Water and Erosion Studies of PARDYP NEPAL

WATER DEMAND AND SUPPLY SURVEY

People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas

IDRC
CANADA

ICIMOD

about ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) is an international organisation devoted to development of the Hindu Kush-Himalayan region covering all or parts of eight sovereign states. Afghanistan  , Bangladesh , Bhutan , China , India , Myanmar , Nepal , and Pakistan . The Centre is located in Kathmandu, Nepal. The primary objective of the Centre is to promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations.

Water and Erosion Studies of PARDYP Nepal

The Water Demand and Supply Survey

Prepared by
Juerg Merz, Gopal Nakarmi, Smita Shrestha,
Bhuban Shrestha, Pravakar B. Shah, and Rolf Weingartner
together with the University of Bern and ICIMOD

December 2002

People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas
International Centre for Integrated Mountain Development

Kathmandu, Nepal

ISBN: 92 9115 667 1

Editorial Team
A. Beatrice Murray (Editor)
Sushil Man Joshi (Layout and Design)

Published by
International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal

Printed in Nepal

FOREWORD

Water is crucial for sustaining life. In the middle mountains of the Hindu Kush-Himalayas water is often in short supply during the winter months and in excess during the monsoon.

The Water Demand and Supply Survey carried out in the Jhikhu Khola and Yarsha Khola watersheds provides insights into community management issues of an increasingly scarce and increasingly polluted resource. In terms of water, the survey area is typical of much of the middle mountains of Nepal and reflects issues and problems faced by thousands of families.

Improved water supply management is crucial, particularly in the context of expanding population and increasing per capita consumption. But proper management means first knowing about needs and farmers' priorities and strategies. We can learn much by understanding how families cope with current shortages, and how they respond to increasing shortages. Equally demand management is important, as agriculture intensifies so demand for water increases. At the same time water quality is becoming an issue, both in terms of microbiological contamination and pollution from ever increasing use of agro-chemicals.

This survey clearly shows trends in water use patterns and how changing scenarios will impact on water availability; it will be used to link hydrology, climate, and land use in an attempt to further understand these complex interactions and processes. Similar surveys have been conducted in the PARDYP watersheds in China, India, and Pakistan, and these will allow a comparison of water issues throughout the middle mountains of the Hindu Kush-Himalayas.

Roger White
Regional Coordinator
PARDYP/ICIMOD

ACKNOWLEDGEMENTS

We would like to thank the Swiss Agency for Development and Cooperation (SDC), the International Development Research Centre (IDRC), and the International Centre for Integrated Mountain Development (ICIMOD) for their financial support of the PARDYP project. Furthermore, without the support of the PARDYP Nepal team, Pradeep M. Dangol, Madhav P. Dhakal, Bhawani S. Dongol, and Bandana Prajapati-Merz this document would not have been possible. The authors would also like to thank Roger White, Regional Coordinator of PARDYP, for his support and encouragement. The local enumerator's efforts to obtain accurate and good information is highly appreciated. Last but not least, the authors would like to thank the respondents of the two surveys for their help and ready cooperation; each of them spent two hours or more answering the questions and providing information.

SUMMARY

Water remains one of the major issues in the middle mountains of the Hindu Kush-Himalayas as in this region people depend to a large extent on rainwater for their supply, and rainfall is highly seasonal. In Nepal, the middle mountain area is the most populated region. Around 85% of the annual rainfall is expected during the monsoon season, which lasts for about four months from June to September, and the major concern at this time is flooding and surface erosion. During the remaining eight months people are consistently faced with problems of water shortage for both domestic and agricultural purposes.

This publication describes the results of a detailed survey of the water demand and supply situation in two watersheds in the middle mountains of Nepal. The survey was designed to discover people's perceptions, requirements, and priorities, as well as to look at the existing situation. The survey revealed the most critical sites within the watersheds and the major concerns of the local residents. The comparison between the two watersheds is particularly interesting in view of their position in relation to Kathmandu, a major market opportunity for vegetable farmers.

Various field programmes were initiated by the People and Resource Dynamics of Mountain Watersheds in the Hindu Kush-Himalayas (PARDYP) project in response to the survey results. These include a closer investigation of water quality aspects of public water sources with the aim of identifying, testing, and recommending simple methods to assess water quality; a training course on roof water harvesting in collaboration with other projects; and implementation of test and demonstration sites for surface runoff harvesting and alternative irrigation methods within the watersheds.

The main results are summarised in this brochure, details and illustrations are provided on the enclosed CD-ROM.

ACRONYMS AND ABBREVIATIONS

FAO	Food and Agriculture Organization (United Nations)
HKH	Hindu Kush-Himalayas
IDRC	International Development Research Centre (Canada)
ICIMOD	International Centre for Integrated Mountain Development
PARDYP	People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas project
RRA	rapid rural appraisal
RWSSSP	Rural Water Supply and Sanitation Support Project
SDC	Swiss Agency for Development and Cooperation
VDC	village development committee

GLOSSARY

bari	rainfed agricultural land
chauri	cross-breed between yak and zebu cattle
gagri	local water vessel
khet	irrigated agricultural land

ABOUT THE CD-ROM

The enclosed Water Demand and Supply CD-ROM is an integral part of this publication. It contains the detailed results and information from the surveys together with additional background information and photographs illustrating the issues.

The CD-ROM is divided into the following sections.

- **Introduction** – provides a background to the research work conducted under PARDYP across the region and introduces the collaborators and supporters of the project
- **Methodology** – provides an insight into the methodology of the survey including a discussion of georeferencing with the help of orthophotos, and the full questionnaires in Nepali and English
- **Yarsha Khola watershed** –provides the results from the survey in the Yarsha Khola watershed including a report in *.doc format
- **Jhikhu Khola watershed** – provides the results from the survey in the Jhikhu Khola watershed
- **Comparison** – the two watersheds are compared in terms of agricultural water use, domestic water use, and other aspects
- **Follow-up** – the proposed follow-up is discussed with a few slides
- **Conclusion**
- **Databases** – all the data from the survey is included in the form of an MSAccess database and shape files

Minimum Requirements

Windows 95 or higher, Pentium 90MHz processor or higher, 16MB RAM, 190 MB free hard disk space (for typical installation), 4 speed CD-ROM drive, SVGA monitor with thousands of colours at 800x600 resolution, sound card and speakers.

How to install the CD-ROM

Set the display to at least 800x600 (small fonts) and high colour (16 bit) (minimum). At this resolution the programme takes up the entire screen. If your display is set to less than 800x600 you will not be able to view the hypermedia document properly. To install, insert the CD-ROM in your CD-ROM drive. Using Windows Explorer, select the drive that corresponds to your CD-ROM drive. In the root directory find the file SETUP.EXE and double-click it. Follow the on-screen instructions. You have two setup options: Typical and Custom. Typical installs all the files onto your hard drive, it runs much faster but requires approximately 190 MB of free space (CD-ROM no longer required to run the programme); Custom allows the user to leave the application files on the CD and only requires 25 MB of free space. To run other programmes at the same time, press CRTL+ESC.

How to navigate in the CD-ROM

All pages of the CD-ROM can be accessed through mouse clicks. Different buttons perform different actions (Figure).

Screen capture of the enclosed CD-ROM

Quit	QUIT	closes the programme and leaves the CD-ROM
Main	MAIN	returns to the main page from which all other pages are directly accessible
Sub	SUB	returns to the sub page from which all pages of this section are accessible
◄	back	moves one page back
►	forward	moves one page forward

Hyperlinks (e.g. BACK TO METHODS) perform specific actions as described on the link. The same is true for normal buttons.

NOTE: the use of data from this CD-ROM must be acknowledged in any publication and one copy of the publication sent to:

Country Coordinator
PARDYP/ICIMOD
PO Box 3226
Kathmandu
NEPAL

CONTENTS

THE WATER DEMAND AND SUPPLY SURVEY

Introduction

Water security for the entire global population is one of the major challenges for the 21st century. Even in areas that are primarily known for flooding and erosion, water scarcity is becoming a problem. In many parts of the Hindu Kush-Himalayas (HKH), both water quantity and water quality issues are of increasing concern. The pressure on water resources is increasing as the population grows and needs more water for both household and agricultural use. Rising temperatures and more extreme events due to climate change might also add to the pressure on water resources in the future, although the pressure might be reduced if there is increased precipitation and sound management systems are employed (FAO 1995). Water quality from the micro to meso watershed scale is being reduced as a result of the impact of more intensive farming with increased use of chemical fertilisers and pesticides. The influence on big river systems in the region is not yet well understood, but the problems in local watersheds are already clear: the great majority of the population are dependent on agriculture but as productivity is raised local water sources are more likely to become polluted, and local sources are the only means of getting water.

The People and Resource Dynamics of Mountain Watersheds in the Hindu Kush-Himalayas Project (PARDYP) is a regional 'research for development' project active in watershed and natural resources management in five pilot watersheds in China, India, Nepal and Pakistan. Aware that water is likely to be one of the major issues in the future, PARDYP started a comprehensive assessment of water resources. PARDYP Nepal is focusing on the Jhikhu Khola and Yarsha Khola middle mountains watersheds for its activities. In these watersheds, interlinked approaches were used to obtain a comprehensive view of water related issues. They included

- **a household survey of the present water demand and supply situation** – the survey focused on the constraints and issues related to water as perceived by the local residents;
- **a survey of public water sources in the watersheds** – with the support of the local authorities, a selected number of springs, taps, and wells was mapped and physical parameters were measured; the local residents selected the locations to be monitored, and the field staff responsible for the mapping added some locations of special interest;
- **regular monitoring of meteorological and hydrological parameters** – a measurement network of hydrological and meteorological stations is regularly monitored in the watershed, the monitoring network is described briefly in Merz et al. (in press). The data is currently being analysed according to different aspects. All data is available in the form of a yearbook for each watershed (PARDYP 2002a; PARDYP 2002b).

The overall aim of these activities is to contribute towards a balanced, sustainable, and equitable development of mountain communities and families in the Hindu Kush-Himalayan region, the aim of the PARDYP project. The water-related activities focus on the generation

and exchange of information on water as a resource and its role in land degradation, and on the identification and testing of options to support and improve water management decisions.

The Watersheds

The Jhikhu Khola is located about 45 km east of Kathmandu on the Arniko Highway and covers an area of 111.4 sq. km, the Yarsha Khola watershed is located about 190 km east of Kathmandu on the Lamosangu-Jiri Road in Dholaka district and covers an area of about 53.4 sq.km (Figure 1). The two watersheds differ not only in size and altitudinal range (Jhikhu Khola watershed 800 to 2200 masl, Yarsha Khola watershed 990 to 3030 masl) but also in physiography. The Jhikhu Khola has a main valley with a large flat valley bottom of alluvial origin where the major land use is irrigated agriculture. Moderately steep slopes confine the watershed on the southern and northern sides and there are many pocket-like valleys on the flanks which make the watershed very heterogeneous. The general aspect of the watershed is south-east. The Yarsha Khola watershed has a general south-west aspect with a south and a north facing slope and a small middle ridge in between. There is no extensive valley bottom and irrigated areas are limited in comparison with the Jhikhu Khola. Overall the Yarsha Khola watershed appears more homogenous than the Jhikhu Khola watershed.

There is a major difference between the two watersheds in terms of access to markets for agricultural products. With the exception of staple food crops, most of the agricultural production from the Jhikhu Khola watershed is sold to Kathmandu. The products include potatoes, tomatoes, and increasingly other vegetables. Agricultural production is intense

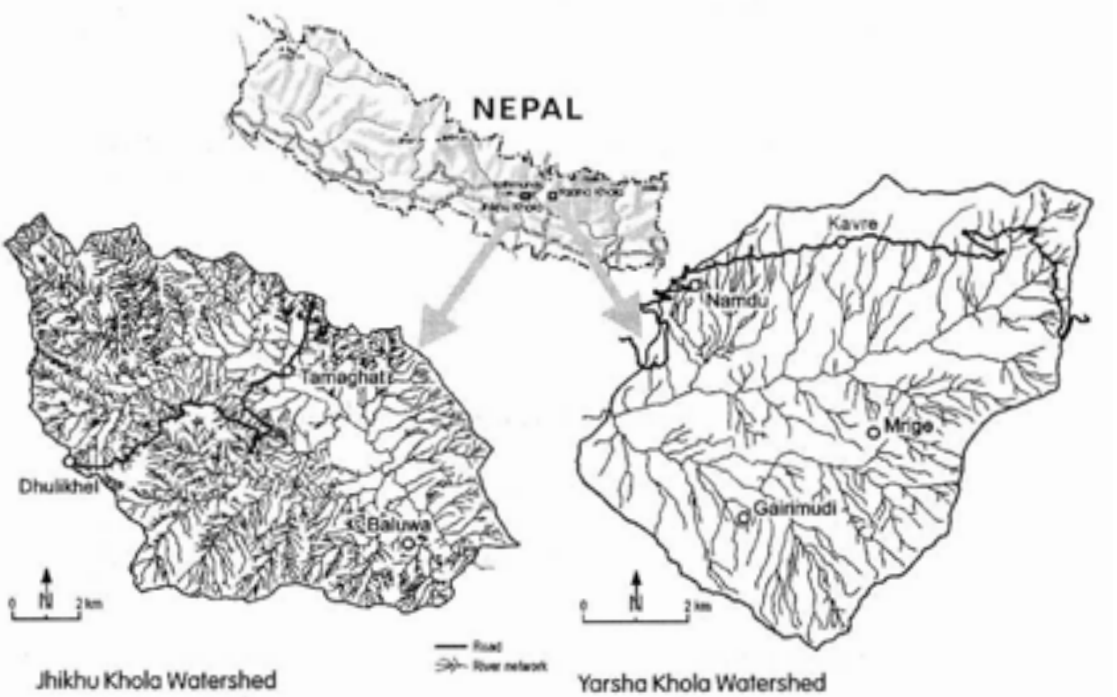

Figure 1: Location of the Jhikhu and Yarsha Khola watersheds

with high fertiliser and pesticide inputs. The two main cash crops in the Yarsha Khola are seed potatoes and garlic, but there are no good markets for them in the area and agricultural production remains more traditional with two and up to three crops on the irrigated land.

Between 1998 and 2000, the average annual rainfall in the Jhikhu Khola varied from about 1100 mm to 1700 mm at sites located between 830m and 1700 masl; at the main meteorological station in Panchkhal (865 masl) it varied from 1167 mm to 1418 mm (Figure 2a). The average annual rainfall in the Yarsha Khola varied from 1600 to 3000 mm at sites located from 1005 to 2640 masl; at the main meteorological station in Bagar (1690 masl) it varied from 2018 to 2469 mm (Figure 2b). The temperature in the Jhikhu Khola (at Panchkhal) varied from a (night-time) low of 0°C in January and December to a (daytime) high of to 39°C in April (1997 to 2000) and in the Yarsha Khola at Bagar from a low of 0°C in January to a high of 31°C in June.

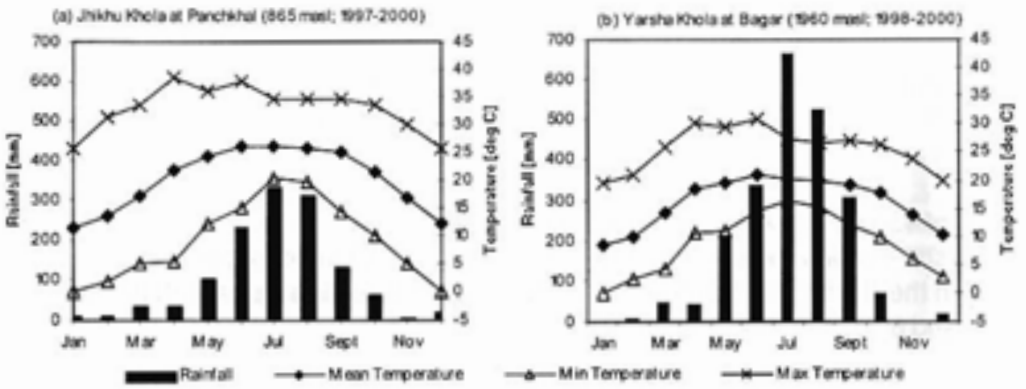

Figure 2: Average annual rainfall and temperature in the Yarsha Khola (a) and Jhikhu Khola (b) watersheds

Study Methodology

For the survey, interviews were carried out using a formal questionnaire in Nepali which was filled out by local enumerators trained by PARDYP. Separate questionnaires were used for the the female and male heads of household, each contained three parts:

- general information (female/male);
- household and animal water supply (female); or agricultural water supply (male); and
- perception of water and water related problems (female/male).

The decision to use separate questionnaires for men and women resulted from an RRA exercise carried out in the Yarsha Khola watershed early on in the project. This exercise and previous studies in the area showed that women were generally responsible for work concerned with household and animals, whereas men took care of most agricultural work including irrigation management.

Different methods were used in the two watersheds to obtain even spatial coverage. The Yarsha Khola watershed was divided into different zones according to altitude and aspect because the rainfall and land use in this watershed are influenced by these factors. The lower areas in the Yarsha Khola are mainly under khet (irrigated agricultural land), while upland areas are under bari (rainfed agricultural land). In addition, the water supply was expected to differ according to topographical location with moisture differences at different altitudes and aspects, and the road leading through the watershed has a big influence on the population pattern and problems related to agriculture (Brown 1998). Twelve different blocks or zones were identified and a given number of households interviewed in each of them. In the analyses blocks M1 and N1 and M2 and N2 were combined as they contained very few households. The Jhikhu Khola watershed was divided according to the kilometre grid on the 1:25,000 topographical map to give an even distribution across the watershed. In general, two households were questioned in each 1 km^2 grid cell. Only one household was visited in cells with few houses, and none in some cells with mainly forest. The altitudes of individual houses were measured during the survey and the households later classified into different elevation classes. The two methods are shown schematically in Figure 3.

The location of each household was marked on a 1:5000 scale aerial photograph and later linked to a GIS to allow spatial analysis and enable reassessment of the water demand and supply situation in the future.

A total of 436 people were interviewed from 218 households (218 female/218 male) in the Yarsha Khola watershed, and 356 people from 178 households (178 female/178 male) in the Jhikhu Khola watershed. The average household size was 5.8 in the Yarsha Khola and 6.9 in the Jhikhu Khola.

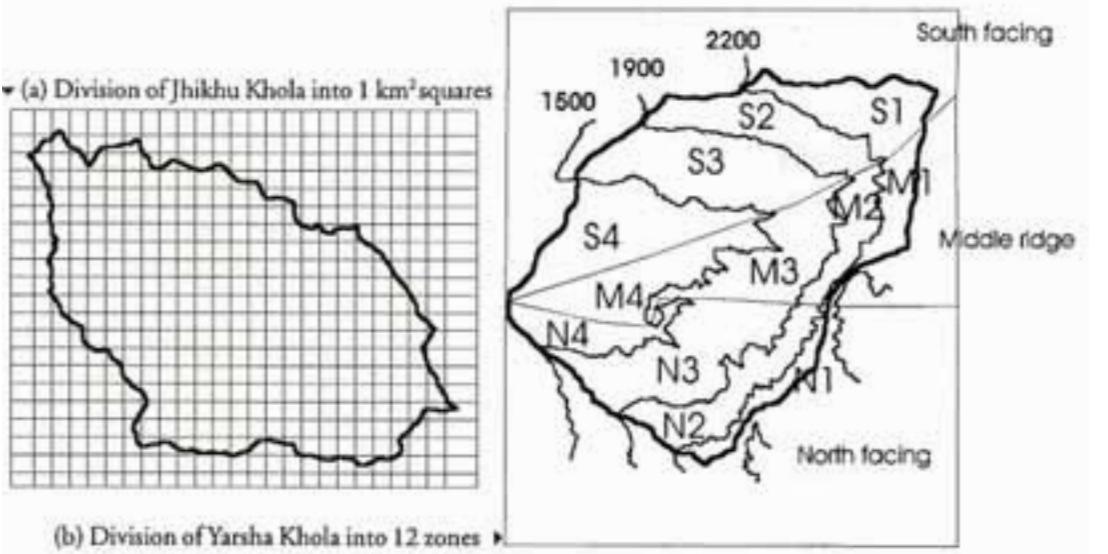

Figure 3: Division of the watersheds to ensure good spatial coverage of interviews

Brief results

The Yarsha Khola Watershed

The 218 households interviewed in the Yarsha Khola were more or less evenly spread throughout the watershed (with a small gap at Kathrigau village) (Figure 4). More than three quarters of the houses were in the elevation band between1200 and 2000m. This is the most densely populated area in the watershed. The areas below 1200m are mainly used for irrigated agriculture and the area above 2000m is mainly bush and forest.

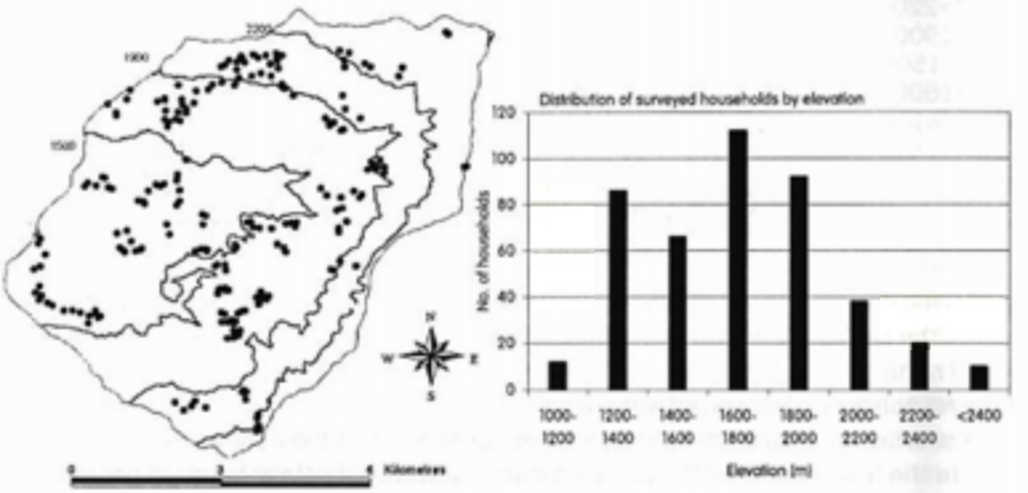

Figure 4: Interviewed households in the Yarsha Khola watershed: (a) spatial distribution; (b) distribution according to elevation

The importance of water is underlined by the words that local people used to describe it: just over half (223 people) chose 'life' as the one word to describe water; others said 'soul', 'important', 'creation', and 'essential thing'. People also considered that there were major problems with water. One half of the respondents considered the watershed to be dry, and 45% considered it wet (Table 1). People generally saw the south-facing slope, the middle part of the watershed, and the lowest part of the north-facing slope as being dry, and the upland areas of the north-facing slope as wet. Table 1 shows the actual rainfall in the different blocks in comparison with the perception of the residents.

In terms of the annual average, there is plenty of rainfall and the watershed can be classified as humid sub-tropical to cool temperate. However, the residents even perceived areas with a total annual rainfall of 1800 mm and more as dry. Thuloban, at 2640 masl, received 3316 mm of rainfall in 1998, but 16 people out of 20 still considered this area to be dry. The same was true of Bagar and Namdu. Overall 50% of the residents thought that the watershed was dry or very dry, particularly those from the south facing slope. It seems that total annual rainfall is not a good indicator of people's perception of the relative wetness/dryness of a location.

Table 1: **Water-related constraints according to altitude and aspect in the Yarsha Khola watershed**

Block (altitude)	Perception (No of farmers)		Yes answers to the question: Do you face problems with water quantity for:				Annual rainfall	
	Dry	Wet	Irrigation No.	%	Drinking No.	%	Amount (mm)	Station (Altitude, m)
South (>2200)	16	4	15	75	14	70	3316	Thuloban (2640)
South (1900-2200)	38	40	50	63	43	54	2554	Jyamire (1950)
South (1500-1900)	33	6	24	60	19	48	2049	Bagar (1690)
South (<1500)	39	1	33	83	18	45	1760	Namdu (1400)
North (>2200)	4	12	14	88	14	88	Installed in July 98	Pokhari (2260)
North (1900-2200)	5	29	21	53	21	53	.	
Middle (1500-1900)	35	16	35	58	23	38	Installed in June 98	Mrige (1610)
North (1500-2200)	0	60	31	52	47	78	1847	Gairimudi (1530)
Middle (<1500)	22	17	32	80	36	90	.	
North (<1500)	26	9	32	78	25	63	1678	Main Hydro Station (1005)
Total	218	194	287		260			

Most of the rainfall (more than 80% on average; Merz et al. 2000) falls during the monsoon period, the remaining months are relatively dry. This partly explains why despite heavy annual rainfall 81% of those interviewed said that they faced water problems. Two-thirds of the respondents (287) faced water shortages for irrigation and 60 % (260) for drinking. Water shortage is a particular concern in the upper areas of the watershed, on the central ridge in the lower part (90% indicated drinking water shortage), and in areas below 1500m. Drinking water quality also seems to be a major issue in the most densely populated areas, which include the settlements of Mainapokhari and Gairimudi: 65 people (15%), all from densely populated areas, mentioned water quality as a problem. Minor problems included slumping (7 respondents) and surface erosion (2).

Water shortage for both agricultural and household supply was mainly felt to be a problem during the pre-monsoon period. Shortage of irrigation water is already apparent in early winter and peaks in the month of Falgun (mid January to mid February), household water shortage problems arise in late winter to early pre-monsoon, the peak felt to be in Chaitra (mid-February to mid-March). No water shortages were expected in Shrawan to Ashwin (mid-June to mid-October), that is the monsoon and post-monsoon periods.

Household Water Supply

Only women were asked about household water supply. Household water shortage was found to be a major concern – more than half the respondents (57%) mentioned water scarcity, with the biggest problems in the upper parts of the watershed. All the eight respondents in the north-facing block above 2200m mentioned water scarcity, and eight out of ten of those on the south-facing slope. Overall the situation was thought to have improved somewhat over the last five years: 137 women (64%) thought that household water availability had increased, 30 (14%) that it had decreased, and 45 (21%) that there had been no change. This increase seems to have resulted from the installation of

an extensive tap system; 84% of the interviewed households obtained their water from tapped sources, which mainly belong to the communities.

However, the problems with water sources mentioned by a number of respondents indicate that many taps are improperly installed: 52 people mentioned sediment contamination as a problem, mostly in the middle and upper parts of the watershed, and there were complaints of bad taste, bad quality ("people often sick") and animal droppings in the water, indicating improper filtering and poor intake construction. Water quality is mainly an issue in the densely populated areas of the bigger villages in the watershed, Gairimudi and Mainapokhari. Water shortage at the source was indicated by answers like "often dry" (27 people). 'Other problems' with taps included that they were too far away, there was only one tap, and pipe breakages.

The average round trip time for fetching water from different water sources was 22 minutes (248 responses; i.e. one household may get water from different sources); the maximum was more than 60 minutes. The average time per day per household spent fetching water was 109 minutes. Water was mainly collected by the female head of household (138 cases) or by female household members generally (265 cases); 174 respondents said that a male member of the household fetched water and 67 that any member of the family fetched water. However, these answers were not supported by personal observations in the field; very few men were seen queuing at the public water taps.

The average household used 107.5 l water per day (calculated as a simple average, total water used for all households divided by the number of households); the average person used 20.6 l water per day (the amount per head calculated for each household separately and then averaged). This is very low: drinking water schemes in Nepal are designed on the basis of an average use of 45 l per person per day which is considered the minimum to ensure sufficient intake and personal hygiene (RWSSSP 1994). However, the survey didn't take into account direct use of water at the source or elsewhere, only that brought to the house. The total amount used will be higher as in many cases bathing, washing clothes, washing vegetables, and even cleaning dishes may be done at the tap or in rivers or streams.

In addition, each household brought an average of 65.5 l per day to the house for animal supply (drinking as well as washing). The average household had 6.5 animals (1 buffalo, 1 cow, 1 to 2 oxen, and 3 goats), with a range from no animals (two households) to as many as 31 (one household with 7 cows, 2 oxen and 22 goats). Two households owned chauri, a cross-breed of yak and cattle. The survey indicated that most households (167 or 77%) bring water for the animals to the house rather than taking the animals to the water source.

In general, it seems that the domestic water supply situation in the Yarsha Khola watershed is better than in many other Nepali middle mountain watersheds. The situation could be improved through work on the tap systems and on source protection, but innovative strategies and techniques will be required to overcome the water shortage periods.

Water Supply for Agriculture

Just over half of the watershed area (51%, Shrestha 2000) is under agriculture, both irrigated and rainfed, thus demand for agricultural water is high. However, lack of water for irrigation is a major concern (Table 1): 181 of 218 men (83%) said that they faced irrigation water shortages. The problem was most acute on the south facing slopes where 93% of the respondents mentioned irrigation water shortage and only 3% said explicitly that they did not face any shortage; 75% of those on the north-facing slopes and 83% on the middle ridge also faced shortages.

Most farmers had not observed any change in the availability of irrigation water over the last five and 25 years; although 17% had experienced a decrease over the last five years and 29% over the last 25 years, and 2% an increase over the last five years and 4.5% in the last 25 years. Historic land use information indicates that there was no major change in the amount of land under irrigation between 1981 and 1996: 15% in 1981 and 14% in 1996 (Shrestha 2000).

The shortage of water for irrigation peaks in the month of Falgun (mid-January to mid-February) when the wheat and potato crops require water. The potato and wheat crops are grown from October/November to March/April, which is the leanest period of the year in terms of water availability. If the winter rains fail, very little water is available and farmers can face a serious problem.

The rice crop faces few if any water shortages during the monsoon season, but there can be problems in the nursery and planting stages, especially if the monsoon is late. Comparison of the irrigation calendar for 1998 (Figure 5) with the climatological water balance derived for Bagar (the main meteorological station of the watershed, which lies in the upper parts of the irrigated area, Figure 6) shows that there were no problems for the rice crop in that year as the monsoon arrived on time (around June 15th).

Summary for the Yarsha Khola

The key points learned from the survey in the Yarsha Khola can be summarised as follows.

- Quantity of water for irrigation is perceived to be the key water issue, followed by drinking water quantity and drinking water quality. Water is considered to play only a limited role in land degradation.
- Drinking water quantity is a particular problem along the divide and on spurs.
- Drinking water quality is an issue in the major villages.
- Access to irrigation water is felt to have been stagnant to decreasing in the last 5 to 25 years.
- Access to drinking water has increased over the last 5 to 25 years for the majority of respondents; this is attributed to improved conveyance of water from the different sources through polythene pipes.
- Sediment is reported to be a major problem in the drinking water supply.
- Water shortages for both irrigation and drinking are felt most during the dry season (winter and pre-monsoon).
- The Yarsha Khola has limited road access, which means limited market access; the result is that agriculture is mainly for subsistence and is low intensity.

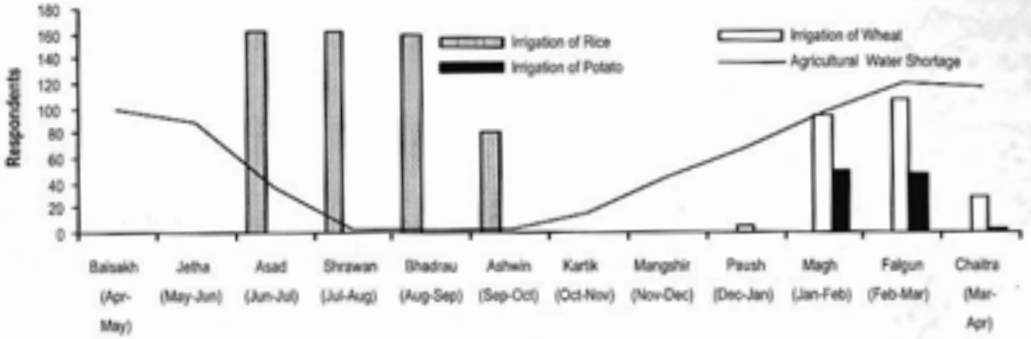

Figure 5: Irrigation calendar and perceived water shortage in the Yarsha Khola watershed

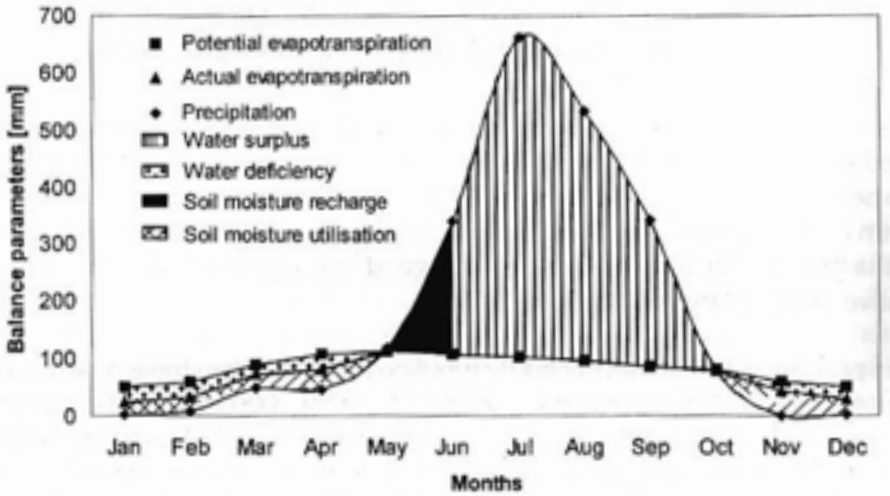

Figure 6: Climatological water balance for Bagar for the period 1998 - 2000

The Jhikhu Khola Watershed

A total of 178 households were interviewed in the Jhikhu Khola watershed. The largest number of interviews was conducted in the biggest VDCs: Panchkhal and Baluwa (Figure 7) and the least in Banepa Municipality, which has the smallest area within the watershed.

The importance of water was again underlined by the words that people used to describe it: 65% of the 159 who answered described water in one word as "life", other words used included "base of life", "biggest", "important", and "precious". There are some problems associated with water in this area, however: 59% of the respondents described the watershed to be dry to very dry and barely 10% mentioned that their areas were wet, mainly those residing near upper sites along the north-facing slopes in Dhulikhel, Kabhre, and Patlekhet. Generally residents along the water divides, on south-facing slopes, and along the foothills considered their areas to be dry.

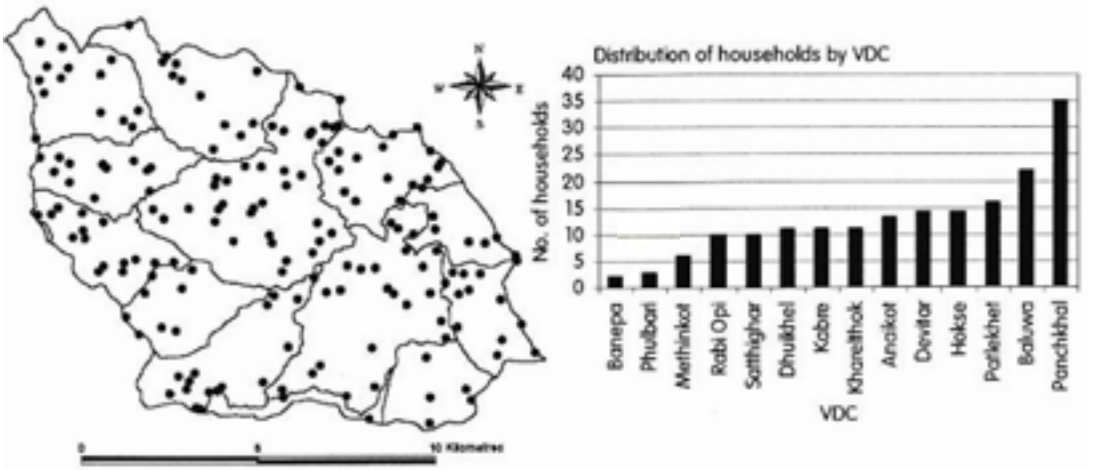

Figure 7: Interviewed households in the Jhikhu Khola watershed: (a) spatial distribution; (b) distribution according to VDCs

In terms of the annual average, there is plenty of rainfall and the watershed can be classified as humid sub-tropical to cool temperate. However, the residents perceived areas to be dry that had a total annual rainfall of 1500 mm and more. Rabi Opi recorded 1790 mm rainfall in 1999, yet 7 out of 10 respondents considered the area dry. As in the Yarsha Khola, total annual rainfall is not a good indicator of people's perception of the relative wetness/dryness of a location.

The main problem is the uneven rainfall distribution with more than three-quarters of the annual total on average falling during the monsoon (Merz et al. 2000). Most of the respondents (90%) indicated that they were facing water problems: 68% (243) faced shortages for irrigation and 59% for drinking (209 people); 34% (122 people) mentioned the poor quality of drinking water; other problems included slumping along agricultural fields (16%), quality of water for irrigation (14%), surface erosion (8%) and flooding (2%).

The number of people facing water shortage for both irrigation and domestic purposes peaks during the pre-monsoon period (April/May). Irrigation water supply is perceived to be a problem from shortly after the end of the monsoon in November; the problem gradually increases to a peak in April/May and extends up to early June. The problem becomes less acute as pre-monsoon showers occur. The problems with household water supply start late in winter and rise sharply during the pre-monsoon period (March to May). If there is notable pre-monsoon rainfall, then local water sources are recharged and relieve the shortage. There is no shortage of water for any purpose during the monsoon, but problems related to excess water such as slumping and surface erosion then become evident.

Household Water Supply

Generally it is the responsibility of women to ensure the supply of water for domestic purposes, which includes both human and animal water needs. The great majority of

women interviewees (151 or 84%) mentioned shortage of water as a problem, with particular problems for those living on the water divides, and the upper and south-facing slopes. The slope aspect played an important role in the water shortage: 69 % of the respondents faced with water shortages on the north-facing slopes were from elevations above 1100m, whereas those on south-facing slopes experienced water shortage at elevations just above 900m. Overall the water supply has worsened slightly in the last five years: although 33% of the women (58) felt that more water was available, 40% (70) thought that there was less, and 27% (49) that it hadn't changed. The improvement observed by some respondents is related to increased distribution through tap networks, 44% of the interviewees collected water from taps, which are generally maintained by the communities themselves.

There are problems with the water that is distributed as the sources are not well protected and become polluted during the rainy season. More than 40% of women (76) mentioned sediment, which reduces water quality and gives it a bad taste, as the main problem pollutant. Animal droppings near the source, poor maintenance and lack of protection of the source, and improper intake construction are major factors contributing to contamination; 14 women reported sickness from drinking water. In general, people do not filter or boil water prior to consumption.

The major other problem mentioned was the distance to the source. Women in the watershed spent 26 minutes per trip on average fetching water. The maximum time of two hours per trip was reported by a few households in Devitar, Panchkhal, and Dhulikhel Municipality. The average household used 161 l water per day with a range of 30 to 700 (calculated as a simple average, total for all households divided by the number of households); the average person used 25 l water per day, with a maximum of 73 l per person in one household (the amount per head calculated for each household separately and then averaged). Family members make between 2 and 30 trips per day to collect water for household consumption, and more time again to collect water for their animals; a person typically carries one gagri (15 l) per trip, although some people take two or three at a time to reduce travel frequency. Water was mainly collected by women (including the wife, daughter, daughter-in-law, and mother-in-law of the male head of house), although in 61 households men and boys were said to help and in four households collecting was by any family member.

Animals are an important component in agricultural farming and the need for water for animals is likely to rise sharply as the number of livestock increases. On average each household has one buffalo, one cow, one ox, and three goats drinking an average 98 l water per day. Only about one tenth of those surveyed (19 households) took their animals to the water source, spending on average 46 min. This work was mainly divided between the wife (27%), the husband (22%), the son (22%), and the daughter (16%) with daughters-in-law and mothers-in-law participating least.

Overall the domestic water supply in the Jhikhu Khola is satisfactory, but there are pocket areas that face a chronic shortage. The supply could be improved to some extent by better management of distribution systems and protecting the sources, but innovative

strategies and techniques and greater involvement of local beneficiaries will be essential to solve the chronic and increasing water shortage during the dry season.

Agricultural Water Supply

Just over half of the watershed area (55%) is occupied by agriculture (Shrestha and Brown 1995), of which one third is irrigated and the remainder rainfed. Timely supply of water is essential for successful agricultural production. In the survey, however, the great majority of farmers had insufficient water for irrigation (87% or 154 out of 178), including 76 of 97 farmers on the south-facing slopes and 78 out of 81 farmers on the north-facing slopes.

Just over half of the men (52%) thought that the amount of water available for irrigation had decreased over the last five (and 25) years, 32% said there had been no change, and 9% thought there had been an increase – probably the result of a reduction in seepage losses through using polythene pipes to divert stream water and of collecting water in open ponds for irrigation. Shortage of irrigation water is felt immediately after the monsoon in mid November when planting of potato commences. The shortage gradually rises to a peak around April/May when some farmers transplant early rice in paddy fields, and maize in upland areas. If the onset of the monsoon is delayed, water shortages can affect transplantation of the major rice crop. In general, there is no problem for the rice crop during the monsoon (Figure 8). Winter rain is unreliable, so farmers growing potato and wheat can face water shortages from January to March.

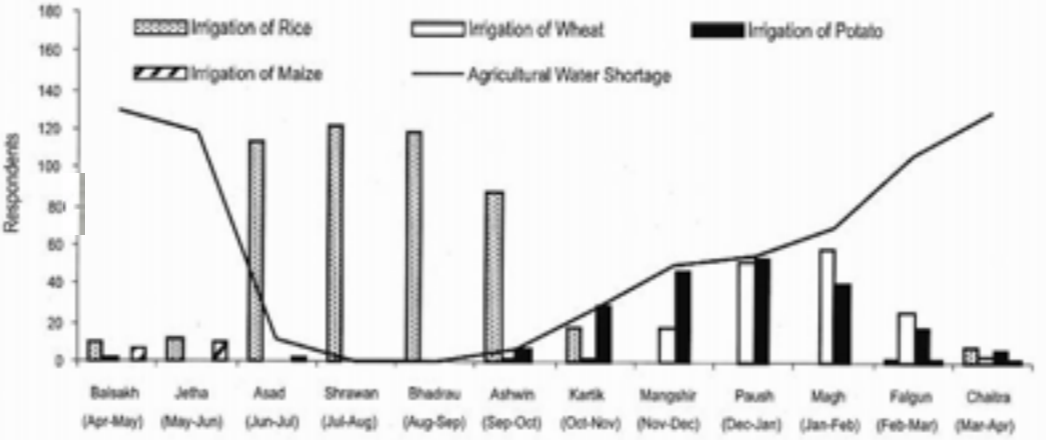

Figure 8: Irrigation calendar and perceived water shortage in the Jhikhu Khola watershed

Summary for the Jhikhu Khola

The key points learned from the survey in the Jhikhu Khola can be summarised as follows.

- The number one problem for farmers is shortage of water for irrigation, followed by domestic water supply and, increasingly, poor water quality.
- The supply of irrigation water is felt to have decreased over the last 5 to 25 years.

- The supply of drinking water is also thought to have decreased over the last 5 to 25 years but not as dramatically as in the case of irrigation water.
- Water shortage is confined to the dry season from October to May.
- Water induced land degradation is viewed as a minor problem.
- Agricultural production is highly intensive with high fertiliser and pesticide inputs resulting in higher yields than on average in the Nepal middle mountains.
- Farmers increasingly plant vegetable cash crops throughout the watershed for the market in Kathmandu.

Comparison of the Two Watersheds

The major differences between the two watersheds are in elevation, topography, and proximity to markets. Both watersheds were thought of as dry – by 75 % of the respondents in the Jhikhu Khola and 53 % of those in the Yarsha Khola. Water quantity is a major issue in both watersheds (Figure 9). Irrigation water in particular is in short supply: 33 % of the respondents in the Jhikhu Khola and 41% in the Yarsha Khola mentioned shortage of water for irrigation. Many residents also face a shortage of water for domestic use: 27 % of those in the Jhikhu Khola and 37 % in the Yarsha Khola. The quality of drinking water is of increasing concern, particularly in more densely populated parts, with 17% of the respondents in the Jhikhu Khola and 9% in the Yarsha Khola indicating water quality problems. Other problems like flooding, erosion, and slumping are not seen as significant.

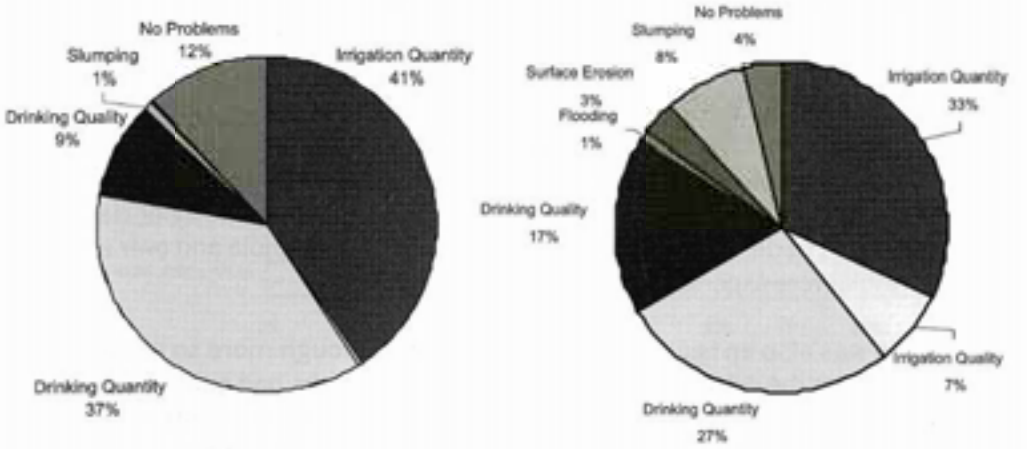

Figure 9: Water related key issues in the Yarsha Khola watershed (a) and the Jhikhu Khola watershed (b) as perceived by the local residents

Agricultural Water Supply

The biggest water-related hardship felt by the local residents of the Yarsha and the Jhikhu Khola watersheds is the inadequate supply of water for irrigation. In the Jhikhu Khola watershed in particular, irrigation water is in short supply for the increasing number of cash crops for the Kathmandu market. Water shortage for irrigation is only an issue in the dry season months, particularly towards the end. Peak shortage was felt in the

months Falgun to Baisakh (mid-February to mid-May) in the Yarsha Khola watershed and from Falgun to Jestha (mid-February to mid-June) in the Jhikhu Khola. This reflects the long-term rainfall pattern in which there is a high likelihood of premonsoon rainfall events that can recharge sources in the more eastern Yarsha Khola, but no reliable annual pattern of such events in the Jhikhu Khola.

The problems with supply of water for agriculture are partly the result of changing practices. It is argued that water used to be adequate when farmers followed the traditional cropping systems with less than two crops per annum. With the introduction of cash crops, demand on water resources has increased significantly but supply per unit area has remained the same. In other words, the supply of water is insufficient for the new agricultural practices.

The water deficiency period coincides with the growing season of winter crops such as wheat and potato. Winter rains greatly facilitate the production of these crops, but they cannot be relied on. Farmers rarely face any problems with rice at plantation time, which generally falls in the monsoon, although there can be difficulties earlier. Transplanting can be postponed if the monsoon rains are late.

Irrigation water is a constraint throughout the watersheds. In the upper areas there is no surface water available and there are no irrigated fields. In the lower areas, most of the production is on irrigated fields, and water availability is the main constraint. Thus interventions aimed at increasing the availability of water should focus on the winter period.

Domestic Water Supply

Water supply for domestic use is also a major constraint in both watersheds. The average water use per person is already well below the design value for rural water supply schemes: 22.4 l per person per day in the Jhikhu Khola and 20.6 l per person per day in the Yarsha Khola. Just under a third of respondents in the Jhikhu Khola and over a third in the Yarsha Khola were experiencing problems with supply.

Water quality was also an issue in both watersheds, although more so in the Jhikhu Khola, in particular the presence of sediment as well bad taste, bad quality, and animal waste. The sediment problem is the result of improper construction of intakes, misused and dirty intakes, broken supply pipes, and collection from turbid sources like rivers. The major problem with sediment is the microbiological pollution that can be associated with it.

The problems in water quality noted by the respondents were confirmed by chemical and microbiological investigations. A total of 31 public water sources and 20 river sites in the Jhikhu Khola were monitored in the pre-monsoon period in 2000. Microbiological parameters like total and faecal coliform were in most cases found to be orders of magnitude above the values recommended by WHO (WHO 1993) (Figure 10).

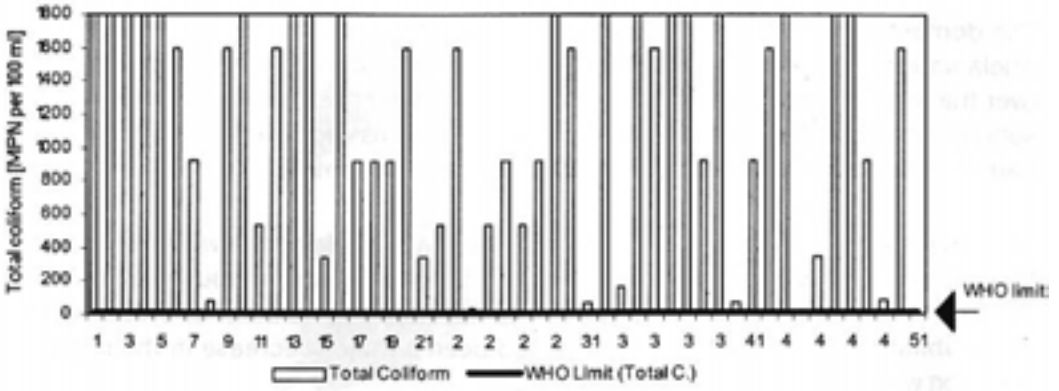

Figure 10: Microbiological contamination of selected water sources in the Jhikhu Khola watershed

Thus it seems that access to safe drinking water has become a major problem, although for local people it is apparently considered to be a secondary issue after quantity. The relevant authorities should take this issue seriously.

Water Resource Dynamics

The overall water resources dynamics were assessed by asking respondents whether they thought the supply of irrigation water (men) and domestic water (women) had changed over the last 5 and 25 years. The results are shown in Figure 11.

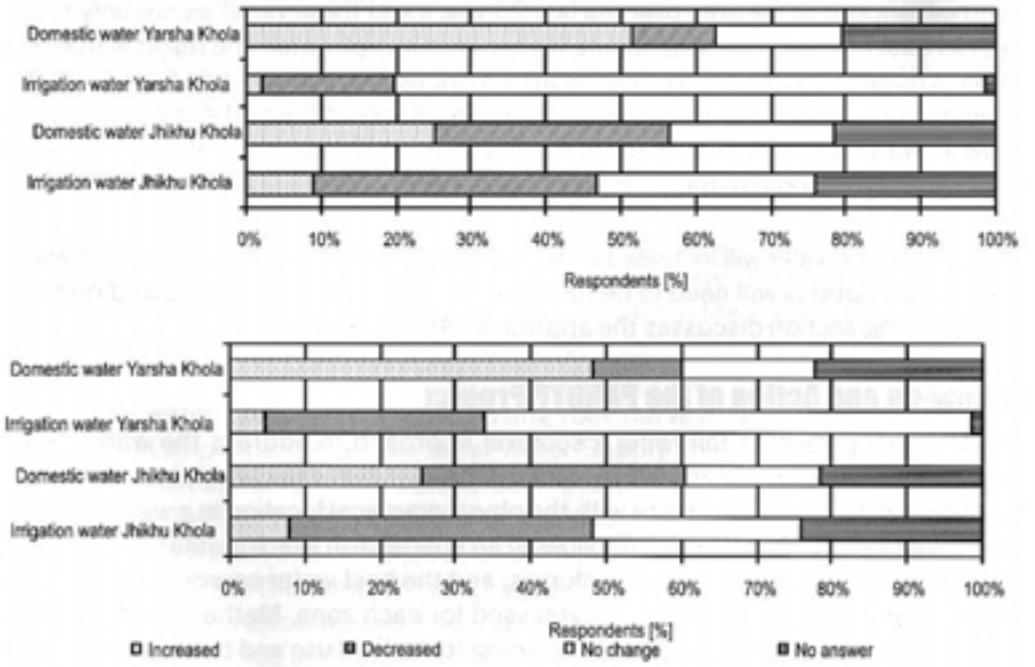

Figure 11: Perceived changes in water availability in the last (a) 5 years and (b) 25 years in the Yarsha Khola and Jhikhu Khola watersheds

The domestic water supply seems not to have changed dramatically. In the Yarsha Khola watershed a majority of the respondents said that the water supply had increased over the last 5 and 25 years, mainly as a result of the construction of drinking water supply systems. In the Jhikhu Khola the situation was less positive, although the supply had increased for many respondents it had decreased for more.

Similarly, the majority of respondents in the Yarsha Khola felt that availability of water for irrigation had barely changed over the last 5 and 25 years, although a substantial minority did think that it had worsened. In contrast slightly more than half of respondents in the Jhikhu Khola thought that there had been a major decrease in the supply of irrigation water.

The observation by respondents that the amount of water available for irrigation had gone down cannot be explained by decreasing rainfall; the long-term data of the meteorological stations in the Jhikhu Khola watershed show no significant change in rainfall over the years 1980 to 1996 with slopes for Dolaghat of –0.00002, for Panchkhal of –0.00002 and for Dhulikhel of +0.0002.

The reason for the decrease in available water is believed to be the intensification of agricultural practices. Shrestha and Brown (1995) reported a slight increase in the area of irrigated agricultural land between 1972 and 1990, and a big change in cropping intensity from 1.3 crops per annum in 1980 to 2.3-2.6 crops per annum in 1994. One survey mentioned by Shrestha and Brown (1995) indicates that 13 % of the households in the Bela area grow four crops per annum. Furthermore, high yielding varieties have been introduced in the area over the last 25 years and these varieties not only require high fertiliser doses, they also require higher amounts of water. The result is that more water is drawn from the sources higher up the slopes, and less remains for those further down the line. The dry season flow of the Jhikhu Khola at the outlet is observed to be lower nowadays than 10 years ago according to personal accounts of PARDYP project staff who have worked in the watershed since 1989.

The demand for water will increase further if development proceeds as currently forecast. Proposed solutions will need to be based on well studied technologies and methods. The following section discusses the approach PARDYP has taken.

Follow-up and Action of the PARDYP Project

The PARDYP project is following a sectoral approach to address the water-related constraints. The results of the survey confirm the idea that water problems in the middle mountain watersheds vary more with the physiographical location in a watershed than with the elevation. Thus PARDYP is following an approach in which a watershed is divided into several zones according to landforms, and the best water source (rainfall, spring water, river water, groundwater) is assessed for each zone. Methods to support the actual supply can then be proposed according to the land use and the water use. Figure 12 shows a schematic representation of a watershed with the different sectors. This scheme is being studied in greater detail and other important factors will be added.

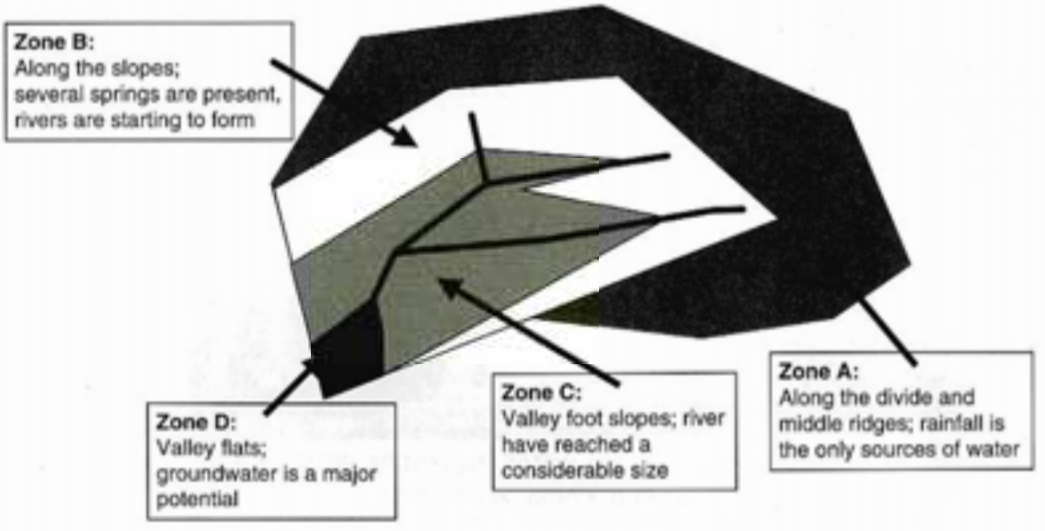

Figure 12: Sectoral approach for water management considerations in PARDYP

The PARDYP project focuses on marginalised and financially weak groups of people, thus its main efforts so far have been directed at the upper areas of the watersheds where people have no access to springs or irrigation water. Harvesting of rainwater and surface flow seems to be the only alternative to the commonly used water sources. In order to improve the situation of these groups, the project has focused on two water management activities:

- ensuring sufficient and safe water for domestic use at a convenient location and reasonable cost; and
- improving the availability of water for production of cash crops on land which was previously lying fallow during the dry season.

Water harvesting

As most rainfall occurs during the monsoon and only a few events are expected during the winter and the early pre-monsoon, the rainwater has to be captured and saved for the dry season. In addition, much of the monsoon rain leaves the system as surface runoff and this water needs to be kept back for use later in the season. To do this, the project ventured into the field of water harvesting.

For drinking water, trials were initiated using roof harvesting of water and the jar technology as implemented by the Rural Water Supply and Sanitation Programme (RWSSSP) in the Lumbini Zone. In collaboration with the Water Harvesting Programme of ICIMOD and RWSSSP, PARDYP trained local masons in the Jhikhu and Yarsha Khola and constructed 13 trial and demonstration units in houses, temples and schools in the Jhikhu Khola and 9 in the Yarsha Khola (Figure 13). The funds for construction were collected from the beneficiaries and local authorities with some support provided by the project. The constructed units are currently under observation, both from a technical and a socioeconomic point of view. Further implementation of the jar technology will

Figure 13: Rooftop rain water harvesting jar in Hokse, Jhikhu Khola watershed

depend on the acceptance and interest of the local residents. The project has clearly stated to the different stakeholders in the two watersheds that it is willing to support any further implementation activities with expertise, but funding will need to be organised from elsewhere.

For irrigation water to be used to grow cash crops on rainfed agricultural land, the project has initiated trials with water harvesting tanks that capture overland flow from suitable surfaces like roads and degraded areas, and introduced them together with alternative methods of applying water like drip irrigation (Figure 14). More detailed information is given in Nakarmi and Neupane (2000) and Nakarmi et al. (in press).

In future PARDYP plans to improve the sectoral approach up to the development of a decision support system. This will include applicable methodologies for all sectors in a middle mountain watershed.

Figure 14: Drip irrigation set for cash crop production

Conclusion

The two surveys have shown that the main water related issue in rural watersheds of the Nepal middle mountains is inadequate water supply, for both domestic and agricultural use. The increasing intensification of agricultural production, progressive population growth, and changing climate may have a major impact on the water resources of these watersheds. This directly affects the livelihoods of the local residents. Water quality, until now only a marginal issue, is becoming a problem as a result of agrochemical pollution, increasing population, unplanned settlements, and expanding tourism infrastructure. Alternative methods for water supply management, water demand management, storage, and harvesting are needed urgently and need to be promoted. Catchment and spring protection should be promoted in order to improve water quality in the long-term; at present low cost water treatment should be disseminated. The impact of agrochemical pollution is still not fully understood and needs to be studied in detail. Although the PARDYP study focuses on only two watersheds in Nepal, similar scenarios can be assumed for other areas in the middle mountains of the HKH.

The CD-ROM provides more insight into the above and illustrates the discussion with photographs, background information, and graphs.

References

Bajracharya, D. R.; Dahal, B.M.; Merz, J.; Nakarmi, G.; Shakya, S.; Sharma, S. (2000) *Capacity Building for Community Water Quality Assessment, Jhikhu Khola, Nepal.* Progress Report submitted to Australian Agency for International Development (AusAid). Kathmandu: PARDYP

Brown, S. (1998) *Gender & Resources in the Middle Mountains of Nepal.* CD-ROM. Vancouver: University of British Columbia, Institute for Resources and Environment

FAO (1995) *Climate Change, Forests and Forest Management – an Overview,* Forestry Paper 126. Rome: FAO

HMG/FINNIDA (1994) *Palpa District Water Supply and Sanitation Development Plan.* Kathmandu: RWSSSR

Merz, J.; Dangol, P.M.; Dhakal, M.P. (2000) 'Comparison of Climatological Balances for the Jhikhu and Yarsha Khola Watersheds, Nepal'. In Allen, R.; Schreier, H.; Brown S.; Shah, P.B. *PARDYP – Research for Development in the HKH – The First Three Years (1996 to 1999).* Kathmandu: ICIMOD

Merz, J.; Allen, R.; Shah, P.B.; Weingartner, R. (in press) Degradation of Land and Water Resources – an Assessment Programme of the Current Situation in Selected Areas in the Hindu Kush-Himalayas. Paper presented at the International Conference on Sustainable Management of Natural and Human Resources for a Better Quality of Life in South Asia, Mainz University and Tribhuvan University, 14-17 October, 2000, Dhulikhel, Nepal

Nakarmi, G.; Neupane, P.R. (2000) 'An Attempt to Harvest Rainwater at Kubinde, Kavrepalanchok District, Nepal'. In Allen, R.; Schreier, H.; Brown S.; Shah, P.B. *PARDYP – Research for Development in the HKH – The First Three Years (1996 to 1999).* Kathmandu: ICIMOD

Nakarmi, G.; Prajapati-Merz, B.; Jha, P.C. (in press) *Alternative Water Management – A Case Study from Kubinde Gaun, Jhikhu Khola Watershed, Nepal.* Paper presented at the International Conference on Sustainable Management of Natural and Human Resources for a Better Quality of Life in South Asia, Mainz University and Tribhuvan University, 14-17 October, 2000, Dhulikhel, Nepal

PARDYP (2002a) *Water and Erosion Studies of PARDYP Nepal: the Data of the Jhikhu Khola Watershed.* Kathmandu: ICIMOD

PARDYP (2002b) *Water and Erosion Studies of PARDYP Nepal: the Data of the Yarsha Khola Watershed.* Kathmandu: ICIMOD

RWSSSP (1994) *Palpa District – Water Supply and Sanitation Development Plan.* Rural Water Supply and Sanitation Project, Department of Water Supply and Sewerage, HMG/Ministry of Housing and Physical Planning, Kathmandu

Shrestha, B.; Brown, S. (1995) Land Use Dynamics and Intensification. In Schreier, H.; Shah, P.B.; Brown, S. (eds), *Challenges in Mountain Resources Management in Nepal – Processes, Trends, and Dynamics in Middle Mountain Watersheds.* Proceedings of a meeting held 10-12 April, 1995. Kathmandu: ICIMOD

Shrestha, B. (2000) Population Dynamics and Land Use in the Yarsha Khola Watershed. In Allen, R.; Schreier, H.; Brown S.; Shah, P.B. (eds.) *PARDYP – Research for Development in the HKH – The First Three Years (1996 to 1999).* Kathmandu: ICIMOD

Shrestha, S.K.; Nakarmi, G.; Merz, J.; Osti, R.C. (2000) Survey of the Public Water Sources in the Jhikhu Khola. *Report submitted to the Capacity Building for Community Water Quality Assessment Project by PARDYP*

WHO (1993) *Guidelines for Drinking Water Quality. Volume 1: Recommendations.* 2nd Edition. Geneva: WHO

International Centre for
Integrated Mountain Development
4/80 Jawalakhel, GPO Box 3226
Kathmandu, Nepal

Telephone: +977 1 525313
Fax: +977 1 524509/536747
e-mail: distri@icimod.org.np
Web site: http://www.icimod.org
Cable: ICIMOD NEPAL