8 WATER-RELATED KEY ISSUES IN MESO-SCALE CATCHMENTS OF THE HINDU KUSH-HIMALAYAS

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Abstract

In many meso-scale catchments of the Hindu Kush-Himalayas (HKH) water is in short supply and water quality is increasingly becoming a concern. A study in five catchments across the HKH in Pakistan, India, Nepal, and China has shown that irrigation water availability followed by inadequate drinking water supply are the main concerns of the local residents. According to the perception of local residents, irrigation water availability has decreased over the last 5-25 years. The main reason for this is the intensification of cropping systems with now up to four crops annually. Drinking water supply has improved in many cases, but is still insufficient. Water demand, due to improved living standards, is expected to increase further. The increase in population, large numbers of livestock, and, in some cases, intensive farming practices have led to water quality concerns. It was found that in general the nature and the mismanagement of water resources are the main reasons for water scarcity.

This paper discusses the preliminary findings from the catchment-based synthesis of water-related activities in the People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas project (PARDYP). It focuses on the key issues as identified by the local residents of the five research catchments. The current status of these issues, the processes leading to these issues, possible future developments, and tested and proposed options are discussed on the basis of results from participatory surveys and intensive hydrometeorological monitoring. The paper concludes with an outlook of the planned programme for phase 3 of the project.

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Introduction

Water is life – a perception that is shared by more than 60% of the residents in the two catchments studied in the Nepal Himalayas. Simultaneously, water is destructive when there is too much and is the reason for great despair in many regions of the world when there is too little. Too much and too little, both issues are experienced in the Hindu Kush-Himalayas (HKH) on an annual basis during the monsoon and the dry seasons, respectively (Chalise and Sial 2000). On the basis of an opinion poll conducted in July 2002 through the Internet, four key water-related issues were identified to be of utmost importance at the regional scale in the HKH. The answers of 49 respondents from 13 countries including India, Nepal, China, the UK, and others were divided into the causes and the effects. There were 63 causes mentioned, including water management, water institutions and policies, deforestation, and climatic constraints. On the basis of these causes the following main effects were identified:

- water availability for human purposes (agricultural, domestic, and industrial use);
- flooding in the foothills and adjacent plains;
- water quality and pollution;
- water-induced land degradation and sedimentation.

The availability of adequate water resources for future generations is not only a regional issue, but is also a subject of concern at global scale. Water demand has increased globally 6-fold in the past 100 years and about half of all available freshwater is being used directly for human purposes (Cosgrove and Rijsberman 2000). Globally 38% of people are living in countries under severe water stress (Alcamo et al. 2000). Within the HKH region, in Pakistan and Afghanistan in particular there are concerns that already most of the available water resources have been exploited. According to Shiklamonov (2000) water availability in south Asia was already very low in 1995 and is expected to decrease further.

After water availability, floods are rated the second biggest issue. The HKH has a long history of floods and annually tens of thousands of people are affected by medium to large flood events in the region. It is the plains adjacent to the mountain ranges where the floods are most destructive in terms of loss of lives and financial losses. This is not only due to the force and magnitude of the floods but also to the number of people and the value of the assets at risk. Flooding also occurs in the inner valleys of the HKH (for example, the Kathmandu Valley in Nepal, valleys in the Garhwal-Kumaon Himalayas and the Eastern Himalayas in India) and is often related to erosive processes such as landslides and debris flow. To what extent effects of land use change and management of natural resources are responsible for large flood events in the plains has been the subject of heated discussions over the last two decades (see, for example, Ives and Messerli 1989; Hofer and Messerli 1998).

Increasingly water pollution is creating a problem not only in urban areas, but also in areas with intensive agriculture. Excessive use of chemical fertilisers leads in many cases to increased eutrophication, which according to Kraemer et al. (2001) has shown the biggest worldwide growth in Asian rivers.

The reasons for the issues mentioned above, such as water scarcity, floods and water pollution, and the impacts of these processes at the local scale in rural areas of the HKH are not yet fully understood, partially due to inappropriate or missing data. Recognising the need for an integrated and interdisciplinary approach to the above problems with a long-term perspective, the People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas (PARDYP) project was launched. For an introduction to the PARDYP project and the location of the sites refer to White and Merz (this volume, Chapter 2). The following provides an introduction to the activities and issues related to water.

Water-related Key Issues in Selected Catchments of the HKH

Water availability was identified to be the main issue for residents of the selected middle mountain catchments (Table 8.1). Insufficient water for irrigation was cited as the main problem, closely followed by drinking water shortages. Increasing water pollution is becoming a concern in some catchments. Other studies in the HKH show similar results. In Changar, Himachal Pradesh, India (part of the Indian Western Himalayas), acute water scarcity prevails for both drinking as well as irrigation (IGCEDP 2001).

Table 8.1: **Water-related key issues at the catchment scale (PARDYP catchments*)**

Priority	Hilkot (Pakistan)	Bhetagad (India)	Jhikhu (Nepal)	Yarsha (Nepal)	Xizhuang (China)
1	Water shortage for irrigation	Depletion of water resources	Irrigation water shortage	Irrigation water shortage	Water shortage during dry season
2	Water management	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	Soil and nutrient losses	Deteriorating water quality		Drinking water shortage
4		Water pollution	Top soil loss and nutrient build-up		

* These issues were identified by the PARDYP country teams through household surveys, focus group meetings, hydrometeorological monitoring and several years work experience in their respective catchments; for location of the catchments refer to White and Merz (this volume, Chapter 2).

Negi and Joshi (2002) identified drinking water as a major problem in the Central Himalayan region. In the Sikkim Himalayas Sharma et al. (1998) likewise postulated that drying up of springs and drinking water scarcity are putting considerable stress on the local population. Singh and Pandey (1989) also report water scarcity due to drying up and decreasing yields of springs in the Kumaon Himalayas. They mainly held the degradation of the natural oak forests responsible for this process. Hill towns in Darjeeling and Shillong, the wettest corner of the Indian sub-continent, face water scarcity all year round according to Subba (2001).

While people of the HKH have learned to cope with seasonality of water availability in the past, new pressure on water resources with decreasing water availability may threaten livelihoods, particularly of marginal people. The root causes of this crisis can be attributed both to human and natural factors. Possible factors leading to reduced water availability are discussed below.

Status of the Main Issue: Water Availability

The main issues reported in the two catchments studied in Nepal are access to irrigation water, followed by adequate drinking water. In the Jhikhu Khola catchment, 33% of the total 356 respondents indicated problems in terms of irrigation water quantity. In the Yarsha Khola catchment, 41% of 436 respondents reported that their irrigation water demand is not met. Similarly, 27% of the respondents in the Jhikhu Khola catchment and 37% in the Yarsha Khola catchment indicated an inadequate supply of drinking water (see Table 8.2).

Table 8.2: **Water-related problems in the Yarsha Khola and Jhikhu Khola catchments (%)**

Problem indicated			Percentage of respondents	
			Jhikhu Khola	Yarsha Khola
No problems			12	4
Irrigation water	-	quality	41	33
	-	quality	0	7
Drinking water	-	quality	37	27
	-	quality	9	17
Flooding			0	1
Surface erosion			0	3
Slumping			1	8

Jhikhu Khola n= 356, Yarsha Khola n = 436 (multiple answers possible)

In the Hilkot catchment of Pakistan the last five years have been exceptionally dry and during this time 52 springs out of a total 152 have dried up. Another 45 springs have very low discharge and only 55 springs now yield an adequate supply. In the Chinese catchment, a karst area, many river courses in the upper areas, where most of the residents live, only show discharge immediately after rainfall.

Water availability is not just an issue of quantity, but also of quality. Water quality has a major impact on drinking water availability. None of the 33 water sources tested in the Jhikhu Khola catchment, including natural springs, water supply schemes, and wells, complied with the World Health Organization (WHO) guidelines for faecal coliform. Similarly in the Indian catchment none of the 12 investigated springs was free from faecal coliform. In terms of chemical pollution, none of the parameters were above guideline levels, although phosphate and nitrate were both elevated in many water sources in the catchments of India and Nepal. This can be attributed to intensive agriculture with high fertiliser application rates. According to a national survey by the National Planning Commission (NPC 2000) the microbiological contamination seems to have a major impact on health. In Nepal 16.2% of surveyed children had had diarrhoea during the 2 weeks prior to the survey, which was conducted during the peak season for diarrhoea in April to May. During a survey of the health posts located in the Jhikhu Khola catchment, 25% of the patients visiting these health facilities in the catchment suffered from water-related diseases. The most frequently occurring diseases are diarrhoea, worms, and dysentery.

Water availability is also limited by restricted access to water resources for social or economic reasons. A case of non-equal water distribution was documented by Nakarmi (1995) where low-caste farmers at the tail end of an irrigation system were not given adequate access to irrigation water during the dry season. The farmers at the head end of the system were from upper castes. As only a few studies have been conducted in this field, a major emphasis will be given to these access issues in the coming phase 3 of the PARDYP project.

Processes Leading to Water Availability Concerns

Reduced water availability may be the result of low natural water availability, high water demand, mismanagement of water resources, inappropriate land management, or any combination of these.

Seasonality of precipitation is the main factor. Very skewed rainfall patterns with a distinct wet season during the monsoon months from June to September and a dry season from October to May in the case of Nepal and India (Figure 8.1) are obvious factors. In the most western catchment, the Hilkot catchment in Pakistan, winter precipitation plays a vital role in the availability of water resources. Snowfall in January is particularly important for these areas mostly for replenishing soil moisture. However these annual snowfall events have not happened in the last few years. In 1998, the Chinese catchment received rain throughout the year with slightly higher values during the monsoon months. However, in the following year a drought occurred with no rainfall from October to May. A similar drought situation was observed in the catchments in Nepal and India.

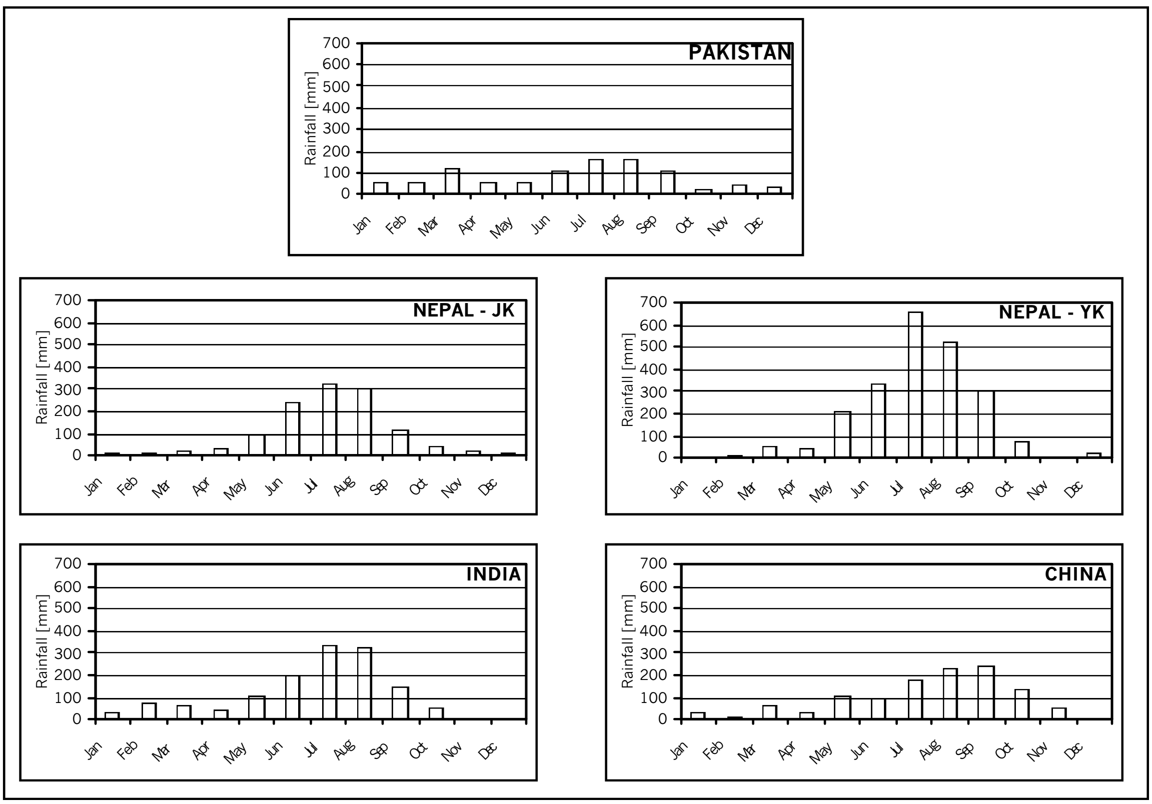

Figure 8.1: **Annual rainfall distribution in the five PARDYP catchments**

It is the months from October to May where rainfall is most variable in all catchments and farmers cannot count on good moisture conditions for their crops. Moisture conditions have an impact on all cropping systems in the four countries. During the second half of the dry season crops can only be grown on irrigated land. However, the timing of the end of the dry season greatly affects the planting of the main monsoon crop, for example, rice and maize in the Pakistan, India, and Nepal catchments, and maize in the Chinese catchment.

The three years' data from the Hilkot catchment in Pakistan show a dramatic reduction in rainfall over the last few years, from 1200 to 800 mm, which is mainly the missing precipitation from the winter season in the form of snow (Figure 8.2). However although these data are disturbing, it is not possible to tell yet whether this trend will continue or whether it is a temporary aberration. Even so, these data and the dramatic change in water yield from springs over the last five years, show how vulnerable these areas are to climatic variability and also to potential climate change in the future. For tropical Asia, the Intergovernmental Panel on Climate Change (IPCC 1998) suggested the following impacts of climate change on water resources.

- The Himalayas play a critical role in the provision of water for continental monsoon Asia.
- Increased temperature and increased seasonal variability in precipitation are expected to result in accelerated recession of glaciers and increasing danger from glacial lake outburst floods.
- Run-off from rain-fed rivers may change in the future. A reduction in snowmelt water would result in a decrease in dry-season flow of these rivers.
- Large populations and increasing demands in the agricultural, industrial, and hydropower sectors will put additional stresses on water resources.
- Pressure will be most acute in drier river basins and in those subject to low seasonal flows.

The removal of forests seems to have had an impact on water availability in the Indian catchment. In India the replacement of broad-leaf forests (oak and elder species) with

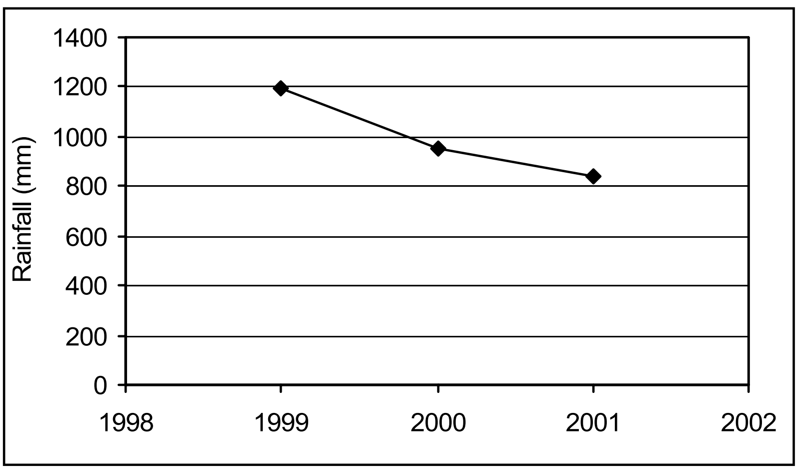

Figure 8.2: **Rainfall (mm) trend in Hilkot, Pakistan, over the last three years**

tea has had a negative impact on water availability (Verma et al. 2003). As the land use change only occurred some five years ago, no long-term improvement in household water availability has been identified yet. The monocultures of pine trees (*Pinus roxburghii*) in the same area have further contributed to the increased water shortage (Verma et al. in preparation).

The perceptions of trends are also very different in the five catchments. There are no trends visible in the long-term rainfall of the catchments in Nepal, for example. In terms of water demand, increasing populations are putting major stress on the available resources, including forests, soil, and water. The population in the Indian catchment has increased in the different villages between 1950 and 1991 from 40% to 160%. In the Jhikhu Khola catchment, the population increased by 3.5% annually during the period 1947-1996. According to the data of 1996, the population density in the catchment is 437 people/km^2. In the Yarsha Khola catchment, population growth rate was 2.7% between 1981 and 1996 with a population density of 386 people/km^2 in 1996. In the Chinese catchment of Xizhuang, the population doubled between 1950 and the present and the current population growth rate is about 2% (Xu et al. 2000). Increasing population has not only had a direct impact on water consumed, but also on water requirements for agriculture and food production. In this context the increase in cropping intensities is also an important factor. In the Jhikhu Khola catchment, cropping intensity has reached an average of about 2.6 with a maximum of 4 crops on irrigated land (Shrestha and Brown 1995).

Improvements in sanitation can also add to the existing pressures. In the Bhetagad catchment in India the numbers of households with flush toilets has increased dramatically over recent years. This development is still on-going and to date 50% of the households have flush toilets (Figure 8.3).

The issue of water mismanagement has been voiced as a problem in all catchments. A case study of one of the largest drinking water schemes in the Jhikhu Khola catchment

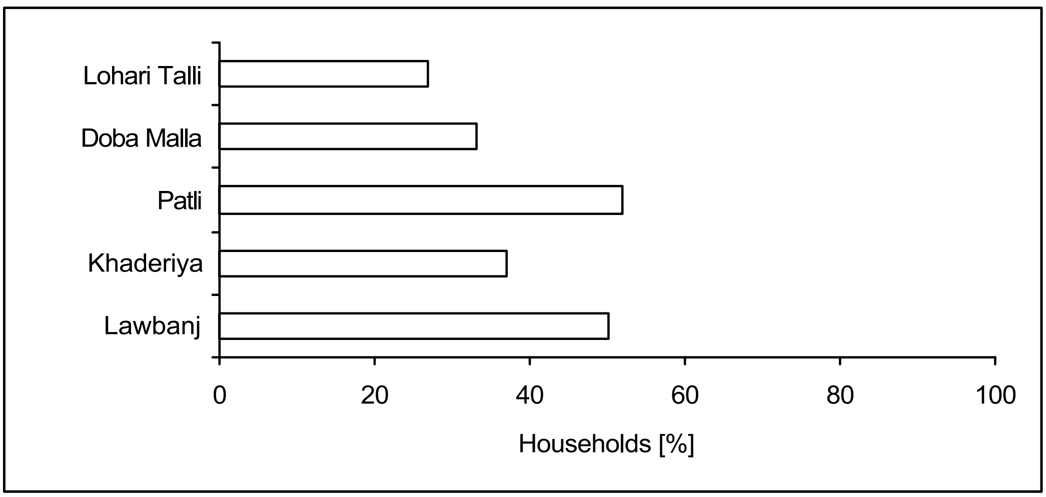

Figure 8.3: **Percentage of households in different villages with flush toilets in Bhetaged catchment, India**

in Nepal has shown that most feeder pipes have leaks. Furthermore some of the distribution tanks have deteriorated to the extent that polluted surface water is leaking into the system. The main reasons for this mismanagement are conflicts in the water users' association. Since the system was handed back to the government line agency, local efforts to keep the system running are limited.

In India adverse policies are held responsible for conflicts between the upstream and downstream users. Irrigation systems as well as the related laws and regulations are the reason for water losses and unequal distribution of water.

In the Hilkot catchment in Pakistan, 31% of the irrigation systems do not have any distribution regulations. In 38% of the systems, distribution is based on time and the remaining 31% work on a demand-based distribution system. Both systems without regulation and demand-based irrigation systems are subject to unequal distribution of water between the farmers at the head end of the system and the farmers at the tail end.

In an irrigation water scheme in the Jhikhu Khola catchment in Nepal, losses of up to 90% were identified between the head and the tail end of the system (Nakarmi 1995). Interestingly, there is often a caste difference between the head and the tail end, with higher castes residing and cultivating land at the head end and lower castes at the tail end, where water often becomes scarce. The quality problems were shown by the results of microbiological as well as chemical testing of a number of springs and other public water sources in the Jhikhu Khola catchment (Bajracharya et al. 2001).

Mitigation of Water Scarcity

Mitigation of water scarcity can be achieved by balancing water supply, water demand, and water quality management options. Both technological as well as institutional mechanisms are proposed in the different watersheds.

In the India catchment, protection through spring sanctuary development is proposed. For this purpose a technology package for catchment area protection of springs was developed by the GB Pant Institute of Himalayan Environment and Development. This appropriate and scientifically sound package has been tested in the Garhwal Himalayas (India) several times and is being implemented in several parts of the Indian Himalayan region. In the same region, infiltration wells with simple hand pumps have been tested. This approach is based on the observation of the drying up of springs. At the location of these springs an infiltration well is constructed to collect the infiltrating rain, which is later lifted by means of a hand pump.

The PARDYP team in Nepal has mainly looked into technological options for increasing water supply by means of water harvesting, and minimising water demand by using alternative irrigation methods. For drinking water, roof water harvesting is an option in areas along the watershed divides, where rainfall is the only convenient water source. To date, PARDYP has mainly focused on household-based options, rather than on community-based options. Tests and demonstrations have been conducted with ferro-cement water jars of 2000 l capacity as recommended by the Rural Water Supply and Sanitation Support Programme (RWSSSP 2000). These jars are household based and have proven to be very effective, not only for water storage during the dry season, but also for making water available close to the house during the wet season and therefore improving hygiene and reducing women's workload (Sharma 2001). As a result of these demonstrations, four families constructed four tanks at their own expense and without external support. In addition, six smaller units were constructed by local farmers with some seed money from PARDYP in four households.

For irrigation, tests were done with a 10,000 l tank harvesting surface runoff from degraded areas and road surfaces and applying this water to cash crops with drip irrigation (Adhikari et al. 2003). Other studies on water use efficiency, economic benefit, and impact on workload were conducted using drip irrigation for bitter gourd (Prajapati-Merz et al. 2003) and cauliflower (Von Westarp 2002). Other approaches to reducing water scarcity include fog harvesting and the use of locally available groundwater; these are discussed in Merz et al. (2003).

PARDYP Pakistan introduced drip irrigation on a small tomato plot of 250m^2 during the dry period from May until the first week of June 2002. Five rows were laid out across the slope with a row-row distance of 75 cm. The number of plants/row ranged between 20 and 25 with a plant-plant distance of 30 cm. The yield obtained was 5 t/ha as compared to a control yield of 2 t/ha from a farmer's field nearby. Most of the plots in the surrounding land suffered due to scarcity of water during that period and as a result many farmers got nothing from their fields. The results showed that farmers could get good returns from their vegetable plots even with a small amount of water if they adopted drip irrigation systems for their fields.

Water harvesting was also implemented in China where water availability is a major constraint for maize in the pre-monsoon season. Maize is an important crop for the local farmers, as they can exchange two bags of maize for one bag of rice. Personal observations were made of farmers carrying water from distant sources to irrigate plant by plant during the transplantation of young maize seedlings. Surface runoff water harvesting in small tanks of size 1.5-6 m^3 adjacent to the agricultural fields has provided water both for initial irrigation as well as irrigation in the case of drought conditions. From 2000 to 2001 an increase in maize yield of 13% was observed. For wheat an increase of 16% was reported for the same plot of 0.6 mu (~0.04 ha).

Conclusions

Water availability is a major concern according to local people as well as the results from the long-term observations of PARDYP in five watersheds across the HKH. The reasons for this scarcity are the natural settings as well as inadequate management of the resources in the catchments. There are no signs of increasing water availability to date. Water resources are believed to be becoming scarcer as a result of increasing demand by an increasing population, higher living standards, and potentially decreasing natural water availability due to climate change. Mitigation measures include technical, social, and institutional mechanisms; PARDYP has mainly looked at the technical possibilities. In the next project phase greater attention will be given to the social and institutional aspects. An important question is the degree of government involvement as well as household-versus community-based solutions. Access to water resources will be at the centre of the discussion in this next phase.

A more detailed and refined account of the content of this paper and other key issues identified in the five PARDYP catchments is in preparation in the form of a CD-ROM. First drafts can be obtained from the corresponding author; the final CD-ROM is expected to be complete in early 2004. This detailed review aims at taking stock of the current knowledge of water-related key issues in the catchments. This supports the efforts in the coming phase of the project related to improved water management and improved water quality. First decisions on the programme of the water and erosion studies have been made on the basis of this exercise. The programme will include a focus on treatment of microbiological contamination, in-depth studies of the irrigation systems in all catchments, and alternative irrigation methods such as drip and sprinkler irrigation.

Acknowledgements

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