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Landslide Disasters and its Management

Meenu
Department of Geography
Email ID: lohanmeenu100@gmail.com

INTRODUCTION:

It is well known that landslides and debris flows are very harmful to mankind. in terms of life loss and economic loss. Therefore there is a vital need to save human life as well as animal lives, but there is a question which arises of "how can we control them and what kind of suggestive measure should we take to reduce the vulnerability from landslides". Thus this is an attempt to conclude all the suggestive measures and methods which are applied throughout the world. This paper suggests how to overcome landslide hazards and how to reduce the economic loss and the loss of human lives. The possibility of suffering from the hazard can cause injury, disease, economic loss, or environmental damage. Today both life support systems and the productivity of land water systems are increasingly threatened by natural hazards by human pressure in Uttaranchal. Certain regions are over shooting in their carrying capacity in producing quite dangerous conditions especially tropical and temperate region in the state.

The down slope movement of large volumes of surface materials under gravitational influences is an important environmental hazard, especially in mountainous terrain Rapid movements cause most loss of life and damage: slow movements, including human induced land subsidence, have less potential to kill but can be costly. Depending on the dominant material, these movements tend to be grouped into Landslides (rock and soil) or Avalanches (snow and ice). Mass movements may be triggered by either seismic activity or atmospheric events. (To that extent this hazard lies at the interface between endogenous and exogenous carth processes.)

The Himalayas are situated in a very sensitive location. They extend from the Shivalik Hills [unstable structure] in the south to the great Himalayan ranges snow covered with steep slopes in the north. The geological studies indica that the Himalayas are susceptible to geo-hazards viz. earthquakes, landslide floods etc. due to the continuing vertical uplift of 1 cm/year in the Shivalik a 2 cm/year in the lower ranges of the main Himalayan region. The uplif movements have not yet ceased for this region and it is still unstable susceptible to earthquakes. Tehri Garhwal 1905 and subsequent shocks in the 1980s and 1990s have rocked the Kamn Prayag and Raudra Prayag. The Shivali Hills are composed of highly unconsolidated deposits, which easily lend themselves to erosion. These hill masses are closely packed often forming minor watersheds. The Topography of this region gives the look of a cup shaped depression with deeply incised gullies backed by the denuded harder strata upstanding here and there. The heavy load of sediments washed down by the beat of the rain chokes the streams and numerous rills down the slopes Therefore, landslides have become a very common feature due to heavy rainfall indiscriminate deforestation in the catchments and the upper reaches of the Ganga river basins. The combination of very high mountains and flat valleys below are the breeding ground of many cloudbursts in many parts of the Himalayan region. Apart from this, the resource base on which mountain people depend has deteriorated at an accelerating rate. Forest has been cutoff, vegetation cover removed and steep slopes have become severely eroded. Together with exploitation, the impacts of population pressure and inappropriate technologies have severely degraded the mountain environment. These are the result of an un-mistakable system of engineering, un-sustainability of the current patterns of resource use and production practices. The overall situation is both a cause and concern for reappraisal of conventional development approaches to maintain areas in general and environment in particular.

The Indian government has taken hazard occurrence as the first priority but the little efforts being made fall short of the requirement of money and material. There is a need for an integrated multi-disciplinary approach to the planning based on sound environmental and ecological aspects for the rehabilitation of effected people and even the command area is prone to natura hazards. Their management includes administrative, political and economic actions to decide whether and how to reduce a particular risk to a certain level.

Nature of Problem

There can be few countries where mass movement processes do not exist, and the landslide risk is increasing worldwide as land hunger forces the new development on to unstable slopes. According to Jones (1992), it is an under recognized threat because the impacts tend to be frequent and small-scale, whilst the process itself is often attributed to other hazards, such as earthquakes and rainstorms. During the early 1970s, an average of nearly 600 people per year were killed by slope failures worldwide but, twenty years later, the figure was several thousand (Brabb, 1991). Perhaps as many as 90 per cent of these deaths occur on the Pacific Ocean region, which is particularly susceptible to mass movements because of the varying combinations of rock type, steep terrain. heavy typhoon rainfall, rapid land use change and high population density. The main cause of increased deaths has been the expansion of unregulated settlements onto unstable slopes in many third world cities. For example, in Caracas, Venezuela, the number of urban landslides increased from less than one per year up to about 1950 to reach 35 40% per year in the 1980s (Jiminez, 1992). The death toll from mass movements is still comparatively low in most Medium Developing countries. In the USA the annual mortality runs at 25-50 people and it has been estimated that, for landslides alone, some 22 per cent of the population are exposed to high hazard conditions while another 20 per cent are exposed to moderate hazard conditions (Petak, 1989). As with many other environmental hazards, it is urban areas, which are most vulnerable because of the large populations at risk (Alexander, 1989). Economic losses due to landslides total more than One billion US $ per year in several counties. including Japan. Other countries with large but un-quantified losses include Indonesia, China and the former Soviet Union. In Italy it has been estimated that over 1,000 urban centers are threatened by landslide activity. In addition to direct damage mass movement hazards cause a variety of indirect losses such as road blockages, flooding due to landslide dams across rivers, reduced agricultural and industrial production, and lower property values.

Snow avalanches are special types of mass movement. They are common features of mountainous terrain throughout arctic and temperate regions whenever snow is deposited on slopes steeper than about 20°. The USA alone suffers 7 10,000 potentially damaging avalanches per year, although only about 10 percent harm humans or property. In the past, casualties were suffered by travellers passing through the mountains as well as the miners located in permanent, but badly sited, mining settlements. The Andean countries are notable for avalanche related mining disasters. The worst avalanche disaster in the USA occurred in 1910 in the Cascade Range, Washington, when three snowbound trains were swept into a canyon with the loss of 118 lives. Historically, the avalanche problem has always been more severe in Europe then North America because the population density in higher in the Alps than in the Rockies. Switzerland has a relatively large number of avalanche deaths amounting to some 20-30 fatalities per year.

Snow avalanche problems have risen as winter recedes. This is mainly due to the greater use of winter recreation and the associated development of ski centres and other holiday resorts. For example, the town of Vial, Colorado. located at an elevation of 2.500 m, was founded, as a resort community only in 1962. The construction of alpine facilities often requires the removal of timber from the surrounding slopes. If left intact the trees would help to stabilize the snow cover and protect the new roads, railways and power lines which are invading these areas. Avalanche problems in the rocky mountains beset the Canadian Pacific Railway and the Trans-Canadian Highway together with sections of US Highways, The Trans-Canadian Highway alone crosses nearly 100 avalanche tracks in 145 km. It has been estimated that at least one motor vehicle is under a major avalanche path at any given time.

NATURE OF LANDSLIDES

Landslides are down slope movements of rock and soil along slip surfaces, They are associated with a disturbance of the equilibrium, which normally exists between stress and strength in material resting on slopes. The relationship between stress and strength is determined by factors such as the height and steepness of the slope and the destiny, strength cohesion and friction of the materials on the slope. Hill slope instability occurs when the strength of the material comprising the slope is exceeded by a down slope stress.

The internal cohesion is produced by the interlocking, or sticking together, of granular particles, particularly in clayey soils and rocks, that enables the material to rest at an angle. Some materials, such as dry sand, are cohesionless. Cohesion is independent of the weight of material above the surface. The internal friction is the resistance of particles of granular soil to sliding across cach other. The friction component of shear strength depends on the weight of material above the surface. In turn, these factors will depend on the weight, or loading. on the slope and the moisture condition.

The term landslide covers most down slope movements of rock and soil debris that have become separated from the underlying part of the slope by a shear zone or slip surface. The type of movement, which may include falling. sliding and flowing, depends largely on the nature of the geological environment. including material strength, slope configuration and pore water pressure. Jones (1995) asserted that slope failure will become an increasingly important hazard, especially in the LDCs country and identified several types of landslide terrain

1. Areas subjected to seismic shaking earthquakes can promote widespread land sliding, which often occur as thousands of individual slides, as in 1950 Assam, India, as earthquake when over 50 billion m3 of material was displaced over an area of 15,000 km2. Major landslides also occurred after the 1991 in Uttarkashi and Chamoli of Uttaranchal earthquake and very recently in June 2004, there was a major landslide in Kumaun region of Uttaranchal, which claimed more than five people in the area, and 26 were injured.
2. Mountainous environments with high relative relief, high or steep slope terrain, such as in the northern portion of the Himalayas and north-western portion of the Himalayas, produces perhaps one catastrophic rock fall per decade in the Himalayan ranges. These spectacular slope failures comprise huge masses of material (up to 100,00,00,00,000 m3), which, at least in the initial stages, travel near vertically at high velocities over long run-out distances.
3. Areas of moderate relief suffering severe land degradation. Readily erodible soils on slopes subject to land degradation caused by deforestation or overgrazing have the potential for gully expansion and land slipping in the middle of the Himalayas. Over the centuries, about 160 villages in Himachal Pradesh and near about 240 villages in Uttaranchal Himalayas have been abandoned because of this process.
4. Areas covered with thick sheets of loss. Any mantling of an existing ground surface with finely grained deposits, such as wind-blown losses or tephra, is likely to lead to a sheer zone at the junction of the two materials and the formation of flow slides in the loose deposits. The loess plateau of central China and the Shillong plateau of northeastern Himalayas are the classical location.

5. Areas with high rainfall inputs. The areas that regularly experience rainfall from monsoons or tropical cyclones are rock weathering and can penetrate tens of metres below the ground surface. For example, in parts of the lower Himalayas and north-east Himalayas of Meghalaya weathered material has moved down slope to cover the bedrock to a depth of more than 10 meters. Throughout the humid tropics, these deep and porous mantles are prone to landslides.

ROCK FALLS IN HIMALAYAN REGION

This is a movement of debris flow or rock falls through the wind and soil crosion. The simplest type of rock movements occurs on steep slopes, where bedrocks are weak, such as joints, and the bedding of exfoliation surfaces are present. Rock falls are presumed to fall directly off cliff faces, rather than to slip along a joint or bedding plane, although both types of movement may occur. The presence of water in clefts and fissures is highly influential, especially in the mid-latitudes where regular freeze-thaw cycles progressively weaken the rock mass by increasing such openings as in Chamoli, Pithoragarh, and the Uttarkashi district of the Uttaranchal Himalayas.

Earthquakes induce many of the largest rock falls but more spontaneous slope instability also occurs, especially in closely jointed or weakly cemented materials on slopes steeper than about 40°. The greatest rock fall hazard exists when joints and bedding planes are inclined at a steep angles, as in the highly folded rocks common in major mountain chains as in the Ilimalayas and Rockies. In these areas the slides took place across bedding planes in a steep anticline formed in the well-jointed limestone of Garhwal Himalayas, which was also subject to mining activity. Groundwater seeping into the joints dissolved the limestone and enlarged the fractures. During the winter this water froze and wedged the rock apart, further weakening the structure. The resulting debris destroyed the southern end of the small towns on the hill slopes.

CAUSES OF LANDSLIDES

Landslides result from a variety of events that combine either to increase the driving force or to reduce the shear resistance on a slope. Factors that increase the driving forces on a slope may be either physical or human induced. .

An increase in slope angle, which may occur if stream crode the bottom of a slope or if the slope is steepened by the building work. Jones et al. (1989) has described how the cutting of a road into the base of the slope during 1984 which left exposed faces 25 m high and colluvium standing at an angle of 55 unsupported by anything other than a 3 m masonry wall. led to the Catak landslide disaster in Turkey in which 66 people died in 1988. Removal of lateral support at the foot of the slope again caused either by natural mass wasting processes or by building activity.

Additional weight placed on the slope by the dumping of the waste or house construction. Residential development not only adds weight to the slope through the buildings themselves but also through excess water supplied from landscape irrigation and seepage from swimming pools and sewage effluent systems. Removal of vegetation either by wildfires or through human activities, such as, logging, overgrazing or construction and hyper urbanization. Surface materials become looser because of the loss of soil binding by roots and the slope is also more exposed to the erosive action of surface water through the loss of plant cover. Local shocks and vibration, which can occur naturally from seismic activity or from the operation of heavy construction (road construction works in Himalayas) machinery.

FACTORS THAT LEAD TO A REDUCTION IN THE SHEAR

Resistance on a Slope

An increase in pore pressure in the slope materials, especially along with a sloppy surface. This is the most important single factor and explains the close relationship which exists between shallow seated landslides, debris flows, and rainstorms. Unfortunately, the detailed interaction of rain- water and soil behavior is rot fully understood and it remains difficult to predict landslides on a site-specific basis. In unsaturated material that is not totally dry, the internal voids or pores will be filled with gas (air and water vapor) and some liquid water. If the slope then experiences additional loading, perhaps as a result of building construction, the mineral grains will be able to slide into a more compact arrangement. Such compression increases the soil density and additional strength will result. However, if there is resistance to a denser configuration due to water in the void space, and rapid surface loading occurs relative to the permeability of the soil, then the additional load is transferred into the pore water causing an increase in the pore- water pressure. In turn. this reduces the friction component of strength and down- slope movement may occur. An increase in slope angle, which often occurs when developed slopes are over steepened by cutting into the base, a process which increases the driving forces.

Weathering processes, which promote the physical and chemical breakdown of slope materials. Certain clay minerals, such as montmorillonite expand when water is present and the behavior of these expansive clays has been implicated in the failure of many Himalayan hillsides (Griggs and Gilchrist). In addition, other natural processes may be involved. The burrowing action of soil animals or soil piping developments on slopes will lead to weakness and the possibility of land sliding.

In most of the urban areas, landslides may be attributed to a combination of the above factors. The progressive human invasion of landslide hazard zones is not confined to the developed world. The need for improved transportation is leading to new road construction in terrain with a high probability of slope movement throughout the LDCs. In these areas limited resources may lead to inadequate hazard protection. For example, the 52 km long Dhahran-Dhankuta road, completed in 1981, provides a key north-south link within Nepal between the Ganges lowlands to the south and the hill villages to the north. The road crosses the unstable Himalayan foothills of East Nepal and is surrounded by long, steep valley-side slopes angled at 30-45° Engineering is difficult and expensive in such terrain and the road was built to a relatively low-cost specification. The road has since proved difficult to maintain because of cut slope failures and the blocking of culverts by debris.

STEPS TOWARDS HAZARD REDUCTION

Insurance

Private insurance against landslides and other mass movement hazards is not generally available in the USA, largely because of the risk of high losses. The unavailability of insurance can discourage development in hazardous areas but, because information about landslide hazards is not widely disseminated, many people remain unaware that they are at risk. Some limited insurance cover in the USA is provided through the national flood Insurance program, which requires areas subject to 'mudslide hazards associated with river flooding to have insurance cover before being eligible for federal financial assistance. Unfortunately, technical difficulties in mapping mudslide' hazard areas have led to comparatively little use of this provision. In some countries, legal liability forms a growing basis for financial recompense after landslide losses. American jurisprudence recognizes civil liability for death, bodily injury and a wide range of economic losses, which may be associated with landslides. The classic defence of 'Act of God' carries decreasing credibility, and recent court judgments have tended to identify the developer, or the consultants, as mainly responsible for damage due to land failure. In some areas, such as Los Angeles County, local government agencies have shared the liability because it has been argued that the issue of a permit for residential development implies a warranty of safe habitation on the other hand, and it is difficult to envisage litigants as an adequate substitute for proper hazard reduction strategies.

LANDSLIDE MODIFICATION ADJUSTMENTS

The ability to assess the probability of landslide risk at specific places is of considerable assistance in implementing mitigation strategies. General indicators include the structure and lithology of slopes, including the presence of weak rock types, clay rich soils and slopes generally in excess of 25°. It is a challenge to translate these factors directly into terms suitable for risk assessment because of the high spatial variability in soil shear strength, which may be greatly affected by plant root systems stabilizing part of a slope, and the usual absence of any piezometric information, which would warn of increasing pore water pressures. Bernknopf et al. (1988) divided the Cincinnati metropolitan area into 100 m2 cells and devised a probability model from a combination of variables that represent the existing physical state of a hillside, the dominant landside mechanism in the area and the types of construction activities that can trigger landsides. The results showed that an uncritical application of the uniform building code to the whole area would not be cost effective. Property damage from landslides usually leads to demands for engineering works to stabilize the slope. However, the human response to slope failure is often complicated by the statutory and funding distinctions, which are made between emergency and permanent works. Emergency response designed to protect public safety and prevent further immediate damage are usually undertaken satisfactorily but government funds are made available only very reluctantly for permanent slope stabilization. This may be because the specialized geo-technical information required is not available or because of the high potential cost to the public purse. Alexander (1987b) drew attention to inadequate geological advice and political muddle as contributory factors to the Ancona landslide disaster in Italy. It is a recurrent feature of all hazard mitigation that few publicly funded authorities are willing to pay for expensive defence work for private undertakings when large profits are to be made from property and land speculation. If these problems can be overcome, the stability of the slope may be improved by a variety of engineering techniques.

Excavation and filling methods can be used to produce a more stable average slope. This type of reshaping is usually successful but becomes more difficult and expensive as the slide area increases. Specific techniques include unloading the head of a slide and loading the toe, with the replacement of failed material with lighter roads.

Drainage, especially sub-surface drainage, can be equally effective where changes in pore water pressure have been caused by a rise in the water table. Drainage methods range from the removal of surface water and the drainage tension cracks to the insertion of trenches filled with gravel or horizontal drains. Properly designed and constructed drainage systems work well but others soon become clogged by fine particles.

Re-vegetation of slopes performs several functions. Plant roots help to bind soil particles together; the vegetation canopy protects the soil surface from rain splash impact and transpiration processes aid in drying out the slope. Whilst evergreen are generally better at providing an all-year canopy, deciduous trees are generally better conifers at removing excess soil moisture because they have higher rates of transpiration during the summer. However, it may be unwise to rely on vegetation for slope stability because of the possibility of fire or disease of the lifetime of a project.

Restraining structures such as piles, buttresses and retaining walls can be helpful for slides covering limited areas, but they are generally too expensive for large, unstable slopes and the location of the property boundaries may also restrict this approach. Guiding structures near the base of the slope, such as diversion walls, can deflect small debris flows effectively.

Other methods include the chemical stabilization of slopes and the use of grouting to reduce soil permeability and increase its strength. In some high-risk urban areas. like Hong Kong, slopes may be covered with materials such as chunam or gunite to reduce the infiltration and keep pore water pressure low. On some construction sites the freezing of mass moving soil has been successfully accomplished, and the freezing plant has been left in operation until the soil retaining structures were completed.

Slope stabilization, along with hazard-resistant construction techniques, appears to be the most effective preventative strategy for controlling new development. In this context grading ordinances, such as the uniform building code adopted in India, are important tools. Along with soil compactation and surface drainage requirements, this act generally specifies a maximum slope angle of 2:1 for safe development. The basis for such a specification, which means a 27° slope, is that the natural angle of repose for dry sand is 34°, and therefore a 2:1 slopes allows for an element of safety over this. Building codes normally require developers to obtain permits before they embark on carthmoving projects on hazard-prone slopes. Ideally they also require reports from geo technical engineers and engineering geologist on proposed building sites before a local authority approves plans. To work properly, this sort of system needs technically trained inspectors to enforce the regulations and levy development fees to become financially self-supporting.

Olshasky ad Rogers (1987) cited the success of the city of Los Angeles. which introduced a grading ordinance as carly as 1952. Before this date more than 10% of all building lots were damaged by slope failure. Initially, the ordinance required only soil testing but it has subsequently been strengthened. In 1965 the requirements for geological reports were added and in 1973 further inspections were made obligatory, along with final certification of completed carthwork by the city engineer. The benefits have been impressive.

Landslide control is most successful when combined with urban risk assessment and land use planning. In an carly programme, begun in 1958, the Japanese government started to enact strong legislation to prevent landslides and debris flows triggered by typhoon rainfall. Mitigation has been pursued through the construction of check dams, drainage systems and other physical controls in combination with development restrictions.

In the landslide track and debris flow zone, various deflectors and retarding devices may be located. Large walls built on the earth, rock or concrete can be used to diverting the debris flow from its chosen path. The slope for diversion is limited, up to 15-20° from the original slide path have proved the most successful. In addition wedges pointing upslope can be used to avoid the slides and then divert the sections around vulnerable facilities, for example, electrical transmission towers or isolated buildings. Towards the slide zone other retaining structures, represented by earth mounds or small dams, can be useful as the slope angle declines and the debris flows lose the energy. Mounds are generally ineffective on slopes steeper than 20.

Direct protection structures, such as debris sheds and galleries, designed to pass the flow over key facilities such as transport lines, obtain the most complete defence against all kinds of slides. Slide sheds typically act as protective roofs and walls along with the roads and railways, but these structures are expensive and need careful design to insure that they are properly located and can bear the maximum debris resisted walls and mounds. In the longer term, there is some incentive to control the landslide hazard by re-afforesting the slopes at risks.

VULNERABILITY ADJUSTMENTS

Community Preparedness

The most formal arrangements for mass movement hazards exist in slide prone areas where a variety of organization which often exists to reduce the risk. There is a vital need to prepare the community regarding the landslides. There is a need for a locally based, rapid response search and rescue team and this is crucial because the debris flow victims die quickly if buried beneath the debris. Thus the chances of survival decline rapidly after 1-3 hours, even when the victim is trapped closed to the surface. The overall survival rate after complete burial is less than 2 in 5. Therefore, local communities should be aware and they should have the rescue trainings and the right tools, which should be provided by the local government absolutely free or on the subsidy, to rescue the life of the victims.

FORECASTING AND WARNING

Various types of forecasting and warning systems exist for mass movement hazards. Remote Sensing applied to mass movement hazards is limited to the production of preliminary large scale maps of previous debris tracks, for example, for avalanches and slides from acrial photographs whilst band 5 imagery shows vegetational changes sometimes associated with landslides. This reconnaissance information can be followed up with low-level air photography (Penn, 1984). Vertical aerial-photographs at scales of 1: 20,000 to 1: 30.000 are often suitable, especially if taken at times of the year when tree foliage and other vegetation cover is at a minimum. Site-specific information is more difficult to obtain. Many landslides are preceded by a period of soil or surface creep before slope failure occurs, often giving rise to surface cracking. This process can be monitored with a view to providing a warning. The most common forms of monitoring include the use of inclinometers and telemeters to record evidences of increased hill slope activity but this information is rarely formalized into official warning messages.

For landslides it is possible to issue generalized regional warnings of debris and mudflows following storms and heavy rainfall based on some locally relevant threshold criteria, such as storm rainfall intensity per hour or the cumulative total of rain over a few days. For example a real time regional landslide warning system was developed for the San Francisco region using known relations between rainfall and landslide generation and tele-metered rainfall data in association with weather forecasts (Keefer et. al., 1987). It was used to issue the first regional, public landslide warnings in USA in February 1986, but the site-specific prediction of landslide remains clusive. Therefore prediction also plays the vital role in the management of the landslide because after the prediction of rainfall or landslide people prepare themselves for the hazard and reduce the vulnerability of the disaster.

LAND USE PLANNING

The recurrence of many landslides and avalanches at the same topographic site means that land use zoning offers a practical method of hazard mitigation. The qualitative recognition of sites susceptible to multiple mass movements is often possible. For example, many avalanche tracks also function as landslide gullies during the summer and spring. Stream channels are the most common paths for debris flows, which occur after periods of heavy rain. Although different from floods, debris flows can aggravate flood conditions by blocking the channel and causing water to overspill the banks.

For landslides, geologists or geo-technical engineers can make a stability assessment for individual sites. Keaton (1994) described a probabilistic approach to site selection. This depends on geological investigations to determine the magnitude frequency of relationships in potentially hazardous processes combined with estimates of the probability that damaging events would occur during a specified exposure period, such as the anticipated life of a structure. The development of information technology with the issue of a GIS database and spreadsheet calculations makes such approaches increasingly feasible. Gupta and Joshi (1990) outlined a method employed in the lower Himalayas where landslide activity is related to rock litho logy, land use, distance from major tectonic shear zones and slope aspect. Geological hazard zoning maps at a scale around 1:20,000 are still the most common form of hazard identification. Seeley and West (1990) provided an example for a forest park in the western USA where slope instability, including seismically included rock falls and avalanches, is the most important hazard.

Once the hazard has been identified, planning law should explicitly encourage local communities to consider mass movement processes when undertaking the landuse changes. Avalanche zoning employs historical data of avalanche occurrence for the identification of hazardous locations and supplements this information with terrain models and models of avalanche dynamics to determine more detailed degrees of risk. Where sites are near established settlements, avalanche frequency will be a matter of local knowledge, At more remote locations, with insufficient records and maps, other methods are necessary. Gruber and Haefner (1995) have reported the developing use of satellite imagery and digital elevator models to map large areas of avalanche risk. Sometimes the long term pattern of avalanche activity can be compiled from trees which remain standing in the track or run out zone but which have been physically damaged by previous events. Sometimes the resulting scarring of tree rings can provide an accurate means of dating avalanches of landslides and producing reliable frequency estimates over the past 200 years or so (1lupp et. al., 1987). Where trees have been destroyed by large events, close inspection of the residual damaged vegetation, including height and species can be a useful guide.

Once potential sites have been identified and frequency estimates made. initial mapping is usually undertaken at a scale of about 1: 50.000 with the aid of air photographs. In India, a snow avalanche atlas is published primarily as an operational guide for highway maintenance personnel (Ministry of Transportation and Highways, 1991). The maps are accompanied by a detailed description of terrain and vegetation for cach avalanche site, together with an assessment of the hazard impact. The same kind of hazard and risk zone mapping work has been successfully done by the National Agency of Thematic Mapping Organization (NATMO) India. In this atlas they specifically divided all kind of hazards into several categories and zones, particularly the seismic map which helps to know about the seismic zone category. It indicates the importance of a map because it is more useful for each and every planner in constructing or planning any kind of structural change in landuse.

Where an avalanche threatens settlements, it is necessary to zone the area on a larger map scale which may be of 1:50.000 and adopted related planning regulations. The length of the debris flows zone is a critical factor here since it determines whether or not a particular site will be reached by the movement of rocks and debris. The zoning methodology is well established in many countries.

CONCLUSION:

Overall it can be said that if we are to prepare ourselves for the landslide hazard, it may reduce the lives lost as well as the economic loss. Community participation should be an essential part of each and every level of planning. Forecasting and warning systems should be very quick and active. Landuse planning should be done on the behalf of a local land utilization pattern. The community should also be involved in the afforestation programmes and the effective personalities i.e. teachers, doctors, engineers, technicians, electrician, postman, landuse planner, pradhan, gram sewak, Block Development Officer, other important peoples of any village and all villagers should be involved in the land use planning. In the meantime the rescue of the local people without waiting for government support, should handle work. The government should provide the rescue kit absolutely free of cost, which contains all the equipment, that is required at the time of landslides and debris flows. The government should provide this kit along with the training programmes, which should i organized at all levels like school, college, university level. And all the government and private employees should get this training free of cost and the rescue kit also. This program should be launched on the basis of hazard zonation maps and the degree of vulnerability of the locality. Overall "prevention is better than cure".

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