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Upstream-downstream Linkages for Catchment Level Water Use Master Plans (WUMP) in the Mid-hills of Nepal

HELVETAS Swiss Intercooperation NEPAL

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Upstream-downstream Linkages for Catchment Level Water Use Master Plans (WUMP) in the Mid-hills of Nepal

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Acronyms and Abbreviations

DADO	District Agriculture Development Office
DDC	District Development Committee
FGD	Focus Group Discussion
ICIMOD	International Centre for Integrated Mountain Development
IES	Incentive for Ecosystem Services
IWRM	Integrated Water Resources Management
KBP	Koshi Basin Programme
NPR	Nepalese Rupees
USD	US Dollar
VDC	Village Development Committee
WUMP	Water Use Master Plan

Executive Summary

In mountainous regions, the resource management practices in the upstream areas, especially land and water management, have a direct impact on the downstream communities; at the same time, water availability can directly affect livelihood-related activities in both areas. Upstream-downstream linkages occur at different scales (from micro-watersheds to river basins), across physiographic regions (mountains to plains), across different administrative divisions (wards to countries), and between countries. Studies have found that good watershed management practices in upstream areas can bring opportunities to downstream communities in the form of sustained spring flow, whereas poor watershed management practices have the potential to increase the likelihood of landslide events upstream and contribute to low water-flow in the dry season downstream. Thus, downstream communities have both opportunities and potential threats linked to the management of water in upstream areas.

HELVETAS Swiss Intercooperation Nepal has been involved in the development of Water Use Master Plans (WUMPs) throughout Nepal. Under the Koshi Basin Programme (KBP), ICIMOD and HELVETAS have initiated collaborative action research to develop Water Use Master Plans (WUMPs) in three districts – Sindhupalchok, Sindhuli, and Saptari – representing three ecological zones (mountains, hills, and Terai, respectively) in the Koshi river basin in Nepal. Previous experience with WUMPs has shown that limiting a WUMP to the single administrative entity of a VDC can reduce efficacy as the plan is unable to take into account the impact of the upstream VDCs, where most of the water sources are located. ICIMOD and HELVETAS carried out a scoping study to assess these upstream-downstream relationships and the implications for WUMPs and integrated water resource planning at different scales, taking the WUMP VDCs in the Adherikhola catchment in Sindhuli district as an example. This publication presents the results.

Sindhuli district is a typical hills area in Nepal. The study collected data and information through a household survey, focus group discussions, and detailed field investigations of water resources and management practices. The results showed that the upstream communities play an important role in watershed conservation. The upstream VDCs (Jalkanya and two wards of Ratanchura VDC) have a total of 99 water sources (springs, ponds, and wells) yielding a total flow outside the monsoon season of 12.7 litres water per second, and the downstream VDC Bhimeshwor just 13 with a total flow of 1.63 litres per second. However, the benefit from the use of these water resources is largely generated downstream. Altogether, 297 ha of land is cultivated in the upstream VDCs, 49% irrigated, and 355 ha in the downstream VDC, 41% irrigated, i.e. more than half the land is not covered by irrigation. The yield of most crops was higher in the downstream VDC, mainly due to the higher level of irrigation and availability of flatter more productive land suitable for agriculture. The total estimated annual monetary value of crops was NRP 101 million (USD 1 million) in the downstream VDC, and NPR 43 million in the upstream VDCs, a per hectare benefit of NPR 285,000 in the downstream VDC, close to double the value of NPR 147,000 in the upstream VDCs.

The study showed that upstream-downstream relationships are very important for local water management. The distribution of resources and subsequent benefits can be improved if both communities work together for integrated watershed management. The downstream communities gain more benefit from the water than the upstream communities who conserve the sources. Thus, it is important for the downstream communities to join hands with the upstream communities for watershed conservation. During the field survey, both communities expressed their willingness to cooperate in integrated watershed management, but there is a lack of institutional mechanisms to bring the two communities together. The traditional WUMP plans do not encompass seasonal water availability and flow from upstream VDCs, the plans should take availability of water resources from upstream into account and include collaboration between upstream and downstream in local water management.

The scoping study was able to estimate how much water is generated and used in the upstream and downstream areas for domestic and agricultural purposes and provided ideas on how the productive use of water can be improved for communities in both areas. There are a number of steps to be followed to operationalize upstream-downstream collaboration, but the report concludes that the two parameters of water quantity and monetary value of productive use provide an entry point for the upstream-downstream dialogue and negotiations on catchment level water conservation and use. Scaling up over a larger area through appropriate dissemination strategies, and capacity building of stakeholders, are the immediate next steps suggested for forging new upstream-downstream linkages; the role of the government in this will be crucial. There is a need for further research in representative watershed areas where water has more competitive uses and strong economic linkages exist between the upstream and downstream communities (for example hydropower, fisheries); findings in such an area may be different and the findings together would enable the development of more consistent policy recommendations.

1. Introduction and Rationale

In mountainous regions, resource management practices in the upstream areas, especially land and water management, have a direct impact on the downstream communities. The challenges and issues vary considerably in upstream and downstream areas, but water availability can directly affect livelihood-related activities in both areas (Nepal, Flügel & Shrestha, 2014). Upstream-downstream linkages occur at different scales (from micro-watersheds to river basins), across physiographic regions (mountains to plains), across different administrative divisions (wards to countries), and between countries. The major issues are also affected by scale: the predominant issue at the micro-scale or catchment level is water availability, whereas floods and sedimentation predominate at river-basin level (Berhanu, Seleshi, Amare & Melesse, 2015; Ives & Messerli, 1989). Studies have found that good watershed management practices in upstream areas can bring opportunities to downstream areas in the form of sustained spring flow, whereas poor watershed management practices have the potential to increase the likelihood of landslide events upstream and to contribute to low water-flow for downstream communities in the dry season (Bhatta, Van Oort, van. Rucevska & Baral, 2014; Bruijnzeel & Bremmer, 1989; Nepal et al., 2014). Thus downstream communities experience both opportunities and potential threats linked to the management of water in upstream areas. In the context of integrated water resources management (IWRM) at a river basin scale, as envisaged in the Nepal National Water Plan 2005, it is essential to have integrated management of land and water resources at the level of the lowest administrative unit.

Local communities in the hills of Nepal experience considerable water scarcity. In general, springs and ponds are the major source of water for domestic use and irrigation. Many villages are situated far above the local streams and rivers, which lie at the bottom of deep gullies and valleys, and the cost of carrying or pumping water from rivers to the hill settlements can be high. In contrast, springs emerge all around the hill slopes close to the village (Sharma et al., 2016). In recent decades, there have been widespread reports of springs drying up in the southern Himalayas in Nepal, India, and Bhutan. Valdiya and Bartarya, (1991) reported widespread drying up of springs in western India and attributed the reduction to deforestation of hill slopes, with a 25–75% decrease in spring flow over 5–50 years. However, the idea of deforestation as the main culprit of Himalayan degradation has been challenged scientifically since the mid-1980s, specifically at the Mohonk Mountain Conference in 1986 (Thompson, Warburton & Hatley, 2006), and more recently with the improvements in forest cover following the adoption of community forestry. Tambe et al., (2012) identified catchment degradation (such as deforestation) as the main cause of drying up of springs in mountain villages and suggested that climate change is emerging as a new threat. Some springs are considered sacred, and Khatiwada, Nepal & Subedi, (2006) suggested that the community value system plays an important role in sustaining these traditional water supplies.

Sustained availability of water resources on the mountain hill slopes not only benefits the upstream communities but also the downstream communities, when water from the springs accumulates and flows downstream. Therefore, changes in water resource availability affect both upstream and downstream communities. It is important to understand the interdependence of these communities in terms of water resource use and resultant socioeconomic benefits.

ICIMOD and HELVETAS Swiss Intercooperation Nepal initiated collaborative action research under the Koshi Basin Programme (KBP) to develop a water use master plan (WUMP) for three districts – Sindhupalchok, Sindhuli, and Saptari – representing three ecological zones (mountains, hills, and Terai, respectively) in the Koshi river basin in Nepal. HELVETAS has already implemented a WUMP in the far and Mid-western regions of Nepal. These master plans plan the water resources within a village development committee (VDC) area. However, administrative boundaries do not necessarily coincide with the hydrological boundaries. To prepare an effective water resource plan, it is important to know the scenario in adjacent VDCs, especially those in which the water resources originate, in order to optimise benefits and minimize future conflicts on water resources. This requires catchment level planning at a higher level that takes into account the supply and demand for water in upstream and downstream areas.

The present study aimed to elucidate the relationship and interdependence of upstream and downstream areas in a typical hilly region in Nepal in terms of water supply and use, resources management, and institutional linkages.

The main research question concerns the differences in water availability and productive use of water resources in upstream and dependent downstream areas at a local scale. The report highlights the evidence for upstream-downstream relationships among a group of WUMP VDCs based on productive use of water resources, and explores the opportunities for integrated catchment level planning. The report will be useful for water resource planning and implementing organizations, integrated water resources management practitioners, and river basin planners, and can be used as a reference document for including upstream-downstream linkages in catchment level planning. The findings may also be useful for river basin approaches, especially building IWRM practices using a bottom-up approach.

2. Study Area

The study focused on VDCs selected for the WUMP study in the hills district of Sindhuli, which lies 134 km east of Kathmandu in the Central region of Nepal. Four VDCs were covered in the WUMP study: Jalkanya, Bhimeshwor, Ratanchura, and Baseshwor (Figure 1). Of these, two upstream VDCs (Jalkanya and two wards of Ratanchura) and one downstream VDC (Bhimeshwor) were selected that lay in a single catchment area – the Adherikhola catchment – and thus shared the same water resources, especially for domestic use and agriculture. The aim was to facilitate a study of the pattern of water sharing, water use, issues, and resolutions among upstream and downstream communities. The catchment lies in the rain shadow area of the hills facing north.

Figure 1: **The study area – the four WUMP VDCs and the borders of the Adherikhola catchment in Sindhuli District**

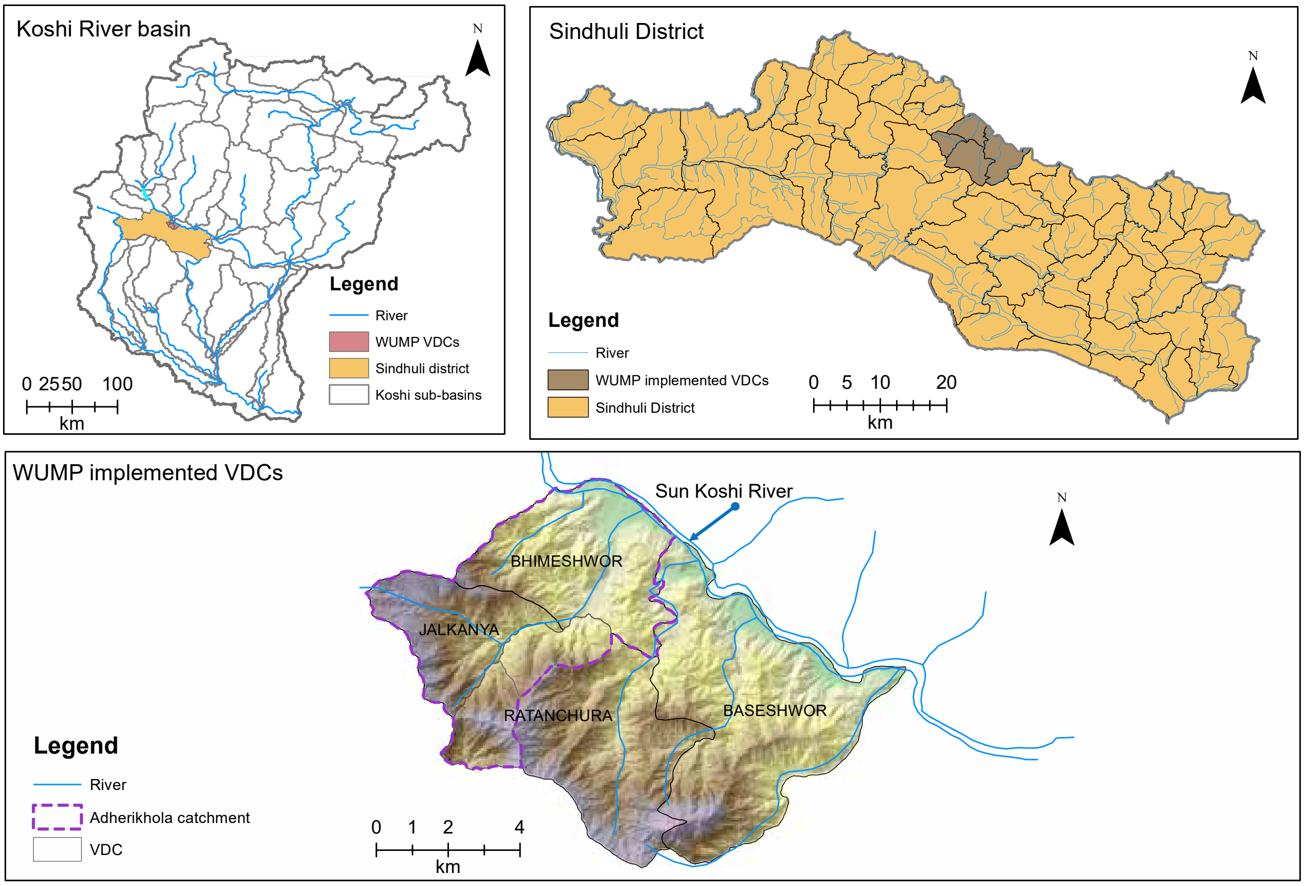


Table 1 shows the major characteristics of the study area. Springs and spring-fed streams are the main sources of water. Water from the springs in Jalkanya and Ratanchura (2 wards) join the Adherikhola (stream) at Kudule at 691 masl. The stream then flows through the lower part of Jalkanya and across Bhimeshwor VDC before joining the Sun Koshi river.

Table 1: **Characteristics of the study area (Adherikhola catchment)**

VDC	Population[a]	No. of HHs	Area (ha)	Elevation range (masl)	Water sources	Water use	Major crops
Jalkanya	2,603	445	903	880–1,855	springs, wells, ponds, streams	domestic, agriculture	paddy, wheat, millet, maize, citrus fruit
Ratanchura[b]	931	161	823	784–1,674	springs, streams	domestic, agriculture	paddy, wheat, maize, citrus fruit
Bhimeshwor	2,841	494	1,505	650–1,461	springs, streams	domestic, agriculture	paddy, wheat, maize, vegetables
Total	6,375	1,100	3,231	650–1,855			

[a] VDC wise population, (Date source: CBS, 2011) [b] Only Wards 1 and 2 in Ratanchura lie in the study area
Source: Field survey 2015

3. Methods

The study used a preliminary survey, focus group discussions, and detailed field survey to gather information on water sources, water use, and agricultural production.

Rapid Assessment and Research Design

A team from ICIMOD and HELVETAS with a representative from the Department of Irrigation (DoI) visited the study area in early 2015 to obtain a rapid overview of water resources, water use, sharing mechanisms, and any special issues in the area. Farmers from upstream and downstream areas and VDC representatives were consulted during the visit. The visit helped to identify the specific study site and fine-tune the research methods and instruments. The study team confirmed the existence of upstream-downstream relationships, with the downstream VDC dependent on the upstream VDCs for water. Some of the upstream communities also owned land in the downstream area. The preliminary survey helped in the development of an appropriate research design and ended with the planning of a detailed survey to collect more information on prevailing issues and challenges. A semi-structured questionnaire was developed through team consultation to capture the socioeconomic attributes of households and a checklist was developed for use in focus group discussions (FGDs) to obtain additional information from the targeted stakeholders.

Focus Group Discussions (FGDs)

The study team conducted three FGDs, one in each VDC. The FDGs were conducted during March 2015 just before the household surveys. Fifteen participants took part in each FDG, including water users, local community leaders, the VDC chairpersons, and others (Figure 2). The FDGs lasted approximately 90 minutes. The FGDs were used to obtain information about the water resources in each VDC, any deficit or scarcity of water, the views of communities on water source conservation, actions on water source conservation, willingness of communities to contribute to water source conservation, forest use, and other issues and challenges. In addition, personnel from the District Development Committee, Department of Forest, Department of Soil Conservation and Watershed Management, Department of Irrigation, and VDCs were also interviewed to get their feedback on the study and ask about the involvement of the VDCs in catchment level planning for water resource use, forest use, and others.

Figure 2: **Focus group discussions**

Bhimeshwor VDC

Jalkanya VDC

Household Survey

A semi-structured questionnaire was used in a household survey to obtain information at household level. A total of 120 households were selected at random, 40 households from each VDC (just over 10% of the households in the study area). Detailed socioeconomic data had been collected previously using a predefined WUMP checklist during the WUMP study; the study survey was used as a supplement to provide the additional information required for the study. Household interviews were carried out between March and June 2015 by two specially trained enumerators. Detailed information was collected on cultivated land, cropping practices, crop yield, prices, and water availability for agriculture.

Water Flow Measurement

Water flow was measured at different times representing three seasonal flows (pre-monsoon, post-monsoon, winter) following exhaustive mapping of the springs in the catchment. The aim was to assess total water availability. Flow measurement was first carried out as a part of the WUMP field survey in May 2015, ie pre-monsoon. Post-monsoon measurements were made in November/December 2015 and dry season measurements in March/April 2016. Water availability is at a maximum during the monsoon season due to the continual rainfall and water is sufficient for agriculture and domestic use, thus our measurements excluded this period.

Data Analysis Tools

Simple statistical tools such as mean, percentage, and standard deviation were used to analyse the socioeconomic data. Qualitative information from the FDGs was systematized and used to help interpret the quantitative data and describe the situation.

Overall, the study explored the interdependency between upstream and downstream communities in one catchment in terms of agricultural and domestic water use. No detailed information was available on the costs of agricultural production, thus crop value was used as a simple proxy for farm revenue. In future, it would be useful to calculate the net benefit derived by upstream and downstream farmers because the shadow price of water in the two areas is different. To do this, it would be necessary to know the actual shadow price of water in each area; this would be instrumental for designing water conservation and management policies for each area.

4. Results and Discussion

The following sections present the information obtained on resource use and upstream-downstream relationships to water.

Water Resources

The major water sources in the study area are springs, shallow wells (kuwa), and ponds (Figure 3 and Table 2). Jalkanya VDC has both the greatest number and highest density of sources, with 86 sources and 9.5 per square kilometre. It is also the only VDC with wells (3) and ponds (5), all other sources are springs. Ratanchura and Bhimeshwor have only 13 sources each, with a density per square kilometre of 1.6 and less than 1, respectively. Five of Bhimeshwor's nine wards (Wards 2, 3, 5, 7 and 8) have no water sources.

Figure 3: **Water sources in the study area (Adherikhola catchment)**

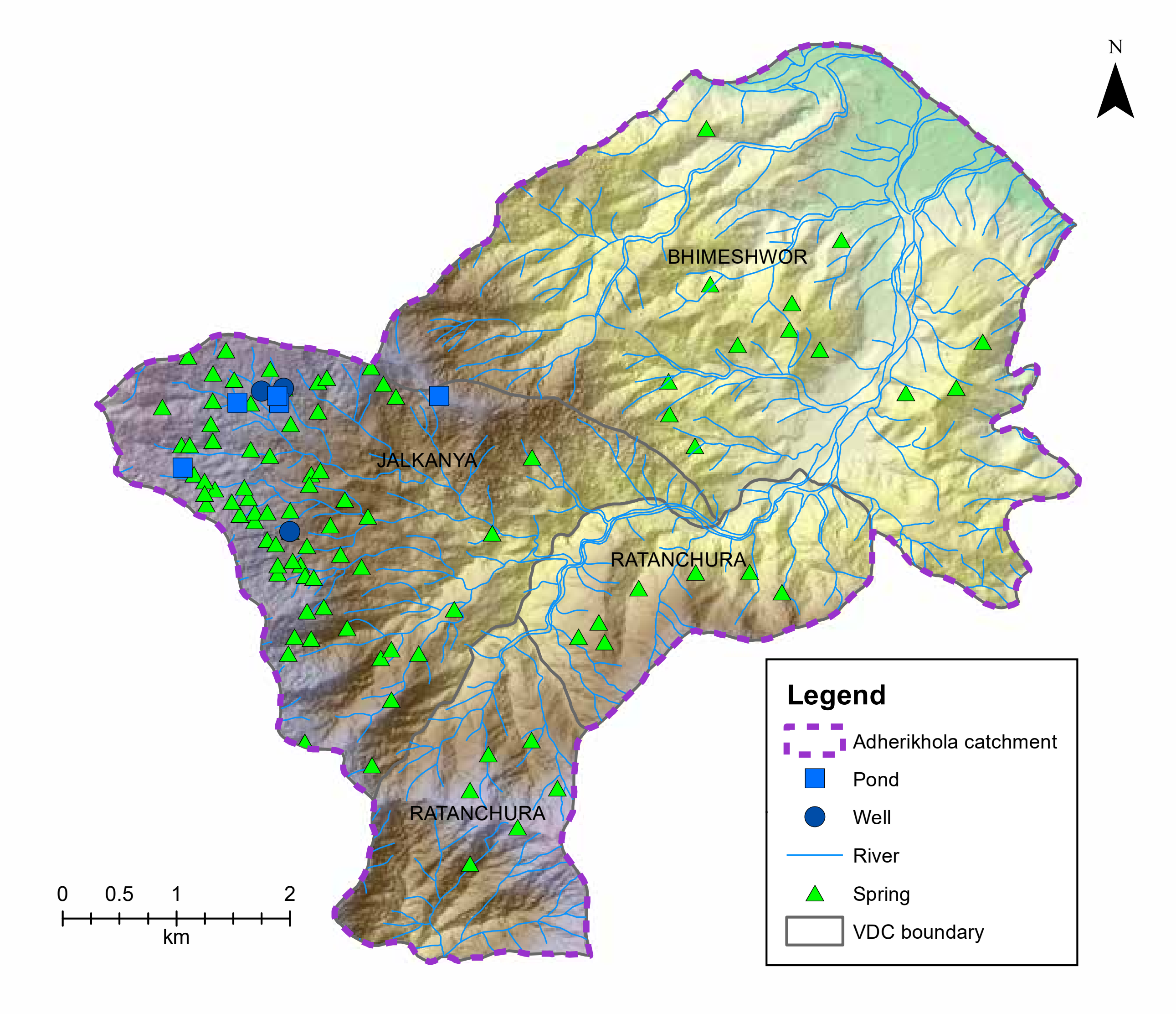


Table 2 shows the average flow from all identified sources in the study area during the three non-monsoon seasons. Jalkanya has 84% of the total flow from all sources with 12 litres per second, which together with 0.7 litres per second from the two wards in Ratanchura gives a total yield of 12.7 litres per second from the upstream VDCs, compared with only 1.6 litres per second in downstream Bhimeshwor.

Water Resource Use

Springs are mostly used for domestic purposes, whereas the wells and ponds are used for both agricultural and domestic purposes. Most irrigation water is drawn from the streams generated by the accumulation of water from springs.

Table 2: **Water resources in the study area**

Sources	Jalkanya	Ratanchura[a]	Bhimeshwor
Springs	78	13	13
Ponds	5	0	0
Wells (kuwa)	3	0	0
Total	**86**	**13**	**13**
Total per km^2	9.5	1.6	0.9
Total HHs per source	5.2	12.4	38.0
Average water flow outside monsoon season[b] (litres/sec)	12.0	0.73	1.63

[a] Only Wards 1 and 2 in Ratanchura lie in the study area
[b] Average flow calculated from measurements in pre and post-monsoon and dry season
Source: Field survey 2015 and 2016

Not all water sources are used directly for water, some simply feed into streams. Around 84% of the identified water sources in Jalkanya VDC are used directly, 31% for agriculture and 52% for domestic purposes; 62% are used in Ratanchura VDC, 23% for agriculture and 38% for domestic purposes; and 69% in Bhimeshwor VDC, 38% for agriculture and 30% for domestic purposes. In other words, Jalkanya VDC not only has the most sources, it also has the highest proportion in direct use; while the downstream VDC Bhimeshwor has the greatest proportion of sources used for agriculture.

Mostly, springs are believed to be safe for drinking purposes. Usually springs are tapped at the origin and the water is piped to a settlement. Piped supplies can be managed in standardised and local way. Standardized managed system uses pipes of standard size appropriate for the calculated pressure and buried to a standard depth (0.9 m in rural areas) along a properly aligned path, and usually they have a water user committee to take care of the scheme. Local systems (or 'dangling pipes') are not designed systematically; the terrain and head alignment are not taken into account in pipe selection and are exposed not buried, rendering them vulnerable to changes in temperature and human interference and opening the possibility of damage and contamination of the water. Where springs are located downstream of a settlement, people fetch water in buckets or jars. During the focus group discussions, locals reported that approximately 25% of the springs were found to have dried up during pre-monsoon season (May). As a result, people often had to walk more than an hour to the next spring to fetch water. It was particularly difficult in Bhimeshwor VDC, which is already considered a water scarce area.

For agricultural use, the springs and spring-fed streams are tapped with a temporary intake and diverted to fields along irrigation canals. The canals are built and managed by the communities using local materials and technology. The schemes were not operating as completely formal farmer-managed systems; communities have their own way to regulate the water, managing distribution by mutual understanding rather than through a specified water-sharing mechanism. The spring water in Bhimeshwor VDC was not sufficient for both agriculture, drinking, and the downstream communities depended on water flowing from the upstream (ie from Jalkanya and Ratanchura) along the Adherikhola for irrigation. The Adherikola catchment has around 650 ha of cultivated land, 297 ha in the upstream VDCs and 355 ha in downstream Bhimeshwor. The household survey showed that about 50% land in the upstream VDCs and 60% in the downstream is rainfed. Expansion of irrigation infrastructure in the upstream is capital intensive. However, increased water availability and good water management could increase the irrigated area in the downstream sufficiently which will significantly increase the production while keeping the other production inputs constant.

Water Resource Management

There are rising concerns among the community in Jalkanya VDC about the risk of springs drying up. The functional springs are already providing less water than before, which has been especially noticeable in the last few years. Most springs are only reliable during the monsoon and are dry during the dry season. Some springs were reported to have completely dried up. There was no evidence that springs had emerged in new places following the 2015 earthquake. The communities are worried about this perceived crisis and its adverse impact on irrigation and the availability of safe drinking water. Lack of water will have an impact on their livelihoods as agriculture is the major livelihood option. The reason for the drying up of springs was not further explored in this study, but studies in other areas in the hills of Nepal suggest that a combination of socioeconomic and environmental changes are responsible

(Sharma et al., 2016). Particularly in Jalkanya VDC, local people reported that the springs below the pine forest had dried up after the pines were planted. Some plant species like pine have high evapotranspiration rates and reduced undercover vegetation, which results in less water infiltrating the ground and replenishing the groundwater, thus reducing the yield in springs.

The field visits indicated that most upstream land was cultivated for millet rather than paddy, with citrus fruit, particularly sweet orange and orange, also popular. The community indicated that the timing of rainfall has shifted (for example with delays), and due to the increasing water scarcity, the timing of rice plantation has also shifted and the number of rice crops has been reduced from two crops per year to one. The possibilities for expanding the area of cultivated land are limited, however, farmers reported being interested in growing cash crops if water were to be available.

The forests in the upstream VDCs are being managed as community forest. There are four community forests in each VDC. Local communities take care of the forest resources and receive fuelwood, fodder, and timber in return. Forest coverage has improved since community forestry was introduced in the area. However, as mentioned above, this expansion may have the unintended consequence of reducing groundwater recharge if species such as pines are used to re-forest.

Information obtained during the FGDs indicated that there are no formal committees for management of irrigation water. Generally, farmers with agricultural land within the area of an irrigation canal carry out the repair and maintenance of the canal before the onset of the monsoon. Irrigation water is distributed based on the crop and timing of water scarcity. For example, irrigation is used for maize at the flowering stage and for rice bed preparation. If water is extremely scarce, a group of farmers visits individual fields to judge the need. The farmers in the downstream do not contribute to the repair and maintenance of the actual water sources, which are mostly located upstream; they are only involved in managing the water which they receive. It is generally thought, however, that the water flow could be increased during water scarce times if the downstream farmers were able to contribute to the repair and maintenance work at the actual sources. There was evidence that the water scarcity downstream has compelled farmers to keep some part of their land fallow and switch to less profitable crops (e.g. from rice to millet/ buckwheat).

Water issues in the upstream area

There is some concern about how the upstream communities assert control over the water sources. According to people living in the upstream, they allow excess water to flow downstream but divert the flow to irrigate their land during the water-scarce winter season as they need more water for maize. The downstream VDC communities do not contribute to forest or spring conservation. We realized that the upstream communities had never thought of having support from the downstream communities. When we raised this issue, they indicated that it would be good if the downstream beneficiaries supported the upstream watershed conservation. They were also aware that watershed conservation helps to protect springs and increases water availability benefiting all the users both within and outside the VDC. When asked about the type of support they could receive from the downstream, they mentioned that help with plantation and pond construction could be useful. They also indicated that the downstream communities should offer help when the upstream communities face problems such as landslides, including provision of cash. Downstream communities also showed an interest to support upstream watershed conservation (such as plantation and landslide control) if there would be a formal request by the upstream communities. At the same time, they indicated that there is no formal communication between the upstream and downstream VDCs. If both communities join hands in watershed conservation, a larger group will benefit, thus the upstream communities considered that the downstream beneficiaries should support upstream watershed conservation.

Water issues in the downstream area

The downstream VDC of Bhimeshwor has limited water sources for drinking and agriculture and is dependent on water flow from the upstream VDCs. The Adherikhola stream is the major source of water for irrigation. The VDC is relatively less water-sufficient than the upstream VDCs, especially during the planting period when all farmers need irrigation water. There is a good possibility for expanding the area under cultivation if water can be made available. The market at Khurkot, which has the most potential, can be accessed easily from any part of the VDC for selling crops. The BP Highway also passes through the VDC and can be used to transport crops to Kathmandu easily within a few hours. But the potential for expansion of farmland is limited at present by the scarcity of water.

People in some wards in Bhimeshwor VDC bring piped water from neighbouring areas in Ratanchura (Ward 4). They had made a request for water to the communities in Ratanchura and came up with the solution of buying the land with the springs. The communities close to the border also ask upstream Ratanchura VDC communities to supply water for irrigation so that they can plant crops on time. The communities resolve these issues privately at local level; as yet there have been no discussions at VDC level. No conflicts have been reported in the area on water use.

Most of the communities considered that the overall yield of the springs was decreasing and that many of the spring sources they were using were drying up. The communities expect water to become increasingly scarce and are aware that spring conservation and water management actions need to be taken now.

Drinking Water

Table 3 shows the amount and quality of water available for domestic purposes among the surveyed households. Access to drinking water is one of the major indicators of the Sustainable Development Goals (SDG 6). Nepal has made significant progress in access to improved water sources and sanitation over the last decade, with 92% of the population now having access to improved drinking water – a good level in comparison with other south Asian countries (World Bank, 2017). However, our analysis in this catchment shows that access to improved drinking water remains a challenge both upstream and downstream. The service is slightly worse downstream because more people in this area rely on dhunge dhara (a traditional uncovered stone water tap fed by a spring) and streams, whereas more people upstream have access to piped water (Figure 4). The values cannot be directly compared with the national figure as the criteria used were different.

Table 3: **Water resources in the study area**

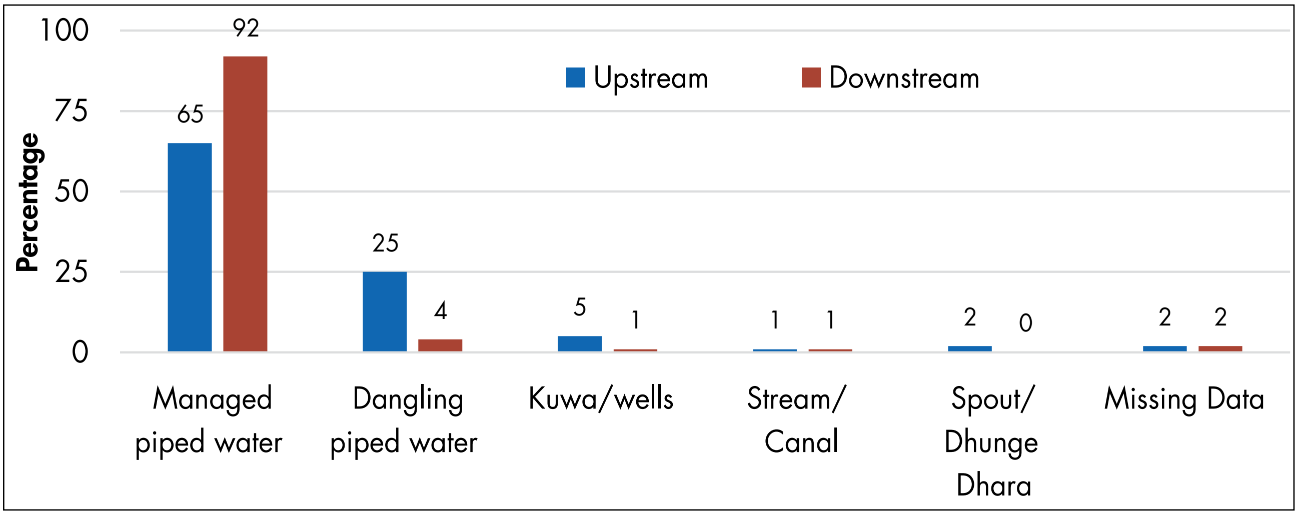
VDC	Good[a]	Moderate[b]	Poor[c]	Very poor[d]
Jalkanya (n=40)	3 (7.5)	2 (5)	1 (2.5)	34 (85)
Ratanchura (n=40)	1 (2.5)	2 (5)	3 (7.5)	34 (85)
Bhimeshwor (n=40)	0	5 (13)	0	35 (87)

Figures in parentheses are estimated percentage of total households.

[a] Good = source <15 minutes away, per capita water availability >45 l/day, free from contamination
[b] Moderate = source 15<30 minutes away, per capita water availability 25<45 l/day, moderate level of contamination
[c] Poor = source 30<45 minutes away, per capita water availability 15<25 l/day, contaminated
[d] Very poor = source >45 minutes away, per capita water availability <15 l/day, highly contaminated

Note: The table was developed based on the hardship scores defined by the Water Use Master Plan and assigning equal weight to the three parameters in each category. Details are provided in the WUMP Plans, Sindhuli. (HELVETAS and ICIMOD, 2017)

Figure 4: **Sources of drinking water in upstream (Jalkanya) and downstream (Bhimeshwor) VDCs**



Agriculture

Cropping patterns in upstream and downstream areas

The cropping patterns upstream and downstream are fairly similar, although the upstream area has a comparative advantage for growing fruit, such as sweet orange and orange, and water is also relatively more sufficient than in the downstream region. Maize is a popular crop in the mid-hills and is the single most widely planted crop both upstream and downstream. The upstream farmers also grow cereal crops, especially millet, although they sometimes encounter problems growing winter crops such as maize which needs irrigation twice during the growing period.

The downstream farmers mainly cultivate paddy, wheat, and maize. Particularly on irrigated land, farmers now grow hybrid maize in the pre-monsoon season as well as in the monsoon, which is a new cropping pattern resulting from the link to markets through the BP highway. The VDC faces particular water scarcity during the pre-monsoon season (May–June) when the maize crop is flowering, which is the most critical stage, and farmers are raising seedlings in the nursery for paddy. This season is the most water scarce period both upstream and downstream. During the peak monsoon (July–August), water is not really a constraint in either area. There is considerable scope for vegetable farming when there is sufficient water, but at present this is not widely practised due to the water scarcity. The downstream community are interested in expanding the plantation of cash crops and vegetables in addition to monsoon paddy, as the area is located near to markets. But the lack of water means that until now the community has made little effort in this direction.

Both the upstream and downstream communities use the Adherikhola stream for irrigation. The downstream communities have few primary water sources and are highly dependent on the stream flow from upstream. At the same time, the upstream community are happy for the water to flow downstream when sufficient is available, but give priority to upstream irrigation when water is scarce. The upstream community feel that the downstream community could contribute to conserving and managing the water sources at their origin and help increase total yield.

Crop yield and monetary value

Crop production depends directly on the cultivated land area, input of fertilizer and labour, and application of water. Irrigated land generally has a higher yield than rainfed land as a result of the controlled application of water. Table 4 shows the total cultivated landholdings and the proportion that is irrigated in the sampled households. Close to half of total land was irrigated in the upstream VDCs Jalkanya and Ratanchura, but only 41% in the downstream VDC Bhimeshwor. If irrigation in Bhimeshwor could be extended across some of the rainfed land, the yield could be significantly improved and farmers could switch to farming vegetables and other high value crops and increase farm income. Empirical evidence indicates that irrigation increases yields for most crops by 100–400% in developing countries (Dorenboss & Kassam, 1979). In the upstream VDCs, the constraint on irrigation is less due to the physical availability of water and more due to the high costs involved in expanding the irrigation infrastructure. In the downstream, the problem is more about physical water scarcity; building irrigation infrastructure (mostly mud canals) is relatively cheap. However, the downstream VDC has flatter and more productive land, as well as access to markets via the BP highway, which has led to greater commercialization of agriculture and higher water productivity than upstream.

Table 4: **Cultivated land and irrigated area in sampled households**

VDCs	Total cultivated area	Irrigated area	
	ha	ha	% of total
Jalkanya (n= 40)	20	10	50
Ratanchura (n=40)	17	8	47
Bhimeshwor (n=40)	29	12	41

Source: Field survey 2015

Table 5 shows the area and yield of the different crops grown in the three VDCs. The crop value was obtained by multiplying the crop production with the farmgate price to provide a monetary estimate for comparison. The yield of most of the crops was higher in the downstream VDC than upstream, and the cropped area was also greater, thus the total value generated was considerably higher in the downstream VDC, NPR 101 million (USD 1 million) compared to NPR 43 million (USD 425,000). The total value generated per area of cropped land was also higher downstream – NPR 285,000 per hectare compared to NPR 147,000 per hectare. The national figure in 2014 for annual crop value from one hectare of land in a system with three crops (i.e. rice-wheat-maize cropping pattern) was NPR 225,000 (DoA, 2015); the crop value generated downstream was higher than the national average and that upstream lower than the national average.

The overall cropping intensity in the study area was 1.7, higher than in other mid-hill districts, and there is room to increase this still further through improvements in irrigation coverage. Extension of irrigation facilities in downstream Bhimeshwor is potentially cost effective and could improve the agricultural productivity significantly. If irrigation could be ensured, then a greater area could be used for vegetable production, which would increase farm returns. Extending irrigation coverage upstream is unlikely to be cost effective, but farm income could be increased by replacing cereals with citrus, which has a higher return, on some of the cultivated land. This would also reduce the irrigation requirement and release surplus water that could be diverted for growing vegetables and other water intensive farm enterprises downstream.

Upstream downstream consideration is an important aspect of IWRM implementation. However, nature of IWRM implementation could be different in local and river basin scale. Understanding the relationship between upstream and downstream communities on water use and benefits at a local scale is very crucial. As suggested by Berhanu, et al., (2015) the various use of water resources within the large river basins (e.g., transboundary Koshi River) will require an understanding of upstream downstream linkages at various intermediate scales for better planning and management of shared water resources. This pilot study was able to analyse upstream downstream linkages of water use productivity in a logical way. The information and knowledge generated from this study can be scaled up in the IWRM implementation at a river basin scale. Issues such as: conflict management at local scale, resources management, water sharing could be a good learning for IWRM at large river basin.

Table 5: **Crop yield and monetary value**

VDC	Net cropped area (ha)	Cropping intensity[a]	Crop	Crop area[b] (ha)	Yield (t/ha)[c]	Farmgate price (NPR/kg)	Crop value[d] ('000 NPR)	Crop value per ha[e] ('000 NPR)
Jalkanya (upstream)								
			Paddy	86	3.2	25	6,880	80
			Wheat	27	2.6	20	1,404	52
			Maize	174	3.2	25	13,920	80
			Citrus	2	10	50	1,000	500
			Millet	109	2	25	5,450	50
			Vegetables	4	12	20	960	240
			Potato	12	12	20	2,880	240
Ratanchura (upstream)								
			Paddy	48	3.2	25	3,840	80
			Wheat	28	2.6	20	1,456	52
			Maize	27	3.2	25	2,160	80
			Citrus	5	10	50	2,500	500
			Millet	9	2	20	360	40
			Vegetables	3	12	20	720	240
			Potato	0				
Upstream total	**297**	**1.8**		**534**			**43,530**	**146.6**
Bhimeshwor (downstream)								
			Paddy	168	4	25	16,800	100
			Wheat	78	3.2	20	4,992	64
			Maize	258	3.6	25	23,220	90
			Citrus	1.3	10	50	650	500
			Millet	0				
			Vegetables	36	12	20	8,640	240
			Potato	52	18	50	46,800	900
Downstream total	**355**	**1.7**		**593**			**101,102**	**284.8**
Catchment total	**652**			**1,127**			**144,632**	**221.4**

[a] Cropping intensity is defined as the ratio of crop area to net cropped area
[b] Cropped area is the whole cropped area of the watershed obtained from the WUMP survey
[c] Yield is the average yield from irrigated and non-irrigated land; the sampled households don't keep separate farm records for irrigated and non-irrigated land
[d] Crop value is the gross value calculated as yield x area x price; there was no information available on production costs, thus these were not accounted for
[e] Crop value per ha = gross value/cropped area

Note: NPR 101 = 1 USD (July 2015)

Source: Field survey 2015; FDG discussions 2015; WUMP survey 2015; DADO Office Sindhuli

5. Summary

This study looked at the linkages between upstream and downstream VDCs in a watershed in Sindhuli district where the Water Use Master Plan (WUMP) study is being carried out. The study went beyond the traditional WUMP approach, which is confined to VDC level, by considering the catchment as a hydrological boundary and looking into the upstream-downstream interdependence between VDCs. The main findings were as follows.

The water resources inventory indicated that upstream communities play a very important role in watershed conservation. The number and yield of springs is much higher in the upstream VDCs. The total average water flow outside the monsoon season from upstream sources is 12.7 litres per second and from downstream sources 1.6 litres per second; a total of 14.4 litres per second from all identified sources in the Adherikhola. However, the downstream VDCs derive greater benefit from water use, especially in agriculture. After realizing how much the downstream VDCs benefit from the upstream water, the upstream VDCs indicated that it would be helpful if the downstream communities would support upstream watershed conservation. Similarly, downstream communities acknowledged the role of the upstream VDCs in watershed and spring conservation and suggested that they would support the upstream VDCs in conservation activities such as plantation.

Rainfed agricultural land is found both upstream and downstream. The opportunities for expansion of irrigated agricultural land are limited in upstream areas by the high cost (labour and capital) of installing irrigation infrastructure, and downstream by lack of water. The average yield of most crops is higher in the downstream VDC than upstream. The downstream VDC (Bhimeshwor) derives a gross crop value (without considering production cost) of NPR 285,000 per hectare, almost double the NPR 147,000 per hectare benefit in the upstream VDCs, suggesting that the shadow price of water is higher downstream than upstream. Downstream communities also have more opportunity to switch from traditional crops to higher profitable cash crops like vegetables and hybrid maize due to their easy access to a road and markets, although this is limited by water availability. In total, the downstream communities generate an average of NPR 101 million monetary equivalent per annum through agricultural activities, compared to NPR 43 million in the upstream VDCs. This suggests that the downstream communities are receiving considerable benefits from the water flowing from upstream. If the downstream community understand how much water comes from upstream and how much they benefit in monetary terms, this can provide a good reference point for motivating them to invest some of the generated benefit in water conservation initiatives upstream, leading to further benefits from irrigation. How much should be contributed by the upstream and downstream communities will depend on negotiation between them. This is the next step and beyond the scope of this study.

The study also provides evidence of the interdependence of upstream and downstream areas at the lowest administrative level (VDC) and on the micro (catchment) scale, and will be useful when scaling up IWRM practices in river basins using a bottom up approach. Initially, the local stakeholders were found to have a below average understanding of the need for integrated watershed planning and the use of locally available scientific and technical information in the planning process. This was addressed in a series of customized capacity building training and orientation sessions. However, although communities in both areas see the potential for integrated watershed management, there are no institutional mechanisms to bring the wider stakeholders together. The line agencies, mainly the Department of Soil Conservation and Watershed Management, suggested that integrated watershed management by both upstream and downstream communities could be helpful for watershed conservation overall, as well as for water conservation in particular.

Recommendations

There is a lack of awareness and sensitization about the need for catchment level water management; communities need to be aware of the potential benefits that can be generated through cooperation between the upstream and downstream. An informal committee could be formed under the leadership of the government line agencies to review the need for catchment level planning. The Department of Soil Conservation and Watershed Management could be instrumental in this. The WUMP developed for the downstream VDCs should acknowledge the contribution of upstream VDCs in watershed conservation and related benefits.

There is a need for capacity building of local communities on climate resilient technologies and practices for water management at plot and landscape scales, both upstream and downstream. The practices could include springshed management using a hydrogeological approach; rainwater harvesting; efficient use of water through drip irrigation, sprinklers, and mulching; and methods like improved irrigation, choosing less water intensive crop and plant varieties, and modifying cropping patterns. Some good watershed management practices for the mid-hills of Nepal are described in ICIMOD (2007). Some of the approaches suggested not only provide additional benefits in agricultural production, but also help to conserve water and optimize water use.

The study highlighted the relationship between upstream and downstream VDCs in an area where there are no strong economic instruments for water uses. In contrast, there are some cases of strong economic instruments related to water use in the mid-hills such as revenue collection from hydropower and drinking water supply. The operational mechanisms for benefit sharing depend greatly on economic trade-offs among different water uses. Further understanding of the interdependence between upstream and downstream areas in terms of economic trade-offs among competing water use sectors (such as irrigation, drinking water, and hydropower) might provide a better understanding for operationalizing benefit-sharing mechanisms. In addition, understanding these linkages in the perspective of the food-water-energy nexus could be useful so that wider communities would benefit by reducing externalities and enhancing synergies. The study suggests the need for further research in a different watershed area where water has more competitive uses and there are strong economic linkages between upstream and downstream communities (for example hydropower, fisheries). Findings in such an area may be different and the findings together would enable the development of more consistent policy recommendations.

Awareness raising and capacity building of stakeholders is one of the key instruments in integrated watershed management. The present study was able to translate the socioeconomic and scientific information into a quantitative form which helped to raise awareness, increase understanding of upstream-downstream dynamics, and prepare stakeholders for collective bargaining and negotiation on the sustainable use of natural resources. This in turn can help to reshape and strengthen local institutions in the long-term (Neupane, 2011). Individuals and groups with increased capacity become resource persons and can act as a vehicle for the dissemination and scaling up of activities to other watersheds in the river basin. Therefore, this study strongly recommends capacity building of the relevant stakeholders for operationalizing upstream downstream linkages.

The study was unable to translate other uses of water such as domestic use and sanitation, livestock use, environmental use, and indirect benefits into a monetary value; this requires more comprehensive analysis. However, it is necessary to understand these parameters in order to develop a clearer and more comprehensive picture of upstream-downstream linkages and to operationalize an incentive for ecosystem services (IES) mechanism. Additional studies at a larger scale are recommended to enable the findings to be used as a basis for solutions to resolve issues at a higher river basin level (sub-basin) and administrative level (intra/inter province level).

6. References

Berhanu, B., Seleshi, Y., Amare, M. & Melesse, A. M. (2015). Upstream-downstream linkages of hydrological processes in the Nile river basin. In A. Melesse & W. Abtew (Eds.), *Landscape Dynamics, Soils and Hydrological Processes in Varied Climates*. Heidelberg: Springer, Cham.

Bhatta, L. D., Van Oort, B. E. H., van. Rucevska, I. & Baral, H. (2014). Payment for ecosystem services: Possible instrument for managing ecosystem services in Nepal. *International Journal of Biodiversity Science, Ecosystem Services and Management,* 10(4), 289–299.

Bruijnzeel, L.A. & Bremmer, C. N. (1989). *Highland - Lowland Interactions in the Ganges Brahmaputra River Basin*. ICIMOD. Kathmandu, Nepal.

CBS. (2011). *Population and Housing Census, 2011. Kathmandu, Nepal:* Central Bureau of Statistics, Government of Nepal. Kathmandu.

DoA. (2015). *Cost, production and price spread of cereal crops in Nepal: a time series analysis*. Retrieved from Department of Agriculture, Ministry of Agriculture Development. Kathmandu.

Dorenboss, J. & Kassam, A. H. (1979). *Yield response to water. Irrigation and drainage paper 33*. FAO. Rome.

HELVETAS and ICIMOD. (2017). *Water use Master Plan, Sindhuli (Nepali language).* HLEVETAS Swiss Intercooperation and ICIMOD. Kathmandu.

ICIMOD. (2007). *Good Practices in Watershed Management: Lessons Learned in the Mid Hills of Nepal.* Kathmandu, Nepal: International Centre for Integrated Mountain Development (ICIMOD).

Ives, J. D. & Messerli, B. (1989). *The Himalayan dilemma: reconciling development and conservation.* London: The United Nations University, Routledg.

Khatiwada, N. R., Nepal, S. & Subedi, D. (2006). Sustainability of traditional water supply facilities in Nepal. *In Proceedings of the International Symposium on "Management of water, waste water and environment",* Kathmandu.

Nepal, S., Flügel, W.-A. & Shrestha, A. B. (2014). Upstream-downstream linkages of hydrological processes in the Himalayan region. *Ecological Processes,* 3(19), 1–16.

Neupane, N. (2011). Political-economy of water distribution in the trans-Himalayan region of Nepal. In W. Doppler & S. Bauer (Eds) Farming and rural system economics, vol 128. Germany: Margraf Publishers.

Sharma, B., Nepal, S., Gyawali, D., Pokharel, G. S., Wahid, S., Mukherji, A., Acharya, S. & Shrestha, A. B. (2016). Springs, storage towers, and water conservation in the midhills of Nepal. ICIMOD Working Paper 2016/3. Kathmandu: ICIMOD.

Tambe, S., Kharel, G., Arrawatia, M. L., Kulkarni, H., Mahamuni, K. & Ganeriwala, A. K. (2012). Reviving Dying Springs: Climate Change Adaptation Experiments From the Sikkim Himalaya. *Mountain Research and Development,* 32(1), 62–72.

Thompson, M., Warburton, M. & Hatley, T. (2006). *Uncertainty on a Himalayan Scale*. Kathmandu: Himal Books.

Valdiya, K. S. & Bartarya, S. K. (1991). Hydrogeological studies of springs in the catchment of the Gaula River, Kumaun Lesser Himalaya, India. *Mountain Research and Development, 11*(3), 239–258.

World Bank. (2017). World Bank database *http://data.worldbank.org/indicator/SH.H2O.SAFE.ZS?locations=NP. Accessed 5th July, 2017.*

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