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Landslide Disaster Management: Need For Effective Infrastructure Development In Hilly Areas

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Abstract

Development of physical infrastructure is the most critical issue for sustainable future growth of the country. For the efficient functioning of community and for operation of the services and amenities, Infrastructure is essential managerial and physical structure. Disaster management is the important factor to be considered for any planned development. Changing environmental conditions are adding the risk of disaster which need to focus on reducing vulnerability in the context of development efforts.

The Massive damages in terms of both direct and in direct costs are result of Landslide, one of the natural disaster. Landslides lead to the devastation of the infrastructure, including the destruction of buildings, and significant deformation of arable land and natural changes. In hilly areas, the unplanned and insecure developments is the one of the triggering factor for the incidences of landslides which will result in huge losses with adverse impacts on the society as well as environment.

With the increasing demand of infrastructure development with growing population and changing land use pattern, there is need for developing appropriate framework for landslide hazard management to mitigate financial and social losses. The paper focuses on the introduction of disaster Management and mitigation of landslide disaster at the hilly areas.

Keywords; *Infrastructure development, Disaster, landslide, Management, Mitigation.*

I. INTRODUCTION

Development of physical infrastructure is the most critical issue for sustainable future growth of the country. For the efficient functioning of community and for operation of the services and amenities, Infrastructure is essential managerial and physical structure. The economic policy in India focuses and has shifted to equitable growth issues. Along with maintaining the growth, there should be additionally spread the benefits of growth to all sections of the population and geological regions of the country. With well performing economy, this changed approach is predominantly important for continuously struggling undevelopment hilly regions of the country. Most of the population dependent on agriculture. Due to different physical, environmental and geological issues, there is limitation for implementation of agricultural policies based on modern inputs in the hilly regions. This has resulted in either migration of the majority of the rural population in or surviving on subsistence agriculture or migrating to other parts of the country for employment.

Since from last decade, there is growth at high rates in hilly areas. Previously, these places were well-known as summer destinations however from last decade they have tourist influx all the year. This leads to increase in demand of infrastructure for residential and business and leisure activities. Because of intrusion of outsiders with business intentions in these regions, deforestation and reckless construction activities are getting progressively common. This is threatening the fragile eco-system of hilly areas, causing extensive

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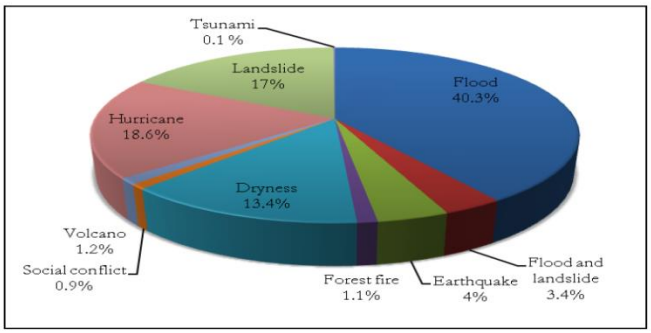
soil erosion and siltation of streams. These factors have a direct effect on productivity of land and on groundwater resources which are crucial for the survival of populations in these areas.

To attract the tourist and for higher monetary gain, building with concept of valley view, long cantilever structures across the valley are conceptualised and constructed. Existing structures are also going for vertical and horizontal expansion. All these ongoing development are unplanned and without considering long lasting impact on stability of slopes which results in increase the number of landslide disasters from last decade.

II. DISASTER



Disaster occurrences in Maharashtra

A disaster is the impact of a natural calamity or manmade hazards that negatively affect society and natural environment. A disaster means a catastrophe, mishap, calamity in any area, arising from natural or manmande causes or by accident or negligence which results in substantial loss of life and human suffering or damage to and destruction of property or damage to, or degradation of, environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area (Indian Disaster Management Act, 2005). Disasters can be broadly classified as natural disaster (Earthquake, volcanic eruption, hurricanes, Floods, Earthquake, Drought, Wildfires etc.) and Human caused disaster (Hazardous material spills, explosions, chemical or biological attack etc.)

Generally, in rural areas with hilly topography and closed to the volcano, landslides occurred. The soil condition in this area is commonly found to be fertile with significant amounts of water resources and a beautiful panorama to stay in. Hence, most of the prone areas were developed as high population density villages or cities. As a result, thousands of people died damage to several thousand homes, and thousands of hectares of land buried as a result of landslide disasters. To minimize damage, landslide sensitive areas need to be identified and maintained. Local people living in prone areas have a strategy of coping with landslides and taking action to minimize the damage.

III. LANDSLIDE

The Massive damages in terms of both direct and in direct costs are result of Landslide, one of the natural disaster.Landslides can happen in isolation however this may be along with or as a consequence of other disasters like earthquakes, floods, lightening, cloud-burst, forest fires, dam / lake bursts etc. The total losses in such disaster are normally incorporated within the primary disaster and are not considered separately. Landslides often cause large-scale socio-economic damage including loss of life and human injury. Also landslide damages the heritage and ecological systems along with the functioning of critical infrastructure. Landslides, defined as the movement of a mass of rock, debris or earth down a slope (Cruden, 1991). Various triggering factor for the landslide are intense rainfall, earthquake shaking, water level change, storm waves or rapid stream erosion. These results in rapid decrease in shear strength or increase in shear stress or of slope-forming materials. The term landslide or landslip is commonly used to several forms of mass wasting which include a wide range of ground movements such as rock falls, deep-seated slope failures, mudflows, and debris flows. According to the environments, Landslides are categorized by either steep or gentle gradients of slope, from mountain ranges to submarine landslide in coastal or even underwater cliffs. The principal

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driving force for the incidence is Gravity but there are also other factors that affect slope stability producing specific conditions that make a slope prone to fail. In many situations, a single occurrence (such as an earthquake, heavy rainfall, cutting and filling of the slope etc.) causes the landslide even though this is not necessarily detectable. Due to certain processes, slope undergoes the change from stable state to unstable state resulting in decrease in the shear strength of the slope structure or an increase in the shear stress endured by the material, or a combination of the two. A decrease in a slope's stability may be caused by a number of causes individually or together. Causes for landslide are as follows:

Natural Causes	Man made activities
• Saturation by rainwater absorption, • snow accumulation or depletion of glaciers; • growth of groundwater or change of pore water pressure (e.g. aquifer recharge in rainy seasons or rainwater penetration) • hydrostatic pressure in cracks and fractures; • loss or absence of vertical vegetative structure, • soil nutrients and soil composition (e.g. after wildfire – last forest fire) • Earthquake-related ground shaking that can either destabilize the slope (e.g. by causing soil liquefaction) or collapse the substrate and trigger landslide cracks; • Volcanic eruptions.	• logging, farming and construction; • equipment or road vibrations; • drilling and mining; • earthworks (e.g. modifying the form of a cliff, or imposing new loads); • Removal of deep-rooted vegetation connecting colluviums to bedrock in deeper soils; • Farming or forestry operations (logging) and urbanization that change the amount of soil-infiltrated water.

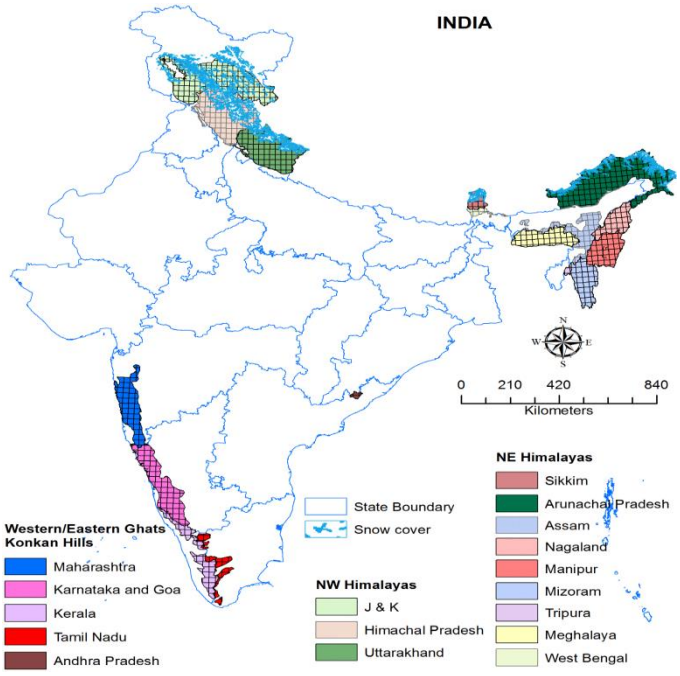
3.1 Global and National Status:

The actual impacts of landslides on the society are more than the most of the reported estimates on landslides losses. The developmental activities, with growing population and human interventions, over unstable slopes, cause increasing risk of landslide destructing to human life, buildings, structures, infra-structures and biodiversity. In many regions of the country, large scale deforestation along with defective management practices have led to high susceptibility to landslides. The intensity of landslides are increased by human intervention on unsafe locations, unscientific mining, and haphazard construction of roads, dams and river training works ignoring natural features. The people may be unaware at the first time landslide strike in the absence of awareness and non-availability of large scale landslide hazard maps.

In hilly areas of the world, Landslides have caused huge numbers of financial losses and casualties. Asia, especially South Asian countries endure extreme harms or misfortunate due to landslides. One of the South Asian country most affected by landslides is India.

In India, almost 15% of its region is inclined to different degrees of avalanche risk much of the time influencing majorly the human life, domesticated animals, living spots, work, structures, foundation, and other resources. India has a sensational record of catastrophes due to landslides. Large parts of India are affected by unique and unparalleled landslides as the major hydro-geological hazards. Landslides are spread in more than 22 states and 2 Union Territories In India including various states from Northern, Western, Southern and easten regions having mountainous topography. The landslide vulnerable zones are the Western Ghats, Nilgiris and Himalayas.

- Through out the year ,Himalayas can experience landslides
- The Western Ghats experiences landslides predominantly during the rainy season.



Landslide prone zones (Source: Geological Survey of India)

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One hazard commonly found in Maharashtra's Western Ghats is Landslide. Almost every position in Mahabaleshwar (Maharashtra region of western Ghats) specially mountainous area typically occurred landslide. Landslide commonly occurs between June and September during the rainy season. It causes significant property damage and loss of life.

Due to various natural and human-induced causes such as topography, haphazard urban development approaches, and poor performing buildings, Western Ghats affected before, during and after the disasters. The disasters occurred over the past two decades, have revealed in particular the country's inherent high risk levels causing significant human, physical and economical losses in urban areas. However, on July 30, 2014, Malin in Pune District's Ambegaontaluka in Maharashtra, India has revealed the truth that areas are developing risk due to building construction. To cope of with the effects of disasters on human being and environment as well as financial systems, it is becoming ever more difficult for national and international institutions.

3.2 Landslide at Western Ghat in Maharashtra with reference to Disaster at Malin

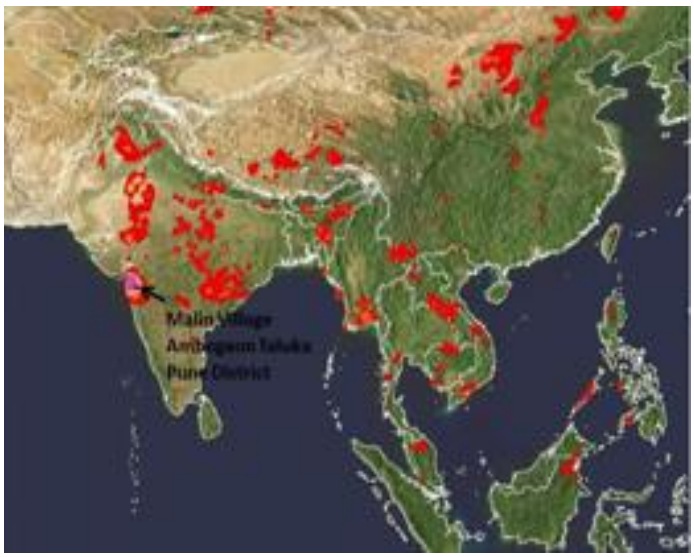
The need of effective planning and implementation of disaster management realised after the Malintragedy in July 2014 which results in amassivelandslidewipedoutthevillageofMalin. This hasbrought thespotlightbackonat thesusceptiblehillsofIndiaespeciallyWesternGhats,HimalayasandNorth Easternstates. Someofthekey factstonoted are,heavyrainfallbeforethelandslide(10.8cmonJuly 29) andheavydownpourthroughoutthefollowingday.This calamiteisalessonfor sustainablegeotechnicalplanningin future toavoidenormouslossof property and humanlife. The main reasons for the disaster are as follows:

3.2.1 Changed Agriculture Practice

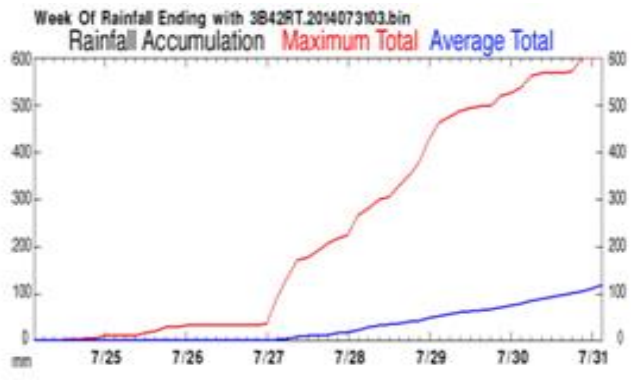
There is a requirement of steep slope get flatten for changed agricultural practice fromfarmingof riceandfingermillettowheat. This is the one of the reasons for instabilityof the hills.

3.2.2 Heavy Rain Fall

Before the incidence, therewascontinuousheavyrainfall fromthelastthreetofourdaysinthearea. The rainwatersaturatedthesoilalong the slope of the village. This developed as loose mud and eventually flowed downwhen gaining momentum, sweepingterraces,wallsandultimatelythehomes withinthevillage.



Malinreceivesveryheavyrainfall onthe29thJuly,9pmbyNASATRMM



TRMMtimeseriesprecipitation graphfortheMalinlandslide

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3.2.3 DeforestationandLevelingOfLandontheHillor cultivation.

For farming,constructionandmining, intensive deforestation has been done at Malin and surrounding which is disruptingtheecology ofthehill. For the implementation of Government schemeinitstribal employmentprojectPadkaischemeunderMahatmaGandhiNationalRuralEmploymentGuarantee Act(MNREGA),deforestration had been done to flatten hillslopesand treeswerealsocutdowntodevelopcultivableplotsin the areas vulnerable to landslides

3.2.4 BackwaterofDimbheDam

One ofthereasonsoflandslide may be constructionofDimbheDam.TheMalinvillagefallsina backwaterzoneofDimbheDam. The GeologicalSurveyofIndia(GSI),Nagpurregion,hassentateamtosurveytheareastoobservethewarnings such as, identifycracksinhills,tiltingoftreesandelectricpoles, of suchupcomingcatastrophe so that relocation of villagers to safe places should be done before the disaster.

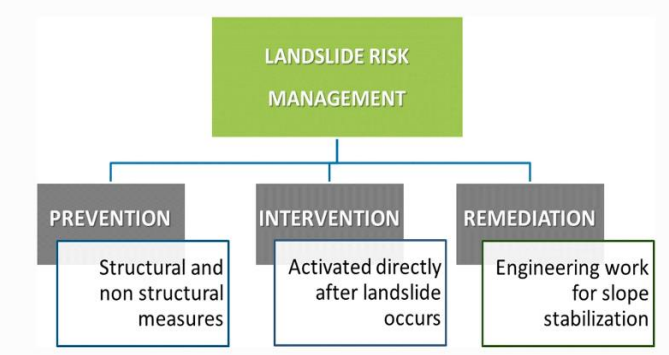
Backwater of Dimbhe Dam

3.2.5 HumanInterferenceinNature

Stone quarrying results in formations that are unstable and could cause sudden landslides. This main reason to be considered for loosentherocksandhelpsthemtoslide in heavy rain fall region like maline is human intervention.

High intense rainfall, morphological condition slope and land use change were the driving factor of the event.

IV. NEED OF DISASTER MANAGEMENT



Before migration hilly or mountainous terrain, there is a need to know the it is important to understand the complexity of their possible exposure to landslide risks. To reduce the economical losses and cost of life due to landslide in the regions, appropriate preparedness and mitigation plans should be prepared with the various policies like land-use, new construction technologies, and services. For natural or manmade Landslides, there is the need for a effective planning and implementation of national strategy. The National Disaster Management Authority through, National Disaster Policy and Guidelines, on Landslides is working on this. India being a vast country, every region has their own inherent problems which change from region to region. For formulating the region wise policies, contribution from a wide variety of stakeholders are necessary. To reduce the losses because of landslide, improving the process of landslide assessment, investigation, mapping and management will play important role. This would help in effective decision making and planning at micro level mapping for various developmental and regulatory activities in mountainous terrains. Landslide prevention and mitigation is achieved by investigation, proper planning, design and execution and proper integration of the development and

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construction activities. However, not much efforts towards research and development pertaining to landslide investigation has been made so far in India. By developing the innovative, eco-friendly, sustainable and cost effective measures for and remediation practices for landslide investigation, there will be reduction of negative impact and consequences of adverse events.

Landslides cause a serious physical and environmental threat for residents in areas vulnerable to landslides. The need of study is for better understanding and reduction of the risk of landfill disasters. Furthermore, effective landslide risk reduction approaches consist of improving methodologies for identifying landslide-prone areas and developing strategies for reducing risk reduction. To take advantage of these approaches, there is necessity of capacity building along with knowledge transfer and preparedness. This strategy involves sharing findings through research, insights learned and anticipated field training for experts and emergency management specialists, such as planners, engineers, architects, geographers, environmental consultant and university professors, and also improving neighborhood readiness by engaging and informing communities.

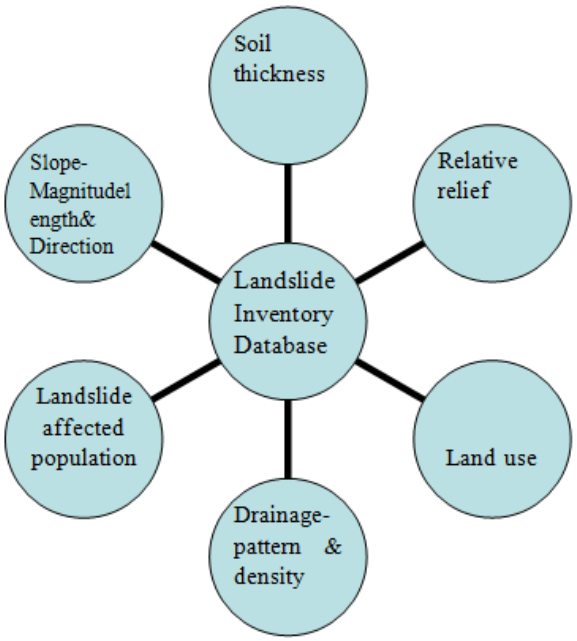
To minimize negative impacts of landslides, various local organizations, both public and non-governmental, are developing plans for disasters. That organization has different interests so the success of disaster management involves coordination and communication between one entity and another in the managing of landslides. Analysis of risk governance is one of the tools to know the level of government's readiness to deal with hazard in their area.

4.1 Landslide Disaster Management Methods

In case of landslide prone area, stability of a slope is the crucial factor which has to be governed. Slope stability can be improved by removing all or part of a landslide mass, or by adding earth buttresses placed at the toes of potential slope failures. The stability of slope can also be increased by preventing or controlling slope movement with construction of Retaining / Restraining walls, piles, caissons, or rock anchors, soil nailing. These measures are mostly used in combination.

4.1.1. Prepare Landslide Inventory Database

Anauthority shouldprepareadatabaseof allthepastlandslides with in the surroundings.Thisinventorydatacan function a very important referenceforunderstandingbehaviorofthezoneovera time period. For identification of the landslide vulnerable areas, LandslidesZonationMappingisamodernmethod which hasbeeninuseinIndiasinceeighties.Theimportant evaluationparameters areas follows:



4.1.2. Monitoring and Warning Systems:

Warning and Monitoring systems can not prevent landslides but help to protect lives and property. However, in time issue warning of slope movement allow the development physical measures for reducing the immediate or long-term risk. This requires keen monitoring on site and for which

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various techniques, including field observation with the use of various ground motion measuring instruments, trip wires, radar, laser beams, and vibration meters, are used. For periodic warnings, these data from these devices is useful.

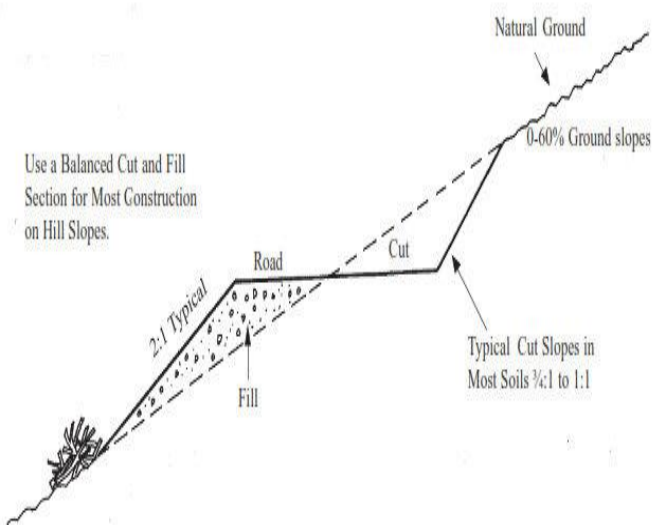
4.1.3. Landslide Insurance and Compensation for Losses:

For compensation and incentive to mitigate the disaster, Landslide insurance would be a valid means. For mortgage loans, landslide insurance coverage can be made mandatory. For mandatory insurance, controls on building byelaws, development, and property maintenance would be required. For mitigating the losses and compensating the sufferers, along with the insurance, appropriate government intervention will be much needed.

4.1.4 Mitigation Measures

a) Structural measures:

To protect the structures from landslide or to avoid the landslide, some of the remedial techniques are adopted such as construction of buttresses, shear keys, sub-drains, soil reinforcement, retaining walls, etc. and that to be in close proximity to public structures.



Balancedcutandfill

Rock bolting and soil nailing

Use of retaining wall

b) Drainage Corrections:

The first and principal mitigation measure is drainage correction. The most significant triggering mechanism for mass movements during heavy rains is the water infiltration into the overburden. This consequently increases in pore pressure in the overburden. Hence for preventing this situation by the natural way is reduction the infiltration and by allowing excess water to move down without interruption. At both micro and macro level on landslide prone zone, there should be need of maintenance of natural drainage channels.

c) Vegetation

Reinforcementof slope can be donebyrootsofground cover, shrubsandtrees. Adesigned vegetationenvelopeshallbesuggested with details of the type of plant to be grown at each level of the slope. Vegetation helps in stabilizing the slopes in numerous ways. When larger trees are growing on the slope, the mass of vegetation is only likelytohavean influenceonslopestability. The planting the largertreesatthetoeof the slopewitha potential rotationalfailure could increasethefactorofsafetyby10%.

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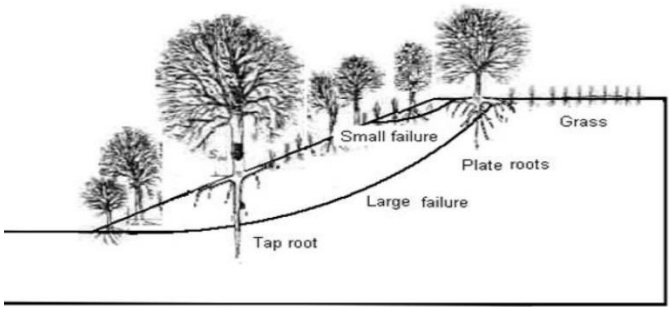

Vegetation at slopes

Erosioncontrol by geotextilefiber

4.1.5 Non-structural Measures

The social and economical losses caused by landslides can be reduced through effective management and planning. These approaches, along with appropriate planning and design, include:

- Use of building codes, formulated after scientific research, with effective implementation of land use laws and regulations
- Proper land use measures
- Controlled of development in landslide-prone areas,
- Efficient use of various construction codes such as codes for excavation, grading, landscaping etc.

V. CONCLUSION

Landslides create a heavy physical and environmental threat for people living in areas vulnerable to landslides.Landslides often cause large-scale socio-economic damage including loss of life and human injury. Also landslide damages the heritage and ecological systems along with the functioning of critical infrastructure. With the increasing demand of infrastructure development with growing population and changing land use pattern, there is need for developing appropriate framework for landslide hazard management The effective landslide risk reduction approaches consist of improving methodologies for distinguishing landslide-prone areas and developing strategies for reducing risk reduction.

The natural causes of the many landslides can't be avoided, but by geological investigations, architectural designs along with good engineering practices and effective enforcement of land use management regulations intensity of disaster can be reduced. To take advantage of these approaches, there is necessity of capacity building along with knowledge transfer, preparedness and essential inputs from a wide variety of stakeholders. Landslide prevention and mitigation is achieved by investigation, proper planning, design and execution and proper integration of the development and construction activities. For formulating the region wise policies and to reduce the losses because of landslide, the process of landslide assessment, investigation, mapping and management will play important role. This would help in effective decision making and planning at micro level mapping for various developmental and regulatory activities in mountainous terrains.

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