Preserving Our Foundation: Effective Strategies for Soil Erosion Prevention and Management in North Eastern Himalaya, India

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Introduction

Soil erosion in India's tropical hilly regions poses a significant threat to environmental sustainability. The Indian Himalayas, comprising 16.4% of the country's area, have higher yearly rainfall in the NEH (1,500-11,500 mm) region than the western Himalaya (350-3,000 mm), affecting a greater percentage of the region's land. Therefore, Soil erosion affects a greater percentage of the NEH region's land (GA: 22.3) than the NWH region (GA: 12.6) (CSWCRTI, 2030). This leads to environmental issues such as topsoil loss, decreased soil fertility, siltation of water bodies downstream, frequent floods, and ecological imbalances. Unsustainable land-use practices, such as deforestation, vegetation burning, urban growth, mining, and quarrying, have made soil erosion more severe. Shifting farming, or jhum, is practiced in key states like Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, Manipur, and South Assam and Tripura. The fallow periods for jhum have decreased from 10-15 years to 2-3 years due to population pressure and land scarcity. Traditional farming methods, such as short fallow jhum, bun, and terrace agriculture, have left land barren and subject to soil erosion and degradation. To restore degraded lands, site-specific methods, including long-term management plans, are essential (Choudhury et al., 2022).

1. Status of Land degradation in NER:

In the northeastern region of India (NER), where unsustainable land-use practices, such as deforestation, result in soil degradation, unstable hillslopes, and the collapse of mountain ecosystems, water erosion poses a serious danger to ecosystem sustainability. Water erosion is responsible for roughly 30% of the nearly 4.60 M ha of degraded land in the area. Acidification of the soil, waterlogging, mining, quarrying, riverine sands, and industrial effluents are further types of degradation. The most degraded land areas are found in Nagaland, Mizoram, Manipur, and Meghalaya, with Mizoram having the greatest percentage of water-eroded GA (7.86%). The most yearly soil loss occurs in Manipur, then Mizoram, then Assam. The severity of soil erosion is mostly a result of widespread deforestation and topsoil exposure to heavy rains on sloped uplands. The area loses 88.3 million tonnes of soil year due to jhum agriculture solely. The soil loss caused by jhum farming in Arunachal Pradesh is projected to be 669.4 million tonnes, or 90.9 t ha-1 year (Mandal et al., 2011).

2. Conservation Measures to Combat Soil Erosion in the Hilly North East India

Only 3.77 million hectares (14.4 percent of TGA) of land in the area is used for agricultural, and 76% of it is used for lowland paddy farming, primarily in the alluvial plains (valleys of the Brahmaputra, Barak, Imphal, Tripura, and Meghalaya) (Dikshit et al., 2014). The 0.82 million hectares (or 3.5% of the TGA) are still under established agriculture (0.50 M ha) and Jhum cultivation (0.32 Mha) on the uplands hill.

2.1. Traditional Soil and Water Conservation (SWC) measures:

2.1.1. Zabo or Ruza system: An integrated community-based agricultural method called the zabo or ruza is used to effectively manage precipitation and minimise soil erosion. It involves ponds to catch run-off water, slope gradients, and siltation tanks. The technology promotes infiltration, allows for maximum rainfall interception, and lessens the potential for erosion to start due to falling raindrop kinetic energy. Further lowering the flow velocity and volume of run-off are retention ponds in the centre of terraces and hills, including rice fields. The Zabo farming approach protects soil from erosion while ensuring food and nutritional security.

2.1.2. Echo System: Under Shifting Cultivation-based land-use practices, the echo system conserves soil and water in hilly watersheds. Controlling run-off flows, enhancing infiltration, boosting water recharge, and increasing the availability of nutrients are all accomplished by haphazardly laying locally accessible bamboo and wooden logs at vertical intervals of 3.0-4.0 m along hill slopes. Over time, the redesigned method creates a permanent contour bunding system by including mechanical soil and water conservation mechanisms. When it comes to lowering run-off and soil loss, this technique is more successful than traditional echo.

2.1.3. Contour trench farming system: By creating ditches down the slopes to stop soil erosion and save rainfall, contour trench farming turns hills with slopes of over 15% into cultivable land. These ditches act as a berm on the bottom by maintaining the same height and running perpendicular to the water flow. The slope gradient and soil characteristics affect the trench's size. Contour trenches minimise evaporation loss, promote deep percolation, delay water flow, reduce runoff velocity, and assist crops in overcoming moisture stress. They preserve soil fertility by capturing eroding soil. The soil moisture is replenished by the runoff gathered in the trenches, assisting in agricultural productivity.

2.1.4. Sloping agricultural land technology approach: The Jhumias, relocating farmers in steep areas, faced many challenges with soil erosion. The slope agricultural land technology (SALT) initiative by Gandhi seeks to overcome these issues. It entails establishing nitrogen-fixing plants as vegetative barriers, reducing soil erosion and runoff, and boosting soil fertility. Regular trimming of the hedges is done, and field crops, vegetables and trees are positioned in the interrow strips. To feed small animals, leguminous fodder crops are occasionally gathered. In shifting agricultural regions, there is possibility for adaptation, as evidenced by a pilot project in the Manipuri village of Aben. A family can eat adequate food because to this sedentary agriculture's reduced labour requirements and environmental friendliness.

2.2 Structural/ Engineering Measures:

2.2.1. Contour bunding: Contour bunding is a SWC strategy that concentrates on retaining surface runoff to prevent soil erosion. It is graded when a grade is supplied for the safe disposal of run-off water and is suited for slopes between 4% and 8%. On less permeable soils that are prone to water erosion and have issues with waterlogging, graded bunds are typically used. They are highly advised for slopes of 6-10% with high annual rainfall of more than 750 mm.

2.2.2. Terracing: Terraces are earthen embankments built across the slope to reduce soil erosion and run-off. They serve as land slope intercepts, reducing the length of the slope, and split hill slopes into strips. Bench terraces are conservation structures that progressively transform steep slopes into level steps and ledges to stop run-off and prevent soil erosion. Broad-base terraces are used for water removal or conservation on sloping terrain. Over extended periods of usage, bench terrace systems have been demonstrated to minimise run-off and soil loss by 78.9% and 88%, respectively.

2.2.3. Trenching: Trenching serves as a flow barrier, encourages water conservation, and treats drainage lines. It is a technique used to stabilise slopes. There are four different categories of trenches: line trench, continuous contour trench (CCT), and graded contour trench (GCT). CCT is appropriate for regions with low to moderate annual rainfall, GCT for regions with 1000–1200 mm of annual precipitation, and SCT for regions with high yearly precipitation and steep incline.

2.2.4. Semi-permanent structures: By lowering flow rates, semi-permanent structures like retaining walls, geo-textiles, sand-bag check dams, loose boulder check dams and rock-filled check dams efficiently prevent gullies and erosion. They might be selected based on the availability of the basic materials. In regions where there are loose rocks and sparse vegetation, rock-filled dams are preferable. For the purpose of releasing water energy, a non-erodible apron is supplied at the base. By installing porous rock filled dams and trash barriers the mountainous sediment output may be decreased by 54.7% by watersheds at NEH (Umroi, Meghalaya).

3. Integrated Farming System (IFS) in NER:

In hilly areas, integrated farming systems (IFS) are an appealing option to satisfy farmer demands while preventing soil erosion. Soil erosion can be reduced by Agri-Horti-Silvi-pastoral land-use systems from 42 to 1.5 t ha-1 yr-1. Studies have showed that implementing Silvi-pastoral IFS coupled with SWC strategies reduced soil loss from wastelands and barren hillocks. As an alternative land use to traditional soil conservation (SC), multiple IFS in conjunction with different SWC measures were constructed in the steep micro-watershed at Umiam. In hill agriculture, combining conservation techniques such as contour bunds, terraces, and grassed rivers proved more successful and reduced soil erosion by more than 25%. Traditional hill farming in Meghalaya was transformed into a micro-watershed based on an Agri-Horti-Silvi-pastoral system, which decreased soil loss and erosion by 99.3% while boosting soil productivity.

Conclusion:

In North East India, soil erosion poses a serious danger to the ecosystem since it degrades the environment and eliminates topsoil. Traditional conservation techniques including contour trench farming, terracing, Zabo and Echo systems, and integrated agricultural systems provide promise for repairing ruined areas and halting soil erosion. These innovative methods protect soil resources and guarantee a robust environment for future generations.

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