An Assessment of the Water Need and Supply Situation in a Rural Watershed of the Middle Mountains in Nepal

Juerg Merz[1], Bhuban Shrestha[2], Bhawani S. Dongol[2], Madhav P. Dhakal[2], Rolf Weingartner[1]

[1] PARDYP/University of Bern

[2] PARDYP/International Centre for Integrated Mountain Development

Abstract

Water supply is critical in many areas of the middle mountains in Nepal. In order to assess the situation in a rural watershed, a survey was conducted of the present situation of water need and supply in the Yarsha Khola watershed. The survey was designed to investigate water demand, water problems, water supply, and other water related issues.

The major hardships in terms of drinking water were experienced in the high altitude areas along the watershed boundary and along the ridges in the watershed. Shortages of irrigation water were mainly encountered in winter when water was needed for cultivation of wheat and potato. Possible improvements within the framework of PARDYP are discussed, and further activities for Phase II of the project suggested.

Introduction

"Without water no life"–one of the perceptions of water often mentioned by the people interviewed in the Yarsha Khola watershed. Although the importance of water is well known, it is in short supply in many parts of the Hindu Kush-Himalayas (HKH), and both water quantity and water quality issues are of increasing concern. The population is growing and the pressure on the resource is increasing as a result of the growing need for water for both household and agricultural use. Rising temperatures and more extreme events resulting from climate change might further increase the pressure on water resources—or they might reduce the pressure as a result of increased precipitation (FAO 1995) providing sound management systems are employed. Intensive farming with increasing use of chemical fertilisers and pesticides is reducing the water quality of micro to meso-watersheds. The influence on big river systems in the region is not well understood at present, but the influence at watershed level is already of concern. Water is as important for the people in mountain communities as for those in the large urban centres, as the great majority of the mountain population is dependent on agriculture and water is only available from local sources.

A survey of current water demand and supply was conducted in the Yarsha Khola watershed in Nepal, as the first step in assessing the water situation in selected areas in the middle mountains of the Hindu Kush-Himalayas. The aim of the study was not only to assess the water need and supply situation at household level, but also to assess water problems at the watershed level. This was mainly done for the purpose of planning the activities in Phase II of PARDYP (the People and Resource Dynamics Project on Mountain Watersheds in the Hindu Kush Himalayas). In future, it is hoped that a similar study will be conducted in all the other project watersheds in order to understand the people's perception of water, and the water need and supply situation.

The Study Area and Methodology

The study was conducted in December 1998 in the Yarsha Khola watershed, which is located about 190 km east of Kathmandu along the Lamosangu-Jiri road in the middle mountains of Nepal (Figure 91). The watershed has an area of 53.4 sq.km. and an altitude range from 930 masl at the outlet in the west up to 3030 masl at Hanumante in the east. The annual rainfall in 1998 varied from 1600 mm in the lower areas to 3300 mm at the top, with a maximum during the monsoon (Merz *et al.* this volume). The watershed is dominated by agriculture with double annual crop rotations on irrigated land and single to double annual crop rotations on rain fed land (Shrestha this volume). The total population in the watershed in 1996 was estimated to be 20,620 (Shrestha 1999).

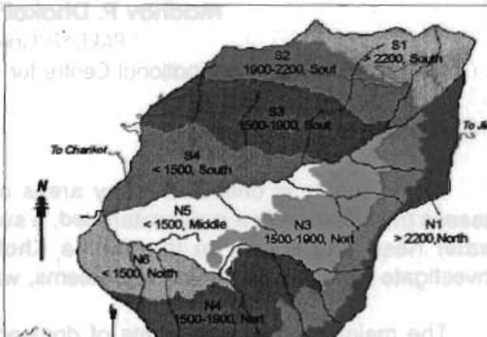

Figure 91: **Location and Layout of the Water Need and Supply Survey of the Yarsha Khola Watershed**

For this study, the watershed was divided into ten different zones on the basis of altitude and aspect because rainfall and land use alter with changing altitude and to a lesser extent aspect (Figure 91). For example, lower areas are mainly under *khet* (irrigated agricultural land) and upland areas under *bari* (rainfed agricultural land). In addition, water supply was expected to differ according to topographical location, with differences in moisture at different altitudes and aspects. Furthermore, the road leading through the watershed has had a big influence on the population pattern and problems concerned with agriculture (Brown 1998), an influence also dominated by a north/south divide.

In each of the ten zones or blocks, a number of interviews were held using a formal questionnaire in Nepali which was filled out by local enumerators trained by PARDYP. The questionnaire, one for the female and one for the male head of household, contained three parts:

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

The decision to develop a separate questionnaire for women and men resulted from an RRA exercise done early in the project phase. Both this exercise and previous studies in the area showed that women farmers are responsible for work concerned with the household and animals, while men take care of some aspects of agricultural work including irrigation management. A total of 436 persons were interviewed from 218 households (218 women/ 218 men). The location of each household was marked on a 1:5,000 scale aerial photograph in order to facilitate future reassessments of the water need and supply situation.

General Assessment of Water Problems within the Watershed

The importance of water is underlined by the perceptions of the local people. 'Life' was mentioned as one word to describe water by 223 people (51%). Other words mentioned were 'soul', 'important', 'creation', and 'essential thing'. However, people also considered that there were major problems with water. Table 69 shows the amount of rainfall in the different blocks together with the perception of the residents in each block of the area as wet or dry, and the percentage of those who faced problems with water shortages. The overall number of those who faced a range of different problems with water is summarised in Figure 92.

More than 50 per cent of respondents considered the Yarsha Khola watershed to be 'dry' and only 45 per cent to be 'wet'. The perception varied with location: people generally saw the south slope, the middle part of the watershed and the lowest part of the northern slope as dry, and the upland areas of the northern slope as wet. On an annual basis, there is plenty of rainfall and the watershed can be classified as humid sub-tropical to cool temperate.

Table 69: **Annual Rainfall in 1998 and the Perception of Residents in Different Blocks**

	Block (masl)	Perception		Yes answers* to the question: 'Do you face problems with water quantity for				Rainfall	
		Dry	Wet	irrigation?'		drinking?'		Annual (mm)	Station (masl)
				No.	%	No.	%		
S1	South (>2200)	**16**	4	15	75	14	70	3316	Thuloban (2640)
S2	South (1900-2200)	38	**40**	50	63	43	54	2554	Jyamire (1950)
S3	South (1500-1900)	**33**	6	24	60	19	48	2049	Bagar (1690)
S4	South (<1500)	**39**	1	33	83	18	45	1760	Namdu (1400)
N1	North (>2200)	4	**12**	14	88	14	88	Installed in July 98	Pokhari (2260)
N2	North (1900-2200)	5	**29**	21	53	21	53	-	
N3	Middle (1500-1900)	**35**	16	35	58	23	38	Installed in June 98	Mrige (1610)
N4	North (1500-2200)	0	**60**	31	52	47	78	1847	Gairimudi (1530)
N5	Middle (<1500)	**22**	17	32	80	36	90	-	
N6	North (<1500)	**26**	9	32	78	25	63	1678	Main Hydro Station (1005)
	Total	218	194	287	70	260	63		
	No. of Respondents	412	412	412	100	412	100		

* Multiple answers possible

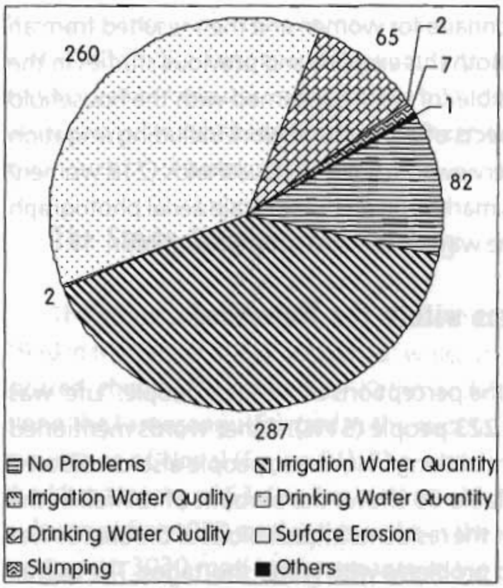

Figure 92: **Problems with Water in the Yarsha Khola Watershed**

However, the residents perception is that south facing areas with an annual rainfall of even 3,300 mm are dry as are north facing areas with an annual rainfall of 1700 mm. Thus annual rainfall alone is not a good indicator for people's perception of the relative wetness/dryness of their location.

Most of the total rainfall (more than 80 per cent on average, Merz *et al.* this volume) falls during the monsoon period. The perception of the watershed as dry is explained by answers to the question 'Do the residents face water problems?', to which 81 per cent of those interviewed answered 'yes'. The majority of those asked faced water shortages for irrigation (70%) and/or drinking (63%). Water for both drinking and irrigation was a particular concern in the upper areas of the watershed (blocks S1 and N1, see Table 69) and the middle ridge in the lower part (block N5), for drinking water on the middle northern slopes (block N4), and for irrigation in areas below 1500m (S4, N6). Drinking water quality was mentioned by 65 people (15% overall, 37% of those in the affected blocks) in the most densely populated blocks (S2, S3, and N4) which include the settlements of Mainapokhari and Gairimudi, indicating that this is also a major watershed issue. Minor problems mentioned were slumping (7 respondents) and surface erosion (2).

The number of respondents facing water shortages in different months on long-term experience is shown in Figure 93. Water shortage, both for agricultural and household supply, a big problem during the pre-monsoon period (Chaitra to Jestha, mid-March to Mid-June). Shortage of water for irrigation started in early winter and peaked in the month of Falgun (mid-February to mid-March, Figure 93), household water shortage problems arose in late winter to early pre-monsoon, and peaked in Chaitra (mid-March to mid-April). There was no water shortage during the monsoon months of Shrawan to Ashwin (mid-July to mid-October) for either households or agriculture.

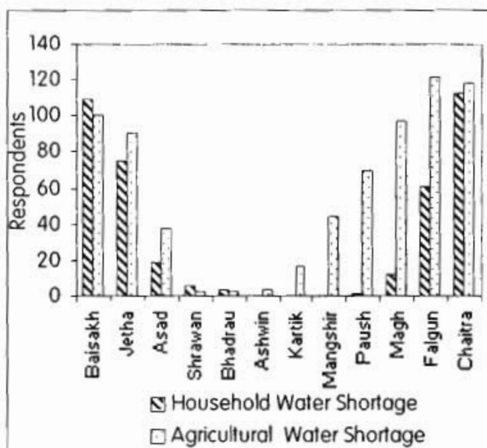

Figure 93: **Months with Water Shortage in the Yarsha Khola Watershed (total number of respondents: 218)**

Household Water Supply

Questions related to household water supply were put to female heads of household (N=218). Household water shortage was the major concern—57 per cent mentioned water scarcity, with the upper parts of the watershed facing the biggest problems. In block N1 (north facing >2200m), eight out of eight respondents mentioned water scarcity; on the high south facing slope (S1) eight out of ten (two gave no answer). However, the situation was said to have generally improved during the last five years: of a total of 218, 137 women thought household water availability had increased, 30 that availability had decreased, and 45 that there had been no change. This overall increase in water availability is believed to be the result of the installation of an extensive tap system; 84 per cent of the households interviewed obtained their water from tapped sources, which mainly belong to the communities.

However, some of these taps seem to be improperly installed, as shown by the problems indicated with the water sources (Figure 94). Contamination with sediment was mentioned by 52 people, mostly in the middle and upper parts of the watershed (S1: 40%, S3: 40%, N2: 45%, N3: 50%). Complaints of bad taste, bad quality ("people often sick"), and animal droppings reveal improper filtering and poor intake construction. Water shortage at the source was indicated by the answer "often dry" (27 people). 'Other problems' included: too far, only one tap, and pipe breakages.

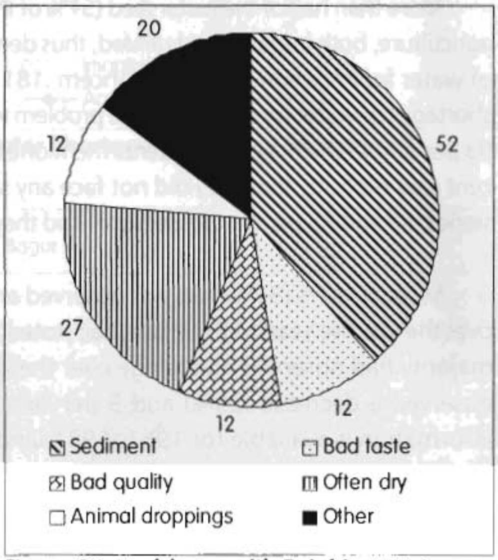

Figure 94: **Problems with Drinking Water Supply, Yarsha Khola**

The average round trip for fetching water in the watershed was 22 minutes (N=218) with a maximum of more than 60 minutes. The average time per day spent in fetching water was 109 minutes. Water is mainly fetched by the female head of household (138 cases). In 265 cases another female member of the family (daughter, mother-in-law) was said to fetch household water. Multiple answers were possible, i.e., the respondents could mention female head, daughter, and mother-in-law at the same time. Although 174 respondents said that a male member of the household, and 67 respondents that any member of the family fetched water these answers contradict the field observations, which showed mostly women queuing at the public water taps.

Each household in the watershed used 107.5 l water per day on average; or 20.6 l of water per person per day. For comparison, drinking water schemes in Nepal are designed on the basis of an average use of 45 l per person per day; this includes the Kathmandu Valley (Mr. Nani Ram Thapa, pers. comm.).

In addition to household water, each household used an average of 65.5 l/day for animals (drinking and washing). The average livestock composition per household was 1.1 buffaloes, 0.9 cows, 1.5 oxen, 3.3 goats, and 0.1 *chauri*. Most of the households in the survey (167 HH, 77%) brought the water for the animals back to the house rather than bringing the animals to the water source.

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

Agricultural Water Supply

More than half of the watershed (51% of the watershed area, Shrestha this volume) is under agriculture, both irrigated and rainfed, thus demand for agricultural water is high. However, lack of water for irrigation is a major concern: 181 male farmers out of 218 (83%) said they faced shortages of water for irrigation. The problem was most acute on the south facing slopes where 93 per cent of the male respondents mentioned shortages of water for irrigation, and only 3 per cent said explicitly that they did not face any shortage. On the middle ridge and north facing slopes, 83 and 75 per cent respectively said they faced irrigation water shortage.

Most farmers (81%) had not observed any change in the availability of irrigation water over the last five years; 17 per cent had noted a decrease and only 2 per cent an increase. The majority had observed no change over the last 25 years either (66%), although more had observed a decrease (29%) and 5 per cent had observed an increase. Historic land use information is available for 1961, 1981, and 1996. There appears to have been no major change in the amount of land under irrigation between 1981 and 1996 (PARDYP Phase I field surveys—in 1981 15 per cent of the watershed was irrigated land, in 1996 14%).

Figure 95 shows the time irrigation water was needed and the time of water shortage according to the long-term experience of the respondents. Irrigation water shortage peaked in the month of Falgun (mid-February to mid-March), when wheat and potato crops require water. The rice crop faces few if any water shortages during the monsoon season, but water shortages might be encountered during the earlier nursery and planting stages, especially if the onset of the monsoon is late.

In 1998, there were no problems for the rice crop as the monsoon arrived on time (at the beginning of Asad, around June 15th). This can be seen by comparing the 1998 irrigation calendar (Figure 95) with the climatological water balance derived for Bagar, the main meteorological station of the watershed, which is situated in the upper parts of the irrigated areas (Figure 96). However, 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, water availability is very low and farmers face a serious problem especially during Magh and Falgun.

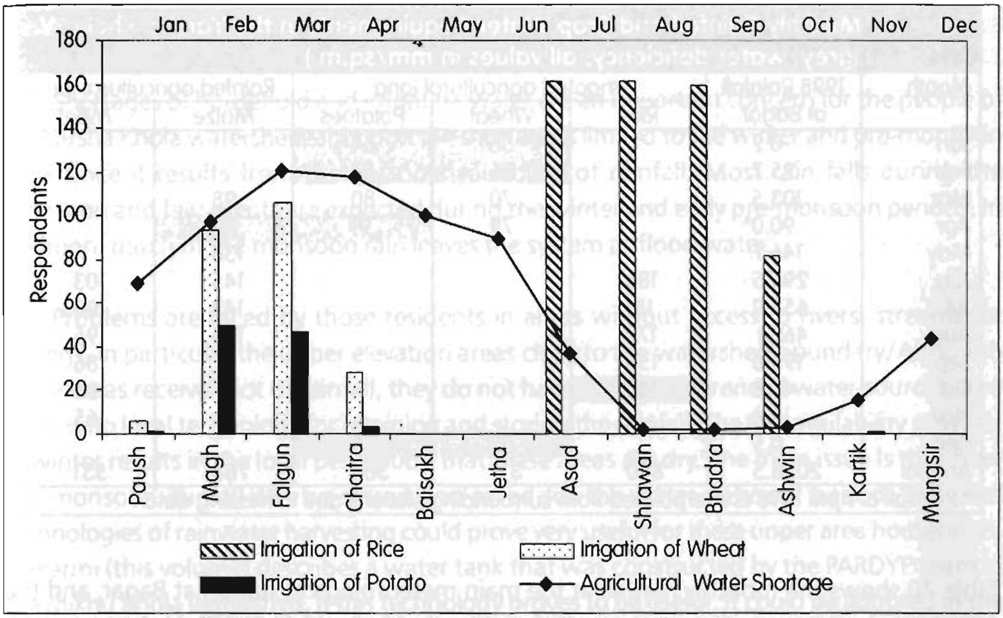

Figure 95: **Times of Irrigation and Irrigation Water Shortage (long-term experience)**

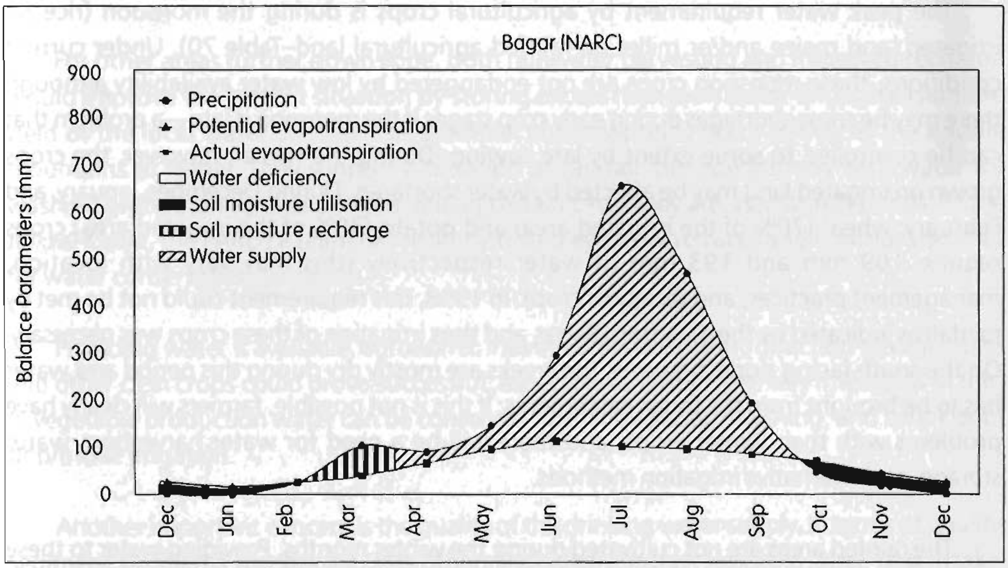

Figure 96: **Climatological Water Balance, Bagar, 1998**

The water requirements of the different crops grown in the Yarsha Khola watershed were assessed using the Blaney-Criddle method (Arora 1996). The cropping pattern was taken from previous PARDYP studies in the watershed (Brown 1998), and crop specific information from northern India (Israelsen *et al.* 1962). Only seasonal crop coefficients were used in this calculation, which results in higher than actual figures for consumption during harvesting in the case of potato and wheat. If monthly coefficients are used, these values drop somewhat.

Table 70: **Monthly Rainfall and Crop Water Requirements in the Yarsha Khola W (grey: water deficiency; all values in mm/sq.m.)**

Month	1998 Rainfall at Bagar	Irrigated agricultural land			Rainfed agricultural land	
		Rice	Wheat	Potatoes	Maize	Millet
Jan	0.2		56	64		
Feb	25.7		56	64		
Mar	103.5		70	80	98	
Apr	90.0*		79	91	112	
May	146.1				138	
Jun	295.5	186			145	103
Jul	653.9	181			142	100
Aug	462.1	172			135	95
Sep	193.8	156				86
Oct	48.8	145				80
Nov	18.4					65
Dec	0.5		57	65		
Annual	2038.5	840	317	364	768	531

* Rainfall of April 1998 is interpolated from surrounding stations due to missing data

Table 70 shows the monthly rainfall at the main meteorological station at Bagar, and the monthly crop water requirements as calculated for the Yarsha Khola watershed.

The peak water requirement by agricultural crops is during the monsoon (rice on irrigated, and maize and/or millet on rainfed agricultural land–Table 70). Under current conditions, these monsoon crops are not endangered by low water availability although there may be some shortages during early crop stages if the monsoon is late—a problem that can be controlled to some extent by late sowing. During the winter, however, the crops grown on irrigated land may be affected by water shortages. During December, January, and February, wheat (70% of the irrigated area) and potato (30% of the irrigated area) crops require 169 mm and 193 mm of water respectively (this may vary with location, management practices, and variety of crop). In 1998, this requirement could not be met by rainfall as indicated by the data from Bagar, and thus irrigation of these crops was necessary. On the south facing slope, however, the creeks are mostly dry during this period and water has to be brought from the forest catchments. If this is not possible, farmers will clearly have problems with their winter crops, and there will be a need for water harvesting, water storage, and alternative irrigation methods.

The rainfed areas are not cultivated during the winter months. Providing water to these areas during the dry periods could have a major impact on the household economy of the small farmers. Farmers said that if they had more water, or more water during normally dry periods, they would mainly be interested in vegetable production (151 in case of more water supply, 145 in case of water supply at different times, out of a total of 218), followed by fruit production. The products that were specifically mentioned were staple crops (rice, wheat), potatoes, garlic, and ginger. To date, only a few farmers store water from the monsoon period using small ponds, no other techniques were observed. The ponds did not seem to be very effective for storing water for later in the year although they may increase infiltration locally.

Discussion

Shortages of household and irrigation water are an important concern for the people of the Yarsha Khola watershed, although the shortage is limited to the winter and pre-monsoon time since it results from the seasonal variability of rainfall. Most rain falls during the monsoon and few events are expected during the winter and early pre-monsoon periods. In addition, much of the monsoon rain leaves the system as flood water.

Problems are faced by those residents in areas without access to rivers, streams, or springs, in particular the upper elevation areas close to the watershed boundary. Although these areas receive a lot of rainfall, they do not have access to perennial water sources, and there is no local technology for retaining and storing the rainfall. The low availability of water in winter results in the local perception that these areas are dry. The main issue is thus how the monsoon rainfall can be stored and saved for the water deficient period. Different technologies of rainwater harvesting could prove very useful for these upper area households. Nakarmi (this volume) describes a water tank that was constructed by the PARDYP team in the Jhikhu Khola watershed. If this technology proves to be useful, it could be adopted in the Yarsha Khola ridge areas. Other techniques are described in Dixit (1991), Agarwal *et al.* (1997), and Chalise *et al.* (in press).

For other areas further downslope, both rainwater harvesting and improved recharge would improve the current situation by storing excess monsoon water and increasing the yield of the local water sources. For example, shallow ponds occur widely in the middle mountains of Nepal. They support infiltration of rainfall, provide farmers with water for washing and watering their animals, and in certain cases they are used as fish ponds. In the Jhikhu Khola, the PARDYP team has recently tested eyebrow terraces and contour trenches for water conservation purposes.

Providing water is available, agronomic interventions like the introduction of vegetables and other cash crops could prove successful, especially as farmers are very interested in this. In vegetable production water can be conserved further by plastic mulching, and sprinkler or drip/trickle irrigation.

Another important concern is the quality of the drinking water supply. In terms of quality, sediment problems top the list, but others include improper supply system, bad intake, broken pipe system, and too few taps. There are several reasons contributing to poor water quality in the main residential areas, but mapping of point-source pollution would be necessary to enable specific causes for each problem area to be identified.

On the basis of these results, the PARDYP project is launching a major study in the field of water harvesting and water management alternatives. After the documentation of local knowledge in Nepal, and learning from other past and present projects, an extensive trial period will be initiated using different techniques as appropriate to the local conditions and as accepted by local residents. PARDYP is a regional project, so that appropriate knowledge from partner countries can be transferred easily to the watersheds in other countries and tested under the given local conditions in those watersheds. Some of the analyses of the PARDYP measurement network data from the five hydrological and eleven meteorological stations in the Yarsha Khola watershed will be directed towards a 'water for the farmer' approach. This mainly involves studies concerned with water availability, low flows, and drinking water quality. The work will be performed together with agronomists, soils specialists, and sociologists in integrated teams in order to achieve the best possible results.

For drinking water, potential collaboration is foreseen between PARDYP and relevant NGOs or government departments. It appears necessary to take a close look at the intakes of the pipe system and maintenance of the existing supply system and, as learnt from a visit to a 12-year-old drinking water scheme, the social aspect should not be forgotten. The improvements proposed by the local residents mainly cover the supply of continuous water close to their houses, in particular involving maintenance and pipe extensions.

Conclusion

The Yarsha Khola watershed has plentiful water resources but the local residents face the problem of seasonal rainfall variability, as do the great majority of watersheds in the HKH. Most of the rainfall is expected during the monsoon, and during the winter and pre-monsoon period there is not enough water for household or agricultural supply. The communities in the watershed all rely on local water sources for their daily supply. The population is increasing by 2.6 per cent annually (1971–1996), leading to intensification of agriculture and of the existing water problems. The situation, especially during the six-month dry period, ranges in different areas between critical and serious—especially in terms of development potential, labour use, and household income.

Water is not an unlimited commodity in the Yarsha Khola watershed. The following steps might help improve the water supply situation in the watershed:

- introduction of rainwater harvesting technology throughout the watershed, and especially in the ridge areas near the watershed boundary;
- introduction of storage systems for river and spring water in order to save water from the surplus period during the monsoon for the deficiency period during the dry season;
- support of measures to improve the natural recharge of springs;
- collaborative programme with drinking water groups and specialists and local women's groups in order to improve the water quality of the community tap water systems;
- agricultural investigations of alternative crop and land/water management systems under given and changing conditions; and
- technical solutions in collaboration with the local technical school in Jiri.

It is important that the social aspects are considered for any technically sound solutions identified–for example, is it acceptable, can it be managed, will the water be equitably distributed, does the initiative/innovation/technology mean more laborious drudgery (especially for women), is technical back-up available, can the technology be maintained, and is training required. Wherever financially and practically feasible, PARDYP will tackle the above problems and challenges in Phase II, which is scheduled to begin in October 1999 and run for three years and three months.

Acknowledgements

The work and efforts of the local enumerators involved in the data collection, and of Ms. R. Lama and Mr. T.S. Karki who were responsible for typing in Nepali, are gratefully acknowledged.

References

Agarwal, A. and Narain, S. (1997). *Dying Wisdom*. New Delhi: Centre for Science and Environment.

Arora, K.R. (1996). *Irrigation, Water Power and Water Resources Engineering*. New Delhi: Standard Publishers and Distributors.

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

Chalise, S.R.; Pradhan, P. and Xinbao, Z. (eds) (in prep.). *Water Harvesting for Mountain Households in the Hindu Kush-Himalayas*. Kathmandu: ICIMOD.

Dixit, A. and Upadhyaya, S. (1991). 'Rainwater Cistern, Its Uses in Nepal - Problems, Prospects and Promotion'. In Show-Chynan, C. (ed) *Proceedings of the 5th International Conference on Rain Water Cistern Systems, Taipei.*

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

Israelsen, O.W. and Hansen, V.E. (1962). *Irrigation, Principles and Practices*. New York : John Wiley and Sons.

Merz, J.; Dangol, P.M. and Dhakal, M.P. (this volume). 'Comparison of Climatological Balances for the Jhkihu Khola and Yarsha Khola Watersheds'. In Allen, R.; Shreier, H.; Brown, S. and Shah, P. B. (eds) *The People and Resource Dynamics Project: The First Three Years (1996-1999)*. Kathmandu: ICIMOD.

Nakarmi, G. and Neupane, P. (this volume). 'Harvesting Rain Water at Kubhinde, Kavrepalanchok District, Nepal'. In Allen, R.; Shreier, H.; Brown, S. and Shah, P. B. (eds) *The People and Resource Dynamics Project: The First Three Years (1996-1999)*. Kathmandu: ICIMOD.

Shrestha, B. (this volume). 'Population Dynamics and Land Use in the Yarsha Khola Watershed'. In Allen, R.; Shreier, H.; Brown, S. and Shah, P. B. (eds) *The People and Resource Dynamics Project: The First Three Years (1996-1999)*. Kathmandu: ICIMOD.