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Seasonal hill River problems and their bio-engineering remedial measures in Shiwalik Himalaya

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Abstract

Doon valley in lower Shiwalik hills of Uttarakhand is infested with large number of seasonal hill rivers originated from Shiwalik hills. The flash flood in the torrent as the peak storm during rainy season caused severe main problems as land erosion and the flood water often inundated the household properties, death of livestock and flooding in agricultural fields. In the study , Sabhawala watershed area land damaged by uncontrolled torrent flow during monsoon period which is very severe to watershed in particular affecting 257.78 ha out of total 1173.6 ha (21.96 %) watershed area. The present paper conclude that bio-engineering measures are essential for the protection and rehabilitation of seasonal rivers affected agricultural area for sustainable conservation of agriculture land resource

Key words: *Torrent*, *Torrential watershed*, *Bioengineering measures*, *Shiwalik region*

Introduction

The Uttarakhand state is particularly sensitive to natural land disturbing activities. Steep slopes, high rainfall and weak geology of the Uttarakhand state make prominent land degradation and soil erosion process at much faster rate than in the plains due to fragile ecosystem. In the head water reaches the sediment is flushed with the high velocity currents and reached the relatively flat foothills along with debris sediment starts accumulating on the river bed causing change of river course and flooding its bank. These rivers with flash flows and high sediment loads are known as torrents. Torrents in Shiwalik Himalaya have been created constant threat to the natural resources as well as human settlements. The formation of torrents though due to geological and climatic factors and its ecological problems due to mismanagement of watersheds of their origin in the headwater reaches. Torrent affected erosion is due to the high run-off down the hill slopes with heavy gravel, sand and silt loads that fill up the channel beds thereby reducing their capacity to carry the run-off and sediment and as a consequence, the flow shifts from the original course. Moreover, the torrents have meandering nature *i.e.* they often change their course and cause damage of adjoining land, life and property. Torrents are causing vast area submergence and damage to life, property and infrastructure almost every year. This is the most common problem in, Himalayas spread over the northern states of India. In the foothills of Shiwalik Himalaya, torrents are the prominent land features. The torrents are seasonal in nature and characterized by high sediment ladder flash flow during monsoon period. These torrents have low banks and thus the flow frequently over tops the banks and cause floods. Torrent have mostly taken as small mountainous streams rushing down to the slopes with flashy floods and often loaded with sediments. On rushing the milder slopes such as

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foothills, they develop into channels with large volumes of debris and low velocity of flow (Tiwari, 2004). Torrent effected states include Uttarakhand, Punjab, Harayana, Jammu & Kashmir, Himanchal Pradesh, Assam and the north eastern states (Juyal *et al.*, 2005 a,b). Torrent training works are basically aimed to control meandering tendency of the torrent by restricting it in a defined and narrow course. If this is achieved, problems of overtopping and undermining of banks and debris deposition in the flow channel can be eliminated. A study was taken up to evaluate the costs of engineering structures and vegetative covers to find out the best economical rehabilitation technology for the management of torrents in Sabhawala watershed on the basis of relative efficacies of different mechanical and vegetative control measures in terms of their effects on the flow, sediment transportation and scour or deposition patterns and also in terms of structural stability and longevity.

Materials and Method

The study was conducted in the Doon Shiwalik range of the Uttarakhand at Sabhawala torrential watershed area. The experimented site located at the longitude 77º 48' E and latitude 30º 20' N in Tehsil Vikasnagar, Block Sahaspur of District Dehradun. Rainfall is quite favorable in this area and is more than 1100 mm per annum. However its main concentration is in monsoon season (about 80% of the total precipitation), which is the major cause of erosion in the rainy season. As a result of poor water holding capacity, it supports less biological activities and that is why drought conditions prevail in the summer months. Due to constant erosion over a period of time, soils have been washed and left with very poor nutrient status. The temperature in summer goes more than 45° C and while in winter it goes sometimes below 0°C. The selected experimental torrent at Sabhawala watershed area originating from Doon Shiwalik foothill regions of Himalaya have been identified and delineated for the experiment.The experimental program was planned taking into account the objectives of the study and the parameters were selected to centralize the aim of sampling to achieve the representativeness and validity of the samples. The study was conducted for two years (April, 2007-March, 2009) and the frequency of sampling was set as per existing conditions during the rainy seasons or flood periods.

Results and Discussion

In the Sabhawala watershed land,damaged by uncontrolled torrent flow during monsoon period is very severe in the area in general and watershed in particular affecting 257.78 ha out of total 1173.6 ha (21.96 %) watershed area. The forest zone consisted 921.1 ha of total area in upper region of watershed in which, the area affected by torrent was found approximately 125.25 ha with 43.01 %. In forest zone, maximum area (20.72 ha) effected by torrent observed in upper reaches of forest zone in transition region of forest and agriculture pasture land. The total area effected by torrent in agriculture land was recorded as 94.18 ha (75.34 %) and played a significant contribution to the flood during the rainy season. Torrent affected area under habitation was recorded as 13.5 ha (27.0 %) out of total 50.0 ha habitational area. The flood plain basin consisting about 77.50 ha out of which 24.85 ha (32.06 %) was affected by torrent (Table.1 and Fig.1).In the upper reach the area affected by torrent is less since the flow is discharged rapidly due to steep slopes. However, in the lower reach area, which used for cultivation and habitation the flood flow spreads along the torrent banks due to sudden reduction in the land slope and caused severe damages affecting over half of the area. It is clear from the recorded data that where the slope is relatively steeper, the flood damage is less compared to the lower reaches where due to flatter slope, the torrent water floods the adjoining lands and affects over half of the total land. This area is most vulnerable to torrent flood hazards the entire cultivation and habitation.The problem has been further aggregated by heavy encroachment of land along the torrent bed for cultivation. About 22 % of the watershed area was affected by the torrent flow hence torrent treatment works was taken up in the lower reaches.

Table -1 Area affected by torrent under Sabhawala watershed

S.No	Particulars	Total area (ha)	Area affected (ha)	Affected area (%)
1	Forest area (upper reaches)	121.0	20.72	17.13
	Forest area (middle reaches)	345.5	41.44	12.00
	Forest area (lower reaches)	454.6	63.09	13.88
2	Agriculture	125.0	94.18	75.34
3	Habitation	50.00	13.50	27.00
4	Flood plain basin	77.50	24.85	32.06
	Total	**1173.6**	**257.78**	**21.96**

In the present study, the torrent treating measures adopted by different developed departments, research organization; NGO's and local communities in selected areas were studied. Comparative per sq/cu meter work cost of different torrent treating measures at Sabhawala watershed was calculated for the identification of effective protective vegetative cover. The cost for the construction of Gabion protection wall of 28.125 cu m volume having the size as length 15 m bottom width 1.5 m, top width 1 m, height- 1.5 m was calculated Rs. 784.71 per cu m work**.** As the cost for construction of Gabion spur of 5.625 cu m volume having the size as length 3 m bottom width 1.5 m, top width 1 m, height- 1.5 m was calculated Rs. 784.00 per cu m work**.** The cost for construction of katta crate spurs of 5.625 cu m volume having the size as length 3 m bottom width 1.5 m, top width 1 m, height- 1.5 m was calculated Rs. 624.00 per cu m work. Coir Geonet cost and bioengineering measures for degraded slope of 45 sq m volume having the size as length 15 m width 3 m was calculated Rs. 45.00 per sq. m work. The construction of earthen embankment of 28.125 cu m volume having size as length 15 m bottom width 1.5 m, top width 1 m, height- 1.5 m cost was calculated Rs. 40.00 per cu m work**.** The cost of planting live vegetative barrier of 45 sq m volume having the size as length 15 m width 3 m was calculated Rs. 20.00 per sq. m work**.**

The cost of dry vegetative hedge row of 45 sq m volume having the size as length 15 m width 3 m was calculated Rs. 20.00 per sq. m work**..** The cost of seed showing of 45 sq m volume having the size as length 15 m width 3 m was calculated Rs. 10.55 per sq. m work Table.2 and Fig. 2. For best economical torrent treating measure various existing torrent control measures was evaluated on the basis of their comparative cost of having the almost same size.

The performance of spur was evaluated on comparative construction cost basis as smaller patches were built on bank of torrent along with short spur about 3 m in length and width angle 45^0 projecting downstream (attracting type) spaced at 4 times the length, suitable for flow guidance.

A long spur (15 m) provided at lesser angle (30^0) also performance well and is suitable for protecting for house or other vital installation near the torrent bank spur caused deposition of sediment behind them which consequently helped in stabilization of torrent bank.

The gabion protection wall requires big size stone which often have to be transported from long distance involving high cost. In order to use the available torrent bed material, which has much smaller in size “Katta Crate” technology was successfully used for construction of torrent training structure. Mortar was filled in empty gunny bags (katta).

These bags were laid as per the design Cement, sand and torrent bed material were mixed in the ratio 1: 6:10 with water and the enclosing them in wire mesh or without it as per the site condition.

Table -2 Comparative cost evaluation of different torrent treating measures for the construction of same size structure at Sabhawala watershed

S.No	Particular	Length	Base /width	Height m	Volume	Amount (Rs.)	Cost of per sq/cu m work
1.	Gabion protection wall	15m	1.25m	1.50m	28.125cu m	22070.00	**784.71**
2.	Gabion spur	3m	1.25m	1.50m	5.625cu m	4412.00	**784.00**
3.	Katta crate spurs	3m	1.25m	1.50m	5.625cu m	3509.00	**624.00**
4.	Coir Geonet	15m	3m	-	45 sq m	2025.00	**45.00**
5.	Earthen embankment	15m	1.25m	1.50m	28.125cu m	1125.00	**40.00**
6.	Live vegetative barrier	15m	3m	-	45 sq m	900.00	**20.00**
7.	Dry vegetative hedgerow	15 m	3m	-	45 sq m	900.00	**20.00**
8.	Seed sowing	15m	3m	-	45 sq m	475.00	**10.55**

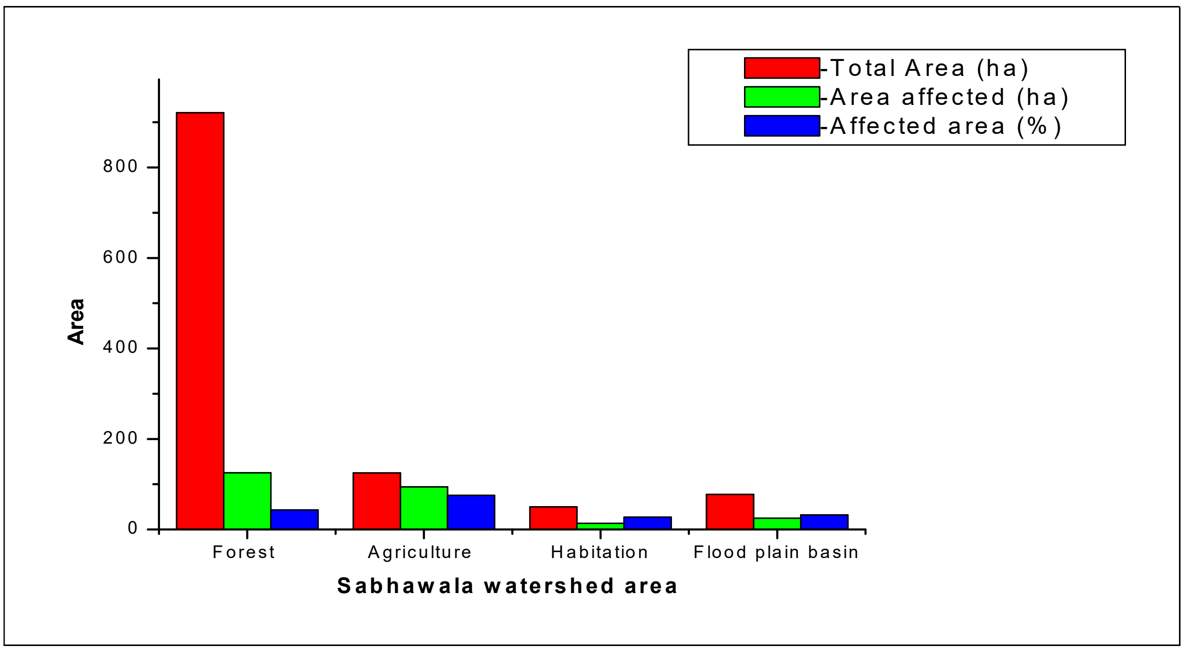

Figure 1 Area affected by torrent under Sabhawala watershed

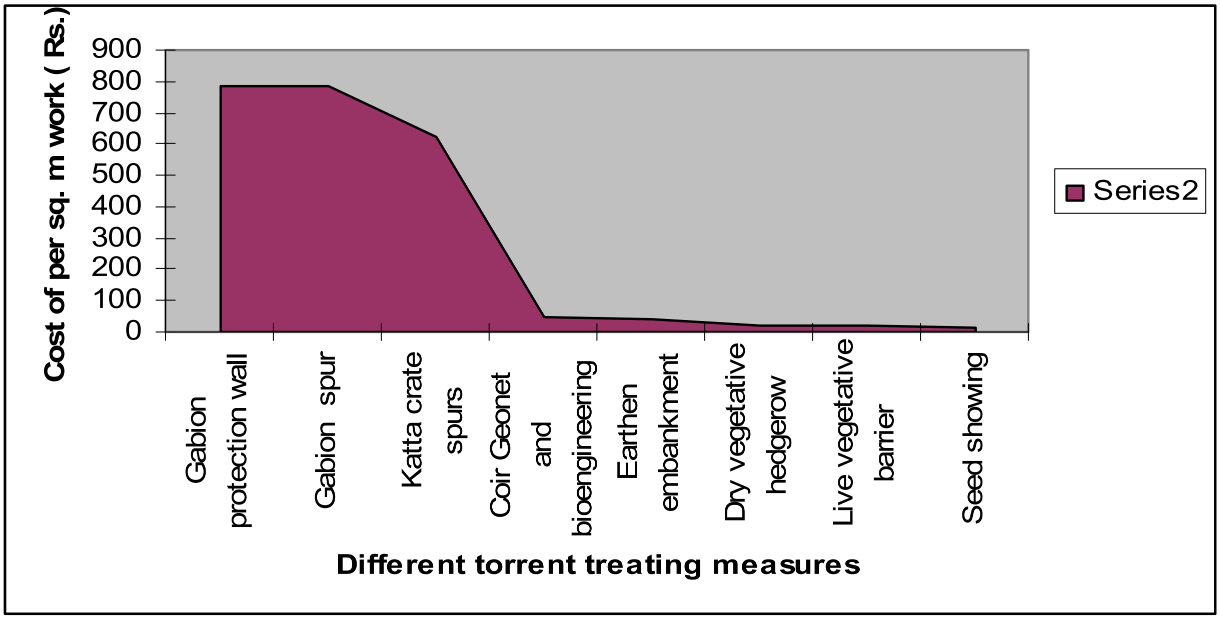

Figure 2 Comparative cost evaluation (of per sq. m/cu m work) of different torrent treating measures

The Katta Crate structures functions well and were 32 % (with wire mesh) and 58% (without wire mesh) cheaper then the conventional gabion protection wall structure respectively. Vegetative barriers and live hedges are used for erosion control purpose in agricultural lands as well as non-arable lands. Vegetative barriers established on farmer's field are expected to perform as erosion diminishing mechanism and also provide fodder, fruits and other minor products. Spurs are structures used for torrent training work. In the present study, various plant species effectively served as vegetative barrier and had better soil binding capacity in the layer, which helped in soil aggregation, increased infiltration rates, improve soil moisture level and conserved maximum runoff. In the present study for the vegetative barrier, live hedges and vegetative spurs, various trees and grasses were planted on bank of the upstream side in the Sabhawala watershed area to identified the best performance of Survival and growth behavior of species like *Dalbergia sissoo, Bauhinia purpenea, Dendrocalamus Strictus, E.hybrid, Ipomea carnea, Vitex negundo, Arundo donax*, *Eulaliopsis binata and Pennisetum purpureum*. Samra and Sharma (1995) made experiment for the soil binding factor for three perennial grasses *(S.munja, S.spontaneum*, *Arundo donax)* in sandy choes at Rei Majra and observed that the *S.spontaneum* had the highest above ground biomass (398 kg) followed by *S. munja* (28.3 kg) and least *A. donax* (3.7 kg). Soil binding capacity in 0-10 cm layer was recorded highest for *S.spontaneum* (1590) followed by *S.munja* (788) and *A.donax* (31).

Conclusion

The present study conclude that bio-engineering measures are essential for the protection and rehabilitation of torrential agricultural area for sustainable conservation of agriculture land resource and checked out the losses in habitational area in Sabhawala watershed region. Vegetative measures are cheaper but difficult to establish. Engineering measures provide greater efficiency and stability but are very costly. Combination of both types of measures can be the best option for the torrent control. Proper and planned combination of engineering and biological remedial measures provides better torrent control than any individual measures used along. The combination of above measures reduced the cost of torrent treatment by ten to twelve times, when compared with the cost of treatment by construction of engineering measures alone at Sabhawala watershed area.

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