper depths are monitored through Chain Deflect meters, Single or Multi Drill hole Extensometers; Single and Multi Point Wire Extensometers; Pipe Strain Meters and Insert Type Pipe Strain Meters. However Slope Indicators and Inclinometers are most extensively used for monitoring the subsurface movements in landslides. Geophysical method of measuring pulse electromagnetic emissions identifies the zones of high stress concentration in the body of the slide. The measurements can be taken in the inclinometer boreholes.

6.2.1.3 Total Regime Measurements

The total regime measurements include recording fluctuations in the behaviour of ground water, which is most often the principal cause of sliding. The purpose of these observations is to record changes in ground water levels, yield of water and consequent development of pore pressure in the slide material. The behaviour of ground water in the slide area can be measured and monitored by installing piezometers at different depths in the boreholes. Of the various types of the piezometers, the Hydraulic, Pneumatic and Electrical Piezometers are most commonly used. Of late, Tensiometers are used for measurement of negative pore water pressure.

Recording rainfall is required to develop correlations between rainfall, slope movement and pore pressures in the slide mass and also impact of these on initiation of slide activity. The rainfall should be measured by installing automatic rain gauges at the slide location.

6.2.2 Real time Automated Monitoring of Landslide

Simple monitoring of landslides, with or without instrumentation, cannot detect changes at the time of initiation of the mobilization event while the real time automated monitoring of landslides can continuously pick up even minor changes enabling transmission of warning signal just at the time of initiation of a slide movement. The continuous data provided by real time automated monitoring through a remote station permits better understanding of dynamic behaviour of a landslide. With rapid advances made in electronics and communication technology, it has become possible to monitor the

behaviour of a landslide continuously and transmit data to processing locations on real time basis. All the instruments are connected to data loggers located in the vicinity of the sites being monitored. The data loggers are connected to data processing stations through telemetry systems that can transmit data to processing stations on real-time basis. The data thus obtained can be processed automatically and immediately by computers having necessary softwares. The results can be utilised for maintaining the records or for issuing warning as per requirements.

Recently, the remote sensing application tools, including High Resolution Satellite Imagery, Light Detection and Ranging (LIDAR), Synthetic Aperture Radar (SAR), Persistent Scatterer (PS), Synthetic Aperture Radar, Differential Interferometery techniques for the correlations between landslide morphology, motion and topographic analysis are used in some countries for landslide monitoring. It has facilitated predictive modeling and risk analysis of a landslide.

These and related studies demonstrate the rich potential of using new technologies for landslide studies. Clearly, the recent advances especially during the past two decades in remote sensing, digital image processing, GPS, and GIS have revolutionizing the study of landslides and improving the ability of the scientific and government agencies to monitor and manage landslide-prone areas. In particular, GPS can play an important role in monitoring landslide-prone areas for signs of current movement, and provide near real-time warning of motion on slides that can endanger life and property. With the advent of multi-antenna GPS instruments, the cost of monitoring by GPS has come down substantially. High resolution imagery and topographic mapping can lead to improved understanding of landslide mechanics and hazard prediction. Continued research into methods of data collection, processing, and synthesis is needed to realize the full potential of these technologies for worldwide use in the coming decades.

Real Time Automated Monitoring of landslide is not generally practised in India till date. As real time monitoring of landslide is a costly procedure involving high risk of losing the expensive instruments due to active nature of the slide, landslides having the potential to collapse catastrophically and threatening lives and property, should be identified and monitored on real-time basis.

6.3 Investigation of Surface Deformation

The investigation of surface deformation is conducted to define the boundaries of landslide, its size, level of activity and direction of movement,

and to determine individual moving blocks of the main slide. Presence of scarps and transverse cracks are useful for determining whether there could be future activity.

6.3.1 Instrumentation used for the surface deformation investigation includes extensometers, ground tiltmeters, movement determination by survey methods including transverse survey, grid survey, laser survey from the opposite bank, movement determination by aerial photographs, and G.P.S.provides an example of instrumentation.

a). Extensometer

The extensometer (Fig.6.4) is used to measure relative movement by comparing the extension of two points over a period of time. The extensometers are generally installed across the main scarp, at transverse crack and at transverse ridges near the toe or front portion of the slide and parallel to its suspected movement. By arranging a series of interconnecting extensometers from the main scarp to the toe of a complex landslide that has multiple slide blocks, the resulting data could aid in clearly delineating the individual block. Measurements should be accurate to within 0.2mm, and the magnitude of the movement and daily rainfall data should be included to establish the relationship between the measurable movement and the precipitation / infiltration.

b) Tiltmeter

The ground tiltmeter (Fig.5.6) is useful in determining the deformation at the head and the toe portions and sometimes along the flanks of landslide, or to assess the possibility of future deformation. A level type tiltmeter is most conventional. The tiltmeter is capable of measuring the N-S and E-W components The magnitude and directions of tilting can be determined directly. Furthermore, in order to determine the characteristics of the deformation, the results are shown chronologically along with daily rainfall totals. The relationship between the magnitude of tilting and the cumulative effect of tilting, rainfall totals and groundwater levels should also be plotted.

c) Differential Settlement Gauge (Fig.6.3)

d) Crackmeter (Fig.6.6)

(i) **Simple Method to Measure Movements**

One simplest method to determine landslide movement is to drive wooden stakes across a tension crack along the direction of slide movement. Then attach horizontal boards to the stakes, and saw through the boards. Any movement

across the tension crack can be determined by measuring the space between the sawed portions of the boards.

(ii) Determination of Movement by Surveying (Transverse Survey, Grid Survey, Laser Survey From the Opposite Bank of the hill, Movement Determination by Aerial Photographs, and G.P.S.).

Transverse Survey:

This survey method establishes transverse survey lines across the landslide blocks with closely-spaced survey stakes. The survey stations should be established both within the slide and outside it on stable ground.

Grid Survey:

This survey method involves constructing grid lines across the entire landslide as well as on stable ground, outside it. The survey stakes are driven at the intersection of the grid lines.

Laser Survey from the Opposite Bank:

A control point (Fig.6.14) is established along the opposite bank on stable ground, and survey stakes are positioned within the slide (Figs.6.8, 6.9, 6.10 & 6.13). It is most effective where movement in large.

Movement determination by Aerial Photographs:

For landslides with a large component of movement, aerial photographic determination extremely useful. An accurate movement can be measured by annual or bi-annual flying.

G.P.S.:

Global Positioning System is the state of the art technology that uses signals from satellites to determine the three-dimensional positioning of the slide. G.P.S. has been used in recent landslide investigations where high degree of success results (Figs.6.5, 6.11 & 6.12).

Automating Survey System

In the past, measurements of slope deformation were being performed manually. Recently, automatic survey systems using data loggers and computers have been adopted (Figs.6.15 to 6.18). The instrument set-up in the field has been so designed that it is easy to install, and is weatherproof, durable, maintenance-friendly and economical. Through remote control in real time and rapid geographical data processing, it is possible to store long term data accurately and effectively and provide an early warning of impending slide, thereby reducing landslide risk. Furthermore, taking benefit of the recent development

in the information based construction systems and adopting the safety control system using the real time at the construction site would facilitate the planning through construction stage.

There are three main advantages in using the **automated survey system**

i) Surveillance of the conditions of landslide failure: Issuance and cancellation of landslide watch and warning announcement based on the velocity of movement, piezometric pressure and variation in the quantity of rainfall. Prediction and forecasting of the landslide failure.

ii) Understanding of the conditions of the landslide deformation: Chronological measurements of movement velocity. Determination of the slide plane depth. Determination of the relationship between the slope deformation and factors of slide occurrence (pore water pressure against the slide plane, critical pore water pressure related to the time of sliding, rainfall and snowmelt).

iii) Effectiveness in determining landslide control works: Measurement of the amount of earth movement and pore water pressure. Measurement of the earth pressure affected by piles and collection wells. Determination of the effectiveness of construction.

6.4 Investigation of Geologic Structure

Mostly this is accomplished by exploratory borings; however in cases where the bedrock distribution is ambiguous or a better understanding of the regional geologic structure is needed, geophysical exploration (seismic and electrical surveys) is added to the boring data.

A) Borings

Majority of the borings are of NX (76mm) size. Core samples are recovered from the borings and are stored in core boxes. Core logs should be prepared along with photographs of the core sample and should include information on geologic and soil description; color; hardness; lithologic description; degree of weathering; alterations and fractures; strike and dip of bedding joints; boring conditions; initial and stabilized ground water levels; and rate of core recovery.

Geologic assessment based on the boring data obtained from the drilling site should include a discussion regarding the differentiation of moving earth blocks, semi-moving earth, and stable ground. Clays within the slide plane

generally have a high moisture content, are highly sticky and plastic and are often associated with abrasion scars and slickensides. During drilling, squeezed earth could occur near slide plane. Slopes where advanced relaxation of the bedrock formation has occurred will often exhibit gentler slopes than that of the unaffected bedrock zone. Formations can bend or form a kink bend near the lower limit of this zone, and could develop into a slide plane. In translational dip slope slides, the slide plane in many instances will develop along a thin, weak bed of mudstone, tuff bed or coal seam sandwiched between hard and competent beds. Borings can sometimes easily miss these thin beds. Therefore, the possible existences of slide planes along these weak beds typically consist of about 10cm wide/thick, and must be considered even though the boring may not indicate their presence.

Furthermore, using the data from the borings, the following information must be assessed or determined.

- Evaluation of slide plane
- Ground water level measurements
- Ground water logging
- Ground water tracer tests
- Standard penetration tests, Horizontal loading tests, In-situ tests such as in situ permeability tests
- Sampling for soil tests
- Geophysical logging

B) Geophysical Surveys

Geophysical surveys (seismic and electric surveys) aid in visualizing the subsurface conditions like dimension and nature of slide material, the lithology, structure and other geological characteristics of the enclosing rocks and the presence and extent of water bodies. In the seismic method, P-wave refraction technique is more commonly used than S-wave and P-wave shallow refraction techniques. P-wave refraction surveys are the most common seismic survey. Other methods, such as S-wave and P-wave shallow refraction, are seldom used. Electric survey is the specific resistance method and is applied to determine the distribution of aquifers and to understand the geologic structure. These surveys include the development of the geotomography method. In some countries, a natural radioactivity survey is used to determine the locations of small fracture zones and cracks.

6.5 Evaluation of Slide Plane / Monitoring of Sub-surface Movements

Determination of the slide plane for actively moving landslides utilize the fact that the rates of movement differ significantly along the slide plane. Depending on the need for surveying accuracy and magnitude of movement, the appropriate instrumentation is selected from the following representative instruments;

a) Pipe strain gauge
b) Inclinometer
c) Multi-layer movement meter
d) Other methods

a) Pipe Strain Gauge

P.V.C. pipes with strain gauges are inserted into the pre-drilled boreholes; the movement causes P.V.C. pipes to bend and their shift is estimated by the change in the strain. The accuracy of the strain gauge can be increased by reducing the intervals of the gauge, however, it is acceptable to widen the space upto 1m for investigations involving very thick slide materials and where it is difficult to handle the survey extension wires. The two lowest strain gauges must be anchored into the bedrock below the slide plane so that data of the stable formation is also obtained. Furthermore, annular space between the borehole and the pipe must be filled with concrete following the gauge installation. The instruments should last at least for one or two years

b) Inclinometer (Figs.6.1 & 6.2)

A grooved casing is inserted into the borehole extending into the bedrock formation, and adequate quality of grout placed into the borehole to assure positive contact with the borehole. By lowering a probe equipped with a tilt sensor, deformation in the casing can be detected and movement of a landslide determined. An accurate measurement is possible where the deformation of landslide is relatively small. As the landslide movement increases, the borehole and casing will bend making insertion of the probe difficult or will exceed the tilt detection limit of the instrument.

c) Multi-Layer Movement Meter

Several wires are anchored at different depths in a borehole and the attached wires must extend up to the ground surface. The magnitude of the displacement of each wire segment can be measured directly using a ruler. It is possible to install 20 to 30 wires per borehole. This method is not suitable for landslides

with small displacement and is most effective where the slide movement is so large that other instruments do not work. Applying the same principle, a vertical extensometer can be formulated by fixing a wire on the bedrock at the bottom of the borehole.

e) Other Methods

Other methods to evaluate the slide plane include: slide plane detection probe; creep wells; and sounding penetration test.

6.6 Groundwater Investigation

Investigation of ground water, which is a driving force of sliding, includes determining ground water level, pore water pressure, ground water logging, ground water tracing test, pumping test, water quality analysis, electrical and geothermal surveys, and geophysical (electrical and radioactive) loggings. Based on the results of the above measurements and tests, ground water control works can be planned, designed and put to use.

a) Ground Water Level Observation

As a general rule, ground water levels should be measured in all the boreholes. In some of the more important boreholes, continuous rainfall data should be obtained by installing automatic recorders to determine the correlation between the slide movement and rainfall and ground water level, and also collect data on the ground water distribution and its movement regime.

b) Pore Water Pressure

Ground water levels in boreholes will often reflect seepage from highly fractured formations or indicate the water level of a predominant aquifer. Therefore, for stability analysis, it is best to measure pore water pressure along the slide plane. Sometimes it is difficult to accurately estimate the depth of the slide plane. In such cases it is desirable to install piezometers (Fig.5.9) in the beds with low seepage or low shear strength. The standard piezometers for landslide investigations must be open piezometer water level type and should be durable.

c) Ground Water Logging

Flow of ground water and flow directions can be determined by computing the increase in specific resistance of ground water in flow over a period of time. The measurements should be continued after lowering specific resistance of ground water by injecting a salt solution into the borehole. There should be at least two borings for ground water logging at the head portion of the landslide where abundant ground water is expected. The measurement results should be recorded along with the boring logs, and the relationship between the

location of ground water flow and bed, and magnitude and variation of specific resistance of ground water should be discussed. Furthermore, the results of the analysis should be recorded along with the cross sections in order to understand the overall ground water flow.

d) Ground water Tracer Tests

Tracers such as a soluble dye, or inorganic chemicals (NaCl) are injected into a borehole. Water samples are then collected chronologically from springs, other boreholes, wells and ponds within or outside the landslide, and are analyzed for the tracer to estimate the ground water flow direction(s) and permeability. This data is used as basic information for developing the design of dewatering works.

e) Drawdown Test

In order to estimate the yield and to calculate the coefficient of permeability, water within a borehole is pumped to certain levels after raising the boring casing every 2 to 3m. A time-recovery curve can then be plotted using Jacob's and other formulae, and the coefficient of permeability can thus, be determined.

f) Water Quality Tests

Water quality testing is an effective way to examine the distribution of the ground water regime and flow directions where landslides are very large and the ground water system is expected to be complicated. Specific tests include determination of water temperature, Cl^{-}, SO_2^{-4}, HCO^{-3}, Na^{+}, K^{+}, Ca^{2+}, and Mg^{2+} content, pH, alkalinity, electric conductivity, SiO^2, and others. The test results are classified according to the analytical data and composition.

g) Geothermal Investigation

This procedure utilizes ground temperature measurements in the entire study area, including ground temperatures near the ground water veins. By measuring the temperature differences at non-ground water areas and near ground water veins, it is possible to isolate the ground water veins where the temperature difference between the two is large. By conducting the geothermal investigation in summer and winter months when near surface ground temperature is influenced by air temperature, good results have been obtained for the isolation of relatively shallow ground water.

6.7 Geotechnical Investigations (Soil and Rock Mechanic Tests)

In order to conduct slope stability analyses and to design appropriate control measures for landslides, physical properties such as strengths, location and

depth of slide plane and stable ground areas must be determined. The following tests are generally performed; physical tests, Standard Penetration Tests, soil and rock mechanic tests (unconfined compression, tri-axial compression, box shear, ring shear, and in-situ shear (along the slide plane)). In order to obtain the earth reaction coefficient for the design of the restraint works, there is currently a tendency to conduct more horizontal loading tests and plate loading tests to determine the modules of deformation. Furthermore, the intensity and degree of alteration of the slide plane clays are evaluated by X-ray diffraction methods. The results have also been applied to analyze the origin of the slide plane.

6.8 Early Warning Systems for Landslides

In a holistic sense, the term early warning includes the whole range of actions and operations right from stages of planning and instrumentation of problematic slopes and landslides to their monitoring, analyses, fixing of early warning alert thresholds, decision making, dissemination of early warning alerts and recurring improvements in early warning practice through sustained location-specific feed backs and new researches. The impacts of these landslides can be mitigated or minimized, if the communities threatened by them, are forewarned about impeding disaster and are prepared to face them.

There are no standard ready-made packages or systems for early warning but all the instrumentation, tools, equipment, observation and data processing systems are available in multiple choices. They are necessarily to be fashioned to suit a particular slope or a landslide according to its type, magnitude, hazard potential and the purpose of early warning alert. The hazard detection and early warning systems for different types of landslides are usually different. For example, planning for instrumentation and early warning for a pre-existing (repetitive) landslide will be different from the schemes for early warning against anticipated first time landslides. Likewise early warning schemes for mass movements such as a debris flow or a rock fall will be different from those for a block slide or a classical landslide with discrete boundary shears. The task of evolving early warning system in a given situation, will necessarily have to be assigned to experts.

An early warning is a process which involves three components:

Scientific & Technical Communities: These are responsible for studying and monitoring natural events to provide models, which can be used to forecast events in terms of intensity, time, and geographical span.

Government Authorities and Civil Agencies: These are responsible for establishing operations, frameworks related to preparedness and response in case of events.

Local Communities: The local communities must understand the nature of the hazards, their possible intensities and ranges, and react according to existing guidelines provided by the institutions identified by the authorities.

People- centered early warning systems empower the communities to prepare for and confront the fury of natural hazards. These bring safety, security and peace of mind to people. The effective early warning systems can provide resilience to natural hazards and protect economic assets and developmental gains.

A complete and effective early warning system comprises four inter-related elements:

- Risk knowledge: Prior knowledge of risk faced by communities.
- Monitoring and warning service: Technical and warning services for these risks.
- Dissemination and communication: Dissemination of easy to understand warnings to those at risk
- Response capability: Knowledge, awareness and preparedness to act

A weakness or failure in any one of them could result in failure of the entire system.

There is a notion among non-professionals that early warning systems for slope failures and landslides are always sophisticated and expensive. The fact however is that in many situations, simple, inexpensive and easily perceptible or measurable indicators can provide premonition of an impending slope failure. Monitoring of rainfall, surface and subsurface slope movements, slope subsidence, slope heave, development and widening of cracks, tilting of trees and poles, sudden oozing out of water or drying of water springs, sub slope piping, under slope erosion, sudden fall of boulders, cracking of building floors etc. often provide irrefutable evidence of unsatisfactory slope behaviour. Randomly picked isolated observations of this kind do not convey much but when all such evidence are collected, analysed and synthesized, early warning alerts do not remain a fantasy.

Simple devices commonly used for early warning against landslides in the past are (1) wire or special switches, actuated by the pressure of moving debris

coupled to a decision-support system that release early warning alerts (2) electrical switch poles – which turn to an upright position upon displacement (3) photo-electrical barriers, especially for a rapidly moving debris flow or earth flow (4) pulsed radar for snow avalanches (5) fiber optic sensors and technology (6) acoustic emission technology (7) auto-actuated photographic systems and (7) GPS observations.

While the capabilities exist at global level to identify areas of occurrence of landslides, the capability of predicting as when these would occur is still developing. The signs of impending landslide can often be detected at an early stage and used for warning the affected communities. The time of landslide occurrence is possible to predict provided the slopes are monitored continuously. Advances in monitoring technology, particularly in real time transmission of information have helped in developing the technique of short- term prediction. More examples of same are rare. Best instance of this is an early warning system established for Yangtze River valley in China that monitors using 70 stations employing over 300 professionals. The network protects a population of 300,000 and so far has forecast 217 landslides and avoided estimated economic losses of US$ 27 million.

Remote sensing, the Global Positioning System (GPS), and Geographic Information Systems (GIS) are now mature and robust technologies that can be used to monitor landslides and landslide prone areas with greater accuracy than could be accomplished previously with field reconnaissance alone. Recent studies that have used these tools, including high-resolution satellite imagery, light detection and ranging (lidar). High resolution imagery and topographic mapping can lead to improved understanding of landslide mechanics and hazard prediction. Continued research into methods of data collection, processing, and synthesis is needed to realize the full promise of these technologies for global use in the coming decades.

Radar is one of the outputs of technological advances that can be used in monitoring the landslide effectively. Radar can be used for monitoring of avalanche movement, detection of crevasses, measuring the thickness of snow on the roads to facilitate their clearance and aiding search of avalanche victims.

Recent developments in remote sensing of weather information have provided the capability for more timely and spatially accurate assessments and warnings of weather-related hazards. Remote sensing of rainfall using Doppler Radar and Infrared Satellite sensing (DrISS) can provide information on rainfall with a spatial and temporal resolution that is potentially useful for near real-time

landslide hazard assessment and warning. Thresholds of rainfall intensity and duration for triggering of landslides have been developed for many regions worldwide using ground-based rainfall measurements and documentation of landslides. Rainfall thresholds have been applied for regional real-time landslide warning system. However, techniques for analyzing the temporal variation in slope stability on a local scale during the course of a storm with interval rainfall input are being developed now. The automatic weather station developed by ISRO can also be deployed in remote areas for collecting meteorological details and transmitting them through the different networks like VSAT, VPN etc.

A great majority of dormant landslides often turn active and become catastrophic during monsoon seasons and high intensity short duration rainfall events. The short term observation on rainfall is enough to underscore the importance of reliable and continuous rainfall measurements and real time analyses of rainfall data and should be arranged preferably at all major landslide sites. Rainfall information will be utilized for developing indicators for landslide alert especially for high landslide hazard areas prone to high intensity short duration rainfalls. For example, the eastern Himalayan region gets very heavy monsoon rainfall punctuated with occasional cloud bursts where the rainfall intensities are in the range of 300mm to 1000 mm/day (the more the intensity, the lesser is its duration). One study developed on this observation in 1980s led to linking of landsliding with the corresponding rainfall event coefficient (ratio of the rainfall of an event to the mean annual rainfall at the location). The findings revealed that event coefficients exceeding 20 % will trigger heavy landslide at all times. Very high probability of landslides was projected where event coefficients are10-20%. The probability of landslides was rated very low when the event coefficient fell below 5 %. The above inference is suggestive of the nature of advanced studies to be undertaken. It is important to encourage such studies and make them more scientific and systematic. Statistical correlation between rainfall and corresponding slope surface, subsurface movements, development of pore water pressure measurements within the slope, provide good insight into the slope behaviour.

Early warning thresholds for a well studied seasonal (repetitive) rain-induced landslide on discrete boundary shears with known pore pressure variations on the slide boundaries are extremely reliable. Such early warning thresholds usually take advantage of the unique, linear relationship between factor of safety (in terms of effective stress) and the pore water pressure (considered in terms of ratio). Since inter-relationships between rainfall intensity, slope surface and sub slope movements and pore pressures provide powerful means for reliable landslide forecasting, studies for these will be encouraged. Rainfall

and the associated slope behavioural information will be utilized for developing indicators for landslide alert especially for high landslide hazard areas known to succumb to high intensity short duration rainfalls. In cases where no such information is available, a warning of a general nature and low reliability may still be possible through study of rainfall records in the back drop of the previous landslide history.

Prediction of landslides is possible and research and development work on it deserves to be encouraged. Attempts to predict landslides have so far been based on time-dependent displacement behaviour of slides, generally in the tertiary stage of tertiary creep. Increasing availability of high-resolution geospatial maps and powerful slope instrumentation techniques can make real-time prediction of landslides possible.

Based on available information inputs when a decision for early warning is taken, the early warning dissemination strategy will be same as the one prescribed for other disasters. Operations such as post early warning interfacing with communities, press and media are common to all types of disasters. Integrated early warning dissemination systems will be evolved.

Even with the best of early warning systems, results will still be catastrophic if early warning signals are not properly interpreted and communities are not educated and trained on how to respond to the early warning alerts in real time. There should be an easily understandable manual clearly bringing out what is to be done when an early warning system flashes such an alert. Quite often the early warning alert may be lost in panic and confusion, if people are not aware of the response that must follow such alerts.

Studies are being carried out in many countries to establish the correlation between the intensity of rainfall and initiation of slides in different regions. Once threshold values of rainfall which will initiate landslide in a particular area, same can be the basis to issue early warning if the amount of rainfall in that particular area can be forecast. The correlations can be established with the help of past records as well as recent monitoring. In our country, IMD and NCMRWF are believed to have developed the capability to forecast the amount of rainfall an area is likely to receive 3-5 days in advance. Collaborative efforts in this field should be pushed. Depending on the success of this study, some more landslide prone areas may be selected for developing the early warning system.

Public response to a forecast is another difficult area. If the people are not educated, they may interpret the same forecast differently. If not fully aware of the lethal consequences, they will generally take warnings lightly. Disaster education must eliminate such possibilities.

6.9 Dissemination and Communication

Dissemination and communication mechanisms, as far as early warning systems are concerned, must be operational, robust and available round the clock. These should be designed to the needs of a wide range of threats for user communities. The dissemination of the information must be based on clear protocols and procedures and supported by an adequate telecommunication infrastructure. At the national level, effective dissemination and communication mechanisms are required to ensure timely dissemination of information to the authorities and communities at risk even in the most remote areas of the country. Each area may require different technological infrastructure to allow effective dissemination of messages. To ensure that all systems work smoothly in tandem, they will be based on internationally agreed standards.

At the national level, the effectiveness of warnings depends on their timely and effective dissemination to all at risk, not only through operational telecommunication systems but also through non-technical social networks. The latter is very important in poor communities that lack technologically advanced communication systems. Effective dissemination requires the establishment of a chain of command, in advance, in order to manage warning issuance and dissemination and ensure that the information is understood by those who need it and reaches all affected locations in the country. It is all the more important in case of landslides as they are localized events and can occur in remote locations.

A typical warning dissemination chain involves channeling warnings from technical and scientific sources through government decision makers and the media to multiple receivers who may also function as onward disseminators. Such users include emergency services, security agencies, operators of utilities, information and communication services, other economic service providers, NGO's, voluntary agencies and vulnerable communities. In a system with integrated disaster management structures, the principal agencies responsible for issuing warnings and the processes for their issuance will be established by prior agreement. Various players are involved in generating warnings, including those in private sectors as in developed countries and civil defence in others. To be effective, early warning activities must cover all relevant areas in the country equally. In order to reach all those who need to take action, there is a need to design warnings for particular groups of stakeholders, such as different language groups, people with disabilities, and tourists. Public broadcast media remains the most widely used mode worldwide. The better systems for warning dissemination are those which are used in daily life and with which the users are most familiar. The role of community-based and grassroots organisations, as well as NGOs and other players, in disseminating warnings are pivotal.

Fig. 6.1: Inclinometer used for monitoring subsurface displacement

Fig. 6.2: Inclinometer installed to identify depth of slip surface

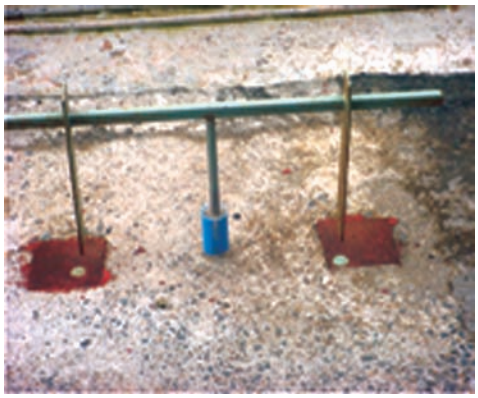


Fig. 6.3: Differential settlement Gauge for monitoring vertical movement

Fig. 6.4: Piped Wire Extensometer for measuring slope displacement

Fig. 6.5: Geodetic surveying for studying spatial movements in slopes

Fig. 6.6: Crack meter to study crack propagation and extension

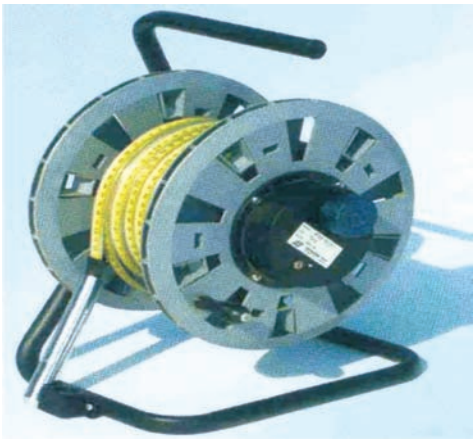


Fig. 6.7: Water Level Indicator

Fig. 6.8: Peg markers used for monitoring slope movements

Fig. 6.9: Total station with GPS and Prisms for slope monitorimg

Fig. 6.10: Slope stability radar

Fig. 6.11: Total Station, GPS and Prisms

Fig. 6.12: Hand held GPS and Total Station

Fig. 6.13: Reflecting stickers used to monitor surficial slope displacements

Fig. 6.14: Permanent station used to monitor movement using peg markers

Fig. 6.15: Solar panels used for power supply in automated monitoring system

Fig. 6.16: An automated landslide monitoring with recording system

Fig. 6.17: Remote Realtime Automated Monitoring System for landslide

Fig. 6.18: Video Camera and Landslide Alert system with power backup

SUB-MODULE 7: LANDSLIDES REMEDIATION

7.1 Landslide Remediation Practices

A comprehensive risk management strategy requires systematic approach in planning and implementing concepts and measures. The risk management comprises pre-disaster prevention strategies and post-disaster management. The pre-disaster strategies include assessment of the hazard, analysis of risk through documentation of existing events, hazard zonation mapping and application of modern techniques that can help in preventing the activation of dangerous process. Comprehensive Hazard Zonation aims at preventing settlements, infrastructural elements to be located in vulnerable areas and also prescribing, to some extent, the appropriate treatment measures required at vulnerable locations.

Remediation practices, including slope geometry correction, providing protection at the toe of slope by retaining structures, management of the surface and subsurface water including development of pore pressures, nailing, bolting, anchoring, micro piling, application of geo-grids and geo-textiles and afforestation, constitute powerful elements of most geotechnical packages commonly used for improving stability of problematic slopes and landslides in India.

In our country, most landslides occur during the monsoon period barring a few which owe their origin to earthquake. Pore water pressure plays a major role in initiating landslide events. There are also instances where toe erosion by rivers or nalas and scouring of hill slope due to high velocity discharge of streams descending from the crown of the landslide gives rise to debris flow/slide. Hence, surface and sub-surface water management on the slopes or in the catchments is the most effective remediation measure for many landslides. Management of surface runoff and subsurface water is done through the development of drainage networks. Subsurface drainage management is hardly practiced in our country for stabilization of landslides. This aspect of landslide stabilization calls for immediate attention and the agencies like BRO, PWDs etc. engaged in slope stabilization activities must be well equipped with the modern technology to construct subsurface drainage network.

Reinforcing technologies like nailing, bolting, anchoring and tie back have provided apt solutions to bewildering varieties of civil and mining engineering

problems. Numerous successful examples of stabilization of problematic slopes, landslides, open cast mines, tunnels, road cuttings etc., bear ample testimony to the great potential, the reinforcing technologies hold.

It is however, somewhat disappointing that the technological interventions in many cases have not always been quite sensitive to the real needs of the specific sites. There have been very little technological innovations in the area of landslide control in India. Research and development in the technological interventions by some knowledge based institutions or organizations in our country may be the only answer to overcome these shortcomings.

Already distressed slopes require immediate remediation. Landslides can be triggered by various factors like excessive rainfall, earthquakes and interference by man. Besides shallow erosion or reduction of shear strength caused by seasonal rainfall, the anthropogenic activities such as adding excessive weight above the slope, carrying excavations on the slope or at the foot of the slope resulting from developmental activities contribute towards large scale occurrence of landslide. However, some times different factors combine together to generate instability and in many cases these appear after some time. Many a times, it is not possible to reconstruct the evolution of the landslide process except in cases where site is well-instrumented. It may also be mentioned that it is nearly impossible to stabilise a failed slope until its morphology is well understood, causes responsible for inducing instability determined and the resultant risk assessed, analysed and adequately addressed. This can be achieved through detailed geological and geotechnical investigations. Therefore, it is necessary to conduct detailed investigations for planning remediation measures, as the extent and nature of stabilisation to be implemented will depend mainly on the results of the detailed investigations carried out at the affected site.

Depending upon the nature and purpose of work, degree of risk, cost effectiveness of remediation measures, the slope stabilisation methods generally include works involving modifications of the natural conditions of landslides such as topography, geology, ground water, and others that indirectly control portions of the landslide. These include drainage control works, soil/ debris removal works, buttress fill works and river training works

The drainage works comprise surface and sub-surface drainage works. The surface drainage control works are implemented to minimize the infiltration of rain water that builds up pore pressure. The surface drainage control works include drainage collection works and drainage channel works. The surface

drainage measures comprising lined catch water drain above the crown of a slide, lined contour drain on different levels of the slide mass, lined cascading chute drain are provided to intercept and divert rain water from the upslope and slide surface and to reduce infiltration and development of pore water pressure substantially. The purpose of the subsurface drainage control works is to remove the ground water within the landslide mass. The subsurface drainage control works include shallow and deep subsurface drainage control works depending up on the nature of the slide. The sub-surface drainage works may include intercept under drains, interceptor trench drains, horizontal gravity drains, drainage wells and drainage tunnels.

Soil/ debris removal works comprise these treatment measures that yield most reliable results and generally can be expected to be very effective in respect of small to medium sized landslides. The soil/ debris removal or offloading of the slide mass is generally undertaken from the crown portion downwards and depending on the properties of the material, benches or berms are created at appropriate intervals.

In case of fill works, buttress fill is placed at the lower portions of the landslide as counterweight to the landslide mass. It is very effective if the removed soil is used.

Scouring and erosion of channel bank or toe of a slope reduce the stability of the slope and often tends to induce slide activity. In such cases, check dams and bank protection can be erected to prevent further erosion. If required, deflection spurs are provided on the upstream of affected slope.

Provisions of restraining structures rely directly on the construction of structural elements with a view to improve the stability of sliding mass. These include pile works that act as keys to tie together the moving landslide and the stable ground to restrain the movement, the anchors and bolt works utilise the tensile force of anchor bodies embedded through the slide mass and into stable earth and construction of retaining and breast walls to prevent small and secondary landslides that often occur along the toe portion of larger landslides.

Once treatment measures have been implemented on a landslide, the treated slopes are required to be protected against the effects of atmospheric elements like rain, snowfall etc. This requires minimizing direct exposure of the treated slope to the atmospheric agencies and can be achieved by providing a protective covering to the treated slope. The common practice is afforestation that not only provides effective covering to the slopes but also improves the shear

strength of the material through network of plant roots. Vegetation can also be directly used to help stabilize slopes using biotechnical methods, commonly referred to as slope bio-engineering. These methods, originally pioneered in Europe, involve aggressive planting of carefully selected varieties and the construction of engineered structures using live materials whose strength will increase in time. Vegetation can also be effective on steep slopes, where it intercepts precipitation and reduces both runoff and excessive infiltration.

Shotcreting with or without a chain link fabric wire-mesh is very effective in protecting slopes with weathered rocks. Drainage holes can be provided along with shotcreting. Covering the slope surface with geo-fabrics made of natural as well as synthetic material is also commonly used in slope protection works.

Table 7.1: A brief list of landslide remedial measures

A	**Modification of Slope Geometry**
•	Removing material from the area driving the landslide (with possible substitution by lightweight fill)
•	Adding material to the area maintaining stability (counterweight berm or fill)
•	Reducing general slope angle
•	Slope stitching using timber or cement concrete (Figs.7.1, 7.2 & 7.18)
B	**Drainage**
•	Surface drains (Figs.7.13 to 7.15) to divert water from flowing into the slide area (collecting ditches and pipes); Example French Drains (Fig.7.53)
•	Shallow or deep trench drains filled with free draining geo-materials (coarse granular fills and geo-synthetics)
•	Buttress counterforts of coarse grained materials (hydrological effect)
•	Vertical (small diameter) boreholes with pumping or self draining
•	Vertical (large diameter) wells with gravity draining
•	Sub-horizontal or sub-vertical boreholes
•	Drainage tunnels, galleries or adits
•	Vacuum dewatering
•	Drainage by siphoning
•	Electro-osmotic dewatering
•	Vegetation planting (hydrological effect)

C	**Retaining /Restraining Structures**
•	Gravity retaining walls
•	Crib block walls (Fig.7.18)
•	Gabion walls
•	Passive piles, piers and caissons
•	Cast in situ reinforced concrete walls
•	Reinforced earth retaining structures with strip/sheet polymer/metallic reinforcement elements/geosynthetic and geotextiles (Figs.7.3, 7.4, 7.6, 7.44 & 7.45)
•	Buttress counterforts of coarse grained material (mechanical effect)
•	Retention nets/meshes for rock slope faces
•	Rock fall attenuation or stopping systems (rock trap ditches, benches, fences and walls)
•	Protective rock/concrete block against erosion
•	Drum Diaphragm Wall or Tyre Walls
D	**Internal Slope Reinforcement**
•	Rock bolts
•	Micropiles
•	Soil nailing
•	Anchors (prestressed or not)
•	Grouting
•	Stone or lime/cement columns
•	Heat treatment
•	Freezing
•	Electro-osmotic anchors
•	Biotechnical measures like planting vetiver grass or using jute/coir mats
•	Mulching

7.2 Mass Improvement Techniques

The stabilisation of hill slopes can be achieved by improving the mechanical characteristics of the potentially unstable ground. It has the following two different approaches:

- Insertion of reinforcement elements in the ground
- Improvement of the mechanical characteristics of the ground through chemical, thermal or mechanical treatment

In measures for slope protection, the reinforcement technology has found wide application. This can be achieved by installation of large diameter wells supported by one or more crowns of consolidated and possibly reinforced earth columns, anchors, networks of micro piles, nailing and grouting with cement or chemical grouting depending upon the properties of the material.

The improvement of mechanical characteristics of the ground can also be achieved through thermal treatment of potentially unstable hillsides made up of clayey materials or by using electro-osmotic treatment in case of homogenous clayey ground.

7.3 Mitigations methods for various types of landslide hazards

The simplest means of dealing with landslides is to avoid construction on steep slopes and existing landslides. However, this is not always practical. Regulating land use and development to ensure that construction does not reduce slope stability is another approach. In cases where landslides affect existing structures or cannot be avoided, physical controls can be used. In some cases, monitoring and warning systems allow residents to evacuate temporarily during times when the probability of landslide activity is high.

7.3.1 Physical Mitigation Methods for Slides & Slumps

1. Drainage

a. Surface drainage (Figs.7.13 to 7.16)

i. Ditches
ii. Regrading (Fig.7.59)
iii. Surface /crack sealing (Fig.7.48)

b. Subsurface drainage

i. Horizontal drains (Figs.7.7 & 7.8)
ii. Vertical drains/Wells (Figs.7.11 & 7.12)
iii. Trench drains/interceptors, cut-off drains/counterforts (Fig.7.10)
iv. Drainage galleries or tunnels (Fig.7.9)
v. Blanket drains
vi. Electro-osmosis
vii. Blasting
viii. subsurface barriers

2. Excavation or Regrading of Slope

a. Total removal of landslide mass
b. Regrading of slope

c. Excavation to unload the upper part of landslide
d. Excavation and replacement of the toe with other material

3. Restraining Structures

a. Retaining walls (Figs. 7.19, 7.20, 7.23, 7.25 to 7.30)
b. Piles
c. Buttresses and counterweight fills (Fig.7.19)
d. Tie rods and anchors (Fig.7.57)
e. Rock bolts/anchors/dowels

4. Vegetation (Fig.7.60)

5. Soil Hardening

a. Chemical treatment
b. Freezing
c. Thermal treatment
d. Grouting

7.3.1.1 Site leveling

Smoothening the topography of slide surface can prevent surface water from ponding or connecting with the ground water. Any depressions on the slope that might retain stagnant water must be removed. Infilling and sealing large cracks in the soil surface by grading the soil mass are beneficial and prevent surface water from reaching the failure plane.

7.3.1.2 Drainage Techniques

Ground water is the most important single contributor to landslide initiation and its continuation. Not surprisingly, therefore, controlling drainage is the most effective element of slope stabilization scheme, for both existing and potential landslides. Drainage is effective because it increases the stability of the soil and reduces the weight of the sliding mass. Drainage can be either surface or subsurface. Surface drainage measures require minimal design and costs and have substantial stability benefits. They are recommended on any potential or existing slide.

The two objectives of surface drainage are to prevent erosion of the face, reducing the potential for surface slumping, and to prevent infiltration of water into the soil, thereby reducing ground-water pressures. Subsurface drainage also is effective but can be relatively expensive. It is therefore essential that ground water be identified as a cause of the slide before subsurface methods are developed. The various methods of drainage are:

7.3.1.3 Ditches and drains

Surface drainage can be either through surface ditches or shallow subsurface drains. Surface drainage is especially important at the head of the slide, where a system of cutoff ditches that cross the headwall of the slide, and lateral drains to lead runoff around the edge of the slide are effective. Ditch gradient should be at least 2 percent, to ensure rapid flow away from the unstable area.

The simplest type of subsurface drain is the lateral trench constructed above an unstable slope. Drainage trenches are economical only for shallow soils overlying bedrock or hard impermeable till. The trenches should be excavated up to the base of the shallow soil to intercept any ground-water flow along the failure plane. They are backfilled with coarse gravel to prevent sloughing of the ditch sidewalls. It is more useful if drainpipes are now and then backfilled with coarse gravel.

7.3.1.4 Drainpipes

Horizontal drainpipe is a widely used measure for landslide prevention in highway construction. It is most effective when installed during initial excavation. Because of the long lag times in lowering of ground-water tables, the drains are effective only if the pipe is carefully installed, failure surface intersected, and the pipe actually drains the soil. As most slopes have varying soil and hydraulic and geometric conditions, drainage systems must be individually designed. After drilling has been done up to the desired depth and the casing installed, the latter is cleared of soil, and sections of slotted PVC drainpipe are covered with filter cloth, and pushed into the casing and coupled together. The casing is then withdrawn and screen is installed over the end of the drain. Drain holes must be thoroughly cleaned of drill cuttings and mud. Uncleaned holes may be only 25 percent effective.

In clay soils, the full change in ground-water tables can take up to 5 years, with 50 percent improvement taking place in the first year. Once water tables are lowered in clay soils, the change is fairly permanent; however, seasonal fluctuations can occur: rainfall will not alter the ground-water level in the slope provided the drains do not clog. In sandy soils, the water table will lower within a few months, but will fluctuate with rainfall.

7.3.1.5 Straw wattles and straw bales

Straw wattles, also known as straw worms, bio-logs, straw noodles, or straw tubes, are fabricated cylinders of compressed, weed-free straw

(wheat or rice), 20 to 30 centimeters in diameter and 7 to 9 meters long. They are encased in jute, nylon, or other photodegradable materials and have an average weight of 16 kilograms. They are installed in a shallow trench forming a continuous barrier along the contour (across the slope) to intercept water running down a slope. Straw wattles should be effective for a period of 1 to 2 years if they can be installed on slopes up to 70 percent; however, their effect diminishes greatly on slopes steeper than 50 percent. Soils can be shallow but not less than about 8 inches. Straw wattles increase infiltration, add roughness, reduce erosion, and add short-term protection on slopes where permanent vegetation will be established to provide long-term erosion control. Straw bales, easily obtainable in most areas of the world, are portable, and have a modular-type application for slope erosion and drainage control.

7.3.1.6 Retaining Walls

For all types of retaining walls, adequate drainage through the structure is essential because very high ground-water pressure can build up behind any retaining wall, leading to its failure. Drainage can be provided simply with a coarse backfill and foundation material.

7.3.1.6.1 Timber crib

Timber crib walls (Fig.7.18) are box structures built of interlocking logs and backfilled with coarse aggregate. They work by intersecting the critical sliding surface, thus forcing the potential failure surface to a deeper, less critical depth. The structure must be able to withstand: (1) shearing, (2) overturning, and (3) sliding at the base. It must, therefore, be strongly built by burying to sufficient depth and extending beyond the critical failure plane. Crib walls are only effective where the volume of soil to be stabilized is relatively small. They are most efficient where a thin layer of unstable soil overlies a deeper, more stable layer of soil. Crib wall structures' volume should be 10 to 15 percent of that of the soil to be stabilized. This relatively small volume provides little counterweight support at the toe; therefore, virtually the entire resistance to failure comes from the strength of the crib.

7.3.1.6.2 Steel bin wall

A steel bin wall is made from corrugated galvanized steel components bolted together to form a box and then filled with earth. The stability of a gravity wall is due to the weight of the wall itself, perhaps aided by the weight of soil

in front of the wall. The bulk of the weight is from the contained soil, not the steel, and this should be kept in mind when the foundation is prepared. Large walls must be individually engineered, with load and foundation requirements calculated. Structural and civil engineering design charts provide stringer (horizontal member) specifications and height-to-width ratios for typical loading conditions. The widths of walls vary from 2 to 5 meters and are one-half to three-fifths the height of the wall. To provide additional sliding resistance, the foot of the wall is usually 0.5to 1.0 meter below grade, although the design should not rely on the additional toe support, as it can erode or be removed inadvertently. The factor of safety is improved if the wall is at a 1:6 slope. Fill material must be well drained and compacted, preferably in 20-centimeter lifts. Material behind the wall also should be well drained and moderately compacted.

7.3.1.6.3 Reinforced earth wall

Reinforced earth is a patented system for constructing fills at very steep angles to vertical without the use of supporting structures at the face of the fill. The system uses horizontal layers of flexible metal strips within the fill to form a composite earth-metal system with high strength.

7.3.1.6.4 Gabion walls

Gabions are wire mesh, boxlike containers filled with cobble-sized rock that are 10 to 20 centimeters size. A gabion retaining wall (Figs.7.13, 7.25 & 7.28) can also be constructed from stacked gabions. Gabion walls usually are inexpensive and are simple and quick to construct. Due to their flexibility, they can withstand foundation movement, and they do not require elaborate foundation preparation. Because of their coarse fill, they are very permeable and thus provide excellent drainage. Gabion walls work because the friction between the individual gabion rows is very high, as is the friction between the basal row and the soil underneath. When failure occurs, it is almost always in the foundation soil itself. Three-tiered walls up to 2.5 meters high can usually be constructed without consulting any detailed engineering analysis. Higher walls are very heavy by nature due to their added bulk and need larger base foundations and possibly counterforts for bracing of the wall. (A counterfort is a buttress bonded to the rear of walls, and is designed to improve stability). Gabion walls built on clay soils require counterforts, which can be constructed as gabion headers extending from the front of the wall to beyond the slip circle. The counterforts serve both as structural components

and as drains. Design charts are available for various combinations of hillslope angle and retaining-wall height.

7.3.1.7 Piles

Large-diameter piles can be placed into the toe of a slope to form a closely spaced vertical pile wall. Pile walls are normally used as a pre-excavation restraint system—the cut slope excavation takes place in front. Whereas large-diameter concrete pile and culvert pile walls have been used successfully on highways, wood or steel piles that are small in diameter are not. For most earth or rock movement, wood piles are not adequate to provide enough shearing resistance. They are suitable only where the volume of soil to be stabilized is small. On average, one wood pile is necessary for every 50 cubic meters of soil, which is not sufficient for large stabilization projects. Too few piles can result in toppling and (or) breakage by the moving mass of soil, as well as by soil movement between the piles.

A major limitation when log piles are used is depth, as many failure surfaces lie below the height of the piles. Wood piles are the best for treating shallow soil failures over deeper stable soils. The piles should extend well below the potential failure surface and be firmly driven into firm subsoil. If the depth of placement is not sufficient to allow the piles to act as a cantilever system, then the piles must be tied back with an additional anchor system.

7.3.2 Debris-Flow Mitigation

This section describes some simple mitigation methods for debris-flow hazards for homeowners, business plans, and others. A short section on erosion and fire control is also included since erosion, fire, and subsequent debris flows and flooding are interrelated hazards.

Physical Mitigation Methods for Debris Flows and Debris Avalanches

1. **Source-Area Stabilisation**
   - a. Check Dams (Fig.7.17)
   - b. Revegetation
2. **Energy Dissipation and Flow Control**
   - a. Check Dams (Fig.7.42)
   - b. Deflection Walls
   - c. Debris Basins (Fig.7.40)

d. Debris Fences (Fig.1.53)

e. Deflection Dams

f. Channelisation

3. Direct Protection

a. Impact spreading walls

b. Stem walls

c. Vegetation barriers

7.3.2.1 Check Dams

These are small, sediment-storage structures built in the channels of steep gullies to stabilize their l bed. They are commonly used in Europe and Japan to control channelized debris-flow frequency and volume. A less common use of check dams is to control raveling and shallow slides in the source area of debris slides. Check dams are expensive to construct and therefore are usually built only where important installations or wildlife habitat, such as a camp or unique spawning area, lie downslope. Channelized debris flows are associated with channel gradients over 25 degrees and obtain most of their volume by scouring the channel bed. Check dams serve three main purposes when installed in the channels:

- mitigate the incidence of failure by reducing the channel gradient in the upper channel.
- reduce the volume of channel-stored material by preventing down cutting of the channel with subsequent gully sidewall destabilization and by providing toe support to the gully slopes.
- store debris-flow sediment, when installed in the lower part of the channel.

When installed on debris slides, the dams store raveled material, which eventually creates small terraces on the slide, reducing the surface slope. Check dams can be constructed of reinforced concrete or of log cribs. Concrete mortared rock dams do not usually exceed 8 m in height, whereas log crib dams must not exceed 2 m. The spacing of dams depends on channel gradient and dam height. For example, a 2-m high dam in a 20-degree channel with 10-degree sloping channel infill will be spaced every 12 m. Lateral stream erosion and scour by spillway water are the main drawbacks.

How to prevent check dam failure

During construction, the concrete wing walls and log crib ends must be tied securely into the canyon wall and streambed to withstand backfill pressures and lateral scour. Wing walls should slope at about 70 percent and extend a minimum of 1–2 meters into the banks. The foundation of the dam should have a minimum width of one-third the total height of the dam and be deeper than any scour holes likely to develop.

Backfilling the dam, rather than allowing it to fill naturally, reduces the dynamic loading on the structure and results in a more stable design. The slope of the backfill should be less than one-half the channel gradient. Dams that have been back-filled will usually survive a debris flow; the backfill material will not be scoured during or after a torrent.

7.3.2.2 Strengthening Slopes for Erosion/Debris Flows

Erosion may cause the steepening and lengthening of gullies and resulting in loosening of soil, plants, rocks, and boulders, which can intensify the effects of debris flows. Keeping an area free of excess fuel for fires can also help in the mitigation of debris flows, as burnt slopes become more vulnerable to the effects of debris-flow initiation and erosion. Loss of vegetation that holds soil in place and physical and chemical changes to the soil that result from intense heat and burning by fires make this soil more prone to debris flows.

7.3.2.3 Debris-flow basins

These catchment basins are commonly built at the base of slopes where debris flows are frequent. They are used especially in areas where the debris must be contained so that soil and debris are stopped from flowing into sensitive ocean or river shorelines areas or where there are structures at the base of the slope that are vulnerable to debris-flow damage. These basins will eventually fill with the debris-flow deposits and must be emptied periodically or they will overflow. Commonly, heavy duty dump trucks and power shovels are needed to empty the debris and carry it away. However, small basins can be emptied manually. They should be designed to be able to contain the maximum flow volumes of an area to prevent overtopping during a flow event.

7.3.2.4 Debris Flow Retaining Walls

These structures can be of various materials. They are designed to stop the accumulation of debris, either by blocking its flow or diverting it around the vulnerable area. These structures should be carefully designed as any deflection of material may be unintentionally redirected to additional vulnerable areas.

7.3.3 Rock Slope Stabilization/Mitigation Techniques

Rockfalls range from a few fist-sized rocks to large cliff sections and boulders which, depending on size and shape, can roll, bounce, and careen down slopes, landing in areas at great distances from the fall lines. Recreation areas such as beaches near cliffs, parks, and open spaces msy be affected by rockfall, and people are frequently exposed to these hazards. People venturing too near the edges of cliffs and rocky slopes can add pressure to already weak overhangs and cause rockfalls to land on people below or sustain injuries themselves on these collapsing edges. Whether hiking, camping, walking, or working around cliffs or rock faces, people encounter the hazard many times without warning. A variety of engineering techniques can be implemented to help mitigate the effects of rockfalls, and some of these are discussed here. In some cases, more than one type of engineered solution is the best.

Physical Mitigation Methods for Rockfalls

1. Stabilisation

a. Excavation
b. Benching
c. Scaling and trimming
d. Rock bolts/anchors/dowels (Figs.7.31 to 7.36 & 7.57)
e. Chains and cables (Fig.7.46)
f. Anchored mesh nets (Fig.7.21)
g. Shotcrete (Fig.7.43)
h. Buttresses
i. Dentition

2. Protection

a. Rock-trap ditches
b. Catch nets and fences (Fig.7.49)
c. Catch walls
d. Rock sheds or tunnels (Figs.7.37 & 7.39)

7.3.3.1 Excavation of Rock / Benches

Horizontal benches excavated into a rock face are among the most effective protection measures for rockfall. In addition to intercepting rockfall, benches reduce tensional forces in the surface rock and reduce surface erosion rates.

They also reduce the rate of occurrence of rockfall. However, they have little or no effect on potential deep-seated rock failure. Bench faces can be constructed steeper than the overall slope angle, as rocks that fall are likely to remain on them. Vertical bench-face angles should be avoided, as tension cracks, dangerous overhangs, and excessive rockfall can result. The placing of bench faces should be stopped at the base of weaker rock layers, fractured rock zones, or water-bearing zones. A minimum width of 4 m is recommended for the benches, and all benches should have drainage ditches to divert water away from the slope.

7.3.3.2 Scaling and Trimming

Loose, unstable, and (or) overhanging blocks of rock, which may pose danger to passing traffic and (or) pedestrians, can be removed by scaling or trimming. Scaling is the removal of loose blocks by the use of hand-held pry bars and small explosive charges. Trimming involves drilling and light blasting by explosives, followed by scaling, to remove larger areas of overhanging or potentially dangerous rock. Scaling and trimming can be reduced by controlled blasting, but it is not always feasible. Overhanging rock is either removed or trimmed back to a stable part of the face. Scaling operations are usually carried out by workers suspended by ropes or other means, using pry bars, jacks, and explosives. These can be time-consuming and expensive (sometimes dangerous) and on active slopes may need to be repeated, say every few years, or as need has to be. Scaling is highly skilled work and can sometimes be dangerous; scaling crews should be trained and the work performed by professionals.

7.3.3.3 Shotcrete and Gunite

Shotcrete and gunite are types of concrete that are applied by air jet directly onto the surface of an unstable rock face. Shotcrete is an all-inclusive term to describe spraying of concrete or mortar either by dry- or wet-mix process. Gunite refers only to the dry-mix process in which the dry cementitious mixture is blown through a hose to the nozzle, where the water is injected immediately before application. This is a rapid and relatively uncomplicated method commonly used to provide surface reinforcement between blocks of rock and also to reduce weathering and surface scaling. Shotcrete contains aggregate up to 2 cm in size and is more commonly used than gunite, which uses smaller aggregate. Both materials can be applied rapidly by air jet so that large areas can be covered in a short time.

7.3.3.4 Anchors, Bolts, and Dowels

These are tools composed of steel rods or cables that reinforce and tie together a rock face to improve its stability. Anchors are post-tensioned members used to support large blocks of rock, whereas bolts are shorter and support surface rock. Dowels are similar to bolts but are not post-tensioned. Reinforcing a rock slope with steel requires a specialist's knowledge of rock stability analysis, of grouting techniques, and of testing procedures. Determination of orientation of the potential failure surfaces is crucial to a successful anchor system and requires considerable engineering experience.

7.3.3.5 Safe Catching Techniques

7.3.3.5.1 Catch Ditches

Wide catch ditches are effective in containing rockfall, but these must be designed taking into account the cliff geometry taken into account, and it is advised to consult a professional about specifications. The bottom of the catchment ditch should be covered with loose earth to prevent falling rock from bouncing or shattering into pieces or shards. If there is not enough space to construct as wide a ditch as is specified, then a combination of smaller ditches with a gabion or rock wall along their downhill edges can be used.

7.3.3.5.2 Cable, Mesh, Fencing, and Rock Curtains

Cable lashing and wire nets are simple, low-cost methods for protecting a road or path from rockfall. For large, unstable blocks, strands of metal cable are wrapped around the blocks and anchored to the slope. Where the rock is too fractured to be restrained by individual cables, cable nets are used. Wire mesh (closely spaced interwoven wires) can be used to prevent smaller rocks, less than 0.75meter in size, from falling. The standard mesh is double-twisted gabion wire mesh or a heavy gage metal chain link. The mesh is either loosely draped over a uniform rock face or bolted or otherwise firmly secured where the cliff face is irregular and the mesh cannot make close contact with the rock. Bolting the mesh to the rock face can prevent rock from becoming dislodged and provides overall stability of the slope or rock face. Wire mesh also is useful on steep soil cuts, especially beneath talus slopes.

Catch nets made of cable and wire mesh can be constructed to catch falling rock at the bottom of gullies and slopes. When suspended from an anchored

cable, the mesh forms a flexible barrier to dissipate the energy of the falling rock and will usually stop boulders up to one meter in diameter, if properly secured. Additionally, catch nets can be used in conjunction with roadside catch ditches.

Rock fences are fairly easy to install and can restrain small rocks from falling onto roads but do not stop rocks that bounce out over the top of the fence barrier. Rock curtains are more effective in directing rocks down to a catch ditch or other catching structure, by preventing them from bouncing outward onto the highway or structures below.

7.3.3.6 Retaining Walls

Retaining walls can work much like those described for soil slope-stabilization techniques in keeping rockfall debris out of an area. They are similar to rockfall fences but are in most cases more substantial and stronger. Retaining walls can be made out of steel, concrete, timbers, or other materials and must be anchored properly so as not to tip over during rockfalls.

7.3.3.7 Rock Sheds/Shelters (Figs.7.50)

These sheds / shelters are built over roads, railways, and sometimes structures to shield the area from rockfall and rock avalanches. Shed structures are either open ended or completely envelope the rockfall area completely in a concrete or steel (or other material) structure that will deflect rockfall away from the road, railway, or structure.

7.3.3.8 Rock Ledge Reinforcement (Fig.7.54)

These are not commonly used because they work only for unique situations and must be carefully engineered and should be structurally strong.

7.4 Slope Stabilization using vegetation

Seeding with grasses and legumes, reduces surface erosion, which can under certain conditions lead to landslides. Plating with shrubs adds vegetative cover and stronger root systems, which in turn enhance slope stability. If not controlled, surface erosion and small, shallow failures can lead to larger problems that cannot be controlled. The terms “Bionegineering” and “biotechnical” slope stabilization refers to use of vegetation as slope protection to arrest and prevent slope failure.

Planning is required for the successful implementation of a revegetation program. Before undertaking seeding, a person with local experience should be consulted. Local knowledge based on successes and failures of projects is invaluable. Seed application should begin immediately following a disturbance, at a minimum of approximately 6 weeks before periods of drought or damaging frost. Controlling surface water drainage, removing cut-bank overhangs, reducing slope angles, and benching all should be done before seeding.

7.5 Mulching

Mulch (Fig.7.51) is nonliving material spread over soil surface to provide protection from surface erosion by rain and retention of soil moisture. Various types of mulches will work – straw, grass or wood fibres, seaweed, and paper products.

7.6 Biotechnical slope protection

This is used to reduce the environmental consequences of landslide mitigation measures. The conventional earth retaining structures made of steel or concrete usually are not pleasing or environment friendly. These traditional hard remedial measures are increasingly being supplanted by vegetated composite soil/ structure bodies that are environmentally more friendly. Common biotechnical systems include geonets anchored by soil nails that hold in place soil seeded with grass and geocells with seeded soils in the interstices.

Research has been done on using plants to stabilize soils to mitigate landslides. One of the most promising types of plants is Vetiver (Fig.7.60), a type of grass that works very well in many different environments, to stabilize slopes. It provides a practical and inexpensive way to minimize landslides.

Biotechnical slope protection consist of 2 elements – biotechnical stabilization and bio-engineering stabilization, both of which entail the use of live materials – specifically biotechnical vegetation stabilization uses mechanical elements (structures) in combination with biological elements (plants) to prevent and arrest slope failures. Mechanical and biological elements must function together in a complimentary manner.

7.6.1 Bio-Engineering Measures for Stabilization of Surficial Landslides

Bio-engineering can be defined as the use of live plants or plant parts in the controlling soil erosion and mass movement, to fulfill engineering functions.

The living plant materials are used as the main structural components or reinforcements in the soil mantle. It provides immediate reinforcement and secondary stabilization occurs as a result of adventitious roots that develop along the length of the buried stems. Finally, vegetation that is seeded or planted provides mechanical and hydrological support to the soil.

Bio-engineering if employed carefully, can prevent minor problems transforming into larger, complex ones. Vegetation affects the surficial stability of slopes in significant ways. The stabilizing or protective benefits of vegetation depend both on the types of vegetation and slope degradation processes. In case of mass stability, the protective benefits of woody vegetation range from mechanical reinforcement and restraint by the roots and stems to modification of slope hydrology as a result of soil moisture extraction via evapo-transpiration.

- Catching material that is moving down a slope
- Armouring the slope against surface erosion from runoff and splash
- Supporting the slope by propping from the base
- Reinforcing the soil by increasing shear strength
- Draining a slope depending on the pattern and density of the vegetation
- Limiting the extent of slope failure by binding soil
- Improving the soil and micro-catchments, thus promoting regeneration

Bio-engineering is often a part of broad design, in conjunction with a number of standard civil engineering measures. These include check dams, prop walls, toe walls, wire bolsters, jute netting etc. However, it is stressed that bio-engineering should always be used as part of the overall design in resolving a particular slope problem. It must always be integrated in such a way that it complements and enhances other measures. Vegetation as a key component in off-road engineering is also environmentally sound and is practical application of several environmental mitigation measures. In the hilly regions, roads are an inseparable part of the slopes that they cross and they must be fully integrated into this landscape if they are to remain sustainable. Bio-engineering techniques offer the best way of blending roads with the landscape and limiting damage to surrounding agricultural, horticultural and forest land. They allow the restoration of the original vegetation and ecosystem, and particularly of tipping sites and spoil disposal

areas. Through both implementation and later productivity, they offer social and economic benefits for poor rural farmers.

7.7 Landslide Dam Mitigation

As previously mentioned, flooding is the primary hazard from landslide dams when a it fails, or flooding occurs when it is overtopped by the ongoing flow of water accumulated behind the dam. The following measures can be implemented when communities are faced with potential hazards from landslide dams:

Diversion of inflow water before it reaches the lake formed by the landslide dam

This can be done by diverting water from the stream into upstream reservoirs or irrigation systems. Although usually only a temporary measure, diversion may slow the filling of the lake to allow the application of a more long-term solution.

Temporary drainage from the impoundment by pumps or siphons

The rising water level can be controlled temporarily by means of pumps or siphons, causing the water to flow over the low point of the dam. This is usually a short-term (less than 1 to 2 years) measure that provides time for more extensive, long-term solutions.

7.8 Construction of an erosion-resistant spillway

The most common method of stabilizing a landslide dam is to construct an erosion-resistant open-channel spillway either across the dam or an adjacent abutment. When the overtopping by water occurs, flow is controlled by the spillway in much the same way that emergency spillways are constructed on engineered dams to control water level. An additional advantage of this type of spillway is that it allows for the lowering of the water level behind the dam, which helps in reducing the upstream flooding that landslide dams may cause.

Spillways are not always successful in preventing dam breaching and downstream flooding; they sometimes fail due to retrogressive erosion (erosion from the spillway outlet to its intake) caused by high-velocity outlet flow. To prevent erosion by minimizing flow velocity, the spillway should be wide and shallow. If possible, it should be lined with erosion-resistant materials (commonly riprap), especially at the outlet. Often, check dams are

installed along steeper grades of the spillway to prevent erosion. Spillways that fail due to erosion may have been partially successful because they limit the total volume of the water behind the dam, thus reducing total discharge even if the dam breaches entirely.

Open-channel spillways across the landslide dam commonly are excavated by bulldozers; however, draglines, backhoes, explosives, and hand labor all have been used. Excavation can be dangerous in rough terrain, so an access road has to be constructed.

7.9 Drainage tunnel through an abutment (Fig.7.38)

A long-term method of preventing overtopping and breaching of a landslide dam is construction of a diversion tunnel through an adjacent dam abutment. Because large landslide dams commonly occur in mountain canyons, they usually have bedrock abutments; thus rock-tunneling methods are commonly used. The landslide may be left as it is, as it is too massive to remove. However, it may be monitored with instrumentation.

Fig. 7.1: Spraying crib works for preventing surficial failures

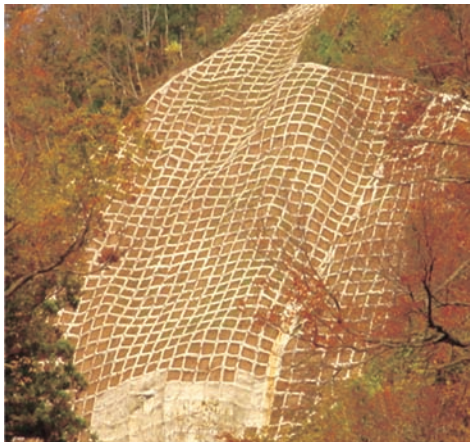


Fig. 7.2: Spraying crib wo for preventing surficial failures

Fig. 7.3: Application of Geosynthetic mats for slope stability

Fig. 7.4: Geosynthetic Grids used for slope protection and vegetative growth

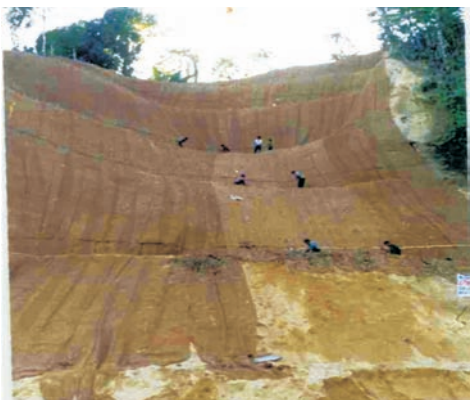


Fig. 7.5: Jute mats used for slope stabilization and vegetative growth

Fig. 7.6: Slope protection with geogrid helps prevent surficial rock failures

Fig. 7.7: Flexible drain pipe system used to dispose off water responsible for triggering and promoting landslide

Fig. 7.8: PVC pipes to drain out water from unstable slopes

Fig. 7.9: Drainage Gallery / Tunnels to collect and dispose off subsurface water

Fig. 7.10: Underground pipes collect sub-surface water from landslide site

Fig. 7.11: Covered well for subsurface drainage

Fig. 7.12: Open well for collecting subsurface water from landslide site

Fig. 7.13: Boulder Gabion wall with surficial drainage system

Fig. 7.14: Surface lined drains to dispose off water properly

Fig. 7.15: Arch type wall structure and drainage system used for stabilizing slopes

Fig. 7.16: Well lined surface drains at landslide site

Fig. 7.17: Debris Control Structures and Mechanism

Fig. 7.18 Timber stitching for preventing slope failure

Fig. 7.19: Sand bags used as retaining structures for reducing landslide impact

Fig. 7.20: Block masonry retaining wall with weep holes

Fig.7.21: Net fencing to hinder rockfall movement on downside

Fig. 7.22: Multiple remedial measures for stabilizing landslide site

Fig. 7.23: Empty bitumen drums filled with debris acting as retaining wall

Fig. 7.24: Wire crated shotcreting

Fig. 7.25: Gabion wall made of boulders and wire baskets

Fig. 7.26: Boulder masonry walls with joints to adjust minor deformations

Fig. 7.27: Banded Random Boulder wall without masonry

Fig. 7.28: Random Boulder Gabion Wall with wire crates

Fig. 7.29: Random Rubble Boulder Masonry Wall

Fig. 7.30: Stone masonry wall with weep holes and drain pipe

Fig. 7.31: Nailing for slope reinforcement

Fig. 7.32: Steel anchors and mesh used as preventive measure

Fig. 7.33: Multi-bar reinforcement with an instrument to record wall pressure

Fig. 7.34: Rock bolting and shot creting for slope stabilization

Fig. 7.35: Rock anchors with tie beams made of reinforced concrete

Fig. 7.36: Rock bolting for slope reinforcement

Fig. 7.37: Tunnel to avert recurring and chronic landslide

Fig. 7.38: Snow Gallery to avoid avalanches and debris flows along roads and facilitate traffic movement

Fig. 7.39: Tin Roof sheds to prevent direct impact of rock fall

Fig. 7.40: Debris Catch Traps to avoid impact of debris flows

Fig. 7.41: Fencing with metallic nets and girdles for saving roads, vehicles and passerbyes from the landslides

Fig. 7.42: Boulder wall barriers to arrest falling boulders and reduce impact of debris flows

Fig. 7.43: Shotcreting with wire mesh and weep holes

Fig. 7.44: Geosynthetic sheets used for stabilizing slopes

Fig. 7.45: Application of geosynthetics for slope stabilization

Fig. 7.46: Chain and cable type ring nets for preventing rock / boulder fall

Fig. 7.47: Drum wall for mitigating landslide

Fig. 7.48: Sealing of cracks with pervious materials beneath the surface and impervious material on top

Fig. 7.49: Catch nets for restraining rock fall

Fig. 7.50: An open rock shed

Fig. 7.51: Rice husk drains (Source: USGS)

Fig. 7.52: Trespassing rock slide area

Fig. 7.53: French drains

Fig. 7.54: A reinforced rock ledge

Fig. 7.55: Polythene sheets used to prevent water percolation

Fig. 7.56: Net Fencing to avoid the impact of sliding on road and traffic

Fig. 7.57: Rock Bolting

Fig. 7.58: Rockfall blocking road

Fig. 7.59: Benching, retaining structures, drainage and plantation

Fig. 7.60: Vetiver plantation for slope stabilization

SUB-MODULE 8 : RESPONSE TO LANDSLIDE DISASTERS

Figure 8.1 : Responding to Landslide Disaster

8.1 Standard Operating Procedures for Responding to Landslides Disasters

The world over it has been experienced that a prompt, well-coordinated and effective response mounted in the aftermath of disasters not only minimizes loss of life and property but also facilitates early recovery. The important ingredients of an effective response system are integrated institutional arrangements, state of the art forecasting and early warning systems, failsafe communication system, rapid evacuation of threatened communities, quick deployment of specialized response forces and coordination and synergy among various agencies at various levels in dealing with any disaster. Most importantly, all the agencies and their functionaries must clearly understand their roles and responsibilities and specific actions they have to take for responding to disaster or threatening disaster situations.

The objectives of the SOP are –

(a) To provide, in a concise and convenient form, a list of major executive actions involved in responding to natural disasters and necessary measures for preparedness, response and relief required to be taken;

(b) To ensure that all concerned Ministries, Departments and Organisations of the Government of India, State Governments and District Administrations know the precise measures required from them at each stage and also to ensure that all actions are closely and continuously coordinated; and

(c) To indicate various actions which would be required by the State Governments/UT Administrations within their sphere of responsibilities so that they may prepare and review the Contingency Action Plans accordingly.

The instructions contained in this SOP should not be regarded as exhaustive in terms of all the actions that might be considered necessary.

The SOP encompasses the following five phases of disaster management for effective and efficient response to natural disasters.

(i) **Preparedness Phase** – This will include taking all necessary measures for planning, capacity building and other preparedness so as to be in a state of readiness to respond, in the event of a natural disaster. This Stage will also include development of Search & Rescue Teams, mobilization of resources and taking measures in terms of equipping, providing training, conducting mock drills/exercises etc.

(ii) **Early Warning Phase** – This will include all necessary measures to provide timely, qualitative and quantitative warnings to the disaster managers to enable them to take preemptive measures for preventing loss of life and reducing loss/damage to the property. In the event of a natural disaster or imminent threat thereof, all the concerned agencies will be informed/ notified for initiating immediate necessary follow up action.

(iii) **Response Phase** – This will include all necessary measures to provide immediate succor to the affected people by undertaking search, rescue and evacuation measures.

(iv) **Relief Phase -** This phase will include all necessary measures to provide immediate relief and succor to the affected people in terms of their essential needs of food, drinking water, health & hygiene, clothing, shelter,

(v) **Restoration Phase** – This will include all necessary measures to stabilize the situation and restore the utilities.

This SOP does not cover long-term measures needed either for mitigation or for rehabilitation/recovery of the affected people and reconstruction of the area.

8.2 Emergency Operations Centre (EOC)

The EOCs/Control Rooms at National, State and District levels will be the nerve centres for coordination and management of disasters. The objectives of the EOCs shall be to provide centralized direction and control of any or all of the following functions:

- Receive and process disaster alerts and warnings from nodal agencies and other sources and communicate the same to all designated authorities
- Monitor emergency operations
- Facilitate Coordination among primary and secondary ESF Ministry/ Departments/Agencies.
- Requisitioning additional resources during the disaster phase
- Issuing disaster/incident specific information and instructions specific to all concerned
- Consolidation, analysis, and dissemination of damage, loss and needs assessment data
- Forwarding of consolidated reports to all designated authorities

8.2.1 Location of EOC

The EOC will be set up at a suitable location and the building should be disaster resistant so as to withstand the impact of disasters and remain functional during the emergency phase.

8.2.2 Communication Network of EOCs

Under the National Communication Plan being implemented by the Government of India, the EOCs at all the three levels shall have a fail proof communication network with triple redundancy of NICNET of NIC, POLNET of Police and SPACENET of ISRO in addition to the terrestrial and satellite based communication to ensure voice, data and video transfer. Under the network, the EOCs/Control Rooms of all the States will be directly connected with the NEOC/ Control Room of MHA at the National level. The district EOCs/ Control Rooms will be connected with

the respective State EOCs/Control Room. All these control rooms will function on 24x7 basis and will be functional round the year. Suitable personnel will be selected and imparted training in the operation of Control Rooms will be posted to man these EOCs/Control Rooms.

8.3 National Disaster Response Force (NDRF)

For the purpose of specialized response to disasters/ emergencies both natural and manmade NDRF has been constituted comprising of 10 battalions drawn from Central Para-Military Forces. Each NDRF battalion has 18 Specialized Search & Rescue Teams including doctors, paramedics and dog squad.

The general direction and control of NDRF is vested with NDMA while the command and supervision of the Force is vested in Director General of Civil Defence and NDRF appointed by the Central Government.

8.3.1 State Disaster Response Force (SDRF)

State Governments/SDMAs shall be primarily responsible for taking preparedness measures and building response capacity as per their vulnerability to various natural disasters and constitute State Disaster Response Forces on the pattern of NDRF.

8.4 National Disaster Mitigation Resource Centres (NDMRCs)

The NDMRCs will be co-located with the NDRF battalions. These will also serve as repositories for NDMR bricks of relief stores for the disaster affected people, in each of the 10 NDRF locations. These will cater to the emergent requirements especially for the first 72-96 hours. These stores will supplement the reserves maintained by the respective states/UTs.

In addition, these centres will assist in running mock drills and capacity development programmes. During disasters, they will act as facilitators to the states/UTs in deployment of central resources and provide much needed additional link to the centre

8.4.1 State Disaster Mitigation Resource Centres (SDRMCs)

The State Governments shall also set up Resource Centres based on their requirements to pre-position essential supplies. The States shall be responsible to constantly evaluate their own capabilities to handle that situation and project the anticipated requirements for the central resources well in time. Memorandum of Understanding may be entered into by the neighboring States for assisting each other during natural calamity. Inter-State assistance and cooperation shall be encouraged.

8.5 Other Disaster Response Services/Organisations

In addition to NDRF at national level and SDRF at state levels, the provisions have been made to strength the Five and Emergency Services as well as Civil Defence to reduce the deployment of armed forces during the disaster times.

8.5.1 Fire & Emergency Services

The Fire Services in the States/ UTs will be strengthened and will be made multi-hazard response units. These will be appropriately equipped depending upon their location and area of operation.

8.5.2 Civil Defence

Civil Defence volunteers will be enrolled for voluntary services in accordance with the provisions of the Civil Defence Act. The services of CD volunteers should be utilized during response to natural disasters. Civil Defence training institutions at the National and State levels will be set up/upgraded to cater to the training of Civil Defence volunteers in relevant areas of disaster response.

8.5.3 Armed Forces

Establishment of NDRF should progressively reduce deployment of the Armed Forces, which would be deployed only when the situation is beyond the coping capacity of State Government and NDRF.

8.5.4 Emergency Support Functions (ESFs)

Disaster response is a multi-agency function. There will be one Lead or Primary Agency which will be responsible for managing and coordinating the response while other agencies will support and provide assistance in managing the incident. Each ESF will be headed by a lead Ministry /organisation responsible for coordinating the delivery of goods and services to the disaster area, and is supported by numerous other organizations. These ESFs will form integral part of the Emergency Operation Centres (EOCs) and each ESF should coordinate its activities from the allocated EOC. Extension teams and workers of each ESF will be required to coordinate the response procedures at the disaster affected site.

8.6 Pre-Contract for Essential Commodities

All the State Governments will ensure storage and availability of essential commodities including medicine in the vulnerable districts well before the onset of monsoon and cyclone periods. They will also enter into pre-contract with the suppliers of essential commodities, medicines, tents, boats etc. on an annual basis for supply of these items at pre-decided rates within a stipulated time framework.

8.7 District Level Preparedness for Response

8.7.1 Vulnerability assessment

Each district will make its vulnerability assessment and identify potential hazards. While making such assessment, the risk involved and capacity to respond will be taken into account. The local community will be informed about their vulnerability to potential hazard/disasters through the representatives of Panchayati Raj Institutions/Local Self-Government and NGOs.

8.7.2 Contact Details

A comprehensive directory of officers involved in disaster management at various levels will be prepared for National and State levels giving their names, addresses, telephone, fax and mobile numbers, email address. Such a directory will be widely circulated and updated periodically.

8.7.3 Review

Annual review of the preparedness measures will be done at the National, State, District and sub-Divisional levels. Annual review will ensure that all loose ends are tied up so that response during natural disasters is efficient, effective and timely. The review will also include rearrangements for essential commodities required for response and relief and emergent basis. The decentralization of authority is an important feature of good management of natural disasters. As such, the States will also review their resources and preparedness in their annual meetings, the present levels of delegation of powers to the Relief Commissioners, Additional Relief Commissioners and District Magistrates.

8.7.4 Mock Drills

Search and Rescue Teams at the National and State Levels will carry out mock drills on various disasters situation annually. For floods and cyclones, these will be carried before the monsoon and cyclone period, tentatively in March and September for cyclones and June for floods. For earthquakes, landslides etc., such drills can be done in the month of March itself. At the district and State levels, mock exercises will be carried out for testing the effectiveness of all the preparedness machinery including manpower and equipment.

8.8 Resource Inventory – IDRN

Government of India has launched India Disaster Resource Network (IDRN), which is a web enabled resource inventory for disaster management. The

state Governments will ensure that necessary entries have been made in the Web-portal and updated at-least once in a month by the designated district authorities.

8.9 National Crisis Management Committee (NCMC)

1. On direction of the Cabinet Secretary, meeting of the NCMC shall be convened
2. NCMC will take stock of the situation
3. It shall give necessary directions to NEC, MHA, other Central Ministries/ Departments/ Agencies and State Governments

8.10 National Executive Committee (NEC)

1. JS(DM), MHA shall take order from Union Home Secretary for convening the meeting of NEC
2. NEC shall assess the situation and give directions to the concerned Ministries/Departments of the centre, the state governments and the State Disaster Management Authorities regarding measures to be taken by them in response to any specific threatening disaster situation or disaster
3. NEC shall coordinate response of various agencies
4. It shall depute a team of Officials to visit the affected States for on the spot assessment of the situation and coordinate with State Governments
5. It shall mobilize resources and dispatch them to concerned States
6. It shall monitor and review the situation on a regular basis

8.11 Role of the Nodal and Other Central Ministries/ Departments

1. On activation of national ESF Plan, the concerned Ministry/Department shall depute the designated officials to NEOC for coordination of response measures
2. Ministries/Departments shall coordinate with their counterparts and make assessment of immediate needs in their respective sectors
3. Ministries/Departments shall provide resources both in terms of men and material for assistance of the States on request of NEC

8.12 State Level

Following shall be the sequence of action at the State level:

8.12.1 SEOC shall discharge the following functions:

1. On receipt of information either from NEOC/DEOC or from Early Warning Agencies or any other reliable sources, State Emergency Operation Centre, shall be activated fully as per laid down protocol
2. SEOC shall issue alerts/warning to all designated authorities at the State level and Districts including for Public Information to AIR/Doordarshan/ Press
3. SEOC shall send First Information Report to NEOC, MHA and thereafter Daily Situation Report till situation normalizes
4. SEOC shall collect all relevant information and appraise the status to the designated decision making authorities
5. It shall arrange Meetings of SEC
6. It shall activate ESFs of State if the situation so warrants

8.12.2 State Disaster Management Authority (SDMA)

1. Meeting of the SDMA shall be convened on the direction of Chief Minister
2. SDMA will take stock of the situation
3. SDMA shall give necessary directions to SEC, Deptt. Of Disaster Management and other Departments/agencies of the State Government and concerned DDMAs.
4. SDMA shall decide on Inter-State assistance and cooperation

8.12.3 State Executive Committee (SEC)

1. Secretary (DM) shall convene the meeting of SEC
2. SEC shall assess the situation and give directions to the concerned Departments/agencies of the State Govt. and DDMAs concerned regarding measures to be taken by them in response to any specific threatening disaster situation or disaster
3. SEC shall coordinate response of various agencies
4. SEC shall requisition NDRF or Armed Forces if the situation so demands.
5. SEC may depute a team of Officials to visit the affected Districts for on

the spot assessment of the situation and supervise the response & relief measures.

6. SEC shall mobilize resources and dispatch them to concerned Districts

7. SEC shall monitor and review the situation on a regular basis

8. SEC shall keep the NEC and NDMA informed of the situation

9. SEC shall constantly evaluate their own capabilities to handle that situation and project the anticipated requirements for the central resources well in time

10. SEC shall deploy State level Incident Command Team on the request of the DDMA as and when required

11. In the event of calamity of severe nature, the SEC will consider appointment of Senior Officers, delegate powers and assign specific areas for timely and effective, efficient management of disasters

12. SEC will also take necessary steps to pool the resources for better management of crisis situation. This includes the pooling of food grains funds and other resources available in the districts under various Government schemes. However, these resources will be reimbursed to the respective schemes/Departments once the situation becomes normal

8.12.4 Role of Other Departments/Agencies

1. On activation of State ESF Plan, the concerned Department/Agency shall depute the designated officials to SEOC for coordination of response measures

2. Departments/Agencies shall coordinate with their National counterparts and mobilize central assistances, such as specialized manpower, equipments, materials etc. to meet immediate needs in their respective sectors

3. Departments/Agencies shall provide resources both in terms of men and material for assistance to the DDMAs

8.13 District Level

Following shall be the sequence of action at the District level:

8.13.1 DEOC shall discharge the following functions:

1. On receipt of information either from NEOC/SEOC or from Early Warning agencies or field functionaries from Sub-divisions, Blocks, Tehsils or any

other reliable sources, District Emergency Operation Centre shall be activated fully as per laid down protocol.

2. DEOC shall issue alerts/warning to all designated authorities at the District level
3. DEOC shall send First Information Report to SEOC and NEOC, MHA and thereafter Daily Situation Report till situation normalizes
4. DEOC shall collect all relevant information and appraise the status to the designated decision making authorities
5. DEOC shall maintain all records and documents related to the response
6. It shall activate ESFs of District if the situation so warrants

8.13.2 District Disaster Management Authority (DDMA)

1. DDMA shall assess the situation and give directions to the concerned Line Departments/Agencies at the District level regarding measures to be taken by them in response to any specific threatening disaster situation or disaster
2. DDMA shall take such other action as may be necessary for coordinated response to natural disasters. These may include the following:

a. Assessing situations based on reports received from various sources and giving directions to different agencies for immediate response, relief and restoration of critical infrastructure

b. Reviewing the resources and capacities of different agencies to deal with the situations and giving directions for pooling available manpower, equipments and resources available with different agencies for speedy and effective response

c. Requisitioning assistance from NDRF/ Armed Forces/ other specialized agencies, if necessary

d. Coordinating with civil society and Non-Governmental Organizations for supplementing the efforts of government agencies

e. Monitoring and reviewing the situations on a regular basis

8.14 First Response

In disasters where there are no early warning signals available, the community members will be the first responder. However, immediate support and assistance shall be available from other important first responders like the police, State Disaster Response Force (SDRFs), Fire and Medical Services.

Other important responders will be the Civil Defence, Home Guards and youth organizations such as NCC, NSS and NYKS drawn from local units.

8.14.1 First Information Report

DEOC shall send First Information Report immediately to SEOC, NEOC and all designated authorities/agencies. FIR shall invariably give an account of the severity of the disaster, damage & loss caused, locally available capacities, priority. The FIR shall briefly summarize,

(i) Severity of the disaster

(ii) Actions being taken locally

(iii) Local coping capacities (including locally available resources)

(iv) Immediate priorities for external relief required and approximate quantities for the same

(v) Best logistic means for delivering relief

(vi) Forecast of possible future developments including new risks.

The First Information Report on occurrence of natural calamity shall be sent to SEOC, NEOC and MHA, Government of India within maximum 24 hours of occurrence of calamity.

8.14.2 Daily Situation Report

A standardized form for reporting of situation report on daily basis has been prepared for the District, State and National levels. This format will be used uniformly for all the States. The State Governments shall submit situation report to the MHA on six hourly basis during first three days thereafter daily till the situation come to normal.

8.14.3 Air dropping of food in inaccessible areas

Airdropping of food and essential commodities shall be undertaken in the inaccessible areas. The State Governments/ district authorities will liaise with Air Force Authorities and the NEC, Ministry of Home Affairs, Government of India for requisitioning the helicopters.

The agencies for preparing food packets for airdropping and items as well quantity to be included in the food packets will be communicated by the district administration in advance.

8.14.4 Rapid Damage Assessment

Rescue & relief operations shall be based on ground assessment of damage and losses. Preliminary assessment shall be carried out immediately within 24 hours for planning the response. Teams shall be constituted of officials drawn from various sectors to make assessment on the basis of on the spot visits, aerial surveys and information collected from primary and secondary sources.

8.14.5 Immediate repair of infrastructure

The Departments/Agencies of the State Governments responsible for various infrastructural facilities such as electricity, drinking water, telecommunication etc shall repair the damage caused by the disaster and will take immediate steps to restore damaged essential services so that rescue & relief operations are conducted smoothly.

8.14.6 Disposal of dead bodies

The State Government/District authorities shall earmark authorities responsible for disposal of bodies in event of mass causalities. The process of identification and handing over to next of kin shall be followed. Mass burial/disposal of bodies shall be done as a last resort. Local religious & cultural practices shall be honoured while disposing dead bodies

8.14.7 Disposal of carcasses

The State Government/District authorities shall earmark authorities responsible for disposal of carcasses in event of mass destruction. The process to be followed for mass disposal of carcasses shall be decided by Department of Animal Husbandry.

8.14.8 Information and Media Management

During disaster situations, the dissemination of accurate information through electronic and print media is very important. Regular press briefings shall be made by District Magistrate/Collector or his authorized representative at pre-designated time as a single source of information from Government

8.14.9 Relief

In the aftermath of disasters the affected people must be looked after for their safety, security and the well being and provided food, water, shelter, clothing, medical care etc. so as to ensure that the affected people live with dignity. State Governments shall be responsible for providing prompt and adequate

relief assistance to the victims of disasters. The minimum standards of relief shall b laid down by the NDMA and by the SDMAs in terms of sections 12 and 19 respectively.

8.14.10 Food & Nutrition

People affected by disasters may be deprived of food and therefore food aid shall be provided to sustain life. The following measures shall be taken:

1. Where necessary free distributions of food shall be made to those who need the food most
2. The food distribution will be discontinued as soon as possible
3. Wherever possible dry rations shall be provided for home cooking
4. Community Kitchen for mass feeding shall be organised only for an initial short period following a major disaster particularly where affected people do not have the means to cook
5. While providing food assistance, local food practices shall be kept in mind and commodities being provided must be carefully chosen, in consultation with the affected population
6. Foods must be of good quality, safe to consume, and appropriate and acceptable to recipients.
7. Rations for general food distributions shall be adopted to bridge the gap between the affected population's requirements and their own food resources
8. Food distributed should be of appropriate quality and fit for human consumption
9. Food should be stored, prepared and consumed in a safe and appropriate manner at both household and community levels
10. Food should be distributed in a responsive, transparent, equitable manner
11. NGOs, CBOs and other social organizations should be involved for supplementing the efforts of the Government
12. The nutritional needs of the population should be met and malnutrition and micronutrient deficiencies of identified at risk groups addressed

8.14.11 Water

Water supply is invariably affected in natural disasters. Safe drinking water might not be available particularly in hydro-meteorological disasters.

The following measures shall be taken by the State Governments/ district administration:

1. The State Governments shall identify alternative sources of water and make necessary arrangements for supply to the affected population
2. The State Governments shall ensure that affected people have adequate facilities and supplies to collect, store and use sufficient quantities of water for drinking, cooking and personal hygiene
3. It shall be ensured that drinking water supplied conforms to the prescribed quality standards
4. It shall be ensured that water made available for personal and domestic hygiene should not cause any risk to health

8.14.12 Health

During post disaster phase many factors increase the risk of diseases and epidemics. These include poverty, insecurity, overcrowding, inadequate quantity and quality of water, poor environmental and sanitary conditions, inadequate shelter and food supply.

8.14.13 Medical Response

Medical response has to be quick and effective. The execution of medical response plans and deployment of medical resources warrant special attention at the State and District level in most of the situations. The following measures shall be taken by the States/Districts:

1. A mechanism for quick identification of factors affecting the health of the affected people shall be established for surveillance and reporting
2. An assessment of the health and nutritional status of the affected population shall be done by experts with experience of emergencies, if possible, local knowledge
3. The voluntary deployment of the nearest medical resources to the disaster site, irrespective of the administrative boundaries, will be warranted
4. Mobile medical hospitals and other resources available with the Central Government shall be provided to the States/UTs
5. Adequate supply of medicines, disinfectants etc. shall be made
6. Where necessary inoculation shall be done
7. Vaccination of the children & pregnant women shall be undertaken

8. Vector-borne diseases are a major cause of sickness and death in many disaster situations. Vector control measures shall be undertaken
9. Water borne diseases may cause sickness and deaths and therefore adequate measures shall be taken to prevent such outbreaks

8.14.14 Mental Health Services

Disasters cause tremendous mental trauma to the survivors. Psychosocial support and mental health services should be made available immediately in the aftermath of disaster so as to reduce the stress and trauma of the affected community and facilitate speedy recovery. The following measures shall be undertaken by States/UTs:

1. A Nodal Mental Health Officer shall be designated for each affected District
2. Rapid needs assessment of psycho-social support shall be carried out by the Nodal Officer/ Health Department
3. Trained man power for psycho-social and mental health services shall be mobilized and deputed for psycho-social first aid and transfer of critically ill persons to referral hospitals
4. Psycho-social first aid shall be given to the affected community/ population by the trained community level workers and relief and rescue workers
5. Psycho-social first aid givers shall be sensitized to local, cultural, traditional and ethical values and practices
6. Psycho-social support and mental health Services shall be arranged in relief camps set-up in the post disaster phase
7. Where large numbers of disaster victims have to be provided psychosocial support a referral system for long term treatment shall be followed
8. The services of NGOs and CBOs may be requisitioned for providing psycho-social support and mental health services to the survivors of the disasters
9. Community practices such as mass prayers, religious discourse etc. should be organized with four preventive and promotive mental health services

8.14.15 Clothings & Utensils

During disasters, people lose their clothings and utensils. The following measures shall be taken by State/District authorities:

1. he people affected by the disaster shall be provided with sufficient clothings, blankets etc. to ensure their dignity, safety and well-being
2. Each disaster-affected household shall be provided with cooking and eating utensils

8.14.16 Shelter

In a major disaster a large number of people are rendered homeless. In such situations shelter becomes a critical factor for survival of the affected people in the initial stages of a disaster. Further, shelter becomes essential for safety and security and for protection from the adverse climatic conditions.

Shelter is also important for human dignity and for sustaining family and community life in difficult circumstances. The following measures shall be taken by State/District authorities for providing shelter to the affected people:

1. Disaster affected people who have lost their dwelling units or where such units have been rendered damaged/useless shall be provided sufficient covered space for shelter
2. Disaster affected households shall be provided access to appropriate means artificial lighting to ensure personal security
3. Disaster-affected households shall be provided with necessary tools, equipment and materials for repair, reconstruction and maintenance for safe use of their shelter

8.14.16 Relief Camp

The following steps shall be taken for setting up relief camps in the affected areas:

1. Adequate numbers of buildings or open space shall be identified where relief camps can be set up during emergency
2. The use of premises of educational institutions for setting up relief camps shall be discouraged
3. One member of the Incident Command Team of the district trained in running and management of relief camps will be deputed for management of relief camps
4. The requirements for operation of relief camps shall be worked out in detail in advance
5. Agencies to supply the necessary stores will be identified in the pre-disaster phase

6. The temporary relief camps will have adequate provision of drinking water and bathing, sanitation and essential health-care facilities
7. Adequate security arrangements shall be made by local police
8 Adequate lighting arrangements shall be made in the Camp Area including at water points, toilets and other common areas
9. Wherever feasible, special task forces from amongst the disaster affected families will be set up to explore the possibility of provision of food through community kitchens, provision of education through the restoration of schools and *anganwadis*
10. Efficient governance systems like entitlement cards, identification cards, bank accounts for cash transfers etc. shall be developed

8.14.17 Sanitation and Hygiene

Sanitation services are crucial to prevent an outbreak of epidemics in post disaster phase. Therefore a constant monitoring of any such possibilities will be necessary. It should be ensured that disaster-affected households have access to sufficient hygiene measures. Soaps, detergents, sanitary napkins and other sanitary items should be made available to ensure personal hygiene, health, dignity and well-being. In the relief camps, toilets should be sited, designed, constructed and maintained in such a way as to be comfortable, hygienic and safe to use

8.14.18 Provision of Intermediate Shelters

In the case of devastating disasters, where extreme weather conditions can be life-threatening or when the period of stay in temporary shelters is likely to be long and uncertain, the construction of intermediate shelters with suitable sanitary facilities will be undertaken to ensure a reasonable quality of life to the affected people. Such shelters shall be designed to be cost effective and as per local needs.

8.14.19 Management of Relief Supplies

Speedy supplies of relief materials shall be ensured in relief operations. A supply chain management system shall be developed. Standard Protocols shall be put in place for ensuring the procurement, packaging, transportation, storage and distribution of relief items. A mechanism shall be developed for receiving donations in cash or kind and their distribution.

8.14.20 Transparency in Relief

SDMAs/DDMAs shall take all appropriate measures for transparency in the relief operations. Affected people shall be apprised of the nature and quantum of

relief admissible to them. Proper formats will be developed to acknowledge the receipt of relief materials and their further distribution.

8.15 Landslide Alerts and Warnings

Geological Survey of India issues alerts and warnings to all designated authorities and agencies of the Central Government and State Governments/ district Administration for landslides in the following categories.

Category IV: Landslides of small dimensions that occur away from habitations and do not affect either humans or their possessions. These may occur near infrastructural installations, agricultural and forestlands and may not affect them in a significant manner. These slides may include small incidents that block communication routes for short periods or do not affect the society in a significant manner. - Yellow

Category III: Landslides which are fairly large and affect infrastructural installations like strategic and important highways and roads, rail routes and other civil installations like various appurtenant structures of hydroelectric and irrigation projects. The landslides that enter large water bodies like reservoirs of hydroelectric projects and could damage some of components of these projects. - Orange

Category II: The landslides that may occur on the fringes of inhabited areas and result in limited loss of life and property. Landslides, which result in blockade of courses of relatively smaller natural drainages. If the blockade is of relatively smaller dimensions its impact would be of a lower order. Although a threat potential is there, it may not be immediate. - Orange

Category I: Landslides of large dimensions that are located over or in close vicinity of inhabited areas like urban settlements or fairly large rural settlements. Activity on these slides can result in loss of human lives, dwellings on large scale. These slides may also inflict heavy losses on urban infrastructure. The slides that block busy pilgrimage routes during peak times resulting in hardships to thousands of pilgrims and sometimes resulting in loss of human life. Landslides which result in blockade of courses of relatively large natural drainages. If the blockade is fairly large it could lead to formation of a very large reservoir of water behind it. Formation of a large landslide dam could result in sudden flooding of areas located upstream. Abrupt breaching of landslide dam would suddenly release enormous quantities of water in the downstream areas leading to flash floods that could result in loss of life and damage to property on large scale. - RED

8.16 FORMAT FOR FIRST INFORMATION REPORT ON OCCURRENCE OF NATURAL CALAMITY

(To be sent to MHA, Government of India within maximum of 24 hours of occurrence of calamity)

From: State ---------- Date of Report ----------

To

JS (DM), MHA (fax : _____ ; email :_____)

I/c National Integrated Operations Centre, MHA (fax: _____; email:_____)

a. Nature of Calamity
b. Date and time of occurrence
c. Affected area (number and names of affected districts)
d. Population affected (approx.)
e. Number of Persons
   - Dead
   - Missing
   - Injured
f. Animals
g. Affected
h. Lost
i. Crops affected and area (approx.)
j. Number of houses damaged
k. Damage to public property
l. Relief measures undertaken in brief
m. Immediate response & relief assistance required and the best logistical means of delivering that relief from State/National
n. Forecast of possible future developments including new risks.
o. Any other relevant information

Fig. 8.2: Fire Gaurds and Civil Defence personnel extricating a dead body

Fig. 8.3: Community volunteers searching and recovering buried bodies

Fig. 8.4: Bull dozer clearing landslide debris from the road

Fig. 8.5: Fire Gaurds and Civil Defence personnel extricating a dead body

Fig. 8.6: Labour and Bull dozer kept for clearing debris, buried by the landslide

Fig. 8.7: People and livestock under heavy mass of rock debris

Fig. 8.8: Steep and negative slopes - a challenge to landslide managers

Fig. 8.9: JCB clearing debris

Fig. 8.10: Bull dozer for clearing road

Fig. 8.11: JCB and Loader used in removing and disposing landslide debris

Fig. 8.12: Community workers rescuing children buried under landslide

Fig. 8.13: First responders helping landslide victims

Fig. 8.14: Tree logs being used to make temporary bridge in landslide affected area

Fig. 8.15: Searching for buried people in bad weather conditions

Fig. 8.16: Mechanical breaking and removal of big boulders

Fig. 8.17: Bulldozer clearing landslide debris from road side

Fig. 8.18: Failure of retaining structures due to weak foundation

Fig. 8.19: Inspecting the damage by landslide in a residential area

Fig. 8.20: Community and Civil Defence acting together in search and rescue

Fig. 8.21: Removing debris and searching children buried underneath

Fig. 8.22: People trying to trespass a landslide

Fig. 8.23: First Aid Vehicle (108) for assisting disaster victims

Fig. 8.24: Road washed off by landslide makes access difficult for rescue & relief

Fig. 8.25: Rescuers helping people cross a damaged bridge and road

Fig. 8.26: Political leaders visiting landslide affected area

Fig. 8.27: Politicians along with officials from administration visiting a landslide affected site

Fig. 8.28: Supply by water tanks after water pipe line got disrupted by a landslide

Fig. 8.29: Local people assisting in disposal of dead bodies

Fig. 8.30: Canine search for locating human bodies under landslide debris

Fig. 8.31: People face shortage of gas and fuel supply due to road disruption by landslide

8.17 Rapid Damage and Loss Assessment

Disaster brings in its wake damages to life, property, infrastructure, economy and environment. For adequate and effective response to disasters it is of paramount importance to assess the extent of physical harm to assets, property and infrastructure which render them less valuable or less effective.

The objective of Rapid Assessment is to determine the precise nature and extent of damage so that Rescue and Relief measures are undertaken in the affected area. The rapid damage assessment has the following major components:

(i) Geographical area impacted

(ii) Structural damage to buildings, housing stocks, establishment etc.

(iii) Damage to roads & bridges, public buildings shops, workshops, stalls etc.

(v) Damage to water supply lines, electricity supply lines, public utilities etc.

(vi) Damage to agricultural crops, livestock, etc.

Tools for Rapid Assessment

Arial surveys
Photographs, video graphs / films of the affected area
Satellite imageries
Field reports
TV/Press coverage
Visual Inspection Checklist
Camera
Laptop
Notebook
GIS Map
GPS
Compass
Charging apparatus and electric supply for camera, GPS, laptop etc.

8.18 Proforma for Rapid Damage Assessment Report (Radar) of a Landslide

Date of Survey:----------Time:---------- (Hrs)---------- Venue:----------

State---------- District---------- Block---------- Tehsil---------- Village----------

A. Event Details: Geographic Location (Longitude, Latitude, Altitude) - Event Type (Slide/Flow/Fall/Subsidence) –

Landslide Dimensions (Length, Width & Depth in meters)

Magnitude of Disaster (Scale & Level)-

Response (Community/Agency)-

Chronology of events – (Time of Initiation, Period/Duration of activity, Sequence of activity, cause of disaster and consequences as well as response); Association with impacts of any other hazard like earthquake, thunderstorm, lightning, flashfloods etc., if any should be mentioned

Total Number of Villages/Towns/ Cities Affected in the surveyed area:

Total Population Affected (males/females/children):

Number of Families Affected:

B. Impacts on Life

Humans: Deaths (Male/Female/Children/Physically or Mentally impaired)-

Injured - Buried/Missing -

Homeless - Orphans (male/female) –

Livetocks (Cows/Goats/Sheep/Hens & Chickens/Mules etc.): Deaths - Injured

C. Impacts on Buildings / Structures:

Residential Buildings: Destroyed - Damaged (kind & extent of damages) -

Cow-Pens/Animal Sheds: Destroyed - Damaged (kind & extent of damage)-

Governmental/Community Buildings(Temples/Community Halls/Educational & Health Buildings): Destroyed - Damaged (kind & extent) –

Commercial Buildings (Offices/Shops/Industries):

Destroyed - Damaged (kind & extent of damage)-

D. Landscape Changes / Ground Failures / Environmental Impacts:

Agricultural Land Damaged (m^2) - Housing Plots Damaged (m^2)–

Drainage Disruption (River/Channel blockade) - Ground Cracks (Dimensions-LxWxD)-

Forest Land affected (no. & types of trees)-

Any other ground changes like river blockade, riverbed upliftment, water pollution etc.-

E. Impacts on Infra-structure:
Transportation (Vehicles/Roads/Bridle path/Bridges/Footpath) –
Communication (Wireless/Phone/Mobile/Internet /Pager) –
Drinking Water Supply – Power Supply -
Sewerage and Sanitation -

F. Projects/Activities affected: Hydel / Power-
Grain Grinders (Gharats)-Other Projects-
Socio-cultural - Economic/Livelihood-

G. Total Losses (Approx.): Tangible (in rupees)-
Intangible (in brief description)-

H. Additional Information:

Name & Signatures of the Survey Team with designation & duties performed
Team Leader (Overall Damage Assessment)
JE/AE, PWD (assessed buildings/structures) AE/JE, Irrigation (Infra-structures)
District Geologist (ground failures) Section Officer, Revenue (Impacts on life)

Note: A local map, hand-held GPS, measuring tape, digital camera, RDAR Proforma and notebook with a pen, pencil & eraser should be carried by the team and data/information may be fed in excel sheet after completion at the NIC Office for use by various authorities and public dissemination on a web portal.

Photos/Sketches / Maps showing extent and distribution of damages

Note: North and scale may be marked on the map

8.19 Search and Rescue Skills

Searching and Locating : A set of techniques and procedures, the purpose of which is to obtain a response or indication of the presence of live victims within a landslide.

Composition of Search Team : A squad leader with 5 or more rescuers.

Squad Leader : is responsible for developing the search plan, diagrams, documentation and making recommendations to the Incident Commander.

Rescuers –carry out the search operation physically and as outlined by the squad leader.

Basic Tools – Probing Radar, Radio equipment to communicate with team members and Command Post, Walkie Talkie, Work site marking supplies, Flags, Cones etc.

Warning and alert devices – Megaphone, Whistle, Hammer, Flags, Horn etc.

Reconnaissance and Vision – Binoculars, Camera, Flashlight, Search Diagrams, Technical search equipment, pen, board etc.

Steps for Searching and Locating

- Compile and analyse available information. Secure the scene
- Inspect and evaluate the worksite
- Rescue victims with easy access on or near the surface
- Select the area of search
- Select the proper tools for searching
- Conduct an appropriate search pattern
- Initiate pre-hospital treatment for the victims
- Confirm the presence and location of potential victims with resources, information and available equipment

8.19.1 Search Modalities

Hasty Search / Primary – is conducted to quickly detect the presence of survivors on the surface. Hasty search accomplishes the following: rapid detection of victims, set priorities

Extensive (Grid) Search / Secondary – This type of search is conducted in a methodical manner to pinpoint the exact location of victims. It is designed to cover the entire assigned area carefully and in detail. An extensive or grid search accomplishes the following a thorough systematic search, redundant checks, and use of alternate search resources.

8.19.2 Search Methods

8.19.2.1 Physical Search – These operations do not require specialists or unique, expensive equipment. These only require senses and some established procedures. This search tactic is the first and sometimes, the only search method used by local rescuers who do not possess technical or canine search resources.

8.19.2.2 Canine Search – It uses the acute sense of smell among dogs, especially trained to detect live humans. Certified canine teams with highly specialized dogs (Fig.8.30) provide the best way to locate trapped victims in a large area in a very short time. They are able to access the areas too small or too unstable for humans to enter. Canines can be used for hasty and extensive operations. A thorough site search with two well-trained dogs has a high probability of conclusive results. The search dogs are trained to detect those victims that are alive. Rescuers should coordinate their activities with canine team during search operation.

8.19.2.3 Technical Search – requires highly trained personnel and specialized equipment for detection of sound, temperature, videos, vibrations etc. It can be carried out using specially manufactured or locally improvised equipment.

8.20 Basic rescue skills

8.20.1 Knot tying

Although there are other knots and hitches in rescue work, the ones mentioned below are the most common and should be learnt if you are to be a good rescue worker. Lives may depend on your being able to tie the right knot securely at the moment it is needed in light or dark, rain or shine. The use of natural fibre rope must be discouraged for the rescue of human life. For most other operations, natural fibre rope will suffice. Beware of ropes or straps that have been in the sun for some time; this may have weakened them. The important knots are simple figure eight knot, reef knot, clove hitch, figure eight-on-a-eight, sheet bend, bowline, round turn and two half hitches, timber hitch etc.

8.20.2 Emergency handling of casualties

The prime purpose of all rescue work is to arrange medical help as quickly as possible and get the injured people out of danger. When there are many casualties, the aim becomes one of trying to ensure the best use of time to effectively help as many people as possible. This decision-making process is called “triage.” In that, those responding to the incident are called upon to

examine all casualties quickly and rank them according to the level of need for both first aid and transportation to medical help. In any rescue or multiple casualty situation, confusion may be evident. It is essential that individuals assigned the job of helping injured people should remain calm and act quickly and carefully, always remain attentive to potential hazards to either themselves or other people in the area. In any situation where one suspects a possible head or spinal injury, if the life of the person is not under immediate threat, seek the help of specialists. If it is essential to move the casualty, and if one's life is not in danger, maintain normal anatomical alignment (nose, belly button, inside of ankles). If the person is not in that position, get the help of qualified personnel.

Try to establish quickly how many casualties are there in the incident. Go to the nearest casualty, provided it is safe, and check for responsiveness. If the person does not answer or respond to attempts to wake him/her, check to see if the person is breathing. The aim is to keep the casualty alive until medical help arrives. One should not waste time dealing with minor injuries until all casualties have been found and stabilized.

If the person is not breathing, try to find someone nearby who is able to do artificial respiration until help gets in there. If the casualty is bleeding severely, apply a pressure bandage before moving to the next casualty. Remember, time is valuable. Give first aid for life-threatening conditions quickly and go to the next casualty.

8.20.3 One-rescuer methods

Never move the casualty any further than needed. Scan the escape routes to determine the best method and route to carry the casualty. If one is alone and must move the casualty quickly, try one of the following rescue carries: human crutch, drag carry, blanket drag, pick-a-back, removal downstairs, firefighter's crawl etc.

8.20.4 Two-rescuer methods

If there are two people to do the carrying, try one of these emergency methods: chair lift, two-hand seat carry, or four-hand seat carry method.

8.20.5 Multi-rescuer methods

If there are more than two of you to do the job, there are a number of different methods that can be used to carry casualties. These include blanket lift, three-person lift and carry, improvised stretchers, blanket and poles stretcher,

stretchers from found materials, blanketing stretchers**, lashing casualty to stretcher,** carrying stretchers etc.

8.21 Five stages of rescue

No hard and fast rules can be laid down for rescue work but, generally speaking, five stages of rescue are followed by trained rescue parties.

*Stage 1- **Reconnaissance and dealing with surface casualties***

Examine the site. Deal with surface casualties. Gather all possible information about other occupants of the building.

Stage 2 - Location and removal of lightly-trapped casualties

Immediate search -accessible areas for casualties, who can be rescued with minimal effort. Maintain contact with casualties inside who can be seen or heard but cannot be moved immediately.

Note: The use of trained air-scenting dogs can greatly increase the likelihood of finding trapped and conscious or unconscious casualties. Dogs used in this fashion should not be worn collars or harnesses that might trap itself when moving through debris. The paws should be checked regularly for injuries.

Stage 3- Exploration of likely survival points

Search the ruins and rescue all persons who can be seen or heard. This may include a calling and listening period.

Stage 4 - Further exploration and selected debris removal

Search farther into the ruins even where the chances of trapped people remaining alive seem remote. This includes removing debris from the likely places where casualties may be located.

Stage 5- Systematic debris removal

Strip selected areas of debris until all supposed casualties are accounted for. This includes removal of the dead bodies and detached body parts. Identify buildings that have already been searched by using spray paint or signs. This method can also be used to mark buildings that may contain bodies.

8.22 Some Do's and Don'ts

Practise in the dark

To be a good rescue worker you should master all skills outlined in this booklet. One *should* be able to do them in the dark. Practise tying knots blindfolded and in cramped quarters.

What should be done before an emergency

- Volunteer to get involved with one's municipality's implementation of an Emergency Plan. One should call local authorities and let them know he is interested.
- Make a family emergency plan.
- Prepare a family emergency kit in case one need s to evacuate the premises.
- Get first aid training.
- Keep a list of emergency telephone numbers.
- Get all safety equipments (gloves, safety glasses, helmet, work boots, anti-dust mask) for protection ready

What to do

- Think before the act and be careful.
- Warn or have somebody warn the authorities about the damages and the number of casualties in one's sector.
- Do a reconnaissance before starting the work. This will not amount to wasting of invaluable time
- Walk as closely to the wall as possible when on damaged stairs and upper floors.
- Use gloves when removing debris by hand.
- Be careful how you move debris from the vicinity of a casualty.
- Protect a casualty from falling debris and dust by using blankets, tarpaulins, corrugated iron sheets, etc.
- Keep off wreckage as much as possible; leave it undisturbed or destroy the neutral voids by further collapse.
- Be careful how you remove debris and obstacles, especially from voids, to prevent further collapse.
- Exercise great care when using sharp tools in debris.
- It is often necessary to use props or struts to strengthen a floor loaded with debris before passing over or working underneath it.
- In situations where the number of casualties is greater than the help available, do not waste time, use resources wisely.
- Examine a casualty before removal and give first aid only for life-threatening conditions

- Free the nose and mouth of a casualty from dust and grit to ease breathing.
- Keep the casualty warm to slow the progress of shock.
- Make sure that the stretcher is properly blanketed so that the casualty has maximum warmth and comfort.
- Use appropriate procedures to carry a stretcher over debris and obstacles. Keep a list of all casualties handled.

Don't

- Move an injured person without rendering first aid unless the casualty is in immediate danger.
- Smoke or light a match stick in case there is a gas leak.
- Crawl over debris or disturb parts of the damaged structure unless you are compelled by circumstances.
- Pull timber out of the wreckage indiscriminately to cause further collapse.
- Enter any site without informing the other members of your party or, if possible, without a companion to help in case of an accident.
- Touch loose electrical wiring.
- Throw debris aimlessly – one may have to move it again.

8.23 Safety in Rescue Operation

Rescue operations are the most complex and difficult activities that first responder teams faces. There may be numerous factors affecting safety during a rescue operation. Every rescuer should follow some basic safety rules like:

- **Personal Protective Equipment**: Anyone entering the area must be wearing personal protective equipment.
- **Hygiene:** To reduce as much as possible the contamination or contagion, one must wash his/her hands with soap and water before and after entering the work area; before and after eating and before and after using bathroom/toilets.
- **Safety Officer** : During the rescue work, one individual from the team will be designated safety officer. He/She will be in-charge of all safety related matters and will have the authority to partially or completely halt all activities.

- **Group Safety** : Each instructor and team leader will also be responsible for the safety of personnel in respective groups. Should one observe any unsafe action or condition, or an emergency, the safety officer should be alerted immediately. For this purpose, everyone will have whistle to use in an emergency.
- **Whistle Signals** : The safety officer will use the whistle to give alarm signals and alerts in the work area using the following signal system
    - One long signal – stop all work and listen for instructions
    - One long, one short – continue working
    - Three short signals – alarm signal, evacuate the area immediately to a previously designated safety zone
- **Safety Zone**: The safety officer will establish a safety zone near the work area. The safety zone will be used in case of any emergency requiring evacuation of the work area.
- **Emergency Medical Services:** A first aid kit and means of communications must be made available to ensure EMS arrival within 15 minutes, should the need rise.
- **Drinking Water** : During rescue work, the rescuers must carry a canteen or drinking water, to prevent dehydration.
- **Team safety:** All operations involving use of tools and equipment must be conducted in pairs, so that one person can use the tools/equipment while the other acts as a safety lookout. The person for safety lookout will use the signal system in which one tap on shoulder means to stop working, and two taps means to continue.
    - The Rescue Team Leader is responsible for the safety of his team members
    - When there is no designated safety officer in CSSR team, every team member must remain acutely aware of safety at all times and look out for each other
    - Every CSSR team members is responsible for giving warning about and preventing unsafe actions and/or conditions during all phases of CSSR operation

SAFETY IS EVERYONE'S RESPONSIBILITY

8.24 Victim Management – The following concepts and procedures should be applied starting from the moment the search is initiated and till the last victim is found.

Precautions during a search

- Never make inappropriate comments and keep a positive note. Always assume someone is listening to you (may be the victim?)
- The victim is in the worst possible position and fighting to stay alive, and you can enhance their chances of survival by being positive about the possibility of finding and extricating them
- You may be first person whom the victim is able to communicate with, therefore, it is important to project a sense of confidence and hope.

Steps for initial contact with a located victim

- Identify and overcome language barriers
- Identify yourself as a rescuer, projecting confidence and calm in your voice and choice of words
- Obtain the following information: Name, Adult or Child, Type and extent of injury, Hydration Status, Warmth, Degree of Confinement
- Provide emergency medical help as quickly as possible
- Ask about other potential victims and their condition
- Inform the victim of rescue operations
- Inform the victim if one has to leave for short periods
- Provide protection as much as possible from the environment
- Consider direct or indirect interventions of a relative or friend

8.25 First Aid

First Aid is the temporary help given to an injured or a sick person before professional medical treatment; it may also be termed as an emergency care offered to a victim of sudden illness or injury until more skillful help is available. This timely assistance, comprising of simple medical techniques, is most critical to the victims and may, often, save life and improve vitals. Any layperson can be trained to administer first aid, which can be carried out using minimal equipments. Basic training in first aid skills should be taught in school, in work places and, in general, be learnt by all, as it is mandatory to our modern and stressful life. Also, it is equally important to know what not to do in such situations.

There are several conditions that require first aid.

"First aid" is a catch-all phrase that refers to two distinctly different categories of medical needs.

- Emergency first aid is the first positive response to an injury, illness or life-threatening (or limb-threatening) medical emergency. In this case more advanced medical care will follow. This type of first aid includes CPR, clearing an airway obstruction, responding to anaphylactic shock, splinting a broken bone, and severe bleeding control.
- Non-emergency first aid is the treatment for minor medical needs. We may or may not seek more advanced medical care after the initial response. This includes taking over-the-counter medications for minor pain or allergies, cleaning and bandaging cuts or abrasions, and minor bleeding control.

When you reach the victim, do the following:

- Assessment of the injured
- Is the person alive?
- Can s/he be removed from the site?
- Quick Triage

  (First attend to the one who is most likely to survive)

Lifting and Extracting injured people:

- Unless the accident site becomes unsafe or further damage likely, do not move the victim
- Do not retrieve if further damage is likely by one's action
- Let injured arm hang free
- One should lock one's arms under those of the injured to lift.
- Stabilize neck

Assessment of the Injured

- Check Pulse
- See Skin Color
- Assess level of consciousness (AVPU: A-Alert, V-Response to vocal stimuli, P-Response to painful stimuli, U-Unresponsive)

Seriously Injured Ones – ABCDE:

A – Airways

B – Breathing

C – Circulation

D – Disability (Neurological and others)

E – Exposure and Temperature Control

Halt further damage/injury; do no harm.

Airways – Look and Listen

- Look for vomitus / foreign bodies (in mouth and throat)
- Look for breathing efforts
- Listen any abnormal sound
- HEIMLICH's maneuvers to clear foreign body from the wind pipe (trachea)
- Lift the chin
- Do not bend/tilt the neck unnecessarily

Breathing:

- Make sure that victim can breath
- Look for rib fracture
- Close open chest wound
- Mouth to mouth respiration

Circulation:

- Check pulse
- See colour
- Check for bleeding (may be internal ?)
- Control bleeding
  - No Tourniquet
  - Direct Pressure (Wound, Pressure point, Elevate the injured part)
- Control bleeding
- Check for fractured ribs
- For shock (Head down and legs up / raised)
- Do not remove the stuck sharp objects from the body before you can stop bleeding
- Tourniquets have done more harm than good

Stabilization

- Neck / spine stabilization (most important)
- Any trauma above the upper chest and neck should be considered as Cervical Spine Injury unless proved otherwise in the hospital
- May not have external / neurological signs of injury
- Place victims in most comfortable / neutral position

- Utmost care to be taken during shifting / transfer
- Reassure the victim that help is at hand

Environment Control

- Halt further injury (damage)
- Prevent hypo / hyper-thermia
- Prevent suffocation / drowning
- Do not feed the victim?

Expert Resuscitation

- Suction
- Intubation
- Oxygen Therapy
- Medication
- Control of bleeding
- Cardio Pulmonary Resuscitation (CPR)
- Defibrillation
- Stabilization

Transportation

- Identify priority cases
- Get appropriate transport (vehicle)
- Appropriate personnel
- Closest versus Most appropriate centre
- Transport in "recovery position'
- Stabilize

(Caution – Transporting unconscious patients on his back without proper attention to his airways is a major cause of death due to ill-care)

First Aid for fractures

Spine Fracture:

- Move victims with great care. Will need many people
- Rolled towel can be used as a collar support
- Keep person's spine as straight as possible
- Can strap him /her to a plank

Pelvic Bones fracture:

- Triangular Bandage
- Put pad between thighs

Fractured Arms:

- Sling and strap to his/her body

Legs fracture:

- Splint (with bamboo etc.)
- Splint to other leg

SurvivaMl Skills

- Avoid / Prevent
- Escape
- Communicate
- Do not be a victim while trying to be rescuer

If injured and if one is fairly conscious:

- Try to make oneself comfortable
- Be calm, do not panic
- Breath normally
- Move as little as possible
- Keep control on heart rate, BP, oxygen demand, blood loss, conserve energy, remain conscious longer

If injured, compress over the bleeding site. Cooperate with rescue team. Ensure your safety first and then help others, if you can.

Things to learn

- Patient in "Recovery Position"
- Vessel Compression\HEIMLICH Manoeuver
- Mouth to mouth artificial respiration\CPR

8.26 Relief

8.26.1 Financial Mechanisms: The 13th Finance Commission (2010 – 2015) constituted by the President on 13 November 2007, to give recommendations on specified aspects of Centre State Fiscal relations, has submitted its report to the President on 30 December 2009. Para 8 of the Terms of Reference (ToR) pertains to review of the present arrangements as regards financing disaster management with reference to the National Calamity Contingency Fund and the Calamity Relief Fund and the funds envisaged in the DM Act 2005.

The commission reviewed the existing arrangement of financing relief expenditure in light of the DM Act 2005 and recommended merger of the

National Calamity Contingency Fund (NCCF) into National Disaster Response Fund (NDRF) as well as the merger of Calamity Relief Fund (CRF) into State Disaster Response Fund (SDRF) with effect from 1 April 2010 and transfer of balance in existing funds into new funds (please refer MHA notification and MoF Guidelines on NDRF and SDRF for more information).

The commission has assessed the relief expenditure requirements of all states and recommended that 75% of the SDRF requirement for general category States and 90% for the special category States be met by the Centre through a grant to the states.

FC-XII found considerable justification in widening the list of calamities covered under the scheme (FC-XII added landslides, avalanches, cloudburst and pest attacks in the existing list of six disasters – cyclone, drought, earthquake, fire, flood and hailstorm). FC-XII recommended that other disasters including chemical and industrial, as also air/railway accidents, may continue to be taken care by the respective ministries.

The claim on the NCCF is made through a memorandum submitted by the State Government, which is assessed by a central team deputed for the purpose. The report of the team is assessed by an inter-ministerial group (IMG), which makes recommendations to the high level committee (HLC) for release. The assistance from NCCF is only for immediate relief and rehabilitation and not for any reconstruction of assets or restoration of damaged infrastructure. In order to finance post-disaster reconstruction which is not covered under NCCF, Additional Central Assistance (ACA) has been given to States in recent years, particularly for Gujrat earthquake 2001, Tsunami 2004, Kashmir earthquake 2005 and Kosi flood 2008. In the year 2008-09, Rs.645 Crore was released to 10 States under ACA for long term reconstruction of assets

The High Level Committee (HLC) will be constituted with Finance Minister, Agriculture Minister, Home Minister and Deputy Chairman of Planning Commission as members. HLC is serviced by the DM Division of MHA. Upon the approval of HLC, Ministry of Finance will release assistance from NDRF to the states.

Although the DM Act uses terms like 'substantial loss of life, or human suffering, damage to and destruction of property and nature or magnitude as to be beyond the coping capacity of the community of affected area; it however does not quantify these terms.

As per DMA, NDMA shall recommend minimum standards for relief in terms of facilities in relief camps, relief to widows and orphans, ex gratia assistance

on account of loss of life and damage to houses and restoration of means of livelihood. NDMA recommends the minimum standards of relief in terms of facilities to be made available in the relief camps, relief to widows and orphans, ex gratia assistance on account of loss of life and damages to houses and restoration of means of livelihood. The executive powers with regard to calamity relief as well as powers to ensure compliance with directions in carrying out the relief measures are vested with SEC.

Sections 46 and 47 of DM Act 2005 deal with the constitution of National Disaster Response Fund (NDRF) and National Disaster Mitigation Fund (NDMF). NDMF is to fund projects exclusively for the purpose of mitigation. NDRF shall be administered by the NEC to meet the expenses for emergency response, relief, and rehabilitation in accordance with the guidelines laid down by the Central Government in consultation with NDMA. Fund for Pooled Procurement – of relief material on short notice - often comes with an associated premium pricing and may adversely impact quality. An initial grant of Rs.250 Crores, in the form of revolving fund, has been provided to National Disaster Response Force for the purpose. NDMF is to fund projects exclusively for the purpose of mitigation and is to be administered by NDMA. Similar provisions have been made for the State and District Disaster Response and Mitigation Funds. Disaster Mitigation should be a part of plan process and the expenditure therein be met out of the plan resources of the respective ministries of the Union and the States. Second Administrative Reforms Commission recommended that disaster mitigation plans should be included in the development plans. The 11th Five year Plan Document emphasized on mainstreaming disaster management into development planning. Every development should include elements of impact assessment, risk reduction and `do no harm' approach. The State Governments need to give priority to hazard identification and risk assessment in their plans and schemes.

The best methodology to assess the requirements of SDRF would be to base it upon Hazard-Vulnerability-Risk Profile of the States, as it would be a good indicator of disasters a state may face. However, there are no reliable exercise that maps the states on such a scale. In its absence, expenditure based approach would continue to be adopted. The existing list of natural disasters covers most of the prevalent events. However, for very specific events that could even be man-made and require high level of funding, but may have low chance of occurrence, financing of relief arrangements is left out to SDRFs.

The Public Liability Insurance Act (PLI), 1991, notified presently for specified quantities of 179 explosives, toxic and highly reactive chemicals, establishes

the principle of liability for enterprises engaged in hazardous activities. Setting up of Environmental Relief Fund (ERF) under the Act in 2008 has further strengthened its provisions. As on 31st March 2009, the ERF has a corpus of Rs.285 Crore. The legal framework therefore, provides another source of relief for financing man-made disasters.

Effective disaster response requires trained manpower to deal with complex situations wherein effective and speedy handling can reduce the impact of a disaster on human life and property. It is necessary to continuously undertake measures to build capacity amongst those handling response and creating awareness amongst people. An additional grant of Rs.525 Crore has been recommended on the basis of the overall size of the SDRF of a state,. This amount may be used for taking up activities for building capacity in the administrative machinery for better handling of disaster response and for preparation of district and state level disaster management plans as envisaged in the DM Act.

SUB-MODULE 9: LANDSLIDES EDUCATION, TRAINING AND CAPACITY DEVELOPMENT

9.1 Landslide Education

Landslide education will address the multifaceted aspects of landslide management, especially preparedness, mitigation and response efforts. In this regard, case histories of actual past disastrous landslides can be used as valuable inputs for disaster education in general, and landslides in particular.

The development of high-quality education materials, textbooks, field training and high standard of teaching at all levels should be given due emphasis. Education and training programmes should be designed, with greater focus on development of the capacity and skills of trainers and teachers. Science and technology courses designed by the experts and designated institutions should be introduced to orient all target groups including school teachers, NGOs and private volunteers and other professionals engaged in disaster management.

9.1.1 Education of Professionals

The knowledge institutions and universities should focus attention on landslide education through revision of syllabi, enlarging the scope of teaching earth sciences, civil engineering and allied disciplines with practical bias and through crafting of new educational programmes. The curriculum in earth sciences, engineering geology, seismology, geotechnical engineering, structural engineering and architectural aspects needs special attention. Another possible intervention is training of professional engineers and architects to ensure that classroom teaching benefits professional practice. A large number of professionals require training and retraining; endeavour should be to enhance on priority the quality of teaching, of text books, of training kits, etc. in the field of landslide education.

The country need to create a breed of professionals who can appreciate the importance of correct diagnosis before slope treatment. Geomorphologists have to perceive both macro and micro geomorphology and use it in slope analyses to deliver a message that present practices of dismembering slope into factors, such as relative relief and slope erosion. Engineering geologists should discuss micro-geological details controlling a landslide, and not just stop at broad description

of lithology. A geotechnical engineer needs the education to realize that the orthodox soil mechanics has long been replaced by modern soil mechanics arming him with concepts, tools and techniques that can help characterize and analyse a landslide reliably. The landslide managers need the education they should insist on a scientific, systematic slope investigation and that ad-hoc measures without sound investigation may prove to be a costly waste.

There is a need to educate professionals in damage and loss assessment due to landslides and create simple tools and uniform procedures by which objective assessment becomes possible.

Technical institutes, polytechnics and universities located in vulnerable areas should develop adequate technical expertise on various subjects related to landslide management. The state governments, if required, in association with the University Grants Commission (UGC), Department of Science and Technology (DST), Ministry of Human Resources Development (MHRD), All India Council for Technical Education (AICTE) etc. will introduce short term Quality Improvement Programmes (QIP) for teachers and professionals engaged in teaching subjects related to landslides. The new technical programmes on the lines similar to those launched by various Central Ministries for college teachers, geoscientists, civil engineers, town planners etc. for developing the additional capacities in landslide management should also be taken up. The GoI should address the gap between the requirement and availability of quality teachers conversant with natural hazards, especially with the landslide assessment and mitigation techniques.

The subject of disaster medicine covers trauma care, epidemic control, emergency medical care by paramedics and emergency medical technicians, telemedicine etc. DM related medical education will receive due attention in undergraduate level, so that graduating doctors are able to handle emergencies with greater confidence. All architecture and civil engineering graduates should be taught in detail all aspects of landslides and related hazards in hilly areas of the country. These educational efforts should encapsulate improving the knowledge and skills of human resources by reviewing and updating the curricula periodically, upgrading the facilities, and institutionalizing the desired capacity building mechanisms in mitigating this hazard. The mainstreaming of landslide management in development planning will be supplemented with the development of the requisite infrastructure in technical and professional institutions, improved laboratories and libraries in identified R&D institutions. These measures should enable these institutions to undertake research and execute pilot projects on different aspects of landslides employing latest technology and set pace setter examples that will build confidence amongst geo-

scientists, geo-technical engineers and communities regarding management of landslides. The results of such studies should also help to develop and update the technical documents that may form important part of resource materials prepared for training programme on education, sensitisation and training.

9.1.2 Community Education and Awareness

The need for community education cannot be over-emphasized since it is usually the first responder to a disaster and their role in containing damage could be of prime significance. It is necessary that the government and the communities together evolve joint action plan aiming at spreading community awareness and development of community leadership. Such awareness will enable communities in ensuring safer constructions. Investments in Disaster Education, Public Awareness, Community Leadership Development, Disaster Education of unemployed youth, physically challenged, elderly, women and school children should be encouraged.

9.2 Training

The geologists from Geological Survey of India (GSI) and State Directorate of Geology and Mining (DGMs) in landslide affected states should be involved in landslide hazard mitigation programmes and studies after proper training. A large number of engineers are involved in the construction activities at the civil engineering and infrastructural project sites in landslide affected areas. Such training programmes should be offered to these professionals as well. The training modules may include both in-class and on-field training.

Fig. 10.1: People engrossed in Village Level Community Based Training on Disaster Management

9.2.1 Training of Professionals

Geologists, engineers and other professionals related to the field of landslide will be exposed to latest developments in the domain of landslide investigations and management being evolved globally on regular basis so that well trained manpower conversant with latest technological advances is available in the country to manage the hazard effectively. This can be done by sending these professionals abroad regularly to acquire theoretical knowledge as well as practical experience on application of latest and more effective techniques. The training programmes will be systematically planned and executed with extensive interdisciplinary exposures for engendering a trained manpower tuned to holistic management of landslides.

These training programmes should be pilot tested, critically evaluated, upgraded, documented, and peer reviewed at regular intervals. The training modules will be continuously updated based on the evaluation and feedback from participants.

In the initial phases, training may be imparted to all engineers, geologists, geophysicists, hydrologists from DGMs and other departments involved in developmental activities in hilly regions, especially in the ULBs and PRIs of such States. In particular, the design directorates, if any, in the State Departments will ensure that they have architects and engineers with background in landslide-safe design and construction. Those who undergo the 'Training of Trainers' programmes will have the onus of training the professionals through a network of professional societies. Minimum acceptable standards of safety, as enumerated in BIS codes, will be disseminated through professional organisations and the training requirements will be integrated with the licensing criteria.

9.2.2 Recommended Areas Requiring Training

- Geomorphological, geotechnical, hydro-geological and GIS based LHM with perception of mapping scales
- Geotechnical Investigation of landslides with particular reference to characterization of slopes, elucidation of landslide boundaries, representative undisturbed sampling from shear zones, handling of samples, simulated stress-path testing and stability analyses in terms of total and effective stresses
- Techniques of monitoring slope surface and sub slope movements and movement rates and cross linkage with rainfall record, piezometric profiles and behaviour of buildings and structures on slopes

- Slope modeling
- GIS based landslide hazard, vulnerability and risk assessments
- Slope kinetics, site effects and earthquake induced landslides in seismic micro-zonation and risk assessment
- Instrumentation of slopes, landslides and avalanches, and early warning
- Design of landslides and avalanche control measures with particular reference to choice of technologies
- Training of first responders in search, rescue and medicare
- Training of communities and local bodies

Training for visual, print and electronic media in the science of disasters for improved and more objective reporting

9.3 Capacity Development

Mechanism should be developed to identify institutions active in the field of landslides, assess capabilities, enhance and strengthen capacities in terms of expertise, knowledge and resources for effective management of landslide hazard. Main areas requiring capacity development in landslide disaster management are as follows:

- Establishment of a nation-wide organized vibrant pro-active, systematic and scientific institutional mechanism that would replace the current piecemeal, ad-hoc, less recognized and poorly appreciated landslide management practices
- Enhancement of expertise and capacities of knowledge centres in different parts of the country for dependable and timely geomorphological, geotechnical and hydro-geological investigations and for scientific design and speedy and effective implementation of control measures.

Strengthening a few objectively identified institutions, their units and departments in all states and union territories to redefine and enlarge their respective mandates/roles to provide/support pre and post landslide routine/ specialized functions.

9.4 Awareness

As a part of awareness generation exercise of landslide hazard mitigation effort, GSI, in consultation with the MHA, initiated a programme to establish contact with various state governments in landslide affected states and create awareness about this natural hazard among the state officers and other agencies

dealing with natural hazards. The programme include audio-visual presentation and distribution of booklet and posters for generating awareness about landslide hazards, familiarising landslide terminologies, causes, treatment measures etc. GSI Training Institute also conducts training programme on regular basis on various aspects of landslide investigations.

NIDM has the mandate to develop training modules, undertake research and documentation in disaster management; provide assistance in national and state level policy formulation; develop educational materials for disaster management and promote awareness for hazard mitigation, preparedness and response measures. Indian Institute of Remote Sensing (IIRS), Dehradun also conducts both short and long term courses especially for orienting the people in the usage of remote sensing data for geological hazards. The Decision support centre at NRSA conducts a two week course for various planners at State and District level in the usage of EO data for hazards.

The mass awareness generation programme is to be made essential component of disaster mitigation plan and is planned to be carried out as sustained effort through electronic and print media, interactive meets and distribution of handbills and posters in local languages. Different NGOs, State Government Authorities have also to undertake exhaustive programmes for mass awareness generation. A series of audio- visual resource material on this aspect has to be prepared and distributed to the above mentioned organizations for this purpose. The services of media, private volunteers and NGO's active in the field of disaster related work can be effectively utilized for this purpose after proper orientation.

Large number of engineers and geologists engaged in landslide hazard management do not possess requisite expertise to manage this hazard. Landslide hazard management techniques, risk assessment and remediation practices are required to be included in the curriculum of technical institutes teaching civil engineering, geology, geophysics and disaster management.

Local communities aware about landslide hazards and their locales, would be in a better position, both physically and psychologically to face consequences. Since landslides are frequent and sudden and cause disasters that affect localized areas resulting in segregated losses, these do not receive appropriate attention due to transitory nature and short-lived human memory. Hence, the level of awareness about landslides has been quite low compared to other disasters like earthquakes, floods and cyclones. In our country's hilly terrain, cumulative losses due to landslides are much higher than any other disaster. Thus, there is an immediate need to educate people about landslides so as to reduce the associated risk / losses.

State Governments / State Disaster Management Authorities (SDMAs) of landslide affected state areas will, in collaboration with the GSI and other key stakeholders, make special efforts to mobilize communities to carry out landslide mitigation efforts. Electronic and print media will also be associated in the endeavor to create greater public awareness about landslide hazard and the importance of landuse zoning practices. Comprehensive awareness campaigns targeting different groups of people living in landslide prone areas, will be carried out systematically. These campaigns will emphasise on the prevalent landslide risk and vulnerability of the areas as well as highlight the roles and responsibilities of communities and stakeholders in addressing this risk. These will also focus on the specific role that each institution/ organization or community will play in order to mitigate the effects of landslides.

9.5 Creation of Public Awareness on Landslide Risk Reduction

Handbooks, posters and handbills containing status of landslide hazard should be distributed and details of landslide indicators along with precautions to be adopted and suggestive measures should be displayed near the landslide prone sites. All above documents should be translated into local and regional languages. Short video films on the landslide risk, vulnerability and importance of preparedness and mitigation measures should be prepared for the benefit of local public. The electronic and print media should also be made integral part of such campaigns.

Communities need to be alerted and made aware of:

- the major disaster threat perceptions in the localities of immediate concern, and the projected disaster scenarios (landslide included)
- the possible landslide hazard distribution scenarios and major known landslide spots and identified elements at risk
- the lessons learnt from the past landslide disasters in the areas and also their (mis)management, if any
- the precursors and early indicators that can avert landslide disaster
- the roads, housing, schools etc. exposed to landslide risk
- the role and responsibility of the government and local bodies before, during and after a disaster
- the expected roles and responsibilities of communities and people at large before, during and after a disaster; the responsibility the residents and communities are willing to shoulder in choosing to live or to do business in high risk areas

- the role of public sector, NGOs and other voluntary organizations
- whether the construction materials, design and construction conform to prevalent building codes and establish engineering practices?

9.5.1 Awareness Drives for Specific Target Groups

One of the most challenging tasks in landslides preparedness and mitigation is the sensitization of stakeholders, and educating and training them to participate in landslide preparedness and mitigation efforts. If the community recognizes the importance of landslides safety vis-à-vis developmental activities, tremendous gains can be achieved in landslide risk reduction.

Big construction companies and contractors engaged in infrastructure development in the hilly regions will undertake campaigns to sensitise their members on the risk and vulnerability resulting from landslides in various parts of the country so that necessary attention to prevent this hazard and mitigation measures are included in designs and construction in vulnerable areas.

A comprehensive awareness campaign should be developed and implemented for following safe practices before, during and after a landslide. The campaign should also highlight the risks and vulnerability of the states and the roles / responsibilities of all communities and stakeholders in addressing the risk.

Public awareness campaigns should be conducted at the national, state and district centres and in high risk areas for disseminating information on landslide risk management among all stakeholders. Case studies documenting the major landslides should be prepared and used for creating greater public awareness among professional and critical stakeholders. Landslide risk management should be done by applying available knowledge and customizing the same through R & D for specific situations and generating new adaptive techniques.

9.6 Landslide Preparedness

DM plans for landslide prone areas should be systematically developed such that stakeholders are able to address landslide risk. These plans should be region specific and should consider the risk profile and the special characteristics of a particular geographic area. Preparedness should include the formulation of family and community contingency plans. Mock drills should be conducted in offices, schools and industrial units etc. and in the neighbourhood of the sites vulnerable to landslides.

The people operating in the mountainous regions will be sensitized about the landslide hazard. They would be advised to remain vigilant and respond effectively in emergency situations.

An exercise in real sense is a focused practice that puts the participants in a simulated situation to function in the capacity that would be expected of them in a real event. Its purpose is to promote preparedness by testing policies and plans and training personnel.

Exercises should be conducted to evaluate an organization's capability to execute one or more portions of its response or contingency plans. Many successful responses to emergencies over the years have demonstrated that exercising pays huge dividends.

Comprehensive exercise programme involves five main types of activities, viz. orientation seminar, drill, tabletop exercises, functional exercises and full-scale exercises.

As per the specific situation these exercises will be conducted to assess the preparedness for all possible hazards present in an area taken together.

9.6.1 Medical Preparedness

The disaster management plans related to medical preparedness developed at the state and district levels will be same as in other hazards. The principal aim of the medical management plan will be to improve emergency medical preparedness and emergency medical response. In case of landslide hazard, the medical preparedness should focus on likely injuries resulting from landslides including psycho-social trauma. It should address the need for surveillance and for planning and rehearsing for disaster preparedness through mock exercises.

Since Medical Management Plans include all disasters existing in the area, there is a need to create greater awareness in all medical teams and the medical community at large about all hazards and types of injuries that can be inflicted especially by landslides.

All public health facilities will develop their own DM plans, with the scope for enhancing their surge capacity in the event of disaster. Training exercises and mock drills will be carried out regularly by doctors and paramedical staff. The medical preparedness plans will also include identification of trained trauma and psycho-social care teams, with nursing and paramedical staff. In high-risk landslide areas, mobile hospitals and Quick Reaction Medical Teams (QRMTs) should be developed as part of the overall disaster health-care delivery system of the states to manage patients with minor injuries at the incident site itself.

The state governments will identify the hospitals, team of doctors and para-medics including mental health and psycho-social service provider at sub-

divisional and district levels, who will be deployed at short notice. Their names, addresses, telephone numbers, mobile numbers, email etc. will be made available to the district and state control rooms. The list will be updated annually. The stock of medicines, accessories and equipment for each of identified teams at the district and sub-divisions will be assessed and updated in advance as per needs.

9.6.2 Animal Care

Animals both domestic as well as wild are exposed to the effects of natural and man-made disasters. It is necessary to devise appropriate measures to protect animals and find means to shelter and feed them during disasters and their aftermath, through a community effort, to the extent possible. It is pertinent to note that many communities have shown compassion to animals during disasters, and these efforts need to be formalized in the preparedness plans of the Departments of Animal Husbandry at the Centre and the States.

9.7 Preparedness Plan for Landslides

Landslides are a serious geologic hazard that causes thousands of deaths and injuries each year throughout the world. Often associated with periods of heavy rainfall or rapid snow melt, landslides are capable of rapid movement with enormous destructive capacity. Earthquakes can also trigger landslides. Landslide preparedness involves individuals knowing about the hazard potential where they live and taking various steps to reduce the personal risk from this geologic phenomenon. Landslide usually strike without warming. The force of rocks, soil, or other debris moving down a slope can devastate anything in its path. the following steps should be taken to keep one in readiness.

9.7.1 Pre-disaster Preparedness

If one is at risk from landslides, one should:

- Develop an evacuation plan. If the home could be damaged in a landslide, one should know where to go. Making plans at the last minute can be upsetting, create confusion, and waste precious time. Contact local authorities to learn about the emergency response and evacuation plans for the area and develop own emergency plans for family and business.
- Familiarize oneself with the land around one It will help in assessment of risk.

- Watch the patterns of storm water drainage on slopes near homes, especially the places where runoff water converges, increasing flow over soil covered slopes. Watch the hillsides around homes for any signs of land movement, such as small landslides or debris flows, or progressively tilting trees.

Noticing small changes could alert you to an increased threat of a landslide.

- Discuss landslides and debris flows with members of household. Everyone should know what to do to stay safe if one occurs.
- Be aware that, landslide insurance is generally, not available; however, in some cases, debris flow damage may be covered by flood insurance policies.
- Get a Ground Assessment of the property.
- Seek specific information on areas vulnerable to land sliding from a geologist. Consult a professional engineering geologist or a geotechnical expert for opinions and advice on landslide problems and on corrective measures one can take.
- Minimize home hazards. One can reduce the potential impacts of land movement by taking steps to remove oneself from harm's way.
- Plant ground cover on slopes and build retaining walls. In mudflow areas, build channels or deflection wall to direct the flow around buildings. (Remember: If one build walls to divert debris flow and the flow lands on a neighbor's property, one may be liable for damages). .
- Build away from steep slopes.
- Build away from the bottoms or mouths of steep ravines and drainage facilities.

Learn to recognize the landslide warning signs

- Doors or windows stick or jam for the first time.
- New cracks appear in plaster, tiles, bricks, or foundations
- Outside walls, walks, or stairs begin pulling away from the building
- Slowly developing, widening cracks appear on the ground or on paved areas such as streets or driveways.
- Underground utility lines break.

- Bulging ground / wall appears at the base of a slope.
- New holes or bare spots on hillsides
- Water breaks through the ground surface at new locations.
- New springs appear or sudden disappearance of existing springs
- Muddy water in creeks, rivers
- Fences, retaining walls, utility poles, or trees tilt or move.
- One hears a faint rumbling sound that increases in volume as the landslide nears. The ground slopes downward in one specific direction and may begin shifting in that direction under the feet.

Make evacuation plans

- Plan at least two evacuation routes since roads may become blocked or closed.
- Develop an emergency communication plan
- In case family members are separated from one another during a landslide or mudflow (this is a real possibility during the day when adults are at work and children at school); have a plan for getting back together
- **Develop a family plan that includes** out-of-locality family contact number, place to join up if family members are separated, decide the safe routes to leave for secure place, and locations of utility shut-offs. After a disaster, it's often easier to call long distance. Make sure everyone knows the name, address, and phone number of the contact person
- **Keep ready emergency supplies like** Food, Water, First aid kit, Flashlights and batteries, Battery-operated radios, Special medications/eye care products
- **Prepare an evacuation kit that includes** Cash (small bills and change), Important documents (Birth certificates, insurance policies, marriage certificates, mortgage documents), Games, toys for children
- **Purchase supplies to protect your home. It may include** Hammer, Nails, Plywood, Rain gauge, Sand, Sandbags, Shovel
- Listen to the radio or watch television for information and instructions from local officials
- Respect the power of the potential landslide. Remember, landslides move quickly, can cause damage and kill people

Insurance

- The local insurance companies can cover mudflow and Landslide risks under natural calamities

Landslide Preparedness and Prevention for Oceanside Residents

- With last winter's heavy rains, the ocean-side and the coastal parts may suffer devastating landslides.
- If there is another potentially wet winter, the Coastal States should initiate an educational program regarding Landslide Preparedness and Prevention for Oceanside residents.
- While entire landslide damage cannot be prevented, this web site offers practical advice on how home and business owners can take a number of precautions to make their property safer.
- As it is the property owner's responsibility to protect the stability of one's property, one should take this opportunity to learn how to protect property and recognize potential landslide risks.
- Eliminate litter and dead and dry plants.
- Inspect slopes for increases in cracks, holes and other changes.
- Contact local public works department for information on protection measures.

What to do during a landslide

- Quickly move out of the path of the landslide or debris flow – Moving away from the path of flow to a stable area will reduce risk
- If escape is not possible, curl into a tight ball and protect your head. A tight ball will provide the best protection for body.
- Take cover under a sturdy table or desk if inside the house when landslide is moving
- If outside, try to get out of the path of landslide or debris flow; Run to the nearest high ground in a direction away from the path of landslide
- If rocks or debris are approaching you, run the nearest shelter such as group of trees or big and heavy rock mass that are unlikely to move with slide
- A sinkhole occurs when ground water dissolves a vulnerable land surface such as limestone, causing land surface to collapse due to lack of support

What to do after a landslide

- Stay away from the slide area – There may be danger of additional slides
- qGo to established meeting point and follow instructions by the assigned responsible person
- Check for injured and trapped persons near the slide, without entering the slide area directly. Direct rescuers to their locations.
- Help a neighbor who may require special assistance, e.g. infants, elderly people and people with disabilities. People who care for them or who have large families may need additional assistance in emergency situations.
- Give first aid to victim, if you are trained
- Listen to local radio or television for the latest emergency information
- Watch for flooding, which may occur after a landslide or debris flow. Floods sometimes follow landslides and debris flows because they may both be started by the same event
- Look for and report broken utility lines to appropriate authorities. Reporting potential hazards will get the utilities turned off as quickly as possible, preventing further hazard and injury
- Check the building foundation, chimney and surrounding land for damage. Damage to foundations, chimneys or surrounding land may help one assess the safety of the area
- Replant damaged ground as soon as possible since erosion caused by loss of ground cover can lead to flash flooding
- Seek the advice of landslide expert for evaluating hazards or designing corrective techniques to reduce landslide risks. A professional would be able to advise you ways to prevent or reduce landslide risk, without creating further hazard.

9.8 Survival Skills

Live by Your Wits, But for Now, Learn Basic Skills

Without training in basic skills for surviving and evading on the battlefield or on after disaster , your chances of living in evasion situation are slight.

Learn these basic skills now–not when you are headed for or are in survival situation. How you decide to equip yourself before deployment will impact on

whether or not you survive. You need to know about the environment to which you are going, and you must practice basic skills geared to that environment. For instance, if you are going to a desert, you need to know how to get water in the desert.

Practice basic survival skills during all training programs and exercises. Survival training reduces fear of the unknown and enhances self-confidence. It teaches you to live by your wits.

Train Yourself to Survive

There is need to train you to survive. But don't make the mistake of thinking that being in a survival situation would be fun. Wilderness Survival is not a game, there are no reward challenges, and there is no immunity. How do you think you would fare in a survival situation? Could you build a shelter? Could you forage for food and purify water? In real life you don't have luxury items, you don't get tarps and matches and camping supplies. In real life you may not have any tools except your own two hands. If you were stranded in the wilderness would you end up a survivor?

Don't worry about those questions. Instead take action and educate yourself on survival techniques. Nature is unforgiving and you must be prepared to fight to stay alive.

Expand the meaning of each letter of the word survival. Study and remember what each letter signifies because you may some day need SURVIVAL.

S - Size up the Situation
(Surroundings, physical condition, equipment)
U - Use All Your Senses, Undue Haste Makes Waste
R - Remember Where You Are
V - Vanquish Fear and Panic
I - Improvise
V - Value Living
A - Act Like The Natives
L - Live by Your Wits, But for Now, Learn Basic Skills

SUB-MODULE 10: MAINSTREAMING LANDSLIDES RISK REDUCTION IN DEVELOPMENT

10.1 Initiatives on Development and Disaster Risk Reduction

The Central Government, State Governments, Public Sector Units and Private Entrepreneurs in the country are engaged in some kind of developmental activities which can enhance or reduce the disaster risks. Thus, development may have both positive or negative impacts on disaster risks. Similarly disasters also provide an opportunity to learn from our mistakes and help us identify good as well as bad practices. The destruction during disasters demolishes the non-resilient structures whereas the resilient ones may remain safe and functional. Post disaster reconstruction and redevelopment should, therefore, promote application of disaster resilient features more for safer sustainable development. Mainstreaming DRR is one such initiative taken by Government of India to develop a culture of prevention and mitigation into the development process. Major developmental programmes of the Government of India which may have wider impacts on DRR are discussed briefly. National Rural Employment Guarantee Scheme (NREGS) under NREG Act assure financial relief to the needy families in drought affected areas. NREGA serves the larger objective of enhancing agricultural productivity because the first priority under NREGA is given to projects aimed at water conservation. Such schemes can be easily integrated with relief programmes to increase the availability of funds for relief expenditure. Similarly Indira Awa Yozana (IAY) accomplished useful relief works in terms of providing housing to the affected families. 10% of the annual allocation under IAY is earmarked for this purpose. Likewise allocation (5%) is also made under the Accelerated Rural Water Supply Programme (ARWSP). National Rural Health Mission provides broad based improvement in health care for rural population. Rashtriya Swasthya Bima Yojana is a new and important innovation providing the population below poverty line with an insurance policy covering hospital treatment for a defined set of conditions with government meeting the premium wit. Bharat Nirman Programme focuses on the provision of key elements of rural infrastructure such as irrigation, rural electrification, rural roads, rural drinking water supply, sanitation, housing for the poor, and rural connectivity via community IT services. Rashtriya Krishi Vikas Yojana (RKVY) incentivize State governments to prepare district

level agricultural plans that take account of local conditions. Swarna Jayanti Shahri Rozgar Yojana (SJSRY) to provide gainful employment to the urban unemployed (below poverty line) as well as Urban Povery Alleviation and Slum Development to improve. Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) seeks to provide central assistance for urban infrastructure development linked to a process of reforms at the city and urban local body level which would make these bodies more financially viable, and ultimately capable of financing the investment needed in urban areas. National Highways Development Programme (NHDP) includes four laning of the Golden Quadrilateral and the North-South, East-West Corridors; 4/6 laning of 10000 km of national highways connecting State capitals and places of tourist importance with the national network (implemented by NHAI). Special Accelerated Road Development Programme for the North East Region (SARDP-NE) is presently under implementation for providing road connectivity to all State capitals and district headquarters in the NER. The 11th plan outlined a broad approach based on Integrated Energy Policy formulated earlier by the Planning Commission. National Food Security Mission launched in 11th Plan aims at increasing production of cereals and pulses. Pradhan Mantri Gram Sadak Yojana (PMGSY) extends rural connectivity. PMGSY aims to provide reliable road connectivity to all habitations with 1000+ population (500+ Population in Hilly regions). Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) has ambitious plans to extend rural electrification to hitherto unserved rural areas. RGGVY aims not only at household electrification but also at energization of pumpsets. Accelerated Power Development and Reform Programme (APDRP) aims at reducing aggregate technical and commercial losses. Mid-Day Meal Scheme and the Sarva Shiksha Abhiyan (SSA) brought additional children to schools. Accelerated Irrigation Benefit Programme (AIBP) incentivize States to complete projects in a time bound manner. Command Area Development Programme (CADP) was modified in 10th Plan to include water management. A model Participatory Irrigation Management (PIM) Act has been circulated to States to promote PIM to improve irrigation water distribution to all farmers, including the tail enders. Under the Environment (Protection) Act 1986, the Central government can intervene where the water table falls (otherwise as per Easement Act of 1882, the ownership rights of groundwater rest with the owner of the land). River Conservation Programme to ensure that river flows are adequate to provide water of at least bathing quality standards. A comprehensive action plan for Yamuna and Ganges (Ganga Action Plan) has been prepared. Similarly National Lake Conservation Plan (NLCP) for

conservation of 46 lakes in 13 States has been taken up through 31 projects (e.g. Dal Lake Conservation Project). A National Action Plan on Climate Change and Clean Development Mechanism (CDM) are being prepared.

It is estimated that the earth's surface temperature has risen by 0.6±0.2ºC over the 20th century. In the last 50 years, the rise has been 0.13±0.07°C per decade and the recent years have been warmest since 1860, the year from which regular instrumental records are available. Recognizing the importance of climate change issues, the Prime Minister established a Council on Climate Change under his own chairmanship in June 2007 to coordinate national action for assessment, adaptation and mitigation of climate change. An action plan for adaptation to climate change would require (i) action in the area of agricultural research to evolve varieties that can cope with likely climate changes, (ii) action to cope with likely increase in water stress, (iii) action to be able to cope with a greater frequency in natural disasters. In 1997, the Kyoto Protocol under United Nations Framework Convention on Climate Change (UNFCC) was adopted. Bali Action Plan came into being after the 13th Conference of Parties at Bali in December 2007 to enable the full, effective and sustained implementation of the Convention through long-term cooperative action. It is argued that with a share of just 4% of global emissions, any amount of mitigation by India will not affect climate change. National Environment Policy of 2006 requires 'equal per capita entitlements of global environment resources to all countries'. India's per capita emissions never exceed the per capita emissions of the industrialized countries. This formulation focuses on per capita emissions rather than total emissions as the relevant variable, and also provides industrial countries with an incentive to reduce their level of emissions as quickly as possible. With urbanization and concentration of population in metropolitan cities, more and more people are becoming vulnerable to locational disasters.

The 10th Five Year Plan (2002-07), prepared in the backdrop of Orissa Supercyclone, Gujrat earthquake, and the end of IDNDR, recognized disaster management as a development issue for the first time. The plan devoted a separate chapter to disaster management and made a number of important prescriptions to mainstream DRR into the process of development. The prescriptions of 10th Plan can be broadly divided into 3 categories: (i) Policy guidelines at macro level that would inform and guide preparation and implementation of development plan across sectors; (ii) Operational guidelines for integrating DM practices into development; (iii) Specific development schemes for prevention and mitigation of disasters.

The plan called for a `multi-pronged strategy for total risk management, comprising prevention, preparedness, response and recovery, on one hand and for initiating development efforts aimed towards DRR and mitigation on the other hand' to achieve sustainable development. The plan suggested development of SOPs for dealing with humanitarian and relief assistance from non-government sources.

- Building disaster prevention and preparedness in development planning by introducing a rigorous process of vulnerability analysis and risk assessment, maintaining data base and resource inventories at all levels, developing infra-structure for mitigation and establishing Disaster Knowledge Network for use of disaster managers, decision makers, community and so on.
- Encouraging community level initiatives for disaster preparedness by involving people at grass root level, particularly those who are vulnerable.
- Developing appropriate zonal regulations, design standards, building codes, and performance specifications for safe construction.
- Inclusion of disaster mitigation analysis in all development schemes in vulnerable areas and building disaster mitigation components into all development projects.

The 10th Plan recommended creation of faculties in disaster management in all 28 states, in addition to community mobilization, human resource development, establishment of control rooms and forging international cooperation in disaster management. A Central Sector Plan Scheme, the National Disaster Mitigation Programme (NDMP), has been implemented since 1993-94. The scheme mainly provided training and capacity building of government functionaries and other stakeholders to manage disasters effectively. This scheme was transferred from Ministry of Agriculture to Ministry of Home Affairs in June 2002. The allocation of this scheme was raised from Rs.6.30 Crore in 8th Plan to Rs.16.32 Crore in 9th Plan and to Rs.30.77 Crore in 10th Plan. Presently there are 29 DMCs in 28 States/UTs besides NIDM at national level, who undertake research, consultancy and documentation for disaster management. NIDM has been set up for training, capacity building, research and documentation on various natural and manmade disasters. A comprehensive human resource plan for DM has also been prepared. 29 DMCs run in the States/UTs and 6 Centres of Excellence are allocated Rs.30 lakh and Rs.25 Lakh per annum respectively. The total financial allocation is Rs.25 Crore over a period of 5 years from 2007 to 2012. The allocation of Rs.21.90 Crore to the training institutions during 10th Five Year

Plan was mainly used by NIDM which incurred an expenditure of Rs.11.56 Crore. Nearly 71,000 persons have been trained under the programme.

The National Building Code has been revised, taking into consideration the natural hazard and risks of various regions of the country. The National Programme for Capacity Building of Engineers in Earthquake Risk Management (NPCBEERM) aims to train 10000 engineer and NPCBAERM aims to train 10,000 architects on safe construction techniques and practices. MHA implemented DRM programme (2002-2009) in 176 (earlier 169) multi-hazard districts and 38 cities in 17 states. The DRM programme ended in June 2009. It had a multi-donor resource framework of USD 41 million and was the largest CBDRM programme in the world. One of the sub-components of DRM programme was Urban Earthquake vulnerability Reduction Project (UEVRP) implemented in 38 cities with over half a million population in seismic zone III, IV and V across India. It was completed in December 2009. Under this programme, DM plans are being prepared from villages to districts; DM teams are being constituted and training is imparted on various aspects of DM at all levels. The new DRR programme with an outlay of Rs.100 Crore (USD 20 million) is being implemented in 80 districts of 26 States and URR component is being implemented in 58 multi-hazard prone cities of 23 States. The programme has 2 components (i) Institutional Strengthening and Capacity Building for DRR with outlay of Rs.63 Crore (USD 12.6 million) and (ii) Urban Risk Reduction with an outlay of Rs.37 Crore (USD 7.4 million). The Programme Management Board is headed by Secretary (BM), Ministry of Home Affairs.

GoI-USAID Disaster Management Support Project was signed in 2003 and extended upto 2015. The total outlay of the project is USD 4.715 million (comprising USD 420,000 for training studies, USD 500,000 for equipment and USD 3,795 million for technical assistance) and USD 5 million to integrate DRR and Climate Change.

An 10 battalion strong NDRF (2 bn each from BSF, CRPF, CISF and ITBP) has been set-up comprising 144 specialized response teams on various types of disasters of which 72 teams are for NBC disasters. Each battalion provides 18 self contained specialist search and rescue teams of 45 personnel each including engineers, technicians, electricians, dog squads, doctors and paramedics. The total strength of each battalion will be approximately 1,158. Four Training Centres will be set up in Kolkata, Latur, Bhanu and NISA (Hyderabad) by respective paramilitary forces to train personnel from NDRF battalions of respective forces. A national level Disaster Management Academy at Nagpur will be setup to provide Training of Trainers and to meet other national/international commitments. National

Disaster Mitigation Resource Centres (NDMRC), co-located with NDRF, serve as repositories of relief stores for 25,000 affected people in each location. These will cater to emergent requirements especially for the first 72 – 96 hours. At Kolkata and Chandigarh, additional bricks of stores for 50,000 people each will be kept for high altitude areas.

National Fire Service College (NFSC), Nagpur is mandated to train personnel in all spheres of fire engineering. A scheme for upgradation of NFSC was launched in June 2010 to meet the requirements of specialized professional training in all aspects of emergency management, especially fire. National Civil Defence College (NCDC), Nagpur is one of the main centres for disaster relief and management training and a nodal centre for CBRN emergency response. The college has been upgraded to an Institution of Excellence to train a professional cadre of trainers for disaster response and recovery management.

The Civil Defence (CD) set-up is being revamped to strengthen local efforts for disaster preparedness and effective response. GoI launched CSS in April 2009 with an outlay of Rs.100 Crore during 11th Plan for revamping CD setup in the country. Similarly Fire Services are also being strengthened / modernized to convert them to multi-hazard response force. A scheme for strengthening Fire and Emergency Services was launched in 2009 with an outlay of Rs.200 Crore in the 11th Plan. The office of the DG NDRF&CD is the implementing agency. It includes procurement of items, awareness generation/school safety programme, ToT on search, rescue and fire fighting, fire hazard and risk analysis, project management and monitoring. A grant of Rs.87,519 is allocated to Urban Local Bodies, a portion of which is available for revamping of fire services within their respective jurisdiction. All municipal corporations with a population >1 million (2001 census) must put in place fire hazard response and mitigation plan for their respective areas. An additional fund of Rs.472 Crore has been allocated to 7 States (Andhra Pradesh, Haryana, Mizoram, Orissa, Tripura, U.P. and West Bengal)

The 10th Plan has set into motion the process of shifting focus from response centric to prevention, mitigation and preparedness – as means to avert or soften the impact of future emergencies. The 11th Plan aimed at consolidating the process by giving impetus to projects / programmes that develop and nurture culture of safety and the integration of prevention and mitigation in development. Hazard identification and risk assessment must be bound by uniform procedures, fine tuned to local conditions. In the absence of such procedures, any sporadic activity based on some ad hoc procedures carries the potential of doing more harm than good. Conceptualization of

damage scenarios requires quality scientific studies in a multi-disciplinary environment, and generation of new data, besides filling data gaps. The data gaps and assumptions made, and their implications should be clearly brought out. Data sharing among various data generators needs to be addressed. All schemes getting Plan funds will be treated as national assets and data would be made available without any pre-condition for use for DM authorities and others. High resolution geospatial database to facilitate temporal analysis of future assessment impact studies in area and also enable integration of all other assessment studies, to evolve a national database. The reliability of hazard, vulnerability and risk assessment will depend upon the quality of maps and other investigation data and various uncertainties involved due to inadequacy of data and other factors. All major stages of development, namely planning, site investigations and designs, are subject to a process of rigorous peer review and accordingly certified.

Mainstreaming DM into development essentially means looking critically at each activity that is being planned, not only from the perspective of reducing the vulnerability of that activity, but also from the perspective of minimizing the activity's potential contribution to the hazard. Every development plan should incorporate elements of impact assessment, risk reduction and the `do not harm' approach. All schemes for generating basic input data for hazard and vulnerability impact analysis should be taken up. Projects / schemes which yield multiplier effect for the greatest good of the largest number will deserve priority. Choice of appropriate technology, best practices and early warning system for disaster management. Stand-alone disaster management projects such as mitigation projects, awareness programmes, capacity building and CBDM projects, upgrading early warning systems, fail-safe disaster management communication network, micro-zoning and so on, to be taken up. Mainstreaming DRR into already approved projects in sectors of education, housing, infrastructure, urban development and the like. Some school buildings need to be identified which will be used as relief centres and buildings which should be so designed that they withstand the impact of disasters and also have adequate capacity to provide space as relief centres. Such schools should be equipped with essential services which assume great importance at the time of a disaster.

National Landslide Mitigation Project to strengthen the structural and non-structural landslide mitigation efforts and reduce the landslide risk and vulnerability in the hilly districts prone to landslides and mudflows. Expanded Disaster Risk Mitigation Project to strengthen structural and non-structural disaster proneness and mitigation efforts to reduce the risk and vulnerability

in the disaster prone districts with community participation. Information, Education and Communication (IEC) programme for disaster risk and vulnerability reduction, disaster preparedness, structural and non-structural mitigation efforts and disaster response by developing ICT materials, print and electronic media products, campaigns, exhibitions etc. India needs to adopt a proactive approach for providing necessary support to the neighboring countries through multi-lateral cooperation and involvement of regional organizations.

- Vulnerability Assessment Scheme – Gujarat has undertaken vulnerability analysis of different parts of the state to different forms of disasters. Such an analysis is urgently required to be carried out by other states too.
- National Disaster Communication Network (NDCN) for dedicated communication and IT support for proactive disaster support functions including early warning and forecasting.
- National Earthquake Risk Mitigation Project for strengthening structural and non-structural earthquake mitigation efforts and reducing vulnerability and risk in high risk districts.
- National Flood Mitigation Project has multi-objectives including effective preparedness and improved promptness and capability, strengthening community capacity, and reduction in consequences of floods.
- Completely new infrastructure to be built for 6 battalions @Rs.80 Crore per bn and existing infrastructure to be upgraded for the 2 battalions @Rs.25 Crore per bn.
- Micro-zonation of major cities to be carried out. The high risk cities in seismic zone V and IV to prepare strategies to reduce earthquake risk and vulnerability.
- NDMA/MHA to take mitigation projects for DRR and also undertake special studies and research programmes.
- NDMA got the National Policy on Disaster Management approved from the Cabinet on 22 October 2009. It has also issued more than a score of Guidelines on Landslides and Avalanches, Cyclones, Earthquake, Chemical Disasters, Drought, Urban Floods, Tsunami, Biological, Chemical (terrorism), Chemical (Industrial), Nuclear disasters and on role of Civil Defence, NGOs, Medical Preparedness, Incident Response System, Psycho-social Support, Training Regime for Disaster Response, Institutional Strengthening and Capacity Building for DRR, State Disaster Management Plan etc.

SUB-MODULE 11: STANDARDS, BYELAWS AND GUIDELINES

11.1 Model Town Planning and Landuse Bye-Laws

In recognition of the importance of a techno-legal framework for regulating the already built environment, the Ministry of Home Affairs (MHA), Govt. of India had constituted a national level expert group to recommend modifications in existing regulations to ensure structural safety. The group recommended modifications in the Town and Country Planning Acts, Landuse and Zoning Regulations, Development Control Regulations (DCRs) and Building Bye-laws and developed a set of Model Bye-laws which are technically rigorous and conform to globally accepted norms. They also prescribe regulatory, quality control and compliance mechanisms. MHA has circulated these Model Bye-Laws to state governments for review of the byelaws currently in force and for ensuring their adoption after revision. The state governments will review and adopt the Model Town Planning Bye-Law.

Bureau of Indian Standards (BIS) has finalized and published the following Codes and Guidelines related to landslide:

- IS 14496 (Part 2): 1998 Guidelines for preparation of LHZ maps in mountainous terrain: Part 2 Macro Zonation
- IS 14458: Guidelines for Retaining Wall for Hill Areas
  - Part 1: Selection of Type of Walls
  - Part 2: Design of Retaining/Breast Walls
  - Part 3: Construction of Dry Stone Walls
- IS 14680:1999 : Guidelines for Landslide Control
- IS 14804:2000 : Guidelines for Siting, Design and Selection of Materials for residential buildings in Hilly Areas
- National Building Code (NBC) 2005

The Part 2 Macro Zonation dealing with guidelines for preparation of LHZ maps in mountainous terrain is under revision and the guidelines for LHZ mapping on meso-scales is under preparation.

It is felt that there should be codes/ guidelines in case of landslides risk evaluation and detailed geological investigations of landslides.

In case of hydropower projects in hilly terrains, all agencies involved, including those in private and public sectors, require to follow these guidelines for

preparation of LSM, LHZ and risk analysis maps and obtain clearance from the concerned authority before initiating the project.

11.2 Model Village Planning and Landuse Bye-Laws

To ensure structural safety on village level in mountainous terrains, a techno-legal framework, akin to town planning bye laws, needs to be developed which will translate and codify the landslide concerns into village development.

Appropriate legislation may be considered for enactment for future safe and planned development in towns and villages affected by landslide hazard.

Other than BIS, there are a number of other bodies that develop design codes and guidelines in the country, e.g., the Indian Roads Congress (IRC), Ministry of Shipping, Road Transport and Highways (MoSRTH), Research, the Designs and Standards Organisation (RDSO), Ministry of Railways (MoR) etc. Codes developed by these organisations should also be updated and made consistent with the current state-of-the-art techniques on landslide safety. These agencies also have a number of internal memos for regulation of construction practices, the review of which should also be undertaken.

11.3 Techno-legal Regime

The techno-legal regime for landslide risk management should cover both technical and legal issues for effective regulation, implementation and management of landslides risks.

All future developmental activities should be regulated by codal provisions which should have all disaster resistant features. Our country does not have any major provisions or good enforcement systems to take care of disaster resistant constructions for landslides. As is known, hazards do not kill people, it is the badly planned and/or adversely located structures that result in damage to property and life. This can be dealt with by adopting a techno-legal regime through introduction of disaster resistant planning features in the development and building regulations.

The DM Act 2005 has clearly defined the institutional and coordination mechanisms at national, state, district and local levels and provides for establishment of Disaster Mitigation Fund and Disaster Response Fund at national, state, and district levels. The Act also provides for legal powers and penalties. The provisions included in the act shall be valid through out the country.

State Governments should update the urban and landuse regulations by making amendments to incorporate multi-hazard safety requirements. State Governments should review, revise and update the Town and Country Planning Acts, Landuse and Zoning Regulations, Building Bye-laws and DCRs, and this process will be repeated at regular intervals.

11.4 Licensing and Certification

All professionals dealing with safety aspects of slopes in hilly areas should be trained and sensitized through a capacity building process initially and certified through a licensing process. Such certification requirements, in accordance with the criteria evolved by the model techno-legal regime, will be incorporated in the DCRs. Engineering Geologists and Engineers working with the GoI and state government organisations should also be subjected to this certification

11.5 Compliance Review

There is need for a sound compliance regime to ensure the effectiveness of legal provisions. It is most important that monitoring, verification and compliance arrangements are in place both at national and state levels.

All landuse and developmental plans in hilly areas will go through a mandatory compliance review by the professionals of ULBs and PRIs to which these are to be submitted for approval. The major projects and critical structures will be put through a mandatory compliance review by qualified external agencies.

The model techno-legal regime recommended by the expert group set up by the MHA, will be incorporated in DCRs to enforce the scrutiny of developmental and landuse plans in hilly areas for their compliance to safety in accordance with the requirements under the DCRs. This scrutiny will be applicable to all construction habitations and structures in both urban and rural areas. The state governments, in consultation with their SEMCs and HSCs, will ensure that the bodies responsible for compliance are equipped with qualified professionals to undertake general compliance reviews. These professionals, who may be government employees or accredited private practitioners, will be trained specifically in the compliance of the bye-laws.

The area selected for expansion of human settlements, industrial clusters and other important projects in hilly areas should be assessed regarding the status of slope stability by accredited agencies or professional for safety of these.

11.6 Technical Audits and Monitoring

All existing habitations and important structures located in vulnerable areas and facing high risk from unstable slopes should be monitored by the ULBs. The slope stability assessment reports and treatment requirements, if needed, should be scrutinised for regulation compliance as per the specifications of the model techno-legal regime. In case of major projects, these aspects should be subjected to detailed technical evaluations before granting the construction permissions.

11.7 Techno-financial Regime

After occurrence of a disastrous landslide, the central and state governments provide funds for immediate relief and rehabilitation. This process does not adequately cover the requirements for reconstruction of damaged structures and land especially those that are privately owned. Expenditure incurred by the GoI in provision of funds for relief, rehabilitation and reconstruction is increasing manifold due to the rapidly increasing risk profile of the country. In most countries, risk transfer through insurance has been adopted as a step towards providing adequate compensation for the loss of property caused by disasters. Such a mechanism reduces the financial burden of the government. Risk transfer mechanisms have been found to be fairly successful in some countries. Therefore, the insurance sector will be encouraged in our country also to promote such mechanisms in future.

Financial institutions should consider the compliance of safety aspects as far as slope stability issues are concerned before offering construction loans in hilly areas. The housing development programmes supported by the GoI and state governments (like Indira Awas Yojana), and all large-scale housing schemes will have to comply with landslide safety regime.

The approval and disbursement of funds from banks and other financial institutions to industrial units will also be linked to the compliance with slope stability norms by these units.

11.7.1 Financial Allocations for Landslide Management

Central and state ministries / departments will mainstream disaster management efforts in their developmental plans. Accordingly annual plans, specific allocations will be made for carrying out disaster awareness, preparedness and mitigation efforts. Corporate sector can also be collected for supporting landslide risk management efforts as part of Corporate Social Responsibility (CSR).

11.8 Integration of Landslide Management with Development Planning

- Creating a vibrant network of agencies and knowledge based institutions dealing with landslide studies for effective implementation of national landslide agenda
- Empowerment of multi-institutional and multi-disciplinary teams
- Switch-over from piecemeal remediation of landslides to holistic implementation of control measures
- Management of change from outmoded approaches in landslide remediation to landslide control by state-of-the-art technology
- Mobilization of private and Insurance sector participation.
- Streamlining of procedures for speedy funding of priority/fast track projects
- Switchover from conventional bureaucratic benchmarking and project progress evaluation to peer-centric progress review, evaluation and mid-course correction
- Seeding the concept of landslide prevention, and opportunity costs in administrative management of landslides

11.9 Recent Government Initiatives

GoI has constituted a number of Disaster Management bodies at national, state, district and sub-district levels to assess the hazard and the risk and to develop early warning systems, evolve techniques for hazard mitigation, generate public awareness about the causes, effects and safety measures to be adopted and to undertake rescue, relief and rehabilitation measures. At national level, the Ministry of Home affairs is the Nodal Ministry for coordination of relief and response and overall disaster management and Geological Survey of India, an attached office of the Ministry of Mines, declared as nodal agency for landslides by the GoI in January 2004. Accordingly an Action Plan on Landslide Hazard Risk Mitigation was formulated by MHA and GSI started its implemention. Subsequently, the National Disaster Management Act 2005 came into being on 23rd December 2005 and the government set up National Disaster Management Authority (NDMA), a statutory body under the chairmanship of Prime Minister as provided for in this Act. The responsibility to cope with natural disaster is essentially that of state government. The role of central government is supportive in terms of supplementation of physical and financial resources. At State level, each State Government has set up

Disaster Management Authority under the direct control of the Chief Minister. The Chief Secretary of the State heads a State level committee which has overall responsibility for the relief operations in the State. The Relief Commissioners who are in charge of the relief and rehabilitation measures in the wake of natural and other disasters in their States function under the overall direction and control of the State level committee. At District level, it is the Collector/District Magistrate/ Deputy Commissioner who exercises coordinating and supervising powers over all the departments at district level. For any natural disaster, the declared nodal agencies are responsible for coordinating/undertaking studies for processes responsible for hazard and suggesting precautionary and preventive measures, monitoring the disasters, developing early warning systems etc.

11.10 National Disaster Management Policy and Guidelines

National Disaster Management Authority has formulated a draft on National Disaster Management Policy. The present Policy envisages two tier measures which pre-disaster measures comprising preparedness, prevention and mitigation and post-disaster Measures comprising emergency response (rescue & relief) and rehabilitation. Unlike earthquakes and floods, landslides are rather localized and induced by some causative factors, which are well understood. This hazard can be very effectively controlled or reduced if initiatives and activities are based on the most modern technological and scientific approach and the policy implemented through a well coordinated institutionalized mechanism.

The approach to formulation of guidelines comprises a participatory and consultative process. The basic concepts of this exercise include:

- An exhaustive review, disaster-wise, of the actions/steps taken so far by various agencies including central ministries and departments, States, academic, Scientific and technical institutions, NGOs etc.
- Identification of the residual agenda in terms of operational, administrative, financial and legal issues.
- Identification of the destination, in terms of goals and objectives, to be attained, in the short, as well as long term, duly prioritized as vital, essential and desirable with timelines and milestones.
- Drawing up of a roadmap to destination duly indicating the milestones to facilitate easy monitoring.
- Putting in place an institutional mechanism that oversees the operationalisation of this roadmap.

NDMA will play a nodal role in initiating the institutional measures for prevention, mitigation and preparedness with a view to generate a holistic, integrated and proactive approach to Disaster Management.

The NEC, statutorily mandated to assist NDMA will be responsible for preparing the national plan based on the policy and guidelines. NEC will also be responsible for getting it approved by the NDMA and its operationalisation.

The National Disaster Response Force (NDRF) will play a pivotal role in specialized response to a threatening disaster situation or disasters. The general superintendence, direction and control of this force will be vested in and exercised by the NDMA.

At state level, the SDMAs, established by the state governments to lay down policies and plans for DM in the state will, inter-alia approve the state plan in accordance with the guidelines laid down by NDMA and coordinate the implementation of the state plan.

Landslide is a very significant natural hazard in the country which not only threatens environment, human safety, and infrastructure and post earthquake relief operations but also hugely impacts the national economy. It deserves much greater attention in terms of multi-hazard mapping, research, scientific investigations and effective mitigation and management practices. The Guidelines addresses varied aspects of landslide mitigation and management and adopts a holistic and integrated approach that maximizes the networking of voluntary agencies, affected communities and other stakeholders.

SUB-MODULE 12: Community Based Action Plan for Multi-hazard Risk Management

Lessons learnt from recent disasters have made it apparent that no strategy may be successful in disaster risk reduction until and unless the affected communities are made an integral part of the management process and come forward to act proactively for risk assessment, prevention, mitigation, preparedness and emergency response. The communities in Garhwal Himalaya suffered major earthquakes (Uttarkashi-1991 and Chamoli-1999), landslides and debris flow (Malpa and Ukhimath-1998, Phata-2001, Budhakedar-2002, Varunawat-2003, Lambagar-2004, Dhanaulti-2005, Dharchula-2006, Syaldhar-2007, Sukhidang-2008, Munsiyari-2009), flash floods (Alaknanda-1970 and Bhagirathi-1978), major forest fires occur almost every third year, hailstorms and lightning etc. Hence, they became very sensitive to such disastrous events that caused heavy loss of lives, economy and environment. Such losses are rising due to increase in frequency and severity of disasters and rampant unscientific developments in vulnerable locations. During the last one decade, the interventions made by the governmental and non-governmental organizations through various efforts like Disaster Risk Management Project by United Nations Development Programme and Ministry of Home Affairs, Government of India as well as pilot projects on disaster management undertaken by local community based organizations have built the communities' capacity to prepare themselves against disasters and reduce the risks by appropriate planning, development and management at local levels. It is believed that an aware, informed and prepared community is better able to avert, prevent and react to disasters than otherwise. With this background, an effort was made to empower communities through training and field demonstrations to initiate local actions for multi-hazard risk management through the inhabitants of 50 villages in Rudraprayag District in Uttarakhand State, Garhwal Himalaya. The chapter elaborates the activities undertaken in developing the methodology for community based disaster risk management, the process of operation, the outcome and its sustenance.

12.1 Introduction

No part of the earth is free from natural hazards that adversely affect the life, economy and environment. But these hazardous events become catastrophic and termed as disasters when they strike any built environment & affect population

that is not prepared against these hazards. Thus, disasters of any kind may inflict the safety and quality of life in a society. Despite all the scientific and technological innovations, it has been difficult to reduce the impacts of these disasters. Governmental or institutional interventions for disaster management do not succeed due to lack of considerations for community dynamics, perceptions and priorities in local context. Rather the frequency and intensity of disasters appears to have increased due to rise in population density, occupation of hazardous areas, unplanned / fast developments, human fault and hostile actions, neglect of unforeseen hazards and so on.

Since most of our concerns are anthropocentric and relate to development of a sustainable environment for its survival, most hazards in remote and unpopulated areas are not cared for and all our efforts focus towards disaster management of populated and built areas. India's most population (about 70%) lives in villages and hence, the present attempt is primarily oriented towards a rural community to reduce disaster risks.

Disasters are linked not only to hazardous events but also to the vulnerabilities of the exposed elements and capacities within the society to cope with them. Thus, there are three major operating factors that influence the degree of disaster in any area i.e. hazard factor (magnitude, frequency, time of occurrence, duration & extent), vulnerability of different elements exposed to hazards (degree/duration of exposure, proximity to hazardous sources, degree of vulnerability and its value) and the capacities (techno-economic status, socio-political system & coping mechanisms). The paper focuses on possible methods of hazard identification and assessment by the community in its locality, by virtue of their natural experiences with these disasters in the past / present that affect their lives, livelihood, livestocks and living places.

A history of these disasters and their impacts on community, its resources and environment is recorded through a community meeting for spatio-temporal assessment of all the hazards and depicted in a sketch called community based multi-hazard assessment plan. The sketch shows not only the hazards (indicating the place and year of occurrence) but also the physiographic details, natural & social resources, infrastructure and community facilities. The second step in the approach relates to collection of information and data on different elements (physical, human, livestock, environment etc.) in a presentable form i.e. Tables or Charts, thus, providing an idea of degree of vulnerabilities of different elements to all the hazards collectively as well as individually. In the third step, capacities within the community in terms of skills, resources, knowledge & information to face or cope with the disaster are evaluated. These three steps give a very good assessment of the potential risks due to possible

disasters in any locality and an action plan is then prepared to prevent, mitigate or manage these potential disasters for reducing the risks / losses.

The planning strategy was then worked out on the basis of the aforementioned three steps. The fourth step (first in the planning strategy) makes an attempt towards hazard management i.e. to explore if the hazard can be avoided, prevented, mitigated, or monitored. The community looks for various options / alternatives that can be applied using the local skills, resources, knowledge and techniques. In the fifth step, an attempt to strengthen the existing vulnerable elements or reduce their degree of vulnerabilities through the use of anti-disaster or disaster resistant technologies will be promoted or encouraged. The last step, which envisages that despite all the efforts, disaster may continue to inflict upon the society, ensures that the community is aware and prepared to face the remnant disasters in a planned way rather than being caught suddenly in a rash manner. It assumes that an informed, aware and prepared community will be better able to cope with disasters than otherwise.

12.2. Why Community Based Disaster Risk Management ?

The need for a Community Based Disaster Risk Management (CBDRM) can be highlighted by pointing out the shortcomings in the existing approach and stating the advantages of CBDRM.

12.2.1 Shortcomings in the existing approach

a. Same plan regardless of the regional characteristics is implemented / imposed everywhere.

b. Local / indigenous knowledge, experience, skills, resources and techniques are not given due importance. Rather external resources and techniques are proposed to be utilized.

c. Negligence about local cultural instincts and heritage.

d. Prioritisation is decided by an outsider and not the stakeholders or the community itself.

e. Local community does not have any information about the disaster management plans for their area and the role of different sectors in helping the community during disasters.

12.2.2 Advantages of Community Based Disaster Risk Management

a. Feelings of coordination and self belonging to the society are developed. As the plan is prepared in local laymen's language, it is better understood by the community (including the illiterates).

b. Local geo-climatic and socio-economic characteristics get attention of the people in development and disaster management.

c. Local initiatives begin and community provides assistance to the executing agencies involved in disaster management.

d. There is exchange of knowledge, information, skills & techniques between the community and the experts involved from outside.

e. Community comes forward to put its ideas and suggestion for selection of appropriate programs suitable to their locality and society.

f. Community can keep a watch / monitor the quality of works being done in its locality. It will also generate a sense of responsibility among the community.

g. It will lead to capacity building of the community on issues of disaster safe developmental activities.

12.3. Development, Testing & Application of Community Methodology

The inception of the idea that CBDRM would be rational and beneficial for the society, led to development of a suitable methodology for use by the community in its aim to reduce disaster risks. Although several scientific and technological methodologies exist for hazard identification, assessment, monitoring and control; yet the community is barely involved or benefited by their application. Therefore, an attempt has been made to involve and use the community's experiences and knowledge in dealing with the issues of disaster assessment and management while applying scientific principles of disaster management in a broader sense.

Basically, six steps were identified – three of which involve assessment of hazards, vulnerability and capacity within a locality and the other three steps deal with action planning for modification or management of the first three issues. A tool called participatory learning and action (PLA) was applied during development of the said methodology to make it practical and easier for the community to adopt,. The draft of this approach was taken to an interior village and discussed with the community there about its objectives and usage. The village community took keen interest in the proposed activity and carried out the whole task without much difficulty in less than two days at a community gathering. The results of this test were quite encouraging and hence, it was planned to extend the methodology to the community in other villages through a training of master facilitators from the members of task forces for disaster management in these villages.

The format of the methodology was designed in a way so that it can cover all the necessary steps in community based action planning for disaster risk management. However, the format was kept in an open style so that the community should be able to add or alter any information necessary to make it more effective and relevant as and when required. After drafting the plan, it was proposed that it should be presented before the community through a gathering of all the villagers and then tested and reviewed. The work plan and schedules of these plans were made available for public information. Further, the roles, responsibilities and operational procedures of the community members involved in planning, testing, review, implementation, monitoring and evaluation were also well defined.

12.4. Procedure for using Methodology for CBDRM

At the onset of this process, some key actions are required to be taken by the community to initiate the work in an organised and systematic way. It involves formation of task forces and supporting groups, their affiliation with village development committee, community mobilization and disasters related sensitization. In the present case, such task forces for disaster management were formed at village levels through Disaster Risk Management Programme of United Nations Development Programme (UNDP) and Ministry of Home Affairs (MHA), Government of India.

A dedicated village level disaster risk management committee should gather necessary information about disasters and their impacts in their locality to sensitize people through awareness campaigns. In order to involve the whole community in the process of disaster assessment and preparation of plan for disaster management, it would be essential that people are made aware about the impacts of hazards and need for preparedness to reduce losses. Community mobilization or motivation can be done through street plays, drama, songs, skits, posters, meetings, interactions, Sandesh Yatras (Message trips) and video documentaries etc. It should gain confidence among community and involve all the stakeholders in drafting, testing, review, monitoring, revision, implementation and evaluation of CBDRM plan. The following paragraph briefly explains this process.

12.4.1 Drafting the Plan

It involves the following activities:

- Disaster Campaign and Community Mobilisation / sensitization
- Information about locality, community and the environment

- Multi-Hazard Identification & Assessment
- Vulnerability and Capacity Assessment
- Risk Categorization and Prioritization
- Existing protection systems and safety / risk management plan
- Where are gaps in our protection and safety? - Identify what is not being done
- What options are available and what action can be taken? – Brainstorming alternatives

12.4.2 Testing and Review

- What is practically feasible and acceptable? Evaluate Actions
- Who else is doing this? – Coordinate with others
- How the implementation priorities will be set? – Define Action Plan
- Who administers the plan and implements actions? – Develop a Strategy
- How the actions will be done?
- When the actions will be started and completed?
- Monitoring and Evaluation scheme? – Adopt and Monitor

12.4.3 Implementation Strategy

Through the process of plan preparation, community determines the WHY, WHAT and WHERE of the plan; WHY damages occur, WHAT you want to do to achieve your goals, and WHERE in the community you want to implement the measures to reduce losses. To ensure that the plan will be implemented effectively, the following additional questions like WHO, WHEN and HOW should be answered.

WHO? Who will lead the implementation efforts? – Establish Implementation Committee. A committee responsible for managing the implementation activities must be assigned. It will be responsible for ensuring that project / plan continues to make progress. He should dedicate a significant amount of time to this task and should have the ability to obtain assistance from others.

WHEN? When will these activities be implemented, and in what order? A proper Implementation Schedule should be prepared defining top priorities, vital, essential and desirable actions with place, time and duration. Some activities may be implemented simultaneously. The following pre-requisites must be met to initiate ground actions.

- Identify all implementation tasks.
- Determine needed order of completion.

- Coordinate with other community activities and determine any special scheduling needs (e.g., seasonal climatic conditions).
- Determine start date and completion date.

HOW? How will community fund the implementation of envisaged actions. An appropriate budget and potential source (s) of funding should be identified. Identification of suitable technical and financial assistance sources is also important. Sometimes, the implementation of actions may require permits or approvals, which should be discussed at planning stage. The number of human resources, the time and skills required to execute the work should also be pre-determined.

12.5 Risk Assessment Process

It includes information population density / distribution, age distribution, mobility, vulnerable groups, and emergency resources etc. Environmental information includes water sources, climatic conditions, landforms, fauna and flora.

12.5.1 Compilation of Data / information related to Past, Existing and Potential Disasters

Before embarking upon the spatial assessment on a chart or a sheet of paper, it is advisable that a list of the past, existing and potential disasters that have affected or may affect the life, economy and environment in the locality is prepared. The list would serve as a basis for indicating the affected or susceptible elements and collection of necessary information on these disasters and their impacts on the community which will ultimately help in planning and management.

The planning committee can identify hazards in the community by using the following methods:

a. Involve the whole committee in the planning process.

b. Research the history of previous hazards in the community. Consult local historical records, old newspapers, local administration etc, for evidence of previous emergencies.

c. Ensure both ‘natural’ and ‘man-made’ hazards are identified. Be completely objective.

d. Brainstorm, using the complete planning committee, to ensure that no hazard has been overlooked.

e. Draw information from emergencies in other comparable communities and localities.

f. Consider hazards identified by higher level planning committees.

The output of this step is a list of hazards, including those which have no history of occurrence in the locality. List hazards randomly; do not attempt to rank them at this stage.

12.5.2 Preparation of Multi-hazard Risk Management sketch of the locality

Based on knowledge and experiences of local people, an attempt is made to depict the village boundaries, physiographic features, natural resources, social or individual resources, community facilities, infrastructure and hazards of all kinds. Such a sketch displays a very good picture of the resources, hazards and the development in the locality. Following steps are taken to achieve this goal.

i. Village territory (boundaries) and physiography (drainages, ridges, valleys, slopes, lake, ground cracks, landforms, rivers etc.)

ii. Natural Resources – Forests, Mines, Water sources such as falls, springs, lakes, medicinal plants

iii. Social / Individual Resources or properties – Human population, live-stocks, Agricultural fields, Cowsheds, Watermills, Open lands, Building sites, Houses, shops, factories

iv Community Facilities – Panchayat Bhawan, Community Centre, Temples, Schools, Society or govt. offices, Police Station, Forest Post

v Infrastructure / Basic Amenities – Roads, Hospitals, Electric lines, telecommunication (phones, WLL, mobiles, wireless, Post office), Water pipelines

vi List of disasters (past, existing and potential). All the information and data on the past disasters and their impacts are collected in a tabular form. The table provides the community a complete idea of the damages suffered by them in previous disasters and the degree of potential risks from future disasters. The details of lives lost, livelihood, resources, environment etc. are well illustrated through this exercise

vii Hazardous areas / Susceptible zones – indicate areas that are or may be affected by any hazardous event and put a symbol for that disaster e.g. landslide, earthquake, forest fires, hailstorms

viii Risk management features indicating existing preventive and mitigative measures, safe/unsafe shelters and routes, evacuation scheme, proposed development and disaster resistant features

Note: Mark north direction on the village sketch and use standard legends (wherever possible) for different features on the sketch.

12.5.3 Hazard Analysis & Disaster Sensitive Periods / Seasons

Hazard analysis is that part of the planning process which identifies and describes hazards and their effects upon the community. The analysis involves: identifying hazards; describing hazards (their frequency, distribution and impacts); describe effects (susceptible zones, vulnerable persons & properties, likely facilities and services to be affected and the potential problems), describing community and environment (vulnerability and capacity assessment); Prioritizing hazards; and determining planning objectives and scope for prevention, mitigation, preparedness, response and recovery. Hazard analysis provides the basis for emergency planning and arrangements.

Temporal analysis of the data on disasters will also reflect the vulnerable periods of the year that may be more sensitive to a particular disaster compared to other periods. Accordingly strategies for prevention, mitigation or preparedness can be planned.

12.5.4 Disaster History

Since most of the information get collected during the last step, the same can be used to write a history of disasters in the locality. The community can add versions of people's experiences with the disasters and the lessons learnt or problems faced prior, during or after the disasters. This will be quite useful to record lessons learnt, good and bad practices as well as to avoid any mis-happenings

12.5.5 Vulnerability & Capacity Assessment

Vulnerability analysis is done by assessing the proportions of each group as part of the whole population, identifying any specific localities where there are concentrations of vulnerable people or other elements, e.g. schools, temples, in proximity to a hazard source. For each group identified, problems which might be expected under emergency conditions are noted. Community information also provides data on those groups in the community that have specialist skills or knowledge which may be useful in emergency management.

In order to bring a sense of belonging to the document by every individual in the community and to evaluate overall vulnerabilities and capacities, detailed information from each household / family should be suggested. The basic information gathered from each household include a reference to the households, the name of its family head, income levels and sources, age groups and physical / health conditions, skills / trainings in disasters management, emergency facilities and so on. Among the data on households, an attempt was made to identify insecure and vulnerable people who will need special and urgent attention in case a disaster strikes.

After an analysis of human and livestock vulnerabilities is completed, the next most important vulnerability concern is structural vulnerability of buildings. It is often seen that the impacts of disasters become high due to structural collapses particularly during earthquakes, landslides and floods. Thus, an attempt is made to collect data pertaining to vulnerability of buildings in the locality. It depends on the type of structure, year of construction (age of building), design and construction practice, and so on. Besides considering the vulnerability aspect, it also deals with the capacities within the structure that may be used for safety, search and Rescue during disaster times. A mention of emergency requirements during disaster times would be helpful.

Just like people and livestocks in households, prepare a separate list of vulnerable buildings so that utmost care can be taken of the people who are resident in such buildings or may get affected by damage or collapse of these vulnerable buildings. The list should be available at Emergency Resources & Operations Centre (EROC) and distributed to responsible members of the task force and supporting groups. It will help them to take quick actions in saving lives as the information would be useful in locating the potential structures that may suffer severe damages during a disaster.

The community can also prepare a sketch map showing the various life line and critical facilities as well as basic amenities available in the village or in the vicinity of the village that can be affected or utilized during a disaster. The contact details of the emergency personnel during emergency should be made known to the community.

12.6. Risk Categorization and Prioritization

Prioritising hazards enables a planning committee to concentrate efforts on those hazards which may have the greatest effect on the community. Prioritization can be assisted by using certain tools, e.g. ‘Matrix Analysis’, and ‘Hazard Scoring & Ranking System’.

Based on the cumulative risk determined on the basis of degree of severity of the hazards and the class of vulnerability of different elements, the various levels of risk can be defined as acceptable, tolerable, adaptable, and non-acceptable or intolerable risks. The categorization will also help prioritizing the focus of disaster risk management actions as vital, essential and desirables within a given span of time.

12.7 Action Plan for Multi-Hazard Risk Management

The procedure for use of CBDRM methodology involves application of the maps, information and data obtained through the process of risk assessment for management of risks / losses in the locality in a way so that disaster incidences as well as the impacts can be minimized.

12.7.1 Hazard Avoidance and Prevention Plan

It may involve the following activities.

- Hazard Zonation – Incentive Zoning and Performance Zoning
- Regulating Development Controls / standards
- Enforcement of Building codes/byelaws
- Promotion of Disaster Resistant Technologies
- Awareness and Dissemination of Safety Guidelines
- Awareness Campaign about hazards & their impacts
- Structural Mitigation Measures
- Non-structural or Regulatory Measures
- Loss Sharing Measures

12.7.2 Hazard Mitigation & Vulnerability Reduction Plan

Disasters that can not be avoided or prevented are considered for mitigation and vulnerability reduction planning. Activities, often long-term, which aim to reduce the impact of a hazard on vulnerable communities, and address the related vulnerable conditions and their underlying causes are known as mitigation. Mitigation planning may include

- Reducing the frequency, severity, duration, extent of hazards by various possible means
- Diversification of incomes / livelihood alternatives
- Food and Water security

- Training for community in disaster planning and management
- Disaster Resistant Housing programmes, Building Codes and Byelaws
- Advocacy to government and community
- Environmental protection

12.7.3 Preparedness Plan

The disaster preparedness aims to:

- Ensure that appropriate systems are in place to provide prompt and effective assistance to disaster victims.
- Prepare the community to handle the disaster in the first 48-72 hours or so when outside help has not reached and the local administration is itself affected by the disaster.

It includes Community awareness/education, disaster plans, training/test exercises, emergency communications, Evacuation plans, Public information, Warning systems, Resource inventories, Provision of special resources.

The planning committee will need to determine whether any specialist functions will be required to be performed in support of the main community plan. These functions may include medical, communications, search & rescue, welfare, transport, engineering, and agriculture.

12.7.4 Establishment of Emergency Resources and Operations Centre

- List of Skilled and Trained Human Resources in and around village
- Available Emergency Resources – List and Storage
- Information & Data on past, existing and potential disasters
- A copy of the community based disaster management plan, its schedules and progress with time
- Training materials for disaster management
- Active stockpiling of emergency resources (This approach for providing supplies usually is more effective than the massive, post-disaster influx of supplies. It also does not tie up capital on stocks that may have a limited shelf life or never be used)
- Facilities for collection and maintenance of disaster funds
- Disaster Reduction Day/Week Celebrations

12.7.5 Warning, Drills and Exercises

Methods used for disseminating the warning may include media messages, door knocks, community networks, audible and/or visual signals. Consideration should be given to warning special needs groups like deaf, dumb and blind.

a. The stages of evacuation which are: warning; withdrawal; shelter; reunion; and return.

b. Identification of: sites suitable as assembly areas; sites suitable as evacuation centres; evacuation routes between the above; organisations responsible for conducting and assisting with the evacuation; registration teams;

c. organisations responsible for arranging and coordinating transport; and

d. organisations responsible for operating evacuation centres.

12.7.6 Response Plan (with local capacities)

Response is the activation and implementation of operational systems which includes activating and staffing the Emergency Resources and Operations Centre (EROC), activating the communications system, collecting, processing, and disseminating information, alerting support organisations, preparing and disseminating warnings and other public information, activating liaison arrangements, coordinating and deploying resources and arranging outside assistance, and providing assistance to other areas. The response plan should include information on

- Reflex Action to disaster and information
- Emergency Communication and Transportation
- Search, Rescue, Emergency Relief & First Aid
- Safe / alternate routes for evacuation
- Safe Accommodation, Temporary Shelters with basic amenities like food, water, light, ventilation (air), communication, health facilities (medicines), sanitation etc.
- Security of private properties and weaker sections particularly young women
- Carcass disposal, disinfectant spray and immunization
- Consolation to the victims
- Rapid Damage Assessment and Relief Distribution
- Repair, Restrengthening, Retrofitting, Reconstruction, Resettlement, Rehabilitation, Recovery, Redevelopment.

12.7.7 Do's and Don'ts

In order to respond properly to disasters, it is vital to know how to react to disasters. The task forces will identify these do's and don'ts for each hazard and make the community aware and prepared with this information. In order to make it more effective, practical rehearsals can be conducted with different target groups for ensuring the right kind of response by all. The necessary information regarding this is available from the District Authorities and the State Emergency Operation Centre at free of cost.

12.7.8 Emergency Communication and Transportation Plan

Since immediately after the disaster happens, one need to communicate with others who can be at risk or who can help; communication strategy should be prepared to trigger the Incident Command System (adopted recently by Government of India for Disaster Risk Management). Most often, the routine communication systems fail during such disasters, therefore, alternative arrangements that can be depended upon during disaster should be made. Transportation is also affected during disasters. So it becomes difficult to reach to the victims in time. An alternative emergency route and conveyance method can be thought of for operations during such emergencies.

A list of important individuals, authorities and offices related to disaster risk management should be kept ready along with their names, designation, addresses (both official and residential), phone numbers, mobile, fax, email etc. in easily accessible manner.

12.7.9 Search, Rescue, and Relief

A separate group of people can be assigned the task for carrying out search, rescue and relief operation during any disaster. Persons with background in army, civil defense, home gaurds or police can be helpful in doing such activities. Nurses and medical practitioners can guide and help in emergency relief and first aid to the victims.

12.7.10 Evacuation Plan, Safe Accommodations & Sites for Temporary Shelters

Since a large population of the village may be affected during disasters, a sketch of the village territory showing safer buildings and sites should be prepared during plan formulation to indicate the places and the routes to the community to be used during disaster periods. The plan map should not only show the evacuation routes but also indicates the routes that may be used by outsiders

for providing relief to the victims. The access route is connected to main road. The evacuation routes are normally the alternate footpaths leading to an area away from the vulnerable structures and susceptible locations.

12. 7.11 Consolation Team

The consolation teams may consist of respected aged persons, religious priests, school teachers or community leaders. Generally, there is a panic and trauma during and after the disaster. Victims need to be properly consoled and inspiration from local known person gives them more solace compared to outsiders.

12.7.12 Disposal of Corpses & Carcasses

Proper disposal of dead bodies at the earliest possible time is essential to avoid outbreak of any epidemic in the disaster affected area. A group of persons may be assigned this duty and trained in proper recording and disposal of dead bodies, particularly from the inhabited areas.

12.7.13 Immunization and Infection Control

Due to large number of deaths and injuries during disasters, the potential of getting affected by any contagious disease are very high. To control this, a team should be dedicated to immunize people and livestock against possible diseases and those affected by such diseases should be treated under control and given a separate facility.

12.7.14 Water and Sanitation

Drinking water supply may be affected during disasters. The water may be polluted by sewerage damage or due to some other reasons. Necessary precautions should be taken to keep a check on water quality and in case it is found polluted, proper treatment of the water sources and supplies should be done. Any leakage of drinking water supply that may occur during disaster should be immediately checked. Proper sanitation should be planned around temporary shelters where large number of people may reside together temporarily.

12.7.15 Rapid Damage Assessment & Relief Distribution

Appropriate objective kind of rapid damage assessment criteria should be well set for assessing the degree of damages and distribution of relief to the affected people. A team consisting of reliable, honest and justified persons can be kept ready for this kind of work.

12.7.16 Rehabilitation Plan

This is the phase in which the community is back on the normal life process and in fact is fine tuning their resources to deal with other emergencies. They are thus also in a position to provide help to some other disaster affected area in the manner that they received help and assistance.

- Shelter Rehabilitation
- Livelihood Rehabilitation
- Psycho-social Rehabilitation

12.7.17 Recovery and Redevelopment Plan

Recovery is restoration of the community structure and facilities, and support provided to affected people. It may include providing short-term emergency accommodation, counseling emotionally-affected people, establishing and managing emergency financial relief schemes, repairing or replacing damaged public utilities, services, and assets, surveying and assessing damage to public and private property.

Rapid steps must be taken to establish a system of continuous contact with the families stricken by the disaster. A system of this kind makes it possible to:

- collect information on requirements,
- route instructions and information,
- distribute where necessary the means of survival (clothing, blankets, food, etc.).
- Transport and highway maintenance; communications and information,
- Water supply, food, means of survival,
- Sanitation
- Health,
- Public law and order.

The mid-term and long term recovery plan will include

- Relief and Compensation
- Repair, Restrengthening, Retrofitting and Reconstruction
- Resettlement and Relocation
- Loaning, Compensation, Insurance and Tax Exemptions

The redevelopment plan of the locality should include the lessons learnt from the disasters, thereby discouraging the bad practices and encouraging the good practices for redevelopment in the affected area.

12.8. Limitations in Implementation of CBDRM Methodology

The experience of local community can help in developing a formally structured information infrastructure. Implementing such a process, however, will not be so simple. It will take time and commitment on the part of all those involved because there are some sources of frustration that will need to be addressed before it can become a reality. For example, a recurring view was expressed by the village community that they had 'heard it all before' at various times, but nothing practical had ever eventuated. They are looking for a worked-through example that they can follow and the resources to do it. It can not be achieved in any meeting, training or workshop; it can only be achieved on the ground in a real-world situation. The lack of communication reaching both top-down and bottom-up at the village level was also seen as a major source of frustration, and consequently a major hurdle. For a process that is all about information and improving the effectiveness with which it may be disseminated and used, the sharing of information about the process is critical – and that depends on communication.

Another frustration revolves around a stated lack of coordination and cooperation between the people and agencies that should be working together to improve community safety. This was seen as part of the power and political processes that tend to build barriers, rather than bridges. Frustration also relates to the perceived lack of resources - human, financial and technical. This is probably a universal frustration for all disaster managers. Typically, they are allocated only limited resources as well as limited time because a vested senior group seem to hold a different view (a disaster is unlikely to happen during their term in office, so why spend too much money on a disaster management system that does not bring significant political/economic gains with it). This may be a simplistic and cynical view, but it seems to correlate well with reality. These are not just technical issues but also socio-economic issues. Fortunately, frustrations can be overcome through strong will and determination by the public, even those as seemingly intractable as the ones identified here.

These established foundations are very sound indeed, and provide an excellent base on which to build an appropriate and sustainable information infrastructure may address issues from the village level to the level of the district and beyond. There are undoubtedly frustrations and problems that will need to be addressed along the way; however, it is clear that the communities are committed to embarking on this journey for a safer sustainable environment.

Another limitation of CBDRM lies in the fact that the local knowledge at the level of community can not always be sufficient to assess large scale phenomena

especially if their origin lies away from the zone of perception of the community or if it results from an exceptional situation (e.g. flooding due to bursting of a landslide dam on upstream side of the community). Therefore, the logic of the concept should clearly indicate the possibility of integrating information received from outside the community (national / state / district level disaster warning centers), even if it is of scientific origin and not expressed in terms to which the community is used to, as another major contribution to the re-assessment of a hazardous situation.

12.9. Conclusions

The successful application of this methodology in more than 50 villages by the community itself is evidently a good indicator of the acceptability and practicability of the approach as well as its outcome in the forms of large amounts of actual data and information generated through the process. The approach seems more rational and context specific for socio-cultural as well as geo-climatic condition. Its participatory nature and learning dynamics helps in deeper penetration of the efforts among the community.

It is essential that local capacities be strengthened to assess and manage disaster risks as well as to utilize indigenous knowledge, resources, skills, information and ideas. The approach considers varied factors like age, gender, geographic location, caste, ethnicity, literacy, community structure / dynamics, local politics, economic disparities and decision making in this process. These factors when accounted in disaster risk management strategies and action plan become a great asset in execution and implementation at ground level by the affected community.

If the methodology is applied in other areas in a similar fashion, it will have, no doubt, a very large database on disasters and a culture of aware and prepared communities in all villages. The approach is open for further modifications to suit to specific requirements of any area / community as is permitted in any context specific approach. Technical and financial support from outsiders will further boost the efforts of these villagers in fully implementing their strategies for disaster risk management at local levels.

SUB-MODULE 13: EMERGING ISSUES

13.1 Research Issues

There are several important areas of research, which need to be addressed leading to standardization of investigation and operating procedures, more reliable LHZ mapping, vulnerability assessment and risk analyses, cost effective landslide stabilization, user friendly multi-hazard mapping, damage assessment and introduction of the state of the art technology. Considerable amount of research and development work is needed to develop basic understanding of various types of landslides in India, their causative factors and mechanisms of development with particular reference to anthropogenic factors.

13.2 Standardisation

Some Institutes and Organisations are carrying out both LHZ mapping and site specific studies of landslides. However, there is no uniformity in the methodology, selection of scale of LHZ mapping and usages of landslide terminologies. As a result, a lot of confusion ha been created among the geoscientists. Standardization of the terminology and classification of landslides, thematic mapping scales and introduction of mapping methodologies for different scales will be accorded priority. Scientific and systematic approaches for site specific study of landslide and procedure of ground validation of LHZ maps are equally important, and so is the development of scientific approach of integrating landslide hazard into multi-hazard mapping. R&D activities will be intensified to standardize the terminology and classification of landslides, thematic mapping scales and to develop uniform methodologies for different scales. Scientific and systematic approaches for site specific study of landslide and procedure of ground validation of LHZ maps will be prepared immediately.

A research programme will be undertaken by the knowledge based organizations/ institutes of our country for developing scientific approach of integrating landslide hazard into multi-hazard mapping.

13.3 Earthquake Induced Landslides

Improved understanding of earthquake-induced landslides will call for research on estimation of site effects in different geological and geomorphological

settings. Research to enhance the understanding of reactivation of old and recent landslides and initiation of first time landslides triggered by earthquake will be encouraged. Other topics of research may include run-out effects of flow slides resulting from earthquake liquefaction.

13.4 Design of Surface and Subsurface Drainage Systems

In India the rainwater from the slide surface is generally drained out through surface drainage system comprising lined catch water drains, contour drain and chute drain (often cascading type). In absence of any data about the catchment characteristics of a particular slope, the design of these drains is generally done on the basis of expert knowledge. On the other hand the subsurface water management from the slide mass or distressed hill slope is rarely practiced in our country. As a result, some of the slides requiring only subsurface drainage arrangement for stabilisation are provided with other makeshift remedial measures triggering the slide instead of containing the slide. Moreover, there is no systematic approach or established mechanism to test the efficacy of the implemented surface drainage measure. Effort should be directed towards research and development of scientific and innovative design of surface and subsurface drainage systems, which are the most important components of landslide stabilization measures.

13.5 Instrumentation for Geotechnical Investigation

In the context of scientific research, geotechnical instrumentation is primarily needed to unfold the mechanism of a landslide , collect evidences and data for its reliable slope analyses and engineering and remove uncertainties by validating assumptions and checking efficacy of control works.

13.6 Development of Early Warning System

There are many major landslides located either along the busy road corridors or close to thickly populated townships / important civil engineering structures that require huge cost of treatment. Such landslides for early warning will be selected through a consultative mechanism in association with state governments and local bodies. Development of appropriate Early Warning Systems may be undertaken for such identified slides. Development of Early Warning System by real time monitoring of some selected slide may be undertaken with a view to firming up both the early warning technology and the early warning thresholds. Correspondence between rainfall thresholds and landsliding should be developed for selected areas based on in-depth scientific studies.

13.7 Landslide Dams

Dams generated by landslides are mainly reported in narrow valleys of mountainous terrain. These may cause devastation by flash floods due to sudden breaching. Barring some preliminary investigation of a limited number of such dams, systematic geotechnical investigation has not so far been attempted. Besides, there is no established mechanism by which the incidence of such dams can be reported to the appropriate authorities immediately after their formation. As a result the preliminary investigation can not be taken up immediately after their formation.

The following aspects of landslide dams can be taken up for R&D:

- Dam break analysis
- Methodologies for providing controlled outlet for dewatering the created reservoir
- Procedure of risk assessment
- Procedure for identification of potential sites of formation of landslide dams and monitoring technique.

13.8 Run-out and Return Period Modeling of Landslides

This is one of the most important fields of landslide studies where extensive R & D is required. The basic requirement for development of Run out and Return period modeling of landslides is to map all the slides, identify causes and mechanism of failure, establish correlation between triggering agents and initiation of slope failure, determine shear strength parameters of the slope forming materials, assessment of hazards, vulnerability and elements at risk etc. In some countries, like Italy, New Zealand, USA, this type of modeling has been done for individual slides but it could not be successfully done for a vast area affected by numerous slides in the absence of reliable historic landslide inventory database.

13.9 Emerging Concerns

Presently global warming and climate change are the most critical fields of concern that can have significant consequences on natural hazards including landslides and snow avalanche.

The “fragile” mountain systems in the country, where most of the landslides occur, are being exposed to increasing risks due to climate change. In the coming decades, the negative impact of climate change will be exacerbated if the mounting human-induced pressures and unplanned urbanization are not checked.

Whereas the whole range of issues connected with climate change including policies and operation strategies are beyond the scope of this document, unfolding consequences of climate change, insofar as mitigation of landslide hazards are concerned, deserve urgent attention. Rich global experience, especially on understanding and managing uncertain weather patterns and landsliding, glacial lake outbursts, landslide dam bursts and community-centric risk reduction measures for human safety, should help speed up our own programmes with innovation and added emphasis on landslide hazard mitigation, early warning and quick response to disasters and long term socio-economic risk reduction.

13.10 Priorities for R & D:

The R & D problems of importance are listed below. This is only suggestive and will be reviewed from time to time in the back drop of emerging national priorities.

- Refinement of methodologies for carrying LHZ both on Macro and Meso scales to bring out a realistic picture of the hazard
- Systematic scientific methods of landslide hazard, vulnerability assessment and risk evaluation on GIS platform
- Integration of landslide hazards into user-friendly multi-hazard mapping; projection of multi-hazard risk scenarios.
- Revisiting past major landslide disasters for scientific post-mortem and documentation of lessons learnt
- Application of recent technological developments in the fields of instrumentation, remote sensing, software and communication technologies for landslide studies.
- Development of simple, quick and effective methodologies for assessing direct as well as indirect losses due to occurrence of landslides
- Quantification of environmental degradation, anthropogenic impact, cost of loss of land, agriculture produce, livelihood and traffic delays
- Establishing best practice examples of deterministic and probabilistic modeling methodologies for conducting detailed stability analyses of complex natural and man made slopes and active landslides
- Scientific design of surface and subsurface drainage systems, technology for their speedy installation and evaluation of their efficacy

- Development of innovative techniques for landslide control especially mechanized construction of complex subsurface drainage networks
- Development of light rugged geotechnical investigational equipment suitable for rugged and inaccessible areas
- Development of cheap and reliable instrumentation techniques for slope monitoring and installing early warning systems
- Systematizing the search and rescue operations and developing effective equipment for the same
- Development of simple and easy to install instrumentation and slope monitoring for real time early warning including early warning thresholds and criteria
- Developing a predictive understanding of landslide processes and triggering mechanism;
- Regional real-time landslide warning systems based on threshold values of rainfall; Real-time monitoring and establishing early warning systems in case of landslides that pose substantial risk to developmental gains;
- Developing methodologies for assessing the potential co-seismic slides.
- Fundamental mechanisms of earthquake- induced and earthquake-triggered landslides
- Remediation practices based on multi-disciplinary field investigations and suitable for local conditions
- Methodology for identification of potential sites for landslide dams.
- Fashioning landslide rescue operations to their typology
- Reservoir induced landslides, coastal landslides, submarine slumping and tsunamis

Besides, post-disaster scenario analysis and simulation modeling are extremely useful for undertaking long-term disaster management programmes and for strengthening preparedness, mitigation and response efforts against landslide hazard. Risk assessment and scenario projections require data for all landslide prone areas and major landslides located in different environs in different parts of the country affecting existing human habitations, environment, infrastructure and economic activities.

The quantification of landslide risk for a specified area requires detailed information for a number of factors, namely topography, geomorphology, geology, climatic conditions, landuse practices, land cover pattern, characteristics of slope forming materials. The reliability of landslide hazard maps will depend on the accuracy of base maps and the approach followed in their GIS based integration and subsequent validation. Freshly occurring landslides and the reactivation of existing and old landslides on account of earthquakes will be studied. The LHZ maps will be prepared based on advanced research studies carried out by knowledge institutions to include the earthquake induced landslides in areas with high seismic risk.

Studies will be undertaken to evolve procedure so that investigations, maps and drawings of landslide in different geographical regions of the country are easily available to users in the form that can be easily comprehended.

There is urgent need to develop mechanism to transfer the results of R&D efforts to public domain so that these can be utilized by scientists/technologists engaged in operations.

The success of all these efforts will depend on a prior presence of a system with streamlined procedures for speedy funding of priority/fast track projects. The mechanism for evaluation of project proposals, periodic reviews and final reviews will be integral part of the system.

13.11 Documentation

It will include preparation of films, manuals and other documents targeting various stakeholders to inculcate landslide safety by following land zoning regulations. State governments will provide landslide safety materials in multiple formats and languages, so that different groups of stakeholders can gather requisite information. This information will include specific details on the landslide risk and vulnerability of the states, landslide management basics and landslide risk mitigation for the safety of natural and built environment.

The state governments will assist subject specialists from academia and industry to prepare technical documents on landslides, which will emphasize technical specifications for expansion of human settlements in hilly areas and simple techniques for assessing landslide hazard in other areas. National and regional libraries and information centres will be encouraged to build repositories of technical resources (books, reports, journals, electronic documents etc.) related to landslides.

Generate and maintain a directory of landslide management professionals in India, containing their brief bio-data and make these available to users.

GSI along with other institutions will undertake the task of documenting the history of landslide studies and other related activities in India. A number of documents on landslide investigations that have been carried out in the past have now become difficult to access or are out of print. GSI will launch a special initiative to digitise these documents from various sources and save the archives on electronic formats in the data bank proposed for this purpose giving due recognition to the source.

13.12 Response Capability

Response to early warnings involve activating coping mechanisms (mainly for orderly movement of people away from risk locales, seeking shelter and safely securing assets) before a disaster strikes. In contrast, post-disaster response implies the wider range of relief, restoration, recovery, rehabilitation and reconstruction efforts in the aftermath of disasters. However, both are part of disaster preparedness and employ common emergency procedures. Warnings of hazard events must be issued with clear instructions about the most appropriate actions to be taken to avoid losses as far as possible. The success of early warning depends on the extent to which it triggers effective response measures and warning systems will include preparedness strategies and plans to ensure effective response to warning messages. The warnings trigger a variety of responses from different agencies at various levels, which must be coordinated. A number of governmental agencies, including various ministries, national disaster management institutions, municipal and local administration authorities etc. are responsible for coordinating disaster preparedness. People are more likely to listen and act upon warnings when they have been educated about their risks and warning-reaction plans are in place.

The management and control of the adverse consequences of future landslide incidences will require coordinated, prompt and effective response systems at the Central and State Governments, and especially at the district and the community levels in the areas affected by landslides. Since many components of response initiatives are same for different types of disasters, systems need to be developed considering the multi-hazard scenario of various regions in order to optimally utilise available resources.

Depending on the magnitude of landslide and scale of required response, the corresponding role players will be identified and mobilised at the district, state or national levels. Systems will be institutionalised by the DMAs, at various

levels, for coordination between different agencies like central government ministries and departments, state governments, district administrations, ULBs, PRIs and other stakeholders for effective post-landslide response.

The preliminary assessment of severity of the landslides is based on its magnitude and the amount of loss it inflicts on the infrastructural elements and habitations. Agencies like BRO/ State PWDs, State Directorates of Mining and Geology, Forest Department, Municipal/ Panchayat Body would immediately communicate information of the occurrence of a landslide along with preliminary details like its location, magnitude and damage caused etc. to the District Emergency Centre or District Disaster Management Control Room. This will help to undertake field observation for making an accurate assessment and follow-up actions.

The Disaster Management (DM) plans prepared by concerned agencies will incorporate detailed guidelines for their activities related to the impact of landslide. The response component of the DM plans will consider the rapid deployment of designated people, supplies and logistics to the site of disaster with function of each functionary clearly defined. The individual teams will be required to vacate the site as soon as their job is over because considering the nature of hazard during the rainy season it is possible that they may be required at another site within short duration. These plans will prescribe appropriate coordination mechanisms among all the agencies working in the affected areas.

13.12.1 Emergency Search and Rescue

The community in the affected neighborhood is always the first responder after any disaster. Experience has shown that initially over 80 per cent of search and rescue operations are carried out by the local communities before the state machinery and specialized search and rescue teams arrive. Thus, trained and equipped teams consisting of local people will be set up in landslide prone areas to respond effectively in the event of disaster.

Community level teams will be developed in each district with basic training in search and rescue. Training modules will be developed for trainers of community level search and rescue teams by district authorities with the help of the NDRF training institutes. The manpower employed by the organizations engaged in maintaining the roads located in hilly regions will also be trained in initial search and rescue operations and equipped with modern search and rescue equipments. On the ground, if required, the NDRF battalions will also assist the state government/ district authorities in training communities for which they will be sensitised. They will be further assisted by the Civil Defence, Home Guards, Fire Services and NGOs. State Governments will develop procedures

for formally recognising and certifying such trained search and rescue team members; they will also provide suitable indemnity to community level team members for their actions in the course of emergency response following a landslide disaster. Youth organisations such as the National Cadet Corps (NCC) and National Service Scheme (NSS) and Nehru Yuva Kendra Sangathan (NYKS) will provide support services to the response teams at the local level under the overall guidance and supervision of the local administration.

13.12.2 Emergency Relief

Trained community level teams should assist in planning and setting up emergency shelters, distributing relief among the affected people, identifying missing people and addressing the needs of emergency medical care, water supply and sanitation, food and temporary shelters etc. of the affected community. These teams should also establish communication with district authorities for arranging evacuation of stranded people, particularly for vulnerable sections. Members of these teams must be made aware of the specific requirements of the disaster affected communities. These teams may also assist the government in identifying the most vulnerable people who may need special assistance when stranded following a large landslide on a highway or in a habitation.

13.12.3 Incident Command System (ICS)

All response activities should be undertaken at the local level through a suitably devised Incident Command System (ICS) coordinated by the local administration through the EOC. State Governments will commission and maintain Emergency Operation Centres (EOCs) at appropriate levels for the coordination of human resources, relief supplies and equipment. Standard Operating Procedures (SOPs) for the EOCs will be developed by State Governments and integrated within the framework of the ICS, which will take advantage of modern technologies and tools, such as GIS maps, scenarios and simulation models for effectively responding to disasters. Geographical Information System (GIS) maps available with other sources, such as the district and municipal planning departments will be compiled considering their potential application after a disaster. Any unusual occurrence should be immediately reported by the community to the authorities, so that its cognizance is taken.

13.12.4 Community Based Disaster Response

The DDMAs should coordinate with the organisations, like NGOs, voluntary agencies, self help groups, youth organisations, women's groups, civil defence, home guards and community at large who normally volunteer their services in

post disaster situations. The State Government / SDMAs will utilize and allocate these human resources for performing various response activities as per their capabilities. State Governments will interact with these agencies to understand and plan their roles in the command chain of the ICS and incorporate them in the DM plans.

Large magnitude natural disasters draw overwhelming humanitarian support from different stakeholders. The relief and response activities carried out by such stakeholders will coordinate and comply with the norms prescribed by the appropriate authorities.

After disastrous landslide incidence, accurate information will be provided on the extent of the losses and the details of the response activities through electronic and print media. State Governments will utilise different types of media, especially print, radio, television, internet and Short Messaging Service (SMS) to disseminate timely and accurate information.

13.12.5 Role of Private and Corporate Sectors

The State Governments should facilitate the involvement of the corporate and private sector and utilize their services and resources if offered to the government during the immediate post disaster situation. IDRN should be maintained and updated regularly so that locally available resources are utilized effectively in case of emergency. The corporate sector, as a part of the CSR effort, can provide, inter-alia, the services of hospitals, power and telecommunication, relief supplies, search and rescue equipment, earthmoving equipment, and transport and logistics of movement of relief supplies. The IDRN is a live system and is updated every quarter both at district and state levels. These can be mobilised promptly at the time of emergency as a component of response. The state governments and district authorities will develop appropriate mechanism to receive and optimally utilise such assistance.

13.12.6 Specialised Teams for Response

The central government has set up ten NDRF battalions for providing rapid response to disasters. The NDRF battalions are provided with communication equipment like satellite phones for establishing continuous connectivity in every part of the country where landslide or other disasters may occur.

The fire services in the ULBs of various states are being used as an emergency-cum-fire services force. The fire service personnel will be trained adequately so that they can respond to different disasters promptly in addition to managing fires.

The police play a very important role after a disaster by maintaining security, law and order, assisting in search and rescue, and in transportation and certification of casualties. In case the landslide disrupts traffic for a longer duration, traffic police can play an important role by regulating and controlling the flow of traffic movement.

The Home Guards serve as an auxiliary arm of the police force and support the district administration in various tasks. The Civil Defence is being reoriented to assist in handling DM. Members of these organisations will be trained in tasks like search and rescue and evacuation, protection of assets in evacuated areas, and management of relief camps and aid distribution centres.

Training and implementation of emergency response should be planned keeping in view that type of rescue operations varies with the nature of landslides.

13.13 Trigger Based Categorisation

Ministry of Home Affairs, GoI, in consultation with GSI has developed a colour coded categorization of stages of landslide for triggering appropriate alerts within the Government machinery. Three colour (Red, Orange and Yellow) coded stages have been defined on the basis of dimension, location and damages caused by the landslide. GSI and other knowledge based institutions in coordination with state governments will take up the geotechnical investigation of the landslides falling within the high alert red category stage and suggest appropriate remedial measures. Landslides in this category are of large dimensions that are located over or in close vicinity of urban settlements or fairly large rural settlements inflicting heavy losses to human life or urban infrastructure. This also includes landslides that block busy pilgrimage routes during peak times resulting in hardships to thousands of pilgrims and landslides which result in blockage of courses of relatively large natural drainages with or without formation of landslide dams. The small or moderate dimension landslides located at the fringes or away from human habitation and causing limited loss/ damage have been categorized under the medium and low alert, viz. yellow and orange. These shall be taken up by the district and state administration. GSI and other knowledge based organisation will provide assistance and train professionals on need basis to state government for geotechnical studies and remedial measures.

13.14 Emergency Logistics

Specialised heavy earthmoving equipment and search / rescue equipments are required immediately after a landslide to clear debris and to carry out

search / rescue of trapped people from huge mass of debris. A list of such equipment and suppliers of such specialized equipment should be compiled to enter into long-term agreements for their mobilisation and deployment in the event of a landslide disaster. India Disaster Resource Network (IDRN), which is a web based resource inventory of information on emergency equipment and response personnel available in every district, should be revised and updated every three months. A mechanism of deploying required equipment at a very short notice in case of occurrence of a disastrous slide should be in place.

The provision of providing temporary shelters and basic amenities for travelers stranded on communication routes would require pre-planning. The DM plans at the state and district levels should address this issue in detail. It is also being considered that semi permanent shelters with basic amenities would be established at certain critical locations that are affected by landslides frequently resulting in people getting stranded for long periods.

In the event of large number of casualties, respective states will develop systems for proper identification of the deceased, recording the details of victims and handing over the bodies to their kith and kin as quickly as possible.

13.15 Emergency Medical Response

In case of requirement, prompt and efficient emergency medical response will be provided by QRMTs, mobile field hospitals, ARMVs and heli-ambulances that will be in place for other disasters like earthquake. These will be activated to reach the landslide affected locations immediately, along with dressing material, splints, portable X-ray machines, mobile operation theatres, resuscitation equipment and life-saving drugs, etc.

The emergency medical plan will be operationalised immediately on receiving information from the landslide affected locations. Hospitals in the affected areas will create a capacity for the required number of beds by discharging non-critical patients and mobilize doctors and support staff, additional orthopedic equipment and supplies at short notice in landslide affected areas, at least during rainy season when majority of landslide occur. After the occurrence of a disastrous landslide, an Information Centre should be set up for disseminating accurate information to public, relatives of victims and media at district level in case casualties are high.

13.16 Loss and Damage Assessment

It is very important to assess the losses resulting from a landslide as this would be an important factor to decide whether it is economical to treat it or not.

Landslide-losses data are generally categorized as either direct or indirect. Losses can occur in a geographic region collectively (many, possibly intermingled, landslides that may affect lifelines and public safety, as well as individual buildings) or as a single, isolated event that affects a small geographic area, such as a highway or residential structures.

Direct costs include the repair, replacement, or maintenance resulting from damage to property or installations within the boundaries of the landslides or from flooding caused by breach of natural dam formed due to obstruction of natural drainage due to landsliding.

Some examples of indirect landslide losses are:

- Loss of industrial, agricultural and forest productivity and tourist revenues as a result of damage to land or facilities or interruption of transportation systems
- Reduced real estate values in areas threatened by landslides
- Loss of tax revenues on properties devalued as the result of landslides;
- Measures that are required to be taken, to prevent or mitigate additional landslide damage
- Adverse effects on water quality in streams and irrigation facilities outside the landslide area
- Loss of human or animal productivity because of injury, death, or psychological trauma; and
- Secondary physical effects, such as landslide-caused flooding, for which losses are both direct and indirect

Indirect costs may exceed direct ones; unfortunately, most indirect costs are difficult to evaluate and thus are often ignored or, when estimated, are too conservative. More often, however, monetary information, being of a discreet nature and in many instances, not in public domain, people and entities prefer to leave their losses as a private matter.

Currently, the damage assessment in case of natural disasters in many countries is done using aerial photography, videography and ground checks. With recent advances made in remote sensing technology it has become possible to use it effectively even for assessment of damages resulting from landslides. In order to be able to use Earth Observation (EO) data for landslide damage assessment, following criteria should be fulfilled:

- High temporal and high spatial resolution products should be available
- Images are taken at the time of disaster or within a few days after the event. These can support the relief efforts effectively

This will be satisfied partly by existing and planned high resolution stereo optical and SAR systems. In cases where damage is extensive, either by a single large event or by many large events spread over a large area, there is need of very high resolution images before and after the disaster. These can be used to supplement the data obtained from airborne and ground exercises.

13.17 Areas requiring special attention

- Effective management of landslide hazard in the country would require detailed studies using state-of-the-art technologies
- Introduction of the practice of real time monitoring of potentially threatening landslides, to avert disasters by early warning
- In the current landslide hazard management practice, investigating agency and implementing agency are generally different. This results in fragmented accountability and communication gap. Therefore, it will be ensured that the recommendations of the investigating agency will be implemented in close association or consultation with it
- Partial implementation of stability measures are understandably ineffective and in general, results in reoccurrence of landslide. Every landslide management project will ensure full implementation of treatment measures in a single working season and take recourse to monitoring of their efficacy during post implementation stage
- The process of data collection is required to be systematized. The system of data sharing among the institutions engaged in landslide studies, landslide hazard management and communities at large will be encouraged through effective networking
- The culture of observational method of design and construction will be promoted to help engineers and builders dealing with uncertainties effectively. The method helps in modulation of designs based on actual measurements as the work progresses
- Culture of monitoring the efficacy of control measures will be promoted to add to the confidence level in design and add value to it, if a situation so demands.

- There is lack of extensive network of rain gauges in country. Due to this it is very difficult to attempt the correlations between rainfall and landslide activity. A proper coordination with the IMD is required to be developed for installation of a network of automatic rain gauges at desired locations. The IMD will also provide daily rainfall data of existing rain gauges on daily basis to data center for landslides so that same can also be utilized by the agencies or individuals engaged in such studies. The concerned institutions will be identified.
- It is proposed that organizations/institutions engaged in landslide studies, government or private, should be identified/selected and given the responsibility for this work in co-ordination with the BRO and respective state governments.
- The resources and resource persons available in the country will be identified so that studies to be taken up in different fields are planned and realistic capacity building programmes designed.
- The gap between the landslide management systems being practiced in the country and those being followed internationally will be identified and attempts will be made by all agencies engaged in landslide hazard management in the country, to bridge these gaps so that latest systems followed elsewhere are also followed in the country.
- Establishment of a nation-wide institutional mechanism that would transform the current piecemeal, adhoc, less recognized and poorly appreciated landslide management practice into an organized vibrant pro-active, systematic and scientific routine.
- Enhancement of expertise and capacities of knowledge centres in different parts of the country for dependable and timely geomorphological, geotechnical and hydro-geological investigations and for scientific design and speed- effective- implementation of control measures.
- Strengthening of a few objectively identified existing knowledge institutions or their units and departments in every state and union territory, if willing to redefine and enlarge their respective mandates/roles to provide/support pre- and post- landslide routine/specialized functions.

SUB MODULE-14: GROUP EXERCISES FOCUSSING ON LESSONS LEARNT FROM PAST DISASTERS AND GOOD/ BAD PRACTICES

14.1 VARUNAWAT LANDSLIDE, UTTARAKHAND – CASE STUDY

Objectives of the Table Top Exercise

- To create sensitization about the landslide disasters.
- To assess the needs and capablities to handle a disaster.
- To evaluate inter-agency coordination & gaps for improvement

Orientation / Preview

- Disaster Scenario (facilitator)
- Stakeholders
- Conduct of Exercise
- Observer's & Evaluator's comments
- Conclusion

Disaster Scenario

You have a landslide located along a national highway and very close to the district headquarter. The upper part of hill slopes fall under Forest Region and the lower slopes are occupied by private residential and commercial buildings, government colony and a mosque (community place). The slide area is evident by the exposed scar and the slide debris but the authorities are scared that it may pose a great risk to lives and structures located at foot-slopes. You are asked to assess the situation and provide adequate measures with action plan to prevent and mitigation the envisaged risks. How would you proceed ahead and tackle this situation?

Salient Features of Varunawat Landslide

Location: At km 150 from Rishikesh on Uttarkashi - Gangotri National Highway (NH – 108);

Latitude:30° 44'10.8"N; Longitude: 78°26'23.0"E (Toposheet No. 53J/6); Altitude: 1680m a.m.s.l.

Elevation: 1680 m (at Crown); 1170m (at road level); Relative Relief: 510m

Average Slope Gradient: 39°; Date of initiation of last major occurrence: Sept. 24, 2003

History of Slide: Not well recorded. Dates back to about more than 2 decades. Recurrent slide

Type of Material involved in movement: Overburden, rock pieces / boulders of phyllites and quartzites – predominantly debris

Type of failure: Rotational (?) in upper part, Free fall followed by skidding, rolling, bouncing and sliding along three different tracks.

Direction of sliding / failure: SW on right flank, southern in the middle and SE on left flank

Area affected by failed slopes: approx. 2 sq.km. Population affected: 2,911

Landslide Precursors: Tilting of trees, development and propagation of new cracks, minor failure activities, rolling topography, presence of old cracks (widening and deepening), extension of old escarpment, increase in pore water pressure and seepage pressure, seismic vibration causing fatigue and failure of rocks, presence of old landslide zone, potential growth of some new plant species or younger plants in unstable / failing zones

State of Activity: Intermittently Active since last several years but continuously active for a period of about one month from Sept. 24 – Oct. 24, 2003; Style of Activity: Widening/Retrogressive

Depth of sliding: >20m; Volume of Displaced / Accumulated Mass (LxWxD): 15,000 cu.m. (?)

IMPACTS:

Economic Losses:

Damage to buildings – 364 (includes both residential & commercial); 63 houses damaged, 132 out of 364 were commercial buildings and 232 were residential or residential cum commercial (55 Kutcha and 175 Pucca buildings), people from 274 houses evacuated for safety.

Damages to Infrastructure (road, power, telephone and drainage lines) – A section of national highway (500m road), power supply lines and telecom facilities, traffic disruption

Economic Activities – 2,911 people lost their homes and jobs

Environmental Losses: Numerous trees uprooted, development of clouds of dust, pollution

Social Impacts: Closure of educational institutions for several days; Hindrance in social and cultural activities like Ramlila Program

Total Estimated Loss: Rs.300 Crores approximately

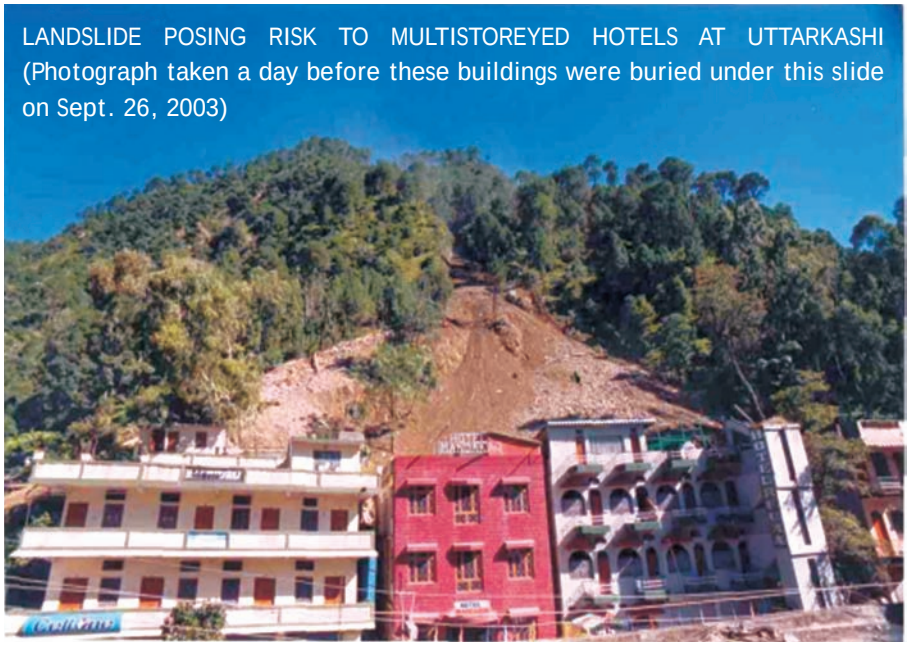


Fig. 14.1: A view of landslide just a day before landslide engulfed the hotels seen here

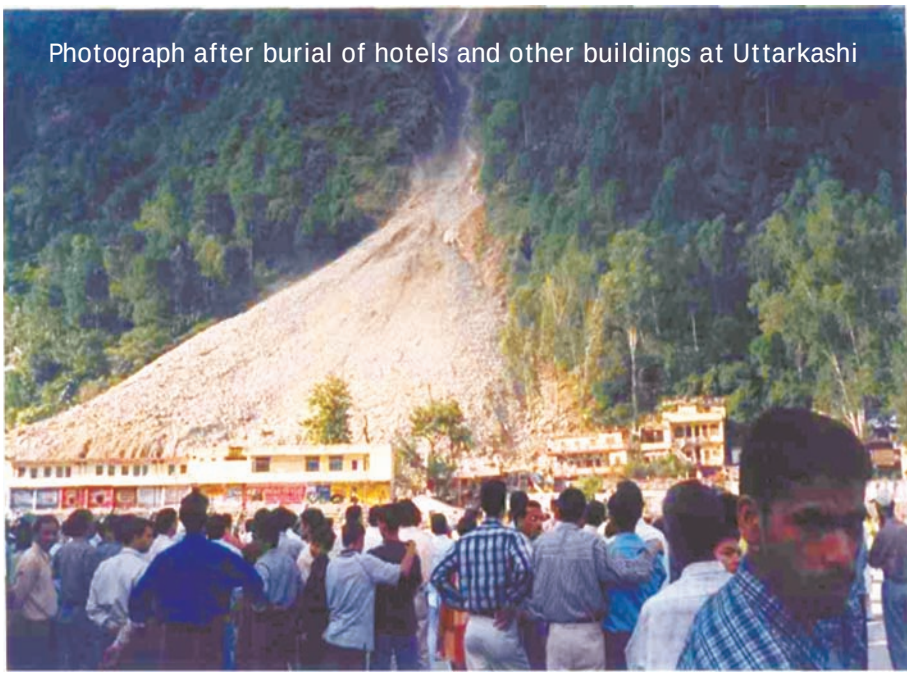


Fig. 14.2: A view of landslide on the day when landslide engulfed the hotels seen above

14.2 MALPA LANDSLIDE, UTTARAKHAND - CASE STUDY

Malpa Landslide Tragedy

Location: Right bank of River Kali, District Pithoragarh

On the fateful night between 17th and 18th August 1998, a huge mass of rock got detached, broke into myriad of pieces and hurtled down the slope. The rock avalanche killed 210 people including 60 pilgrims. The heap of debris so created were about 15m high and contained rock pieces as big as 5m. The estimated velocity was 30m/sec. Before the disaster, the hillslopes surrounding Malpa looked green, virtually without any visible sign of instability. In the landslide, the entire village was wiped out.

Disaster Scenario

A catastrophic landslide has occurred last night (1 am) at Malpa. Several pilgrims (who were resting at that site) are buried along with some local residents of the village. Most of the buildings at landslides have been destroyed and carried away by the slide and / or buried under the debris. The district headquarter is 100km away. You have received this report at 4 am from a villager. How would you respond to the situation?

Fig. 14. 3: An artist's recapitulation of rockfall area before the disaster (Courtesy -Dr. R.K. Bhandari)

Fig. 14.4: Photograph of rockfall area after the disaster (Courtesy -Dr. R.K. Bhandari)

14.3 GUINSAUGON LANDSLIDE, PHILIPINES - CASE STUDY

Introduction

A rapid and long-traveling landslide occurred on 17 February 2006 in a rural area of Leyte Island, Philippine. The Landslide engulfed the Guinsaugon village including a church. The 4m deep landslide covered 3 square kilometer, killing more than 1,200 persons (154 fatalities and 990 people missing) and displacing 18,000 people. The estimated volume of landslide was 2.1x107 m^3. The horizontal distance from the top of landslide and the toe of landslide deposit has been measured to be around 4km.

The area had already been identified as risk prone and predictions of disaster had been made.

Fig. 14.5: A view of landslide after it wiped off the village at Guinsaugaon, Leyte Province (Source : Internet)

Timeline: Guinsaugon had been evacuated a week prior (on 10/2/06 due to heavy rains), but when rains temporarily stopped, villagers returned (due to a break in rains between 11/2/06 and 16/2/06) and became the victims.

- A very low magnitude earthquake of magnitude 2.6 occurred prior to slide.
- A slide occurred at 10am and recurred at 10pm.
- Mudslides blocked the tributaries of river and raised threat level of flooding.

Actions

S&R operations started within 3hrs of the disaster.

Relief efforts began including flying in response teams, tents, blankets, water, communication equipments, food, medical and psycho-social care

11 villages evacuated as preventive measure

PWD cleared road (blocked by slide) for relief operations

Flood warning issued to neighbouring areas

NGOs started coordination and relief operations

Landslide Experts arrived to determine causes and guide response / recovery actions (including a Japanese and Philippines joint team of 22 scientists and engineers)

Who's Doing What, Where, Database developed and monitoring commenced

Schools used as evacuation centres

Construction of housing in permanent relocation areas underway.

Situational Challenges (due to disaster circumstances, weather, topography, geographical remoteness etc.)

Debate over cause of slide: Illegal logging, heavy rains, small earthquake, planting of non-native coconut trees with shallow roots without adequate erosion protection

Landslide blocked roads so that only point of rescue was by boat from sea

S&R efforts were hampered because rescuers were in danger in the shifting mud, blocked roads, collapsed bridges and severed communication lines

Continued rains hampered relief efforts; tributaries blocked by landslide caused fear of flooding

Construction was considered time consuming due to lack of safe land and numerous official procedures for land acquisition

Rescue hampered due to threat of additional landslides

On the first day, area was accessible only by air

Unstable ground impeded movement of heavy machinery, rescuers had to dig manually making relief effort harder and slower.

Absence of light at night led to suspension of rescue on day-1 (the first 24hrs are critical in saving lives)

Heavy clouds impeded the arrival of helicopters; more rain fall in the next 48hrs after disaster

People were buried upto 40m deep in mud; it was hard to rescue them

Cracks were seen in the area where slopes have failed.

Internal Resources or Infrastructure Challenges *(logistic, financial, personnel, physical, technological, informational, infrastructure resources constraints)*

- Vulnerable buildings and siting conditions
- Scale of destruction hampered efforts
- The closest airport became congested due to numerous flights arriving for relief. The distance to airport with respect to disaster area more (flying time and time to travel by land to reach site was also more)

The evacuation centres were overcrowded, compounded by poor water/ sanitation facilities, with inadequate number of latrines, no proper disposal of garbage & waste, poor supply of water for bath and cleaning, children and women were uncared

Lack of political will during relief effort slowed the government response

Large number of organization involved in response complicated the relief effort.

What Went Right?

More efforts to coordinate relief organizations to make operations effective

Efforts to learn from disaster to prevent and respond better to future disasters

Technology like thermal imaging equipment, canine units was used to make rescue & relief effort more effective

Latrines were designed in consultation with locals.

Who's Doing What and Where Database made to coordinate efforts and prevent duplication

Specialized task forces formed for coordination and focus on logistics, supply management, environmental health and children in emergency

Surrounding susceptible areas were pre-emptively evacuated to avoid any further sufferings

What Went Wrong?

The need assessment took several days to complete and the results were not shared timely, affecting SRR efforts

Not enough effort was made to prevent the disaster. Although the danger was recognized in advance but the government failed to act in time.

When the area was evacuated prior to disaster, the residents did not clearly understand the magnitude of danger or when they should return. However, pre-emptive evacuation was a good move, it was not supported by instruction when to return.

Sphere standards of relief were not followed.

Lessons Learnt

An assessment should be made in such areas where landslides are common, regarding the ground condition to determine if it is safe for people to stay or they should be evacuated. The residents in Guinsaugon had returned because rains had stopped and it was ill considered safe to return, but no-one made an objective assessment of the area. An expert should have been in-charge of advising when to evacuate and/or when to return.

First 24-48hrs after disaster are important and critical for survival of victims. It was hampered due to bad weather and road conditions.

Establishment of a permanent relief centre close to disaster prone areas (but not so close that it may also be subject to damage during disaster) would accelerate the response. An effective layout for the centre to access the goods and supplies for SRR.

Technology and timing are two logistic strategy foci that work effectively. There should have been an agile strategy to meet the immediate and changing demands of SRR.

NGOs are critical to relief efforts. They are more local, on the ground, continuously carry out needs assessment and are able to adjust their response based on latest needs. They are also able to build on existing connection in communities and quickly obtain funds

It is important to share the learning from each disaster so when disaster strikes again, the response improves.

Predisaster trainings on community based disaster preparedness in pre-identified areas by NGOs helped the disaster response

Socio-psychological services need to be continued to help residents cope and heal from their incredible loss

Medium and long term plans should include relocation, community based disaster preparedness, continued psycho-social support, construction of houses and community facilities, and livelihood programmes.

Players / Actors / Stakeholders

Civil Administration
Red Cross
Local Government
Mines & Geology Department
SDRF
Army / Police / Civil Defence / Home Gaurds
NGO
Locals
National and International NGOs
UN Agencies: OCHA, UNDP, UNICEF, UNDAC

PUBLICATIONS CONSULTED

The drafting of the training module involved extensive consultation of research papers, books and reports published by many individuals and institutions / universities / organizations in India and abroad. Some of the consulted reports are listed below. Authors, compilers and editors of the documents consulted are gratefully acknowledged.

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Documentation of Mountain Disasters, Eds. Hübl J., Kienholz H. and Loipersberger A., International Research Society INTERPRAEVENT, Klagenfurt, Austria, 2002

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National Disaster Management Guidelines, Medical Preparedness and Mass Casualty Management, National Disaster Management Authority, Government of India, 2007

National Disaster Management Guidelines, Management of Landslides and Avalanches, National Disaster Management Authority, Government of India, 2009

National Landslide Hazards Mitigation Strategy- A Framework for Loss Reduction, Elliot C. Spiker and Paula L. Gori, Circular 1244, USGS, 2003

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Web Resources for Videos related to Landslides

What are landslides and how are they caused?: This clip explains the chain of events that causes mudslides. Taken from the show "When nature strikes back: landslides" available on FirstScience.tv.

Download in full from: http://firstscience.tv/landslides.htm

http://www.youtube.com/watch?v=HiNwmj5ALZs&feature=player_embedded#!

When Nature Strikes Back: Landslides (Full Program) http://www.youtube.com/watch?v=Vd7eHG2b_tQ&feature=related

Landslide hits east Cairo shanty town in Egypt: A massive rockslide has hit a crowded Cairo shanty town, sending rocks and boulders crashed down onto dozens of houses.

http://www.youtube.com/watch?v=uCDhgtWH6t4&feature=player_embedded

Raw Video: **Dramatic Mudslides in Italy**: Around 200 residents of a southern Italian town were evacuated after an enormous landslide split the side of a hill.

http://www.youtube.com/watch?v=zl7_OMqOZbo

Dramatic amateur footage of deadly mudslide in Colombia: Rescue workers resumed their search and rescue efforts after up to 30 people were buried by a mudslide near the town of Giraldo in northwestern Colombia. Authorities had reported that the strong rainy season caused flooding and made many roads unusable across Colombia. The magnitude of the mudslide was making rescue operations very difficult. Amateur video shows the slide as it tumbled down, wiping out several homes.

http://www.youtube.com/watch?feature=fvwp&NR=1&v=BKTG58Bpziw

Mudslide Vancouver Hope BC June 29 2011 Canada: An extensive mudslide has Highway 1 closed in both directions at Popkum Road in the Hope area. The slide happened approximately 100 meters from the Herring Island exit this morning. It measures 25 feet deep and 200 feet long. Search and rescue crews had little to show after a ground search of a 60-metre wide mudslide on the Trans-Canada Highway between Chilliwack and Hope. In June 2000, a mudslide ripped the same stretch of highway between Chilliwack and Hope. No injuries were reported and both westbound and eastbound lanes were cleared within a

day. In January 2002, a more devastating mudslide -- provoked by a winter storm -- struck the Trans-Canada Highway and surrounding areas in Hope and Chilliwack. According to previous reports, the storm and ensuing slide caused hundreds of thousands of dollars of damage to roads, homes and businesses in the area.

http://www.youtube.com/watch?v=S0kKtmkMgJM&feature=related

Raw Video on **Mudslides Destroy Homes in Bolivia** : A mudslide swallowed at least 50 houses and displaced 600 people in Bolivian capital La Paz. The landslides were caused by the presence of subterranean water.

http://www.youtube.com/watch?v=EzOk_lxk4Ww&feature=player_embedded

Mudslides, Flooding Kill 84 in Brazil: After days of heavy, flooding rains throughout Brazil, it is mudslides that rescue workers are now fighting against. Dozens are dead, another 30 remain missing. Officials estimate 54,000 people are displaced from their homes.

http://www.youtube.com/watch?v=HA7YtAojmU0&feature=relmfu

Frank Slide: Largest Landslide in History

http://www.youtube.com/watch?v=B-C3MCI1H7A&feature=related

Giant Sink Hole/Landslide Caught On Camera In Canada : This footage is from around Ontario, Canada.

http://www.youtube.com/watch?v=fbKDgF8CvmQ&feature=related

Massive Landslide Caught on Tape

http://www.youtube.com/watch?v=XC9AqJlaCj4&feature=related

Landslides in Svizzira, Switzerland http://www.youtube.com/watch?v=zGHCiXWR4DE&feature=relmfu

Quick Clay Landslide at Rissa - 1978 (English commentary) : On the 29th of April 1978, a quick clay landslide devastated large areas of the rural district of Rissa I mid-Norway. One person died whilst 13 farms; 2 homes; a cabin and a community centre were taken by the clay masses.

http://www.youtube.com/watch?v=3q-qfNIEP4A&feature=related

Raw Video: **Deadly Landslide Hits Train in Italy** – A landslide hit and derailed a train in northern Italy on Monday, killing 11 people and leaving some 30 injured.

http://www.youtube.com/watch?v=ktxDjqQIouw&feature=player_embedded

Raw Video: **Landslide Kills 6 in China** - A landslide in China's southwest killed at least six people and damaged a bridge that is a key link for reconstruction in areas hit by a devastating earthquake.

http://www.youtube.com/watch?v=3nAlQxOrQxs&feature=relmfu

Raw Video: **Landslide Buries Chinese Village** : A state media report says a massive landslide in northern China partially has buried a village and killed at least 23 people, and that rescuers are seeking survivors.

http://www.youtube.com/watch?v=3nAlQxOrQxs&feature=relmfu

Tibet to Nepal road with landslides - freaking scary 2: This is the continuation of my other video post "Tibet to Nepal road with landslide - freaking scary" where you can actually see the landslide "live". Bulldozer to the rescue, then continuing on, stumbling upon other landslides,

http://www.youtube.com/watch?v=mxoAUG9nmhE&feature=related

Landslides in La Rinidad, Benguet Particularly in Buyagan and in Puguis : Landslides In La Trinidad, Benguet Particularly In Buyagan and In Puguis During Typhoon Pepeng, This Devastating Disaster Have Claimed Many Lives, Most Are Them Are Families and Only Few Survived.

http://www.youtube.com/watch?v=weGGWdw7UHc&feature=related

Huge rock slide into lake! - shatters in half on the way down,

http://www.youtube.com/watch?v=PFAGPYbgqIM&feature=related

Half Dome rock fall, 5/27/11, Yosemite Valley : from top of Washington Column. Large blocks came all the way down the Death Slabs - would have been fatal for anyone approaching the NW base.

http://www.youtube.com/watch?v=xGzU_sQrMsk&feature=related

Landslide in Japan - The following of website:
http://www.kkr.mlit.go.jp/plan/2004-jisuberi-0810/index.html
other http://www.ajiko.co.jp/bousai/nara/nara.htm
(picture & 3D video)

Giant Landslip hits village. Caught live on camera - Movie of an giant Landslip hitting an village in Italy

http://www.youtube.com/watch?v=MQvNm-Swdb8&feature=related

Rock Slide As It Happens - Coffee Creek – Kootenays : TMTV News - Nelson BC Canada (UNEDITED) A rock slide as it happens on Highway 31 at Coffee Creek north of Nelson BC closed the highway for several hours. Boulders come crashing down onto the highway while filming.

http://www.youtube.com/watch?v=B4RYtNJpdLY&feature=related

Huge rockfall on Mount Rainier : Smaller and larger rockfalls happened during the day about hourly. Around 4pm a huge part of Nisqually Cleaver fell down, creating a fast river of rock and snow.

It was the biggest that day.

http://www.youtube.com/watch?v=fzRhLs5GkYs&feature=related

Malaysia Landslide : landslide occur at Seaside Malaysia on 1993 year,this video was taken on the spot at that time. That year, I received a call by the owner of a tin mine (the element tin, not tin as in cans...). He said that his mine, which had been running for a few decades, was about to collapse. I rushed to the scene with my video camera and waited for a few hours. Finally, I took this valuable footage. Although the footage lasted only a few minutes, it is horribly exciting enough. I hope that this video can let you all appreciate the consequence of ruining our environment."

http://www.youtube.com/watch?v=H6Ma0SVjMHA

http://www.youtube.com/watch?v=hMnAfY5H-8E&feature=player_embedded# (link to TV program in USA)
Extreme landslide caught on camera VIDEO : http://www.youtube.com/watch?v=kNrmczkpcPU&feature=related

Raw Video: **Many Missing After Mexican Landslide** : Rescue efforts continued on Wednesday in a town in Mexico's Oaxaca state, after the area was hit by landslide caused by torrential rains.

http://www.youtube.com/watch?v=yZUxIfltlT4&feature=player_embedded

Italy 16.02.2010: **Impressive landslide caught on video** - Italien Erdrutsch auf video - Italy http://croazia-alloggi-privati.info

http://www.taramtamtam.com/Urlaub-Reisen/Reiseangebote.php?c=Italien&lid=101

The landslide, which caused power failure, could have been caused by heavy rains in the region, initial reports say.

http://www.youtube.com/watch?v=R__3DYQCVnA&feature=related

Heyelan - Land slide

http://www.youtube.com/watch?v=F31ywRvtNkY&feature=related

Heyelan-Land Slide 2

http://www.youtube.com/watch?v=KmjcBb_tR2k&feature=relmfu

Land Slide-Heyelan-3

http://www.youtube.com/watch?v=9mI-TAL6SDc&feature=relmfu

Destroyed in seconds, The Frank Slide – 1903- The community of Frank NWT is obliterated on April 29, 1903

http://www.youtube.com/watch?v=cb_0D1epHcU&feature=related

Awesome Landslide : Glad you weren't driving on this Tennessee road when the cliff came down

http://www.youtube.com/watch?v=LeaX0ueZD-g&feature=related

Outrunning a Landslide : In Portland, Oregon, two men find themselves battling for their lives as a landslide hits their vehicle... and pushes it down the side of a mountain. They have to outrun the deluge of dirt and mud in order to survive. (from Discovery Channel's "Against the Elements")

http://www.youtube.com/watch?v=K1qY8nPqcCw&feature=related

Mount St. Helens Disintegrates in Enormous Landslide : Is any distance away from a volcano safe? Find out when an eruption causes one of the largest landslides in recorded history on Mount St. Helens. Unbelievable footage is studied and explained. (from Discovery Channel's "Raging Planet")

http://www.youtube.com/watch?v=UK--hvgP2uY&feature=fvwrel

Landslide Repair : The machine has arrived to repair our landslide that happened in January. The "spider" handled the 25 foot drop with little problems.

http://www.youtube.com/watch?v=O_XIXeLITdw&feature=related

!!Landslide In California!!

http://www.youtube.com/watch?v=pCMMwQmUjHI&feature=related

Oliver Mudslide : Six families are homeless, after a massive wall of mud, water and debris rushed down a hillside just south of Oliver, in the Southern Okanagan. Homeowners heard the roar of the hillside giving way, and went door to door. Amazingly everyone got out alive -- and no one was injured. Emergency technicians surveyed the damage, and with rain in the forecast, they're concerned more slides could be triggered. Highway 97 is buried in meters of mud, and is expected to be closed for days. Homeowners affected by the slide will receive money from the Provincial Government's Disaster Assistance Plan.

http://www.youtube.com/watch?v=6YA1W4z_3kg&feature=related

Mudslide - June 2 2011, Keystone Colorado

http://www.youtube.com/watch?v=CyY3bCV8K-M&feature=related

Varunawat Land slide in 2003 : Varunawat landslide clip, Uttarkashi www.drm.dmuttarkashi.com

http://www.youtube.com/watch?v=IamLdh2O8Iw&feature=related

Varunawat land Slide in 2003(2) : www.drm.dmuttarkashi.com Varunawat landslide on district Uttarkashi (uttarakhand) india

http://www.youtube.com/watch?v=Z95nQw6Tzio&feature=relmfu

Live Landslide at Manali - Leh Highway : The landslide occurred between Sissu and Koksar in the Manali-Leh Highway. Huge pieces of rock started falling from the cliff above.

http://www.youtube.com/watch?v=6Hi_Osg2dY4&feature=related

Landslide shot live near Dalhousie : Very recent landslide shot live while coming down from Dalhousie. this is about 15 kms down from Dalhousie enroute Pathankot. while we reached a small part of the mountain had fallen completely disrupting trafiic and rendering them immobile. while I stood there, there was this whole mountain which came sliding down and honestly it was a lifetime experience bringing in mixed feelings of surprise...joy...and fear...the roads are albeit good such things keep on happening during monsoon...keep visiting Dalhousie...it makes for an exciting holiday.....no tie up with Himachal tourism..:-))

http://www.youtube.com/watch?v=Vc6ouosXk0Q&feature=related

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nidm
Towards a disaster free India

NATIONAL INSTITUTE OF DISASTER MANAGEMENT
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Annexure P-13

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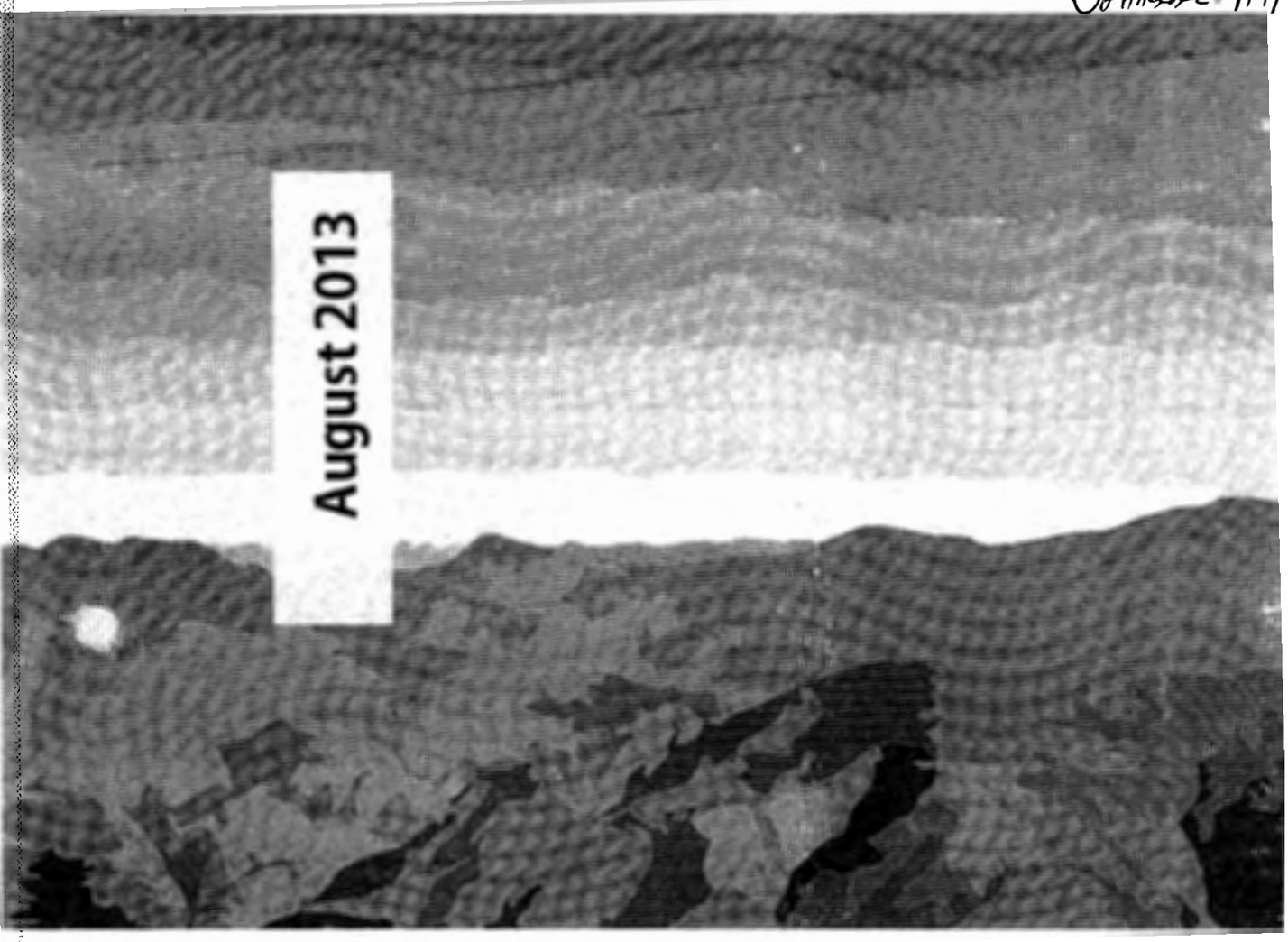
Annexure A1/13



Policies to Mainstream Adaptation to Climate Change and for Sustainable Development in the Himalayas

The Role of the Indian Himalayas Climate Adaptation Programme

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

IHCAP Indian Himalayas Climate Adaptation Programme

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Executive Summary

This report looks at the interventions that the Indian Himalayas Climate Adaptation programme can make in the policy sphere to advance the cause of adaptations to climate change effects and sustainable development in the Himalayas.

The principal findings of this preliminary report are two:

1. There are policy prescriptions at the Government of India and State Government levels that advance these goals, but there are existing policies, mainly at the State Government and Municipality/Panchayat levels that are not in consonance with these policy prescriptions
2. There are significant implementation gaps even when policies at the Central, State and local Government levels are in consonance

Based on these findings, this report makes three recommendations for the IHCAP programme:

1. To carry out a detailed policy analysis in key areas such as water, urbanization, transport, tourism etc. so that the exact points of policy dissonance and implementation gaps can be identified.
2. After doing this detailed policy analysis, to use the findings to carry out capacity building workshops at State, Municipality and Panchayat levels for lawmakers, bureaucrats, members of the civil society and the media, so that they are made aware of these points of dissonance and implementation gaps and can take or advocate corrective steps
3. To supplement existing activities such as building environmental awareness, through activities in educational institutions and with the help of the media

Following discussions with officials in the Government of India for this report, it is recommended that the Ministry of Environment and Forests be the coordinating agency for the policy aspect of the IHCAP programme, and that the IHCAP works closely with this ministry while implementing the programme in the field.

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Background

The Indian Himalayan Region (IHR) spreads across 0.53 million square kilometres, comprising 16.2% of India's geographical area. It controls the climate of South Asia by forming a barrier to the annual monsoon winds from the Indian Ocean, feeds the sub-continent's perennial rivers and is a rich reservoir of biodiversity. Sustainable development of the IHR in the face of climate change and threats to biodiversity is critical for South Asia.

The Government of India (GoI) has developed a holistic plan for this purpose, called the National Mission for Sustaining the Himalayan Ecosystem (NMSHE). The mission plans to address the important issues concerning the effects of climate change on Himalayan glaciers and associated hydrological consequences downstream; biodiversity conservation and protection; ensuring livelihoods and improving the standard of living of people who live in the IHR; and community-based planning and management that will sustain this ecosystem.

With the effects of climate change already making themselves felt in this region, as elsewhere, and with these effects projected to accelerate in the coming years, adaptation to these effects is an integral part of the NMSHE plan. While the Ministry of Science and Technology, GoI, is the nodal ministry for the NMSHE, plans for adaptation are also being coordinated by the Ministry of Environment and Forests (MoE&F) and are to be implemented by the state governments in the IHR. Many of the adaptation plans also require the active involvement of the civil society and individuals.

Recognizing the enormous challenge of climate change for the IHR, the Division of Climate Change and Development, Embassy of Switzerland in India, is developing a new programme called the Indian Himalayas Climate Adaptation Programme (IHCAP). The IHCAP is under the Global Programme of Climate Change supported by Swiss Agency for Development and Cooperation (SDC). The outline of the programme is being developed in consultation and with inputs from several organisations including GoI and some State Governments in the IHR.

The IHCAP plans to build on capacity and knowledge enhancement related to three pillars:

1. Scientific and technical knowledge cooperation between Indian and Swiss scientific institutions for long-term research in the field of glaciology, hydrology and climatology; and short-term research in the field of science based adaptation;
2. Adaptation measures and risk reduction for vulnerable communities
3. Mainstreaming adaptation policies for improved action in the IHR by linking grassroots voices with science and policy.

This report deals with the third pillar – the policy issues. It is based on consultations with relevant officials in the Ministry of Science and technology, MoE&F, and the State Governments of Himachal Pradesh and Sikkim, two states in the IHR. These consultations, in turn, were based on a study of

- The NMSHE plan;
- The Shimla Declaration on Sustainable Himalayan Development that was issued after a conclave of chief ministers from the IHR states on October 30, 2009;

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- Governance for Sustaining the Himalayan Ecosystem: Guidelines and Best Practices – a publication of the MoE&F and the GB Pant Institute of Himalayan Environment and Development (GBPIHED);
- The report of a Task Force set up by the Planning Commission of India to look into problems of hill states and hill areas;
- The draft state action plans for climate change developed by the two State Governments; and
- Some of the existing policies at Central, State, Municipality and Panchayat levels that affect or may affect the mainstreaming of adaptation and other NMSHE goals

There have been three more important inputs to this report: (i) The National Workshop on Sharing of Lessons and Wise Practices for Sustaining Himalayan Ecosystem, organized by GBPIHED at its Almora headquarters on August 10-11, 2011; (ii) The inputs received via the Solutions Exchange coordinated by the United Nations Development Programme (UNDP) to the query posted by the Swiss Embassy on planning for the IHCAP, which will be a five-year programme starting in January 2012; and (iii) the consultation for IHCAP planning organized by the Swiss Embassy and UNDP in New Delhi on August 30, 2011

Based on these inputs, this report identifies key areas where policy intervention and/or implementation is necessary to mainstream adaptation and to attain other NMSHE goals, and then recommends how the IHCAP could play a constructive and complementary role in this important sphere.

The Policy Issues

For purposes of brevity, the plans laid out in the NMSHE, and the associated plans of the Central and State Governments will be jointly referred to as NMSHE plans henceforth in this report. The NMSHE plans are clear on the need for mainstreaming adaptation and sustainable development in the IHR and have laid down detailed guidelines on the policies needed to achieve this. However, there are two major obstacles in the way: (i) Those policies of the Central, State, Local Governments (municipalities and Panchayats) that are not in consonance with the NMSHE plans; and (ii) The implementation of the NMSHE plans

The four basic questions posed while preparing this report were

1. What are the policies of Central, State and Local Governments that lead to better adaptation to climate change?
2. What are the policies that hinder this?
3. Are there any policy conflicts? If so, how can they be resolved?
4. What can be done to improve implementation of policies that promote better adaptation to climate change and therefore sustainable development?

This report will take a brief look at the policy dissonance in some key areas before recommending the role that IHCAP can play in resolving these issues to achieve the goal of mainstreaming adaptation and sustainable development in the IHR. The areas examined in this report are illustrative and not exhaustive. The policies examined in each area have also been chosen for the purpose of illustration,

and are not exhaustive. A more comprehensive analysis of these policies at every level is necessary before the actual intervention by IHCAP.

Water

In this critical area, a key NMSHE policy prescription is to rejuvenate springs, make inventories of mountain springs and do detailed geological mapping to identify the spring recharge zones. While the Himachal Pradesh Government follows the same policy prescription, there is considerable concern that large-scale hydroelectric projects in the state are interfering with water recharge in the springs. Hydroelectricity planners have tried to minimize such impacts by shifting to run of the river projects from dam projects. But run of the river projects above a certain size have to channel water through tunnels, and there is anecdotal evidence from residents and civil society representatives that this channelling is interfering with natural percolation of groundwater and therefore spring rejuvenation. It also has effects on the silt carrying capacity of the stream as well as biodiversity downstream. While the need for electricity cannot be ignored and run of the river projects are among the cleanest forms of electricity generation known so far, there is still a dissonance between these projects and the NMSHE policy prescription. In Sikkim, as in Himachal Pradesh, spring and stream rejuvenation and local water storage area already major components of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) works. The State Government is very keen do detailed inventory of surface and groundwater and seeks collaboration for this. But there are major hydroelectricity projects ongoing in Sikkim, in the Teesta basin. And though the MoE&F has given clearance to these projects only after studying the carrying capacity of the basin, the study has not taken into account underground water percolation upstream in the small tributaries or spring rejuvenation.

Another example is the NMSHE policy prescription to protect high-altitude lakes through law and by prohibiting construction activities on/around them. Both Himachal Pradesh and Sikkim Governments have guidelines in consonance with this policy prescription, but officials in both State Governments agreed that apart from some showcase exceptions, these guidelines were not being implemented, nor had they really percolated either to officials in the tourism departments or to local government authorities.

Urbanization

The NMSHE policy prescription says: Do not permit unplanned growth of new settlements; consolidate existing settlements and govern them through land-use planning incorporated in a municipal master plan. Provide these settlements with basic facilities such as water supply, waste disposal and power, before permitting further growth. State authorities have been asked to prescribe regulations, taking into account the particularities of the local ecosystem, including seismic vulnerability, the need to respect local aesthetics and harmony with Nature, and the optimum population load the settlement can sustain, given the availability of water and power. Specifically, the NMSHE says, municipal bylaws should be amended, wherever required, to prohibit construction activity in areas falling in hazard zones or across alignments of natural springs, water sources and watersheds near urban settlements. There will be strict enforcement of these bye-laws, including through imposition of heavy penalties and compulsory demolition of illegal structures. Construction activity will be prohibited in source-catchment areas of

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cities, including along mountain lakes and other water bodies. Their feeder channels will also be kept free of building activity.

The Himachal Pradesh State Environment Master Plan follows this policy prescription and its authors have carried out a detailed vulnerability assessment by Tehsil, which can be very useful for all micro-level planning, including urban planning. The Master Plan also has detailed guidelines by sector, and the blueprint for a query based software that will enable a local official to decide whether to permit an activity that will lead towards urbanization, for example. But bureaucrats in the state's urban planning and housing departments appear largely unfamiliar with these developments. Officials in the Shimla Municipal Corporation said they had not been informed about these new norms, and thought their colleagues in other municipalities would not have been informed either. The local level officials said they would need substantial capacity building before they were able to implement such norms in urban planning. These officials were aware of norms laid down for earthquake-resistant buildings, an important consideration since the entire IHR is in a high-vulnerability seismic zone. But they pointed out that these norms were not mandatory except in Government buildings, so they had no means of implementing them in private buildings. There were no punitive laws at all, nor were they aware of any plan to have such laws.

In Sikkim, the State Strategic Urban Plan looks at developing a total of 16 urban centres by 2040, which includes the current 9 centres. The long term urban growth of Sikkim is proposed to be guided by the structure of "Moderated Multiple Nuclei Structure". While that has some points in common with NMSHE norms, there are important points of divergence that need to be reconciled.

Solid Waste Management

The NMSHE plan says: Ban plastic bags, provide certified potable water, amend municipal by-laws to make waste segregation and composting mandatory, tax plastic and non-biodegradable packaging.

While plastic bags have been banned in both Himachal Pradesh and Sikkim, officials admit to lack of enforcement when it comes to tourists who come from outside these states. Neither state has taken any serious step to provide local certified potable water, which could obviate the need for bottled water. There is however, a well-known model for such water supply in Leh, which has the added benefit of providing significant local employment. In Himachal Pradesh and Sikkim, while waste segregation is encouraged, it is not mandatory in any of the municipalities or Panchayats in either state, nor is there any tax on plastic or non-biodegradable packaging. Officials in both states said these steps would require the passage of laws in the state legislatures, and there may be considerable opposition from the tourism industry.

Tourism

Many places in IHR are very popular pilgrimage sites visited by thousands every year. The NMSHE policy prescription says: Analyze carrying capacity of each pilgrimage site and restrict numbers accordingly; create 10-km radius no-road/no-vehicle buffer zone around protected pilgrimage sites; give larger stake to local community to manage and benefit from tourism, both religious and secular; promote audited

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homestead tourism and discourage 3 to 5 star variety; impose tourism tax, raise parking fees, make town centres vehicle-free.

The carrying capacities of major pilgrimage sites have been analyzed in the state action plans, but as yet there is no move to restrict numbers accordingly. Officials in both Himachal Pradesh and Sikkim said such a move may be politically risky, and therefore may be opposed by legislators. For the same reason, and more so because many of the pilgrims are elderly and/or infirm, there has been no move to create a vehicle-free buffer zone around any pilgrimage site. The Uttarakhand Government has, however, restricted the number of pilgrims to the Gangotri glacier and more recently on the famous Char Dham Yatra. That, according to officials in the state's Disaster Management Department, has brought down the number of road accidents on the pilgrimage route as well.

The Forest Department in Uttarakhand also has an example from the Valley of Flowers of providing a larger stake in tourism to the local community, in the process also helping solid waste management in the popular tourist area. While these are models of best practice that can be emulated throughout the IHR, and while all state government in the region are promoting homestead based tourism, the problem is that there is no apparent move to discourage any 3 to 5 star variety of tourism, nor of any move to impose any special tourism tax or raise parking fees. However, the centres of some towns have been made vehicle free.

In Sikkim, where tourism is the mainstay of the state's economy, the SAPCC plans to (i) introduce enhanced licensing norms for hotels and home-stays to incorporate high level of energy efficiency, water harvesting and water re-cycling norms; (ii) provide renewable energy to all tourism and trekking camps and high-altitude and remote monasteries; Kanchenjunga National Park is to also have battery operated patrol and visitor vehicles.

Transport

The top demand from the majority of residents in the IHR is for reliable paved roads and transport services to their villages. At the same time, poorly-planned roads have often been held responsible for landslides that block the same roads, as well as for causing major damage to the ecosystem. Taking this into account, the NMSHE policy prescription is: Mandatory EIA for all roads longer than 5 km; align roads along ridges rather than river valleys; cost estimates for road construction to include mandatory treatment of hill slope instabilities resulting from road-cutting, cross drainage works and culverts, disposal of debris at suitable and identified locations; norms for hot mix plant sites; all hill roads to provide adequate roadside drains and, wherever possible, be connected to the natural drainage system; alignment of proposed roads to avoid fault zones and landslide prone zones wherever possible; explore alternative forms of mass transport like railways and ropeways; enforce fuel quality standards and clean filters, especially for diesel vehicles

While there is mention of such green road-building norms in the Himachal Pradesh SAPCC, officials in the state Public Works Department professed ignorance about them. There is no such mention at all in the Sikkim SAPCC. A bigger problem pointed by senior officials in both State Governments is that the construction and maintenance of major roads are not under their jurisdiction, but under that of the

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Border Roads Organization (BRO), a department of the central Ministry of Defence. BRO officials in the Sikkim capital Gangtok said they were unaware of any such green road-building norms. Officials in Sikkim were keen to discuss with their Swiss counterparts various mass transport options such as sky train or fast ropeway.

The Findings

The literature review and consultations with officials at Central, State and Municipal government levels made it clear that while there are some policies at all levels that foster adaptation to climate change effects and sustainable development in the IHR, there are others that hinder this. There is a telling example in Uttarakhand: while both the NMSHE and the state government officially promote organic farming in the state and discourage the use of chemical fertilizers and pesticides, the agriculture department of the same state government continues to provide subsidies to farmers to buy chemical fertilizers and pesticides.

There are similar policy conflicts in other key areas such as water supply, energy generation, transport, tourism and others. While some conflicts have been outlined in this report, a detailed policy analysis will provide a more comprehensive list. While such an analysis was beyond the scope of this preliminary report, it is necessary before effective intervention of IHCAP in the policy space.

It was also found that there are sometimes significant gaps in implementing sustainable development policies, though these policies have been endorsed at all levels of government. A common example is that of the failure to fully implement the ban on plastic bags.

The Recommendations

Officials in the GoI as well as the state governments agreed that such policy dissonances needed to be reconciled in order to mainstream adaptation to climate change and advance sustainable development in the IHR. They suggested that the best way to do this would be to build the capacity of various stakeholder groups to make/support policies that will further NMSHE goals. Key groups are

1. Legislators at State, Municipality and Panchayat levels
2. Bureaucrats, especially from departments other than environment
3. Civil Society - NGOs, CBOs, Media, Academics, Students

Suggested Activities

It was suggested by the officials that in the policy sphere, this is where the IHCAP can play a very useful role, by holding capacity building workshops at state, district, municipality and Panchayat levels that would enable the legislators to formulate policies to mainstream adaptation to climate change and advance sustainable development. Knowledge of potential consequences of non-implementation of such policies will also help enable the bureaucrats to implement these policies, for example to stop illegal riverbed mining for construction material, or for maintaining the rainwater harvesting systems that are now mandatory in government buildings but which often lie neglected. Holding such capacity building workshops at dispersed levels would have the additional benefit of spreading knowledge and awareness of NMSHE goals throughout the IHR.

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However, as mentioned earlier in this report, such a set of activities should be preceded by a more detailed sector by sector policy analysis to identify the exact laws and/or policies that are in dissonance. The sectors to be analyzed should include

- Water
- Agriculture
- Transport
- Tourism – both religious and secular
- Solid Waste Management
- Urbanization
- Industrialization
- Energy generation
- Air pollution

Coordinating Agency

Another issue examined for this report was whether IHCAP should in any way help implement the decision taken by the 2009 Chief Ministers' Conclave to establish a Himalayan Sustainable Development Forum. This was conceived as a forum through which IHR states could jointly make their case to the GoI on issues related to climate change adaptation and sustainable development. However, the forum has not really got off the ground yet, and the annual summit of IHR state chief ministers planned under this umbrella has not taken place even once. Senior officials in the GoI, Himachal Pradesh and Sikkim all felt the reason was political – that some IHR states felt others would obtain undue advantage from such a forum, and therefore did not want to take part. Apart from this, the Prime Minister's Office has already initiated a coordination mechanism for ensuring planned implementation of NMSHE goals. Though that has not yet got off the ground, the mechanism involves the Chief Ministers of all IHR states. Given this situation, this report is not making any recommendation on the IHCAP attempting to play any role in the revival of the Himalayan Sustainable Development Forum.

The scientific and technical cooperation for IHCAP is being coordinated with the Ministry of Science and Technology (MST) in GoI. This is also the nodal ministry to implement NMSHE. However, officials in the MST felt they were not the best coordinating agency through which IHCAP could address the policy issues. Officials in the Ministry of Environment and Forests (MoE&F), who have far more experience in coordinating activities of this kind, said they were willing to act as the coordinating agency for IHCAP in the policy sphere. This report therefore recommends that the MoE&F be the coordinating agency for the policy aspects of IHCAP.

Policies that advance mainstreaming of adaptation practices and sustainable development naturally come from indigenous knowledge as well as new scientific knowledge. Since a separate report on community involvement in IHCAP is being prepared, this report will not go into details in that sphere, except to recommend that IHCAP may provide an effective platform for more fruitful interactions between the civil society and policymakers. This will have the additional benefit of bringing knowledge institutions and community based organizations closer to one another for mutual benefit in reaching the goal of sustainable development. The NMSHE plan includes the establishment of such a platform to be

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coordinated by the Prime Minister's Office. Again, the details have not been worked out yet, but when that is done, the IHCAP can play a useful catalytic role.

Apart from helping reconcile the policy dissonances, the IHCAP can also play a complementary role in areas where there is policy consonance. An example is the building of environmental awareness. The NMSHE has a list of potential activities for this purpose, for example by holding awareness camps in schools and colleges, and by providing information to the media on steps being taken to advance adaptation to climate change effects. All State Governments in the IHR carry out these activities to a greater or lesser extent. But there is always scope for improvement, and the IHCAP can play a role in this by providing both content and trainers.

Annexure

The officials consulted for the preparation of this report

Many of the officials consulted for this report at Central, State and local government levels spoke on the condition of anonymity, because they felt they could not speak freely on this issue if they were going to be identified.

Here is a partial list of officials consulted for this report. It contains names of officials willing to be identified. It also contains names of academics and civil society members consulted for this report.

Name	Organization
B.M.S. Rathore	Ministry of Environment and Forests, Government of India
Akhilesh Gupta	Ministry of Science and Technology, Government of India
Sandeep Tambe	Government of Sikkim
Nagin Nanda	Government of Himachal Pradesh
L M S Palni	G. B. Pant Institute of Himalayan Environment and Development
Kireet Kumar	G. B. Pant Institute of Himalayan Environment and Development
Sejuti Basu	Pragya
Mahendra Lama	University of Sikkim
Mukul Sharma	LEAD India
Prabjhot Sodhi	Centre for Environment Education
Gurpriya Kapoor	Himachal Institute of Public Administration
Kashi Nath Vajpai	Climate Himalaya Initiative
Shalini Misra	G. B. Pant Institute of Himalayan Environment and Development
RS Tolia	CHEA
Kiran Sharma	Development Alternatives
Vinay Tandon	Government of Himachal Pradesh (retired)
Arup Banerji	Government of Uttarakhand
JS Rawat	IUCN India
Sachidanand Bharti	State Planning Commission, Uttarakhand
VRS Rawat	Indian Council for Forestry Research & Education

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About Indian Himalayas Climate Adaptation Programme (IHCAP)

Recognizing the enormous challenge of climate change for the IHR, there is an urgent need to build institutional and individual capacities. National policy frameworks such as the National Action Plan on Climate Change (NAPCC), the National Mission on Sustainable Himalayan Ecosystem (NMSHE) and the 'Shimla Declaration on Climate Change Actions', focuses on a range of measures for adaptation and mitigation, including scientific collaboration and establishing a Himalayan Sustainable Development Forum.

Climate Change and Development (CCD), Embassy of Switzerland in India, under the **Global Programme of Climate Change** supported by Swiss Agency for Development and Cooperation (SDC) in collaboration with the Department of Science & Technology, Government of India has initiated the **Indian Himalayas Climate Adaptation Programme** (IHCAP). The IHCAP builds on capacity and knowledge enhancement related to three pillars: (a) scientific and **technical knowledge cooperation** between Indian and Swiss scientific institutions; (b) **adaptation measures** for vulnerable communities; and (c) main streaming adaptation policies for improved action in the Indian Himalayan Region.

The goal of the Indian Himalaya Climate Adaptation Programme is that the "resilience of vulnerable communities in the Himalayas is strengthened and knowledge and capacities of research institutions, communities and decision-makers are connected and enhanced". IHCAP focuses on three areas:

- **Strengthening institutional capacities at the State level in Himachal Pradesh** of the different levels of stakeholders in the government on climate adaptation planning and implementation.
- **Science capacity building on glaciology and related areas** to enhance the understanding of the scientific dimension of climate change dynamics and scenarios on snow, glaciers and water flows.
- **Facilitate dialogue between Himalayan States** so that they can review, integrate and mainstream climate change aspects in their development policies, plans, and action.

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IHCAP **Indian Himalayas Climate Adaptation Programme**

True Copy

Gaurav Kumar Bansal
Advocate

Annexure P-14

BEFORE THE NATIONAL GREEN TRIBUNAL,
PRINCIPAL BENCH, NEW DELHI

Original Application No. 498 of 2014

IN THE MATTER OF:

Gaurav Kumar Bansal Vs. Union of India & Ors.

CORAM : HON'BLE MR. JUSTICE SWATANTER KUMAR, CHAIRPERSON
HON'BLE MR. JUSTICE M.S. NAMBIAR, JUDICIAL MEMBER
HON'BLE MR. DR. D.K. AGRAWAL, EXPERT MEMBER
HON'BLE PROF. A.R. YOUSUF, EXPERT MEMBER

Present:	**Applicant:**	**Mr. Gaurav Kr. Bansal, Adv.**
	Respondent No. 1:	**Ms. Panchajanya Batra Singh, Adv., MoEF & CC**
	Respondent Nos. 2&3:	**Mr. Ardhendumauli Kumar Prasad, Adv.**
	Respondent No. 4:	**Ms. Prerna Singh and Mr. Prashant Mathur, Advs.**
	Respondent No. 5:	**Mr. Anil Shrivastava and Mr. Sanyam Saxena, Advs.**
	Respondent No. 6:	**Ms. Kankana Arandhara and Mr. Prashant Mathur for corporate law glove**
	Respondent No. 8:	**Mr. Atul Jha, Adv.(State of Chhattisgarh)**
	Respondent No. 9:	**Mr. Atmaram, Mr. N.S. Nandkarni, Mr. Datta Prasad Lawande, MR. Pradosh Dangvi, Mr. Rebello, Mr. Anshuman Shrivastava**
	Respondent No. 10:	**Mr. Tushar Mehta, ASG with Mr. Parth Bhatt**
	Respondent No. 11:	**Mr. Anil Grover, AAG of Haryana with Mr. Rahul Khurana, Adv.**
	Respondent No. 12:	**Mr. Suryanarayana Singh, AAG**
	Respondent No. 13:	**Mr. Devashish Bharuka, Ms. Anu Tyagi and Ms. Priyanka Sinha, Advs.**
	Respondent No. 16:	**Mr. Jogy Scaria and Mr. Reegan Sbel, Advs.**
	Respondent No. 18:	**Mr. Preshti Surshe, Adv.**
	Respondent No. 19:	**Mr. Sapam Biswajit & Mr. Meitei and Ms. Kalyani, Advs.**
	Respondent No. 21:	**Mr. Pragyan Pradip Sharma, Mr. Ravikant Pal and Mr. Pulkit Prakash, Advs.**
	Respondent No.22:	**Mr. K. Gnatoli Sema, Adv.**
	Respondent No. 23:	**Mr. S.P. Sharma, Mr. Sumit Rajor (for Govt. of NCT), Advs.**
	Respondent No. 24 :	**Ms. Kriti H., Adv. for the State of Orissa**
	Respondent No. 25 :	**Mr. Abhimanyu Garg and Ms. Preety Makkar, Advs. For Puducherry**
	Respondent No. 26 :	**Ms. Richa Kapoor with Mr. Anil Soni, Advs.**
	Respondent No. 27:	**Ms. Alpana Poddar, Adv.**
	Respondent No. 28:	**Ms. Aruma Mathur and Mr. K. Vijay Kumar, Advs.**
	Respondent No. 29:	**Ms. M. Yogesh Kanna, Mr. Jayant Patel, Advs.**
	Respondent No. 30 :	**Mr. Gopal Singh with Mr. Rituraj Biswas, and Mr. B. Khushbansi, Advs. for state of Tripura**
	Respondent No. 31 :	**Ms. Savitri Pandey and Ms. Azma Parveen, Advs.**
	Respondent No. 32 :	**Mr. Rahul Verma, Adv.**
	Respondent No. 34 :	**Mr. G. Indira and Mr. K.V. Jagdishvaran, Advs. for A&N Administration**
	Respondent No. 35 :	**Mr. Shubham Bhalla, Adv.**
	Respondent No. 36 & 37 :	**Mr. D.K. Thakur, Mr. Deepak Jain and Mr. Alok Kumar, Advs.** **Ms. Nupur Kanungum, Adv.** **Mr. Ranjan Mukherjee, Adv.** **Ms. Aprajita Mukherjee and Mr. Samridhi Arora, Advs.** **Dr. Abhishek Atrey, Mr. Atif Suhrawardy and Mr. Sumit Rajora, Advs. for UT of Lakhadeep** **Mr. G.M. Kawoosa and Ms. Antima Bazaz, Advs. for State of J&K** **Mr. Rudreshwar Singh and Mr. Gautam Singh for State of Bihar**

	Date and Remarks	Orders of the Tribunal
	Item No. 17 **July 23, 2015**	The prayer in this Application is that the Respondents should be directed to place on record the relevant material and documents relating to the steps taken by them in order to implement National Action Plan on climate change. Further it is prayed that the State Governments should be restrained from acting in violation of the said plan and they should finalise and implement the State Action Plan with reference to the National Action Plan. Learned counsel appearing for MoEF submits that the National Action Plan for climate change is already in force and they requested different states to implement and act in accordance with the said plan. The States have already been requested to bring the State Action Plan in conformity with the National Action Plan. Learned counsel appearing for some of the States including Gujarat, Jharkhand, Odisha, Tamil Nadu, Arunchal Pradesh, Punjab, Uttarakhand, Goa, Nagaland and Manipur and Union Territories of Lakhshyadeep and Andman Nicobar submit that their Action Plan has already been prepared and approved by the MoEF. Learned counsel appearing for some other States submit that they have prepared the State draft plan and it is in the process of being finalised. In view of the above circumstances, we dispose of this application with a direction to the State Governments to comply with the directions issued by the MoEF and

		prepare their respective draft plan and get the same be approved expeditiously. We grant liberty to the Applicant to file a specific case for violation of National Action Plan, its impact and consequences thereof, In case there is any such specific violation. We find it difficult to deal with this issue in general form as it is to be a case of a specific State with specific violation and climatic consequences thereof. Original Application No. 498 of 2014 stands disposed of as no orders as to costs. .....,CP (Swatanter Kumar) .....,JM (M.S. Nambiar) .....,EM (Dr. D.K. Agrawal) .....,EM (Prof. A.R. Yousuf)

NATIONAL GREEN TRIBUNAL, NEW DELHI

1175

BEFORE THE NATIONAL GREEN TRIBUNAL,

SITTING AT KOLKATA

ORIGINAL APPLICATION NO OF 2023

(Under Section 14 of the National Green Tribunal Act, 2010)

VANNEIHSIAMI NOTARY Aizawl District Regd. No. 15/2022 GOVERNMENT OF MIZORAM

IN THE MATTER OF:

PI VANRAMCHHUANGI .....**APPLICANT**

VERSUS

UNION OF INDIA AND OTHERS .....**RESPONDENTS**

KNOW ALL to whom these present shall come that I, Pi Vanramchhuangi, applicant in the above mentioned Original Application do hereby appoint:

Nandita Dhar (D-2233/12), C-55, Vikaspuri, New Delhi - 18

(herein after called the advocate/s) to be my/our Advocate in the above noted case authorize him:

1.To act, appear and plead in the above-noted case in this tribunal or in any other Court/Tribunal in which the same may be tried or heard and also in the appellate Court including High Court subject to payment of fees separately for each Court by me/us.

2.To sign, file, verify and present pleadings, appeals, cross-objections or petitions for executions review revision, withdrawal, compromise or other petitions or affidavits or other documents as may be deemed necessary or proper for the prosecution of the said case in all its stages subject to payment of fees for each stage.

3.To file and take back documents, to admit and/or deny the documents of opposite party.

4.To withdraw or compromise the said case or submit to arbitration any differences or disputes that may arise touching or in any manner relating to the said case.

5.To deposit, draw and receive monthly cheques, cash and grant receipts thereof and to do all other acts and things which may be necessary to be done for the progress and in the course of the prosecution of the said case.

6.To appoint and instruct any other Legal Practitioner authorizing him to exercise the power and authority hereby conferred upon the Advocate whenever he may think fit to do so and to sign the power of attorney on our behalf.

7.And I/We the undersigned do hereby agree to rectify and confirm all acts done by the Advocate or his substitute in the matter as my/our own acts, as if done by me/us to all intents and proposes.

8. And I/We undertake that I/We or my/our duly authorized agent would appear in Court on all hearings and will inform the Advocate for appearance when the case is called.

9.And I/We the undersigned do hereby agree not to hold the advocate or his substitute responsible for the result of the said case.

10. And I/We the undersigned to hereby agree that in the event of the whole or part of the fee agreed by me/us to be paid to the advocate remaining unpaid he shall be entitled to withdraw from the prosecution of the said case until the same is paid up. The fee settled is only for the above case and above Court. I//we hereby agree that once fee is paid, I/We will not be entitled for the refund of the same in any case whatsoever and if the case prolongs for more than 3 years the original fee shall be paid again by me/us.

IN WITNESS WHEREOF I/We do hereunto set my/our hand to these presents the contents of which have been understood by me/us on this 27th day of Jan 2023. Accepted subject to the terms of the fees.

Nandita

Advocate

24/1/23

VANNEIHSIAMI
Advocate & Notary Public
Aizawl : Mizoram

Client

Notarial Registration
No. 241
Dt. 24/01/23