Measurement and distribution of rainfall, runoff and soil losses from the selected watersheds in the Hindu-Kush Himalayan region

S. Zokaib[1], M.Jehangir[1], H. Shah[1]J. Merz[2] and R. White[3]

[1] PARDYP Project, Pakistan Forest Institute, Peshawar, Pakistan; [2] University of Bern, Switzerland; [3] PARDYP/ICIMOD; E-mail: suhailzokaib@yahoo.com

Abstract

Population pressure and climate change effect water and erosion related issues of the Hindu Kush-Himalayan region. Presently problems in terms of water are mainly concerned with quantity. "Too much" during rainy season and "Too little" during the dry period of the year are the basic problems. With increasing population and intensifying agriculture there is no relief on the water resources in sight. In many places of the region depletion of ground water and drying up of springs is taking place. During monsoon however vast amounts of water are leaving the upland watersheds as surface runoff, causing erosion on the slopes, sedimentation and flood problems further downstream.

For this purpose runoff and sediment losses were monitored on erosion plots on different land uses i.e. degraded, pasture, forest and agriculture land. Total annual rainfall in the region ranges between 972 mm to 2400 mm. On the basis of quarterly distribution of rainfall, about 44 to 66% rainfall occurs in quarter 3, which prolongs from June to August, which is mostly monsoon season in the region. In general about 60 % of the annual rainfall occurs in the monsoon season. Results show that runoff and soil losses were higher in the months of May to September, when rainfall duration and intensity were higher in all the watersheds. There were some big events which contribute most of annual runoff and soil loss in the area. Highest runoff was recorded from degraded land uses. Most of the runoff in all watersheds occurred in 2nd and 3rd quarter. In JK (92 to 96%), in HK (75 to 90 %), in BG (83 to 94%) and in XI (87 to 90 %) runoff was recorded in 2nd and 3rd quarter. Soil loss from JK was recorded highest in most of the land uses while it was very low in HK and BG watersheds. Soil loss in April to September was higher in almost all watersheds. In JK watershed (95 to 99%), in HK (80 to 90%), in BG (83 to 96%), in Xi (90%) of soil loss occurred in 2nd and 3rd quarter of the year in all land uses.

Keywords: Runoff, Soil loss, watershed and Hindu-Kush Himalaya

Introduction

The Himalayas are the greatest of all mountains and its eco-system is one of the most important and most threatened of life support systems on earth. The rivers, which arise in the Himalayan, flow down to the plains and support essential agriculture which sustain the people in recent years. The watersheds in the Himalayan eco-system are being widely devastated. The poorly managed human activities in the terrain are causing accelerated erosion. The Hindu-Kush Himalayan region (HKH) extends across the boundaries of eight countries. Bhutan and Nepal are predominantly mountainous. The others, Afghanistan, Bangladesh, China, India, Myanmar and Pakistan are covered by mountains to varying degrees. The HKH is the source of the six mighty rivers of Asia i.e. the Indus, Ganges, Bramaputra, Mekong, Yangtze and Yellow rivers. The southern and western parts are relatively drier with some precipitation during winter (Merz, 2000).During monsoon however vast amounts of water are leaving the upland watersheds as surface runoff, causing erosion on the slopes, sedimentation and flood problems further downstream. (Bruijnzeel and Bremmer, 1989).

The HKH region is the area in which the International Centre for Integrated Mountain Development (ICIMOD) has a mandate. The Centre has assembled some background information about the major characteristics of this region.

This paper discusses the findings of runoff and soil loss studies from the four watersheds located in China, India, Nepal and Pakistan. It focuses on the key factors that have impact on runoff and soil loss in different watersheds.

Methodology

PARDYP monitoring network and data collection

The People and Resource Dynamics in Mountain Watersheds of the HKH (PARDYP) project are conducting research activities in five watersheds of four countries of HKH region. These watersheds are Xi Zhuang watershed (XI) in China, the Bhetagad watershed (BG) in India, the Yarsha Khola watershed (YK) and Jhikhu Khola watershed (JK) in Nepal and the Hilkot watershed (HK) in Pakistan.

Rainfall Monitoring

In all the watersheds rain is measured by using automatic rain gauge (tipping bucket). The rain gauges are installed close to each erosion plot. Data from the loggers attached to the tipping bucket are downloaded once a month by using the Box Car programmes.

Runoff and erosion measurements

Surface runoff and soil losses were recorded at erosion plots on different land uses in all watersheds. Galvanized metal sheets were installed along the line with 15cm kept inside the ground and 30 cm sticks out. The forth side (lower end of plot) is left open for the gutter that diverts runoff water and sediment into collection system .The gutter is metallic and 5 cm long converting the plot width. Rain water runs off the plot and accumulates into the gutter, which streamlines the flow into the first drum. After each rainfall event, depth of water in each drum was recorded and samples from each drum were taken.

Samples were processed in the field laboratory in the following manner. Almost similar procedure is adopted in all the watersheds with little differences according to their requirements.

Results

Annual Rainfall and Distribution

Annual rainfall in the region ranges between 972 mm to 2048 mm. The annual trend shows that XI receives higher rainfall as compare to other watersheds and rainfall at Hilkot watershed is lower. Maximum annual rainfall was recorded in BG watershed i.e. 2048 mm in 2000 while Hilkot receives minimum i.e. 972 mm in 2001. Average annual rainfall in all watersheds was 1338, 1078, 1382 and 1550 mm in JK, HK, BG and XI watershed respectively.

On the basis of quarterly distribution of rainfall it is obvious from the Figures 2 below that about 44 to 66% rainfall occurs in quarter 3, which prolongs from June to August and is mostly monsoon season in the region. Quarter 2 also receives some rainfall. About 22 to 30 % of rainfall occurs in this quarter which is from April to June. While 1st and 4th quarter remains dry in most of the region. Only in HK watershed winter receives some rainfall. Distribution shows that JK receive almost all rainfall in April to September while winter rains are almost negligible. While HK watershed receives rainfall throughout the year i.e. evenly distributed rainfall.

Watersheds	**1999**	**2000**	**2001**	**2002**	**Average**
JK	1419	1167	1110	1656	1338
HK	1324	1001	972	1017	1078
BG	1011	2048	1147	1084	1322
XI	1254	1689	1706	NA	1550

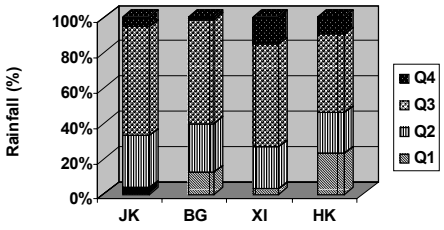

Figure 1: Annual rainfall and its quarterly distribution in all watersheds

Runoff

Distribution of Runoff

High intensity monsoon rainfall causes the major portion of annual runoff on all land uses in all watersheds. Figure 2 shows that in JK 92 to 96 % runoff in all land uses occurred in 2nd and 3rd quarter of the year i.e. April to September (which covers whole monsoon period in all watersheds) while runoff in first quarter of the year i.e. Jan to March is almost 0 in all land uses and in the forth quarter i.e. November to December little runoff was measured. Similarly in HK watershed total

annual runoff contribution from 2nd and 3rd quarter was very high about 75 to 90 % of runoff was recorded in these months from all land uses. Rainfall distribution and intensity in the watershed varies throughout the year. In the first quarter about 12 to 17 % of total annual runoff was measured from different land uses but in 4th quarter it was comparatively less i.e. 6-7% from Oct to November when very low amounts of rain occurred. BG watershed also produced most of the runoff i.e. 83 to 94 % in 2nd and 3rd quarter from all land uses. Runoff in first quarter was comparatively low except for the degraded plots where in early quarter 15% of total runoff was recorded. Run off in last quarter is 0 from all land uses. In XI watershed 87 to 90 % runoff was recorded in 2nd and 3rd quarter while runoff in 4th quarter was 9 to 10 % in all land uses while runoff in 1st quarter i.e. Jan to March was zero in all land uses.

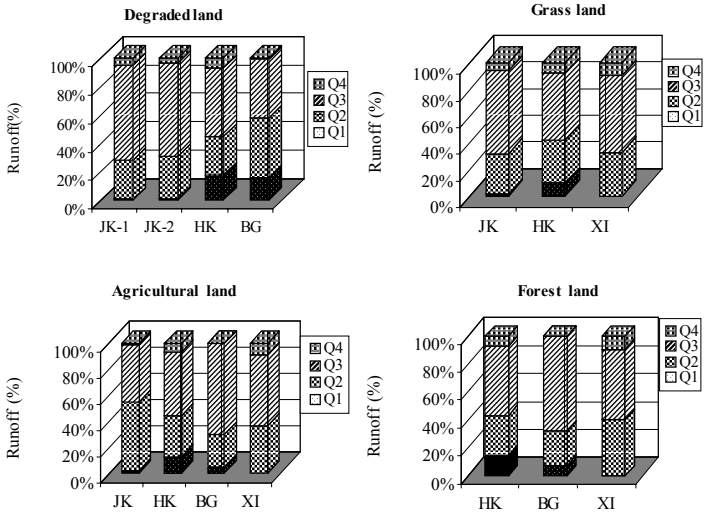

Figure 2: Quarterly distribution of runoff from all watersheds

Soil Loss

Distribution of Soil Loss

Areas within the monsoon region have the most of rainfall from June to September. Rainfall in this season is of high intensity causing sudden runoff and soil loss. All the plots show their highest soil losses in 2nd and 3rd quarter of the year i.e. April to September.

Figure 3 shows that in JK watersheds 95 to 99% of soil loss occurred in these two quarters on all land uses and soil loss on rest of year were negligible because of the little rainfall. While in HK 80 to 90% of soil loss was recorded in these two quarters on all land uses soil loss in first quarter i.e. Jan to March was comparatively very low because rainfall amount and intensity during that period was comparatively low while in 4th quarter of the year i.e. October to December soil loss in negligible on all land uses. In BG watershed soil loss shows the same trend as other watersheds contributing most of annual soil loss in April to September. About 83 to 96% of total soil loss was recorded in these two quarters. In first quarter soil loss was very low while in last quarter soil loss was negligible due to less rainfall in the region. XI watershed shows the same trend of total soil loss contribution. Almost 90% of soil loss occurred in 2nd and 3rd quarter of the year in all land uses. Soil loss in 4th quarter of the year was low i.e. 9% of the total annual. While soil loss in 1st quarter was zero on all land uses.

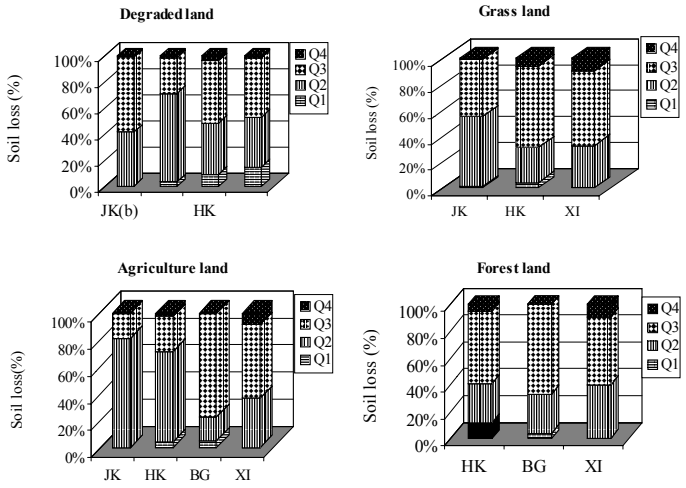

Figure 3: Quarterly distribution of soil loss from different land uses

Conclusions and Recommendations

1. For every land use two erosion plots i.e. treated and controlled should be established to compare the results of interventions.
2. Soil loss is less in forest and agriculture area due to vegetation, yields less runoff than bare ground, so vegetation should be improved.
3. Runoff and soil losses were low in agricultural field due to well maintained terraces.
4. More water is lost as runoff during monsoon therefore water harvesting technologies can be useful for utilization of excess water in dry periods.
5. Modern water management techniques should be introduced to get maximum advantage of present water resources in the watersheds.

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List of Abbreviations used

HK:	Hilkot Watershed, Pakistan	Q1: Quarter 1 (January to March)
JK:	Jhikhu Khola Watershed, Nepal	Q2: Quarter 2 (April to June)
YK:	Yarsa Khola Watershed, Nepal	Q3: Quarter 3 (July to September)
BG:	Bhetagad Watershed, India	Q4: Quarter 4 (October to December)
XI:	Xizhaung Watershed, China	t/ha: ton/hectare