

ROLE OF VEGETATION IN LANDSLIDE DISASTER MITIGATION

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Abstract: Heightened human activity and urbanisation in hills has increased the incidence of active landslides, mudflows and erosion in general in the fragile Himalayas. The housing system and construction of the roads in this region needs to be changed. Structures must be light with minimum possible use of concrete and stone dumping excavated soil into rivers should be made punitive offence and all construction activity must be regulated by the strictest of laws. Simultaneously, State Governments may start to restore / rehabilitate the deforested or bare lands by planting the multipurpose trees and grasses scientifically tested (under agro or social forestry programme) along with the help of local people or community (Panchayats) in the fragile Himalayan regions. For this purpose the Govts. of State and Central must prepare a solid policy cum planning to mitigate the problem of landslide disaster in the Himalayas which almost occurred every year.

Keywords: Disaster, Landslide, Vegetation

INTRODUCTION

Landslides are significant hazardous geologic process, brings large-scale damage to properties and life. However it can be defined as “a movement of rock mass, earth or debris down a slope”. Basically Landslides can be described as outward and downward movement of slope forming materials composed of rocks, soils, artificial fills etc. This is becoming more complicated with deforestation, soil erosion and human activities. The process like deforestation and development of hill slopes affect the environment and often leads to mass movements. In addition the intense rainfall is one of the single major triggering factors for landslides and mass movements on the fragile hill slopes. In geodynamically active, the Himalayan belt, landslides are most frequent natural hazards or disasters. It is difficult to predict and forecast the nature of landslides. The steep slope, high relief, weak geological strata, highly crushed and pulverized nature of rocks along thrust and facets, minor and major seismic events, increased population pressure, deforestation, unscientific exploitation of natural resources and implementation of time bound rapid development of infrastructure facilities with inadequate finances have made the Indian Himalayas most vulnerable to landslides.

In India, the Western and Eastern Himalayan regions face an increasing risk of landslides. The risk of

landslide has increased in some areas by seismic activity, by flash flood or by excessive rainfall. It is hardly possible to estimate the volume of potential movements particularly sliding. During Monsoon period particularly from June to September most hill slope along Himalayan valleys of western and eastern Himalayas face the problem of Landslide and mass movement activities and cause maximum degradation to hill slopes every year in India.

Landslides and other mass movements can be predicted and the damage minimized or even averted with proper and systematic studies and with the adoption of remedial or mitigation measures (HPC, 2001). Cloudbursts and flash floods accompanied by heavy rainfall are still the main causes of landslides in India.

Vulnerability

Landslides are one of the natural hazards that affect at least 15 per cent of the land area of our country—an area which exceeds 0.49 million km². Landslides of different types are frequent in geodynamically active domains in the Himalayan and Arakan-Yoma belt of the North-Eastern parts of the country as well as in the relatively stable domains of the Meghalaya Plateau, Western Ghats and Nilgiri Hills. In all, 22 states and parts of the Union Territory of Pudducherry and Andaman & Nicobar Islands are affected by this hazard (Fig.1).

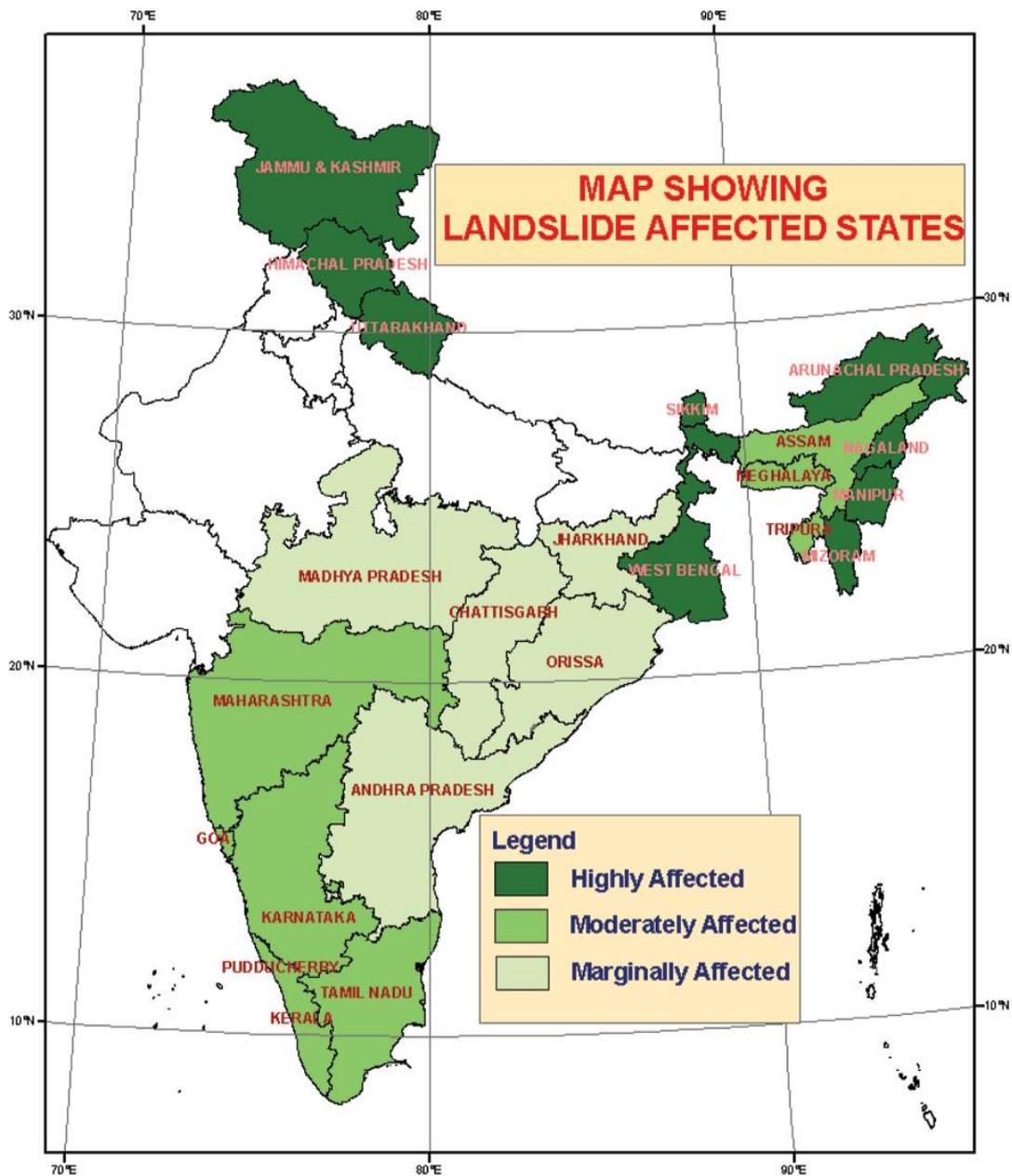


Fig.1: Map Showing Landslide Affected States
Source: National Disaster Management Authority, GOI, 2009

For a long time landslides have had disastrous consequences causing enormous economic losses and affecting the social fabric. In 2005 alone, more than 500 human lives were lost due to this hazard in our country. In particular himalyian region, the following one or more than one factors or causes may be responsible for occurring landslides or soil erosion as reported by Geologists:

a) External Causes

- Earthquake shocks or blasting
- Removal of a landmass by hill side excavation
- Undermining due to erosion
- Cutting of hills with improper slopes
- Excavations for formation, cutting in a hairpin bend and zigzag road on the same hill slope to attain the vertical climb.

- Deforestation
- Diversion of a water source
- Heavy rain/ snow melting
- Forest fire and then followed by heavy rain.

b) Internal Causes

- Loss of Cohesion
- Increase of pore water pressure
- Seepage and saturation due to ground water and terrace cultivation
- Friability of Soil.

MITIGATION MEASURES

The vulnerability to landslides can be reduced by creating a culture of safety through careful land use planning, timely and appropriate engineering intervention, conscientious maintenance of slopes and connected utilities, early warning, public awareness, and preparedness. There is need to develop a culture of quick response to managing disasters to reduce the impact of landslide disasters.

Soil is a store of minerals, reservoir of water, a conserver of soil fertility, a producer of vegetative crops and ultimately a home of wild life and livestock. Such fertile top soil upon which the productivity of agricultural crops, forests, forage and the vegetation is become lost during a landslide due to destructive influence.

Landslide disasters have both short-term and long-term impact on society and the environment. The short-term impact accounts for loss of life and property at the site and the long-term impact includes changes in the landscape that can be permanent, including the loss of cultivable land and the

environmental impact in terms of erosion and soil loss, population shift and relocation of populations and establishments (NDMA 2009).

The best process among all system is Soil Conservation by planting the various types of plant species under different schemes of bioengineering and social forestry programmes carried out by Forestry sector or other concerned sectors to mitigate the impact of landslide or soil erosion particularly in Himalayan region. It means the use and preservation of the natural resources of the earth and their protection from destructive influence i.e. disaster, misuse, decay, fire or waste. Singh (2010) observed that bioengineering is highly cost effective and has very high cost-benefit ratio. Bioengineering techniques when used in combination with civil and social engineering measures reduce the overall cost of landslide mitigation considerably which is the key factor for developing nations. Bioengineering has a very high success rate and is much more sustainable, eco-friendly and affordable than other available options. Landslide mitigation or soil conservation includes the retention of water especially on slopes and its utilization to the best advantage, maintaining or increasing the soil fertility and productivity by adopting the massive planting technologies on slopes of Himalayas.

Use of Multi purpose Trees

When the hedgerows between rows of agricultural crops are planted, the species of some trees reduce soil erosion and improve soil fertility for crops. When planted on slopes, hedgerows slow down runoff of rain water and trap sediments, which can form natural terraces after some years (Table-1).

Table 1. Different species used for Alley Cropping to mitigate the impact of landslide or soil erosion in hills.

S.No.	Botanical name	Local name	Remark
1.	<i>Alnus nepalensis</i> (Timber used in sports goods)	Utis	Ideal for soil erosion control soil fertility improvement
2.	<i>Populus ciliata</i>	Poplars	Alley Cropping
3.	<i>Bauhinia racemosa</i>	Jhinjha, Hitri	Alley Cropping in hills
4.	<i>Dalbergia Sissoo</i>	Shisham	Alley Cropping in hills
5.	<i>Desmodium sp.</i>		
6.	<i>Emblca Officinalis</i>	Anrila	

7.	<i>Butea monosperma</i>	Dhak	
8.	<i>Dendro calanus strictus</i>	Bans, Vahado	
9.	<i>Ailanthus excelsa</i>	Arru	
10.	<i>Calotropis procera</i>		Soil Binder

Source: *Proceedings of the School on Plant Ecology, R. Mishra and R.R. Das, 1971.*

Besides the above plant species, some grasses such as *Saccharum munja*, *Saccharum spontaneum*, *Saccharum bengalensis*, *Cynodon dactylon*, *Heteropogon contortus*, *Cymbopogon distans*, *Arundinella nepalensis* and *Chrysopogon montanus* are used extensively as land or soil binders to mitigate the impact of soil erosion or landslide in hilly regions.

Alley cropping

Alley cropping means growing hedgerows of closely spaced trees (20 cm less) between strips of food crops. If the land is sloping, farmers should plant the hedgerows along the contour. (Fig. 2).



Fig. 2: In alley cropping, multipurpose trees grow between rows of agricultural crops. They may mitigate soil erosion, Landslide and improve soil fertility for the crops in the hills.

Source: *Auburn University, Technical Bulletin No. 2006-1*

Farmers should prune hedgerows regularly to prevent them from competing with nearby crops for sunlight and water. When pruned regularly, hedgerows can provide fodder and fuel. Farmers can cut trees when they reach ht of 40-60 cm. longer cutting cycles of 4-6 months provide relatively more wood than shorter cycles. Short cycles produce relatively more foliage.

Most species should not be pruned more often than every 30-day. If planted in double lines, hedgerows can produce almost twice as much foliage and wood without greatly increasing competition with nearby crops for water, nutrients and sunlight. To obtain green manure farmers can prune the tops of the trees branches every 6 & 8 weeks as green manure is an

organic fertilizer, so it may improve the trees growth. Thus in Alley cropping, trees grow between rows of agricultural crops. They may reduce soil erosion, and improve the soil fertility. Thus this planting technique can reduce the frequent landslides repetition in an affected area.

Contour Planting or Farming

Contour planting or farming is usually employed in hilly regions. In this method the land is ploughed against the direction of the slope instead of Upward and Downward of the slope and thus farming, seeding and harvesting operation on the contour or cross-wise becomes easier to plough than Upward and Downward the slope. By this technique, the cross-wise depressions left by plough can catch and hold up water until it is soaked and the ridges check the flow of water and thus avoid the Sheet & Gully erosion or landslide (Fig. 2 A&B).

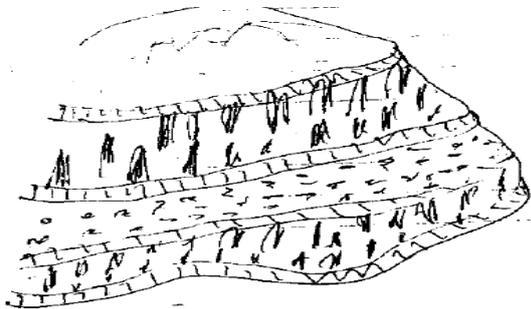


Fig. 3A. Contour planting or Farming employed in Hills.

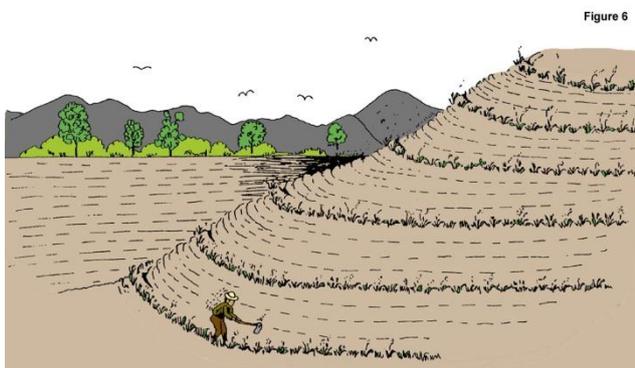


Fig. 3B. Contour Planting or Farming
 Source: *BENSON Agriculture & Food Institute & Corporation*

Terrace Planting

In this method, the slope is divided into several flat strips for the purpose of plantation and cultivation. The technique of dividing slope into several flat fields is called terracing. Each terrace works as an

Embankment of earth built across a slope to control runoff and reduce erosion or mitigate landslide occurrence (Fig.4 A&B).

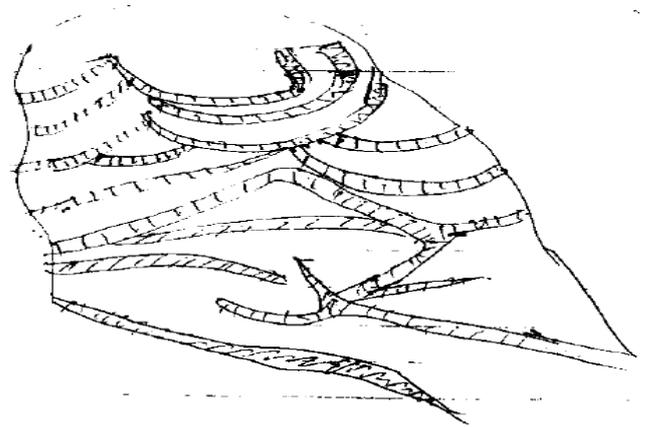


Fig.4A. Terracing technique employed in Hill region.



Fig.4B. Terracing Plantation

The purpose of contour planting and terracing is to reduce the catchment distances between drainage points and slope of the run-off path, which is helpful in reducing the movement of run-off water. In contour, excess water is directed laterally and water is kept in contact with the soil for longer periods of time so that holding capacity is increased. While in case of terraces, water is directed laterally and outlets are then made in such designs so that discharged water could cause no erosion or landslide.

An Experimental Approach

Experimental designs and methods for determining the extent of role of different characteristic plant species in checking erosion of soil and legging of problem of landslides up to a great extent due to rain and runoff are as follows:

Of the several grasses, sedges and weeds growing in the eroded areas of rivers Ganga & other river banks,

seven species (07) were selected for quantitative studies. These are *Cynodon dactylon*, *Saccharum munja*, *Cyperus rotundus*, *Alhagi camelorum*, *Euphorbia hirta*, *Ruellia tuberosa* and *Scoparia dulcis*. 10 Sloping plots divided into equal compartments were constructed, one left bare as control & rest were planted with different species (07). Seedlings were first raised and then transplanted at equal intervals of space on experimental sloping plot for (03) three months. Species coming up naturally were weeded out at very young stage.

The cement reservoirs of each plot were cleared before rain or artificial showering. Artificial showering was done through fine nozzles to make identical on all the plots with regard to quantity of water, area, showered, height of can nozzle at the time of showering, etc. Runoff water with eroded soil was allowed to collect in respective reservoirs and settle. The quantity differed from different plots and was much less from vegetative plots as compared to that from bare one. The percentage of soil checked from getting eroded by plant species is termed as soil conservation value. This can be calculated easily

from the data obtained through this experiment by use of following formula-

$$Cv = 100 - \frac{(Swp)}{Swo} \times 100$$

Where Cv= Conservation value; Swp & Swo are quantity of soil washed from planted and bare plots, respectively.

During rain runoff water eroded different size particles selectively to different degrees. Particles like clay & silt are eroded out in much greater proportion.

This experiment indicates that sloping plot was constructed with a soil having 56% of sand, 21% of silt & 20.5 % of clay. After several weeks of its construction during which period, there have been several showers the soil samples from bare and vegetated plots and from one deposited in reservoir were analysed for their mechanical composition. Erosion has altered the original composition to such an extent that runoff sample has only 44 % sand (original 56%), 24% silt (original 21%) and 29% clay (original 20.5%). The slopping plot under the cover of *Cynodon dactylon* had 68.7% sand 17.5% silt and 13.2% clay and from bare plot had 77.25% sand, 14.5 % silt and 8.7% clay (Table -2).

Table 2. Mechanical composition of soils (in %) of slopes during erosion experiment

Soil Sample	Sand	Silt	Clay
Sloping plot when constructed	56.2	21.0	20.5
Runoff soil due to erosion	44.3	24.0	29.4
Bare plot after erosion	77.2	14.5	8.7
Plot under <i>Cynodon dactylon</i> after erosion	68.7	17.5	13.2

The Table -3 shows that Conservation values (Cv) of *Cynodon dactylon*, *Saccharum munja* and *Cyperus rotundus* were very high being 89.4% to 97.5%, 92% to 96.4% & 81.9 to 92.9%, respectively. In order to

assess the role of roots and rhizomes separately from shoots (as in grazing) in binding the soil, the shoots were clipped in 1 sq m. area.

Table 3. Conservation values of different plant species in percentage

Erosion treatments	<i>Cynodon dactylon</i>	<i>Saccharum munja</i>	<i>Cyperus rotundus</i>	<i>Alhagi carnelorum</i>	<i>Euphorbia hirta</i>	<i>Ruellia tuberosa</i>	<i>Scoparia dulcis</i>
Rainfall artificial showering	89.4	92.0	81.9	30.0	6.0	80.0	64.7
Do	97.5	96.4	92.9	32.0	10.2	91.0	83.0
Do	94.2	92.5	90.9	35.2	12.2	87.0	82.1
Rainfall artificial showering with shoots clipped	76.5	96.4	66.2	10.5	8.5	69.0	62.7

This runoff out of this area from each of the plots was again separately collected. Conservation values of the underground parts are again remarkably high for these two grasses and a sedge. Weeds were of much less effective and their roots also had soil binders (Ambasht 1963 & 1968). However, these findings were different from the findings of Weaver and Harmon (1935) obtained through a different experimental technique on American native grassland species.

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