Mapping gully erosion patterns in foothills of lower Shiwaliks

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Abstract

Gully erosion is most prevalent type of water erosion in foothills of lower Shiwaliks. Efforts are being made by different agencies to control the gully erosion in the region but with little success. More than 70 per cent of the permanent structures were damaged either completely or partially. The damage was of two types-physical damage or siltation on the upstream side. In more than 75 per cent cases the siltation was complete up to the crest level of the structure. The possible reasons for the failure of these gully control structures as analyzed could be a complete lack of information about the gully network and most of the structures were installed in the highest ordered. Mapping of gully erosion in a few catchments in the region have revealed that gully texture-number of first-order gullies per unit area ranged from 253.8 to 767.9 per km^{-2} whereas gully density ranged from 8.73 to 16.3 km km^{-2}. The first order gullies constituted 57 to 85 per cent whereas the second order gullies constituted about 15 to 33 per cent of the total gullies. Of the total length of the gullies, first order gullies represented 60 to 88 per cent whereas the second order gullies represented 12 to 27 per cent.

Introduction

Soil erosion by water is a serious problem of land degradation in foothills of lower Shiwaliks. Gully erosion is the most spectacular form of erosion as the damage caused by it is relatively permanent. Nearly 20% of the total land in the region is under gullies (Kukal and Sur, 1992). Gully erosion is most prevalent type of water erosion as it dissects the fields, impedes the tillage operations, damages agricultural, residential and recreational land and causes environmental pollution. The damage caused by the gullies is significant compared to other forms of erosion as the sedimentation production form the gullies is to the tune of 147% of that from other types of erosion (Grissinger and Murphy, 1989). Further the gully network in the region is responsible for the generation of higher amount of runoff despite of the presence of sufficient vegetation cover. Various factors controlling gully growth are catchment characteristics viz. area (Burkard and Kostaschuk, 1997), slope steepness (Kukal et al., 1991), slope shape (Meyer and Martinez-Casasnovas, 1999), gully dimension parameters, surface runoff, precipitation, soil moisture and piping (Stocking, 1980).

The foothills of lower Shiwaliks, covering an area of 2.14 m ha, falls in the state of Punjab, Haryana, Himachal Pradesh and Jammu and Kashmir and because of peculiar geological formations represent the most fragile eco-system of the Himalayan ranges. These are exposed to greater biotic pressure due to their proximity to plains. Ecological

degradation in Shiwaliks is the outcome of continued over-exploitation and mismanagement of soil resources through deforestation, over-grazing and clearance of land for agricultural purposes disregard to slope and topography of the land. Efforts are being made by different agencies to control gullies in the region but with little success. The present study is being carried out under the auspices of Department of Science and Technology, New Delhi to examine the pattern and growth of gullies in relation to catchment characteristics in foothills of lower Shiwaliks.

Materials and Methods

A survey was conducted during September 2001 to January 2002 in different catchments in the region to study the performance of various gully erosion control structures installed by different agencies and data collected on various parameters viz., catchment area, slope, vegetation, land use etc. Information on these parameters was collected in about 10 catchments representing different soil and land characteristics. The physical damage was categorized as (i) partial- the structure was not completely destroyed but part of the runoff water was flowing from the side of the structure either due to physical damage to the structure or due to the erosion of the gully bank and (ii) complete when the structure to such an extent that little runoff was being intercepted.

Gully erosion mapping was carried out in four catchments of Saleran in district Nawanshahar through ground surveys so as to find out the extent and distribution of different ordered gullies in the area in the form of gully density, gully texture etc. The catchment characteristics viz. shape, size, relief and vegetation density were recorded.

Results and discussion

The physical damage to permanent structures, which constituted about 7.5 per cent of total structures, was comparatively less compared to other structures. About one-third structures in Brahmanawala and Basu Khad catchments were partially damaged and an equal number were completely damaged (Table 1). On the other hand in all the catchments where such structures were installed, these were silted on the upstream side to different levels. The siltation up to 50-75 per cent occurred in about 25-75 per cent of the structures in different catchments whereas complete siltation occurred in 75-100 per cent of the structures in various catchments. Permanent structures were least damaged physically as these could resist the energy of runoff water more efficiently due their strength. However, the siltation on the upstream side within 2-3 years resulted in a situation where the runoff water fell from a greater height thereby becoming more erosive and carried the silted particles along with it. The presence of gully control structures in the highest order gully means that all the lower order gullies were contributing freely to this gully resulting in build up of runoff of sufficient amount and velocity. Before planning the installation of gully control structures in a catchment, no information on gully networks including distribution and extent of different ordered gullies, gully density, gully texture etc. was collected. These gullies collect runoff from each nook and

corner of the catchment and poured it into the highest order gullies via other intermediate order gullies. In many instances, the catchment boundaries were not delineated while

Table 1. Extent and status of permanent structures in different catchments in foothills of lower Shiwaliks.

Catchment	Total number of structures installed	Per cent damaged structures		Per cent structures silted upstream with different levels of siltation		
		Partial	Complete	25-50	50-75	100
Brahmanawala	3	30	30	--	30	70
Bathalaur	6	--	--	--	70	--
Sahora	5	--	--	80	20	--
Sadhu Chak	9	--	--	--	25	75
Basu Khad	15	33	33	--	--	100

treating for gully control in the area. This results in non-availability of the expected runoff volume from that area which probably leads to under-design of the structures.

The mapping of gully networks in four catchments of Saleran showed that gully texture--number of first-order gullies per unit area, ranged from 253.8 to 767.9 km^{-2} (Table 2) The gully density--total length of gullies per unit area ranged from 8.73 to 31.9

Table 2. Extent of gully erosion in study catchments.

Catchment	Gully texture (km^{-2})	Gully Density (km/km^{-2})	Average Relief
I	767.91	31.93	1.36
II	436.89	15.50	0.09
III	742.86	16.31	0.13
IV	253.8	8.73	0.07

km km^{-2}. The gully density and gully texture were both a function of average relief of the catchments studied. The first order gullies constituted 57-85 per cent of the total gullies whereas second order gullies ranged from 15-33 per cent in the four catchments (Table 3). About 60-89 per cent of the total length of gullies was represented by first order gullies and 12 -27 per cent length was represented by the second order gullies (Table 4).

Thus both length and number of gullies were dominated by first order gullies which are a neglected lot while deciding the installation of gully control structures.

Table 3. Number of different ordered gullies in study catchments.

Catchment	1st	2nd	3rd	Total
I	91	22	1	114
II	90	16	--	106
III	65	21	---	86
IV	108	63	19	190

Table 4. Length of different ordered gullies in study catchments.

Catchment	1st	2nd	3rd	Total
I	3006	688	90	3784
II	2810	383.5	----	3193.5
III	1070.6	356.9	-----	1427.5
IV	2214.5	994.8	506	3715.3

The study thus shows that the knowledge on gully network is a pre-requisite for their successful control. These being the continuous network need to be treated as a whole system rather than the individual gullies more so the lower order gullies. However, further studies are continuing so as to reach a logical conclusion.

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