Developing Incentive Based Mechanisms for Watershed Protection Services through Participatory Hydrological Studies

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Abstract

Peoples' Science Institute (PSI), Dehradun and Winrock International India (WII), Gurgaon jointly initiated participatory hydrological studies in two micro-catchments i.e., the Bhodi-Suan and Kuhan catchments that lie in the Changer region of Kangra district of Himachal Pradesh from August 2005 with the objective of promoting incentive-based mechanisms (IBM) for watershed protection services and improved livelihoods. Low cost hydrological monitoring stations and systems were established with the help of the watershed communities. Thereafter, selected members from the communities were trained and involved in measuring and recording the hydrological data. The data collected has been further analysed for the period August 2005 to July 2006 for generating baseline information on rainfall, stream flow and sediment yield. Bhodi-Suan and Kuhan catchments received a total rainfall of 1700 mm and 1192 mm respectively during August 2005 to July 2006. The base flow in the catchments ranged from 0.22 to 0.34 cumecs during the reporting period. The suspended sediment yield for Bhodi-Suan and Kuhan catchment is 6.5 tons/ha/yr and 11.9 tons/ha/yr respectively. It indicates that the Kuhan catchment is more degraded than the Bhodi-Suan catchment. These results are comparable to observed silt loss studies done in similar catchments in Palampur district of Himachal Pradesh. The estimated annual sediment yields from the micro-catchments are below the national average of 16.4 t/ha/yr. However, the estimated silt yields from both the catchments, particularly Kuhan catchment exceed the values for tolerable erosion for soils according to the soil depth condition. The baseline data gives useful insights in to the status of the two catchment areas and has been shared with the concerned communities for planning of catchment area treatment measures to be undertaken in future. Negotiations have been initiated between the upstream and downstream communities of the micro-catchments for developing IBM for watershed protection services and improved livelihoods.

Introduction

Accelerated soil erosion and consequently, the sediment outflow from agricultural lands is a serious global problem. The sediment, which is the byproduct of soil erosion, may find its way to the stream outlet as suspended material along with runoff called suspended sediment load or may move by rolling over the land surface as bed load. These sediments not only lead to the reduction in storage capacity of the downstream reservoirs but also result into uneconomic returns from the upstream agricultural lands due to poor yields. Ever since independence, India's planners and policy makers have shown concern for efficient use of land, water and other natural resources for accelerated and sustainable development. Various approaches have been advocated and experimented to halt the process of degradation of natural resources. Community based watershed management has been considered as the most appropriate approach to

reduce the scale of degradation and accelerate the process of development and conservation of land, water and vegetation in an integrated manner. Here, participatory hydrological studies can prove to be a very effective tool for promoting incentive-based mechanisms (IBM) for watershed protection services and improved livelihoods. It can mobilize the concerned communities to undertake catchment area treatments for ensuring sustainable flow of benefits.

Keeping the above in view, the Peoples' Science Institute (PSI), Dehradun and Winrock International India (WII), Gurgaon jointly initiated participatory hydrological studies in two micro-catchments of Himachal Pradesh from August 2005 to July 2006. Low cost hydrological monitoring stations and systems were established in both the catchments with the help of the watershed communities. The data collected has been further analysed for generating baseline information on rainfall, stream flow, sediment yield, and stream water and sediment quality. The present paper discusses the baseline data giving useful insights in to the status of the two catchment areas. Negotiations have been further initiated on the basis of the data collected between the upstream and downstream communities of the micro-catchments for developing IBM for watershed protection services and improved livelihoods.

Study Area

The two action learning sites i.e., the Kuhan and Bhodi-Suan watersheds lie in the Changer region of Kangra district of Himachal Pradesh (Fig.1).

The catchment areas of Bhodi-Suan and Kuhan watersheds at the selected cross-sections for stream gauging are 406 ha and 209 ha respectively. The average slopes of Bhodi-Suan and Kuhan watersheds are 14 and 9 per cent respectively.

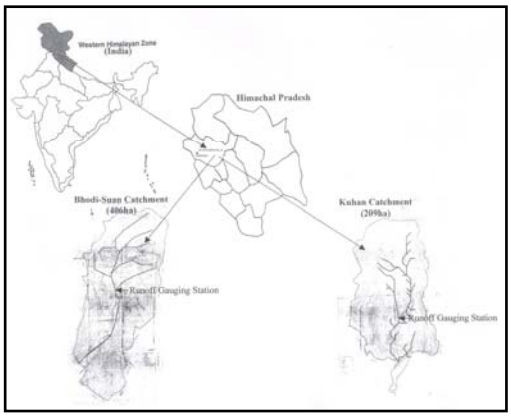

Fig.1. Location map of Bhodi-Suan and Kuhan micro-catchments

Methodology

A reconnaissance survey was undertaken in both the catchments to establish the hydrological monitoring stations and systems with the help of concerned Village Development Committees (VDCs).

a) Rainfall Measurement

One set of non-recording (Symon's) raingauge and recording (Siphon type) raingauge was established in the roof of two houses in the middle reach of the concerned catchments, after consulting the villagers. The rain gauges were installed in Suan and Oach-Kalan villages of Bhodi-Suan and Kuhan catchments respectively. The house owners were made responsible for collection of daily data from these instruments. They were given demonstration for the above purpose and also made to do the same on their own.

The recorded daily rainfall data was further analyzed to determine the monthly rainfall (in mm) of both the catchments. Similarly, the daily rainfall charts from recording rain gauges were analyzed in order to develop hyetographs and calculating rainfall intensities.

b) Stream Gauging

One manual stream gauging station was established in both the catchments. The villagers were consulted regarding minimum and maximum depth of flow in the concerned streams. In Bhodi-Suan catchment, a stable natural cross section was selected in village Suan having rocky stream banks and bed while in Kuhan catchment, the spillway of an existing cement concrete dam located in village Kuhan-Khas was selected for the stream gauging. A scale was marked on both the cross sections with the help of colour paint.

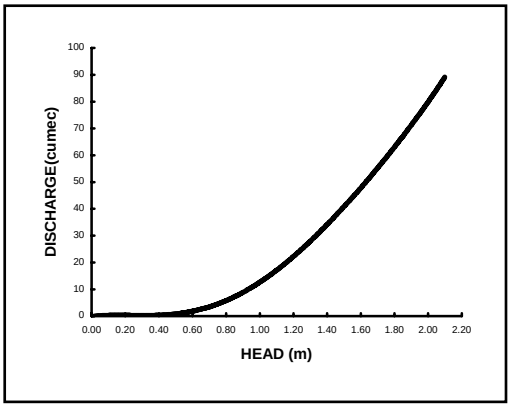

Fig.2. Stage-discharge curve for selected cross-section of runoff gauging station in Bhodi-Suan catchment

A person from both the villages was selected for measuring the depth of water in the section on a daily basis throughout the year. The depth of water in the section was measured once in daytime. In addition, the rise and fall of different flood events especially during the monsoon season were also supposed to be recorded. Rating curves (stage-discharge relationship) for both the streams were developed on the basis of stream cross-sections (Figures 2 and 3).

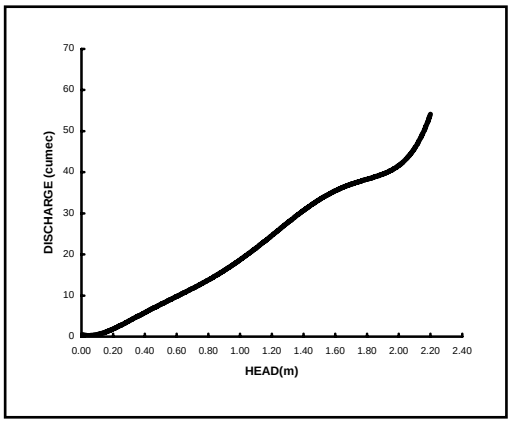

Fig.3. Stage-discharge curve for selected cross-section of runoff gauging station in Kuhan catchment

c) Silt Measurement

For suspended silt load measurement in Bhodi-Suan catchment, the cross-section used for stream gauging was also selected for collection of silt samples. In Kuhan catchment since lot of silt had already been deposited in the upstream of the check dam site, another site about 250 m upstream of the stream-gauging site was selected for silt measurement. One water sample was collected in 650 ml capacity bottle on a daily basis. These samples were further filtered with the help of Whatman filter paper (No.1). The collected water samples were further analyzed to determine the suspended sediment yield for both the silt monitoring stations. The weight of suspended sediment (gm/day) for a particular cross-section was then determined by using the following formulae:

Weight of suspended sediment in 650 ml of water (W_3) = (W_2 - W_1) where,

W_1 = Weight of oven dried filter paper in gm (without sediment)

W_2 = Weight of oven dried filter paper in gm (without sediment)

Therefore, Suspended sediment yield (gm/day) = [W_3 x 1000/650] x Runoff (litre/day)

Results and Discussions

a) Rainfall Data

The daily maximum and minimum rainfall recorded for the Bhodi-Suan catchment is 217 mm and 0.4 mm respectively for the period August 2005 – July 2006. Similarly, the daily maximum and minimum rainfall for the Kuhan catchment is 176.2 mm and 1 mm respectively during the reporting period. No rainfall was recorded in both the catchments for the months of November and December 2005. The Kuhan catchment received no rainfall in the month of February 2006. Monthly rainfall distribution of Bhodi-Suan and Kuhan Catchments for August 2005 – July 2006 is shown in Fig.4.

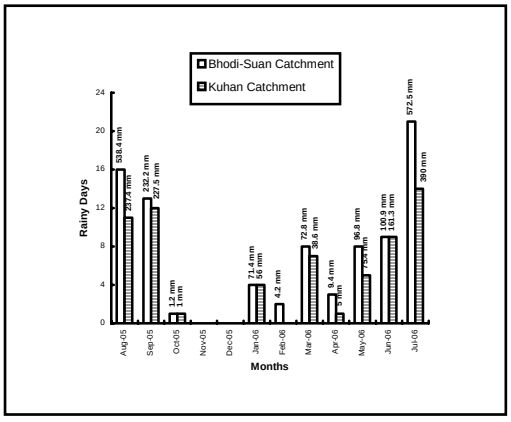

Fig.4. Monthly rainfall distribution

In Bhodi-Suan catchment, the total rainfall recorded was 1700 mm in 85 rainy days for the period of August 2005 – July 2006 whereas Kuhan catchment received less amount of rainfall i.e., 1192 mm in 64 rainy days.

Hyetographs were generated from rainfall charts. Fig.5 shows a representative hyetograph of Bhodi-Suan catchment for the storm event of August 31, 2005. From the analysis of daily rainfall charts of August 2005 to July 2006, maximum and minimum rainfall intensity for the Bhodi-Suan Catchment is 85.71 mm/hr and 0.6 mm/hr respectively. Fig.6 shows a representative hyetograph of Kuhan catchment for the storm event of September 12, 2005. The maximum and minimum rainfall intensity recorded for the Kuhan Catchment is 85.71 mm/hr and 1.5 mm/hr respectively during August 2005 to July 2006.

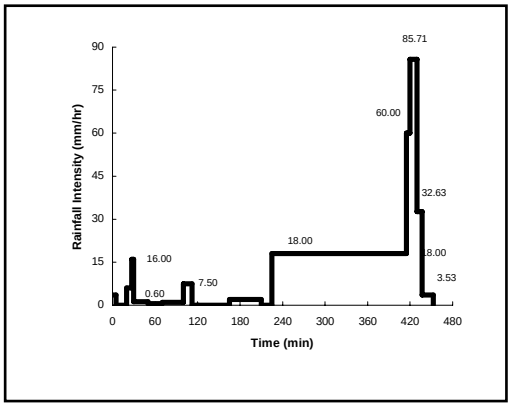

Fig.5. Hyetograph for the storm event of August 31, 2005 in Bhodi-Suan catchment

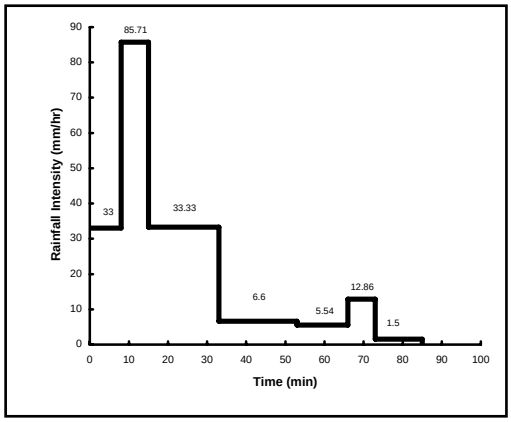

Fig.6. Hyetograph for the storm event of September 12, 2005 in Kuhan catchment

b) Stream Discharge Data

In Bhodi-Suan catchment daily discharge varied from a minimum of 18.90 M Litres/day to a maximum of 301.41 M Litres/day, whereas in Kuhan catchment daily discharge varied from a minimum of 20.14 M Litres/day to a maximum of 576.36 M Litres/day during August 2005 to July 2006.

The base flows at the selected cross-sections of Bhodi-Suan and Kuhan catchments range from a minimum of 0.23 cumecs to a maximum of 0.34 cumecs.

c) Silt Load Data

The monthly variations of Suspended Sediment Yield (SSY) at selected cross-sections in Bhodi-Suan and Kuhan catchments are shown in Fig.7.

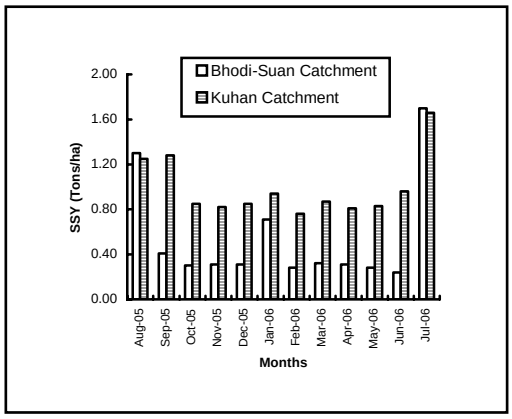

Fig.7. Suspended Sediment Yield at selected cross-sections

The annual suspended sediment yield (from August 2005 to July 2006) was estimated as 6.5 tons/ha/yr and 11.9 tons/ha/yr for Bhodi-Suan and Kuhan catchment respectively. These estimates are less than the actual annual suspended sediment yield, as some of the flood events that occurred during the nights could not be recorded manually. However, the estimates clearly indicate that the Kuhan catchment is more degraded than the Bhodi-Suan's catchment.

The above estimates are comparable to observed silt loss studies (3.6-22.5 t/ha/yr) done in similar catchments in Palampur district of Himachal Pradesh (Negi, 2002).

The estimated annual sediment yields from Bhodi-Suan and Kuhan catchments are below the national average of 16.4 t/ha/yr (Singh et al., 1992). The permissible limit of soil loss ranges from 4.5 to 11.2 t/ha/yr (Mannnering, 1981). Thus, the estimated sediment yield of Bodhi-Suan is within the permissible limit whereas that of Kuhan is slightly higher than the permissible limit. However, the estimated silt yields from both the catchments, particularly Kuhan catchment exceed the values for tolerable erosion for soils according to the soil depth condition (Zacher, 1982).

Conclusions

The hydrological baseline data of Bhodi-Suan and Kuhan catchments has been generated on the basis of measurements done by the watershed communities over a period of one year. Although, the study has its own limitations with regard to time frame and manual errors, it gives useful insights about the status of the two catchment areas. The sediment yield data indicates that Kuhan catchment is in more degraded state than the Bhodi-Suan's catchment.

The baseline data has been shared with the concerned communities for planning catchment area treatment measures (gabions, loose boulder check dams, brush wood check dams, vegetative bunds, trenches, plantation, etc.) to be undertaken in the near future. The watershed communities on a voluntary basis have already initiated construction of brushwood check dams and plantation.

Negotiations have been initiated between the upstream and downstream communities of the micro-catchments for developing IBM for watershed protection services and improved livelihoods. For example, water users of an irrigation dam located in the downstream of Kuhan catchment are now ready to contribute towards the catchment area treatment of the reservoir, in the upper reaches. Similarly, about 12 ha in the upper reaches have been closed for open grazing. In the Bhodi-Suan catchment, communities have initiated forest protection measures. These interventions would not only improve the status of the degraded lands but

would also contribute towards enhancing livelihood opportunities for the upstream communities through increased availability of fodder and fuelwood, and for the downstream communities in terms of increased soil fertility and subsequent agricultural production.

The pilot study demonstrates that participatory hydrological studies can be a very effective tool for promoting incentive-based mechanisms (IBM) for watershed protection services and rural livelihoods. It can mobilize the watershed communities to undertake integrated management of natural resources for ensuring sustainable and equitable flow of benefits.

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