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ORIGINAL ARTICLE

Soil Erosion in Northern Himalayan region: a case study of Lahul block

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Soil is the earth's fragile outer layer which supports all forms of life on earth. It anchors large number of species which create a dynamic and complex ecosystem. Soil formation is a natural process and takes many years. During soil formation, small pieces of weathered rocks and minerals mix with the organic matter of decaying plants as well as animals.

Among the natural resources soil is the most precious resource for mankind. The increasing demand for agricultural products causes conversion of forests and grasslands to farm fields and pastures. But the transition from natural vegetation to agriculture has very limited capacity to hold the soil and some types of plants play a vital role in the enhancement of soil erosion beyond the soil's ability to maintain itself. Soil erosion is a regular process which occurs either slowly or at an alarming rate. This process includes three steps *viz*., detachment, transport and deposition (Meyer and Wischmeier, 1969). The beating action of raindrops and shearing forces of flowing water against the soil surface results in detachment of soil particles (Jain and Kothiyari, 2000). In the hilly regions, soil particles are detached either from hill slope or slope segment (Toy and Renard, 1998). Soil erosion is a major challenge for environment and agriculture which culminates to economic, political and social implications (Thampapillai and Anderson, 1994; Grepperud, 1995).

Northern Himalayan soils are highly dynamic systems that may react sensitively to environmental changes. Soil erosion is the most prominent issue in ecological environment of northern Himalayan region as it leads to extensive and frequent loss of top soil and organic matter, which are essential for plants growth. Erosion in hilly province is serious, because of fragile eco-environments and rugged terrains. Soil

erosion has been extensively studied by agricultural researchers, and reduction in the rate of soil erosion is widely recognised as a key factor for sustainable agriculture.
Himachal Pradesh state in North Western Himalayas is very prone to soil erosion. In this state, most of the Research Institutes have carried out their research on soil erosion aspects. Dr. Y. S. Parmar University of Horticulture & Forestry, Solan, Himachal Pradesh determined the ***"Erodibility Status of Soils under Different Land uses in Shiwalik Hills of Himachal Pradesh"*** and recommended that 'marginal lands such as barren and scrub lands in Shiwalik hills need special management practices for soil and water conservation to check further degradation. ICAR-National Bureau of Soil Survey and Land use Planning also made a study on 'Soils of Himachal Pradesh: Land capability classification and assessment of soil degradation status for suggested land use' and found that only 21.4 percent of the state's land area was moderately and marginally suitable for agriculture purposes.

Thus, a case study has been undertaken in Lahul block of Lahul & Spiti district in Himachal Pradesh to assess the soil erosion aspects. The total population of the area is 22545 and Majority of the population belongs to Schedule Tribes. The block falls under Western Himalayas, cold and dry semi-arid agro-ecological sub-region region (AESR) 4.1 covering an area of 2,01,085 ha. The average temperature of the block is -3°C to 8 °C. The elevation ranges from 5000-6500 m AMSL.

The major physiographies are summits & ridge tops, mountain & valley glaciers, side/reposed slopes, glacio-fluvial valley and fluvial valley of Greater Himalayas. The major soil are shallow to moderately deep, gravelly (loamy sand, sandy loam and loam) occurring on granite-gneiss and shale parent materials.

The area is renowned for snow fields, ice caves, glaciers, snow clad mountains and passes. The Lahul Block remains cut off from the rest of world for about 7 months every year due to closure of vehicular traffic through Rohtang pass because of heavy snowfall Forest area covers major area *i.e*., (70%) whereas net sown area covers only 1.1%, culturable waste (0.5%), permanent pastures (20%) and barren (7.1%), respectively. The economy is mainly agrarian (Fig. 2) and most of the workers in the area are engaged in cultivation of pea, potato, barley, apple, wheat, ogla / phafra, maize, hop and kuth.
(Fig.1).

Fig 1. Snow fall

Fig 2. Agriculture system

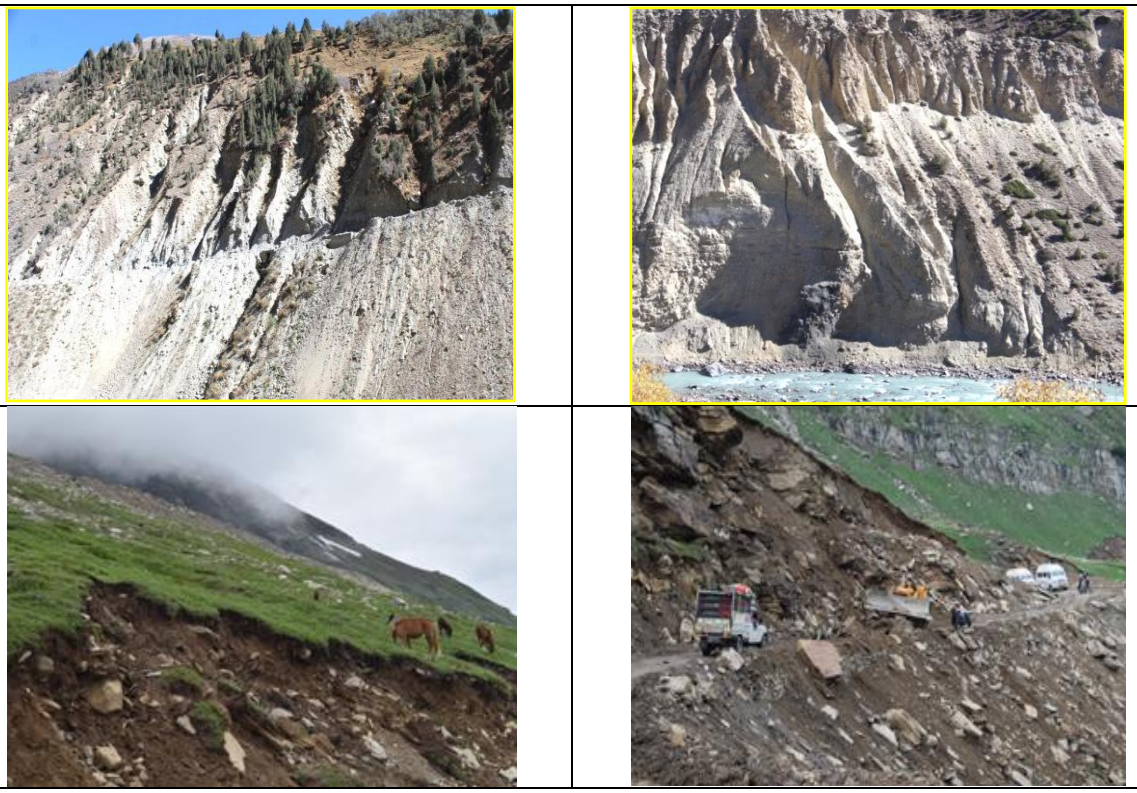

Fig 3. Soil erosion

In this block, soil erosion occurs due to both natural and anthropogenic activities, and is continuing over the years with varying intensities (Fig 3). The natural causes of soil erosion in this block are sloppy landscape, cold arid climate, heavy snow fall, rugged terrain, glacial movements and landslides etc. Concentrated rainfall with frequent rainstorms, broken topography with steep slope and highly dense gully are also important natural factors resulting in soil erosion. Besides, anthropogenic activities like uncontrolled deforestation and unscientific land utilization especially slope farm land aggravate the process of soil erosion. Due to these constraints the cropping season sustain only for a limited period which results decline in crop productivity.

CONSERVATION OF SOIL EROSION

Prevention of soil erosion is also known as conservation of soil. This block is highly susceptible to various kinds of degradational constraints *viz*., severe to very severe soil

erosion, deforestation, landslides, etc. The present agriculture system in this region is under threat due to these degradational features and continuous exploitation of the natural resources. Thus, agricultural sustainability and food security have become a major concern in this hilly region. Hence, it is required to adopt the proper soil conservation measures to minimise the risk of natural resource degradation for enhancing crop productivity. The soil conservation practices to be implemented includes (i) ***Contour ploughing*****:** this refers to ploughing along contour lines. (ii) ***Terrace farming*****:** In this farming, agricultural activities are carried out by cutting steps on the slopes of the hills which lowers the flow of water and soil removed from one step but are deposited on the next step. Thus, in this farming system soils are never removed completely. (iii) ***Plugging of gullies*****:** to control gully erosion and (iv) ***Inter-cropping/Strip-cropping*****:** In this cropping system, the crops are cultivated into long narrow strips to prevent soil erosion. It is applicable where the slope is too steep. Depending upon the rate of soil erosion (slight, moderate and severe), the following conservation measures should be adopted, accordingly (Table 1).

Table 1. Soil erosion rate and their conservation measures

S.No.	Soil erosion rate	Conservation measures
1.	Slight soil erosion	Adoption of close spacing erosion resistant crops and inter-cropping or strip cropping; application of soil management practices to improve organic matter and soil structure; land leveling and development of terraces as well as grass waterways.
2.	Moderate soil erosion	Crop diversification; soil and water conservation practices be adopted; safe disposal of excess runoff to water harvesting bodies; introduction of silvi-pastoral and horti-pastoral systems on degraded land; appropriate engineering measures such as land leveling, terracing, contour trenching and contour farming to check soil erosion and conservation of soil moisture in soil profile.
3.	Severe soil erosion	Combination of biotic and abiotic measures such as emphasis of catchments to reduce sediment flow; insitu soil moisture conservation for establishment and growth of forest ecosystem; diversion of excess runoff to water harvesting structures for supplemental irrigations to plans; establishment of permanent cover on the current fallows; proper resource utilization and adoption of silvi-pastoral or horti-pastoral systems.

Soil management practices such as land leveling are required to improve organic matter and soil structure. Adoption of silvi-pastoral or horti-pastoral systems with emphasis on cover management, vegetation or plant cover, pasture and forest development, terraces

and grass waterways to reduce the soil erosion. Development of proper engineering structures may be implemented for disposal of excess rain water to water harvesting bodies' *viz*., ponds, reservoirs, etc. to minimise the degradations caused by water erosion.

On the degraded lands the good grass cover, shrubs and trees should be practicised which will conserve the land from degradational problem and will also help to protect the soil resources as well as its quality (Dhyani *et al*., 2005; Prasad and Dhyani, 2010; Nagdev *et al*., 2017). Hence, afforestation and plantation may be encouraged on priority basis in non-cultivable areas to arrest erosion of soils. The areas of shallow soils which are not suitable for agriculture and tree growth may be used for pasture development (Singh *et al*., 1990; Sidhu*et al*., 2010).

CONCLUSION

The Lahul block is highly suffering from acute soil erosion problem. The, sloppy landscape, rugged terrain, glacial movements, landslides, heavy rainfall, deforestation and unscientific land use are major key factors for soil erosion. The distinct soil erosion problem prevailing in the area, affect the agricultural sustainability, threatening the food security. Thus, proper soil conservation measures should be adopted to arrest further degradation. In addition, various steps should been taken, including broad social propaganda, special technological education and effective checking mechanism to administrative officials, to raise the awareness of whole society on soil and water conservation as well as environmental protection. The soil health can be maintained by adopting these recommendations for sustainable agricultural production and livelihood security of the tribal people of this difficult hilly area.

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