Watershed Management Hydrological Findings:

Collaboration between PARDYP and the University of Berne, Switzerland

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PARDYP Nepal

Water shortage for domestic purposes is a pressing problem in PARDYP catchments

The Geographical Institute of the University of Berne (UoB) has been involved in projects in the Himalayas for several decades. This work resulted in key publications such as *The Himalayan Dilemma: Reconciling Development and Conservation* by Ives and Messerli (1989) and *Himalayan Environment: Pressure, Problems, Processes - 12 Years of Research* by Messerli et al. (1993).

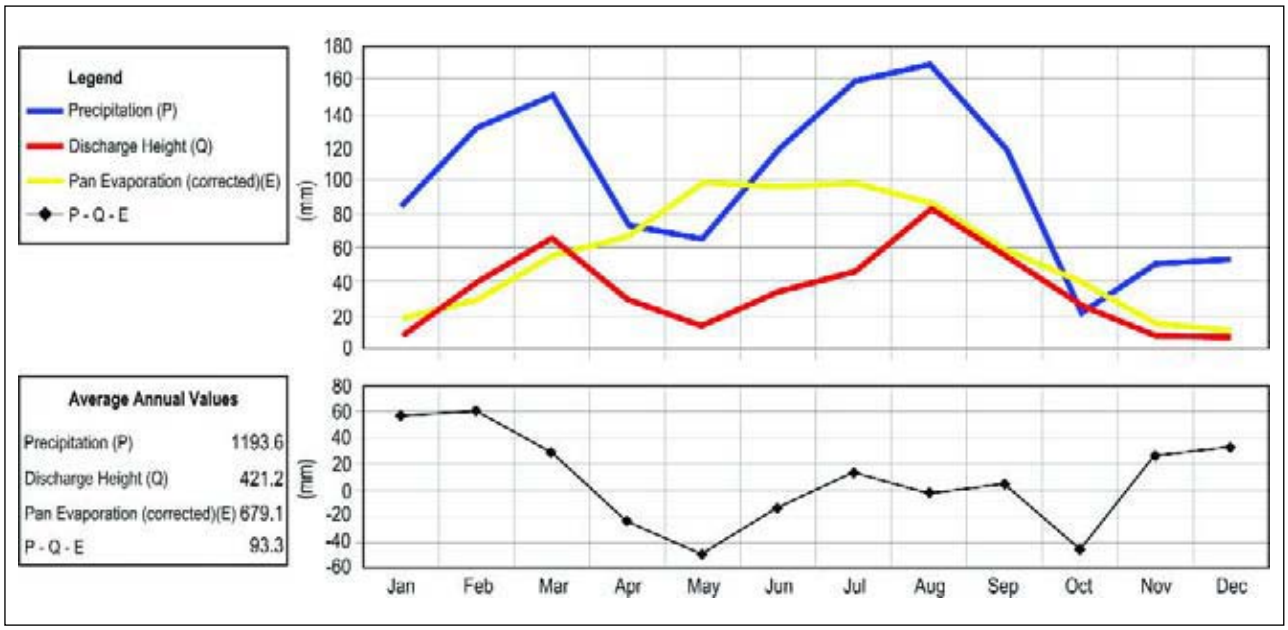
This experience led to the Institute's Hydrology Group being assigned a backstopping role (choice of test areas, supply and installation of measuring instruments, training and monitoring scientific personnel) in PARDYP in 1996. Selected research contributions of the UoB are described briefly in this article.

Planning the measuring network

In order to achieve the interdisciplinary aims of PARDYP new test areas were set up in Nepal, India, Pakistan, and China (Weingartner and Hofer 1996). They were modelled on the Yarsha Khola sample test area in Nepal and the same instruments were installed in the new areas (Doppmann 1996). A summary of this first phase can be found in Hofer (1998) 'Hydrometeorological Measurements and Analysis in Interdisciplinary Watershed Projects'.

Geomorphological investigations, Yarsha Khola

Two important questions during the first phase concerned flood discharge and soil erosion. The work carried out by Tschanz (2002) focused on mapping the activity and intensity of geomorphological processes (fluvial processes, movement of masses, surface processes) in Yarsha Khola. Information on the impact of these processes was collected and possible preventative measures were devised. Tshanz observed that around three-quarters of the surface of the test



Souce: Haenggi 2005

Monthly water balances (2000–2004)

area could be considered unstable from a geomorphological point of view.

Voegeli (2002) looked at micro-scale erosion processes on steep and intensively-cultivated rainfed terraces ('bari') in Jhikhu Khola catchment. Surface degradation was determined in 18 test zones of 1 m^2. The results indicated highly dynamic soil erosion: 60-90% of the total soil degradation occurred during the one or two heaviest rainstorms.

It was possible to show that vegetation cover was a key factor in relation to soil degradation: if a second crop is planted before the start of the monsoon, soil degradation is reduced considerably.

Hydrometeorological analysis of Hilkot catchment, Pakistan

In Pakistan, Haenggi (2005) carried out a comprehensive analysis of the hydrometeorological data of Hilkot watershed. Snowfall, remaining snow cover, and ablation were also examined to obtain a spatially and temporally high-resolution water balance. Haenggi developed a simple model based on temperature and precipitation. Direct measurements (class A-pan) and indirect values (after Penman and Haude) were used to determine evaporation. Using hydraulic calculations (Strickler-Manning) new values were added to the gauge height-discharge ratio. Special attention was given to analysing the low precipitation and low water conditions in Hilkot watershed.

The particular characteristic of Haenggi's study is that all calculations in the digital version (estimated snowfall, actual evaporation, hydraulic calculation of the P-Q ratio, analysis of low precipitation) can be reproduced, enabling similar analyses to be carried out in other catchments.

Assessing and improving the quality of drinking water in Jhikhu Khola watershed, Nepal

During the PARDYP project, the focus shifted from floods and erosion to resources, an issue which was seen from the intermediate results obtained to be far more urgent.

Schaffner (2002) examined the quality of drinking water in the Jhikhu Khola catchment to find ways of improving the situation. The results obtained underlined the enormous problems of microbiological quality of the water: *E.coli* was found in all the water collection systems examined (public water sources, wells, rainwater harvesting jars) during the dry season and monsoon, the highest concentrations being observed just before the onset of the monsoon. According to WHO guidelines, the health risk in many water collectors is high to extremely high. Schaffner showed that using the WHO sanitary inspection method (checklist), a detailed picture of water quality in a collector can be obtained without carrying out complicated and expensive tests.

Water balance, floods, and transport of sediments in the Hindu Kush-Himalayas

Merz's thesis (2003) provides a detailed quantitative and representative insight into water

problems in the Hindu Kush-Himalayas. As far as water is concerned, this study can be seen as a summary report for PARDYP. The first two chapters provide an excellent overview of the region and the areas used for PARDYP'S investigations, including information about the availability of water, flood risks, and soil degradation. The hydrological data are analysed, compared, and interpreted (e.g., precipitation, evaporation, discharge, mobilisation, and sediment transport) in Chapter 3. River bank erosion turned out to be a more important source of sediment than was previously thought. Using three hydrological models (UBC, Tank, PREVAH) Merz reports on the hydrological impact of possible future scenarios in Chapter 4. Due to problems encountered in choosing parameters for the models (too little high resolution climatic data, lack of data on vegetation), Merz could only make generalised predictions about possible developments. The various model runs indicate that discharge during the dry season is likely to decrease while floods during the monsoon will probably become more frequent. The summary includes indices (water poverty index [WPI], flood generation index [FGI], water-induced degradation index [WDI]) for the different PARDYP test areas, either further developed or newly devised by Merz) and these are also compared. The last chapter provides answers to three essential questions about water.

Priority	Hilkot	Bhetagad	Jhikhu	Yarsha	Xizhuang
1	Water shortage for irrigation	Depletion of water resources	Irrigation water shortage	Irrigation water shortage	Water shortage during dry seasion
2	Water manage-ment	Inappropriate management of water resources	Drinking water shortage	Drinking water shortage	Too much water during wet season
3	Poor water quality and quantity for drinking	Solid and nutrient losses	Deterio-rating water quality		Drinking water shortage
4			Water pollution	Top soil loss and nutrient build-up	

Source: Merz (2003)

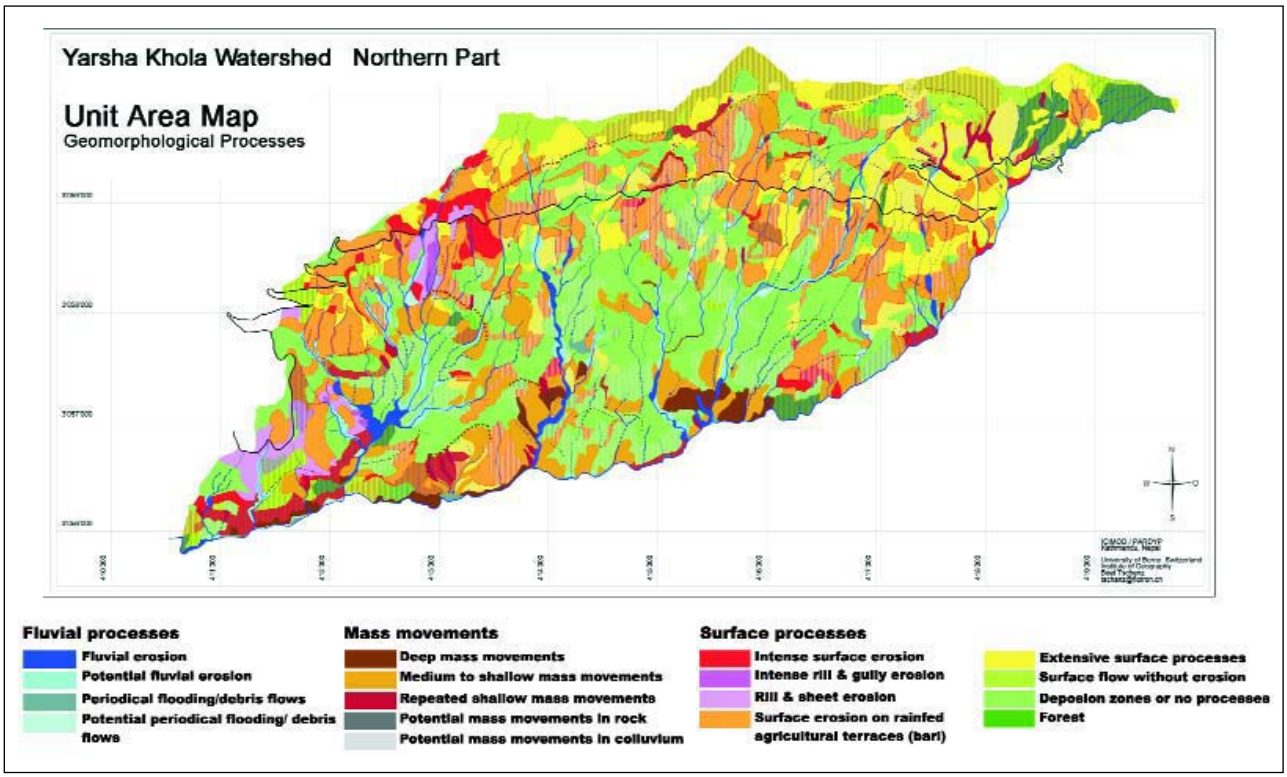
Key water-related issues (catchment scale), PARDYP

1. *Is there a water shortage today in Jhikhu Khola and/or Yarsha Khola?*
   Analyses show that there is sufficient water if resources are used economically. Optimum water management requires introduction of additional irrigation methods for the dry season (drip irrigation) and efficient water harvesting.

2. *Do agricultural activities in the upper areas of the catchment accentuate and accelerate the build-up*

PARDYP Nepal

Water-related issues become a major concern in middle mountains, here the Daphne Khola, Kabhre District (Nepal)



Merz 2003: (modified from Tschanz, 2002)

Geomorphological processes on the south-facing slope of the Yarsha Khola catchment

of flood water and does this lead to a more critical situation in the lower areas?

From a hydrological perspective, the way the land is cultivated at present (wet fields, terracing) is good because it reduces medium and minor floods. The impact of cultivation is less important in relation to massive floods because of the intensity and/or volume of precipitation. Water management is extremely important in relation to this issue.

3. *Is loss of soil through erosion a major problem?*
From the results of the study, soil erosion appears to be only a minor problem. The high sediment loads observed in the receiving water are not due to widespread erosion. The main sources of sediment are river-bank erosion, poor road construction, and degraded surfaces, although the latter represent only a small part of the total area. Good management can reduce the sediment load, including protection of river banks, appropriate road construction, and reconstruction of degraded areas.

Overall, it would appear the way the land is used at present helps stabilise the hydrological system in the area. A decisive factor for future development will be whether an efficient management system is established at various levels.

Publications in international journals

Numerous articles have been published in scientific journals in recent years as a result of close collaboration between the UoB and PARDYP. In this context, three papers presenting the results of the water and supply surveys which have been conducted in some of the PARDYP catchments (Merz et al. 2003a, 2003b, 2004) have documented the significance of socioeconomic aspects within hydrological investigations. These publications have been trend-setting for the hydrological activities in the following years.

The two most recent articles published in international journals are described below.

Road construction impacts on stream suspended sediment loads

In this report, Merz et al. (2006a) describe the considerable impact of road construction on sediment loads. In the case studied, the annual volume of sediment rose by 300-500% despite measures taken along the new road to reduce erosion. This rise, it can be assumed, is far higher in the case of road construction projects where no such measures are taken.

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Rainfall amount and intensity in a rural catchment

In the *Journal of Hydrological Sciences*, vol. 51 (2006b) Merz et al. present the results of precipitation measurements in the Jhikhu Khola watershed using intensity-duration-frequency curves with various return periods. The heaviest rainfall, which occurs immediately before and at the start of the monsoon, can reach an intensity of 79.2 mm/h over 30 minutes (return period 20 years).

Reflections

For the University of Berne, collaboration with PARDYP was fruitful and successful from various perspectives. Many studies were carried out by students to the advantage of both parties. The concept of back-stopping should be applied in future projects, in the interests of local institutions. From the perspective of the external institution, better integration with ICIMOD is desirable and would bring about a win-win situation. One problem encountered was that certain projects partners were unwilling to exchange scientific data. An interdisciplinary project such as PARDYP is after all based on communication and open data management, which is the only way to ensure that all parties involved gain the maximum benefits possible.

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Information on the studies mentioned in this article is available on request from Professor Weingartner (wein@giub.unibe.ch) at the University of Berne.