HI-AWARE Working Paper 25

Springshed research: A study from Charghare Village Development Committee in the mid-hills of Nepal

Consortium members

About HI-AWARE Working Papers

This Hi_AWARE working paper is based on the work of the Himalayan Adaptation, Water and Resilience (HI-AWARE) consortium under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) with financial support from the UK Government's Department for International Development and the International Development Research Centre, Ottawa, Canada. CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The programme supports collaborative research to inform adaptation policy and practice.

HI-AWARE aims to enhance the adaptive capacities and climate resilience of the poor and vulnerable women, men, and children living in the mountains and flood plains of the Indus, Ganges, and Brahmaputra river basins. It seeks to do this through the development of robust evidence to inform people-centred and gender-inclusive climate change adaptation policies and practices for improving livelihoods.

The HI-AWARE consortium is led by the International Centre for Integrated Mountain Development (ICIMOD). The other consortium members are the Bangladesh Centre for Advanced Studies (BCAS), The Energy and Resources Institute (TERI), the Climate Change, Alternative Energy, and Water Resources Institute of the Pakistan Agricultural Research Council (CAEWRI-PARC) and Wageningen Environmental Research (Alterra). For more details see www.hi-aware.org.

Titles in this series are intended to share initial findings and lessons from research studies commissioned by HI-AWARE. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the HI-AWARE consortium, they have only undergone an internal review process.

Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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HI-AWARE Working Paper 25

Springshed research: A study from Charghare Village Development Committee in the mid-hills of Nepal

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Executive summary

ICIMOD, along with Practical Action, conducted a reconnaissance research visit to Nuwakot, a mid-hill district in the Gandaki basin of Nepal. The aim of the visit was to identify potential VDCs as sites for springshed research in Nuwakot; this was done in consultation with relevant line agencies in Nuwakot and through direct field research.

The team then adjudged Charghare VDC as an ideal location for springshed study as it faces water scarcity and the problem of declining and drying springs. In Charghare VDC, springs are an important source of drinking water. The selection was also validated by the fact that multiple line agencies, as well as earlier research findings, had recommended the site.

A robust springshed monitoring methodology was followed during the study with the active participation of the local community and other stakeholders. The research found that the spring sources have declined over the past few years, largely due to the 2015 earthquake and subtly due to the changes in precipitation pattern, which can be attributed to climate change.

The long-term monitoring of spring discharge and rainfall gave indications regarding spring behaviour, which is dependent on season, rainfall pattern, and geology. Therefore, it is essential that a scientific approach be combined with local knowledge in order to carry out spring revival activities in Nepal's mid-hills.

The research also found that there is a lack of awareness amongst the local community about springshed dynamics and conservation techniques. As part of the study, four springs were thoroughly explored, paving way for detailed technical recommendations, with an aim to recharge these springs in a sustainable way. The study also lay emphasis on the issue of water access and distribution conflicts, as well as on the challenges within the communities, and the recommendation in this regard is that water has to be allocated judicially at the community level. The study further advises that coordination and collaboration are necessary among the various stakeholders at the community, local and national levels to conserve the springs for the future.

This working paper captures the first four steps of spring revival activities and suggests appropriate intervention measures to ensure the success of this process.

Abbreviations and acronyms

ACF	Action Contre La Faim
CBS	Central Bureau of Statistics
DDC	District Development Committee
DTO	District Technical Office
DWSSD	District Water Supply and Sanitation Division
EC	Electrical Conductivity
EW	EastWest
FECOFUN	Federation of Community Forestry Users Nepal
FGD	Focus Group Discussion
GoN	Government of Nepal
GWR	Ground Water Recharge
HH	Household
HI-AWARE	Himalayan Adaptation, Water and Resilience
KII	Key Informant Interview
LPM	Litres Per Minute
NE	North-East
NMIP	National Management Information Project
NNW	North-North–West
NW	North-West
OSOCC	On-site Operation Coordination Centre
pH	Potential Hydrogen
RC	Research Component
RWH	Rainwater Harvesting
SE	South-East
SSE	South-South–East
SW	South-West
TDS	Total Dissolved Solids
VDC	Village Development Committee

1. Introduction

1.1. Background

Springs are the lifeline for rural communities in the Hindu Kush Himalayan region as they depend heavily on them to meet drinking, domestic and agricultural water needs (Chapagain, Ghimire, and Shrestha 2017). The springs are fed by groundwater, which accumulates in aquifers that are located underneath the earth's surface. These underlying aquifer systems govern spring discharge (Mahamuni and Upasani 2011). The drying up of springs in the mountains has to do with climate change and other factors, including population growth and erratic precipitation pattern, leading to acute water shortage in the region (Tambe et al. 2012). Meanwhile, the lack of a legal policy for managing groundwater means that there is a pressing need for a specific paradigm in the Himalaya for spring water management which involves scientific study and community participation (Mahamuni and Kulkarni 2012).

In the context of Nepal, around 43 per cent of the country's total population live in the mid-hills, of which around 80 per cent rely on springs as their primary water source (Central Bureau of Statistics – CBS – Government of Nepal 2012). There is almost negligible contribution from the major rivers and streams originating from the Himalaya, as most of them lie far below the hill settlements; this renders the task of fetching water for daily-life activities quite difficult; also, the cost of carrying water manually or lifting it is rather high. This underlines the extent to which springs are important for upland settlements (Chapagain et al. 2017).

Similarly, the depletion of spring discharge and the vanishing of springs over time have led to serious water scarcity, especially in the rural areas of Nepal (Poudel and Duex 2017; Sharma et al. 2016). Further, following the massive earthquake in 2015, there has been a drastic change in the behaviour of springs – some of them got shifted, which caused either drying up or a reduction in the discharge, and some new springs emerged. This phenomenon threatens the entire way of life of hill communities and people, as they have to fetch water by covering long distances, especially during the dry months (Khanal 2016).

The Water and Sanitation Survey conducted by the National Management Information Project (NMIP) in 2014 showed that springs are the major source of water in Nuwakot, as more than three quarters (86 per cent) of the households (HHs) depended on piped water that came from the springs (NMIP 2014). Similarly, the District Drinking Water Profile of Nuwakot for 2014/2015 reported that out of the total 1,190 HHs in Charghare VDC, 829 HHs (69.7%) depended on public taps, 22 HHs (1.8%) on private taps, 43 HHs (3.61%) on conserved springs, 86 HHs (7.2%) on unsafe traditional sources such as mul or kuwa (well), and a significant number of HHs i.e. 17.6% depended on local streams and canals for their drinking water. The springs feed all the existing piped water supply system of Charghare VDC (Government of Nepal 2014). In 2015, around three quarters of the households (a total of 851 HHs, or 71.51 per cent) benefitted from this source, but this declined to 622 HHs (52.27 per cent) after the 2015 earthquake, thus showing a decrease by 19.24 per cent (Nuwakot District Water Supply and Sanitation Division – DWSSD – 2015).

The hydrogeological spring water dynamics of the mid-hills in relation to global environmental change and climate change has been poorly studied and understood despite springs being the key source of water in the hills (R. Shrestha et al. 2017). Taking these issues under consideration, ICIMOD, through its HI-AWARE programme, initiated Springshed Monitoring Research at Charghare VDC in collaboration with its strategic partner, Practical Action in 2016. This paper describes the spring research conducted in the mid-hills of Nepal and summarizes the results and findings

Objectives of the study

The overall objective of this research was to understand the water use patterns from various sources, with a particular focus on spring water.

The specific objectives of the study were:

- Comprehensive mapping of the springs and springshed
- Setting up a data-monitoring system
- Understanding the socio-economic and governance aspects of springs
- Hydrogeological mapping of the springs

2. Methodology

2.1. The study sites

During the study period, Charghare Village Development Committee (VDC) was one of 61 VDCs of Nuwakot in the Bagmati zone (Central Development Region of Nepal, as shown in Map 1). The major villages in Charghare VDC selected for the HI-AWARE springshed monitoring research were: Gauribesi, Mulabari, Bhattagau, Charghare, Khanigau, Khatrigau, Dhungentar, and Munthala.

The geographical location of the study area is between N27°52'8.20"– N27°55'26.1" and E85°05'34"–E85°08'22.39", spanning a toposheet index of 2785 01A and 2785 01B. The elevation of the study area ranges from 1,668 masl at its highest point to 510 masl at its lowest (CBS 2012) . As per the new federal structure, all the nine wards of the former Charghare VDC were merged into Bidur municipality and now fall under wards 6 and 12. Since this study was completed prior to the restructuring, the report presents the results and findings as per the previous local structure.

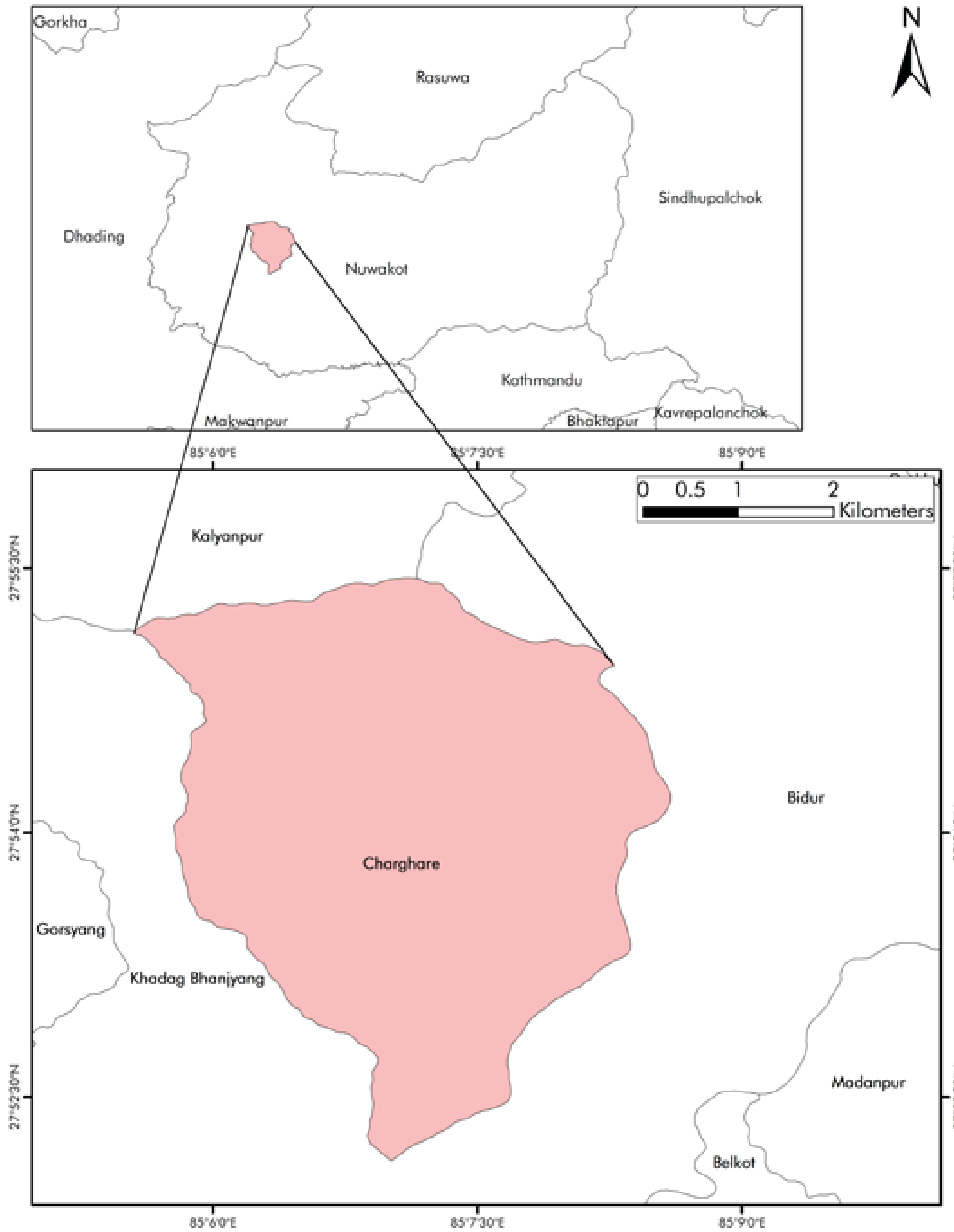
The major rivers and streams in Charghare VDC are: Trishuli, Gauri Khola, Kali Khola, Chainpur Khola, Kafalbote Khola, Naa Khola, Bhalu Khola, Falche Khola, Gaado Khola, and Guhe Khola (Map 1).

2.2. Comprehensive mapping of springs and springshed

2.2.1. Multi-stakeholder consultation and reconnaissance survey

A multi-stakeholder consultation and reconnaissance visit was conducted to explore the springshed and potential study area for spring research in Nuwakot from 7–10 April 2016. The reconnaissance survey was conducted, with local participation, to make primary field observations on the pattern of spring distribution, land use, forest cover, and the local socio-economic situation. The following stakeholders were consulted for the research and demarcation of the springshed areas:

- District Technical Office (DTO)
- Nuwakot District Development Committee (DDC – now District Coordination Committee)
- Federation of Community Forestry Users Nepal (FECOFUN), Nuwakot
- Bidur Drinking Water and Sanitation Consumers' Office
- Nuwakot Drinking Water Supply and Sanitation Division (DWSSD)
- Charghare VDC Office



Map 1. Location map of Charghare VDC, Nuwakot

2.2.2. Mapping of springs and springshed at Charghare VDC

After a detailed reconnaissance survey, the geographical position of all the springs in Charghare VDC were recorded using GPS instruments from 23–29 May 2016. In addition, a one-time measurement of spring discharge was recorded by a tracer, based on five water-quality parameters: temperature, salinity, electrical conductivity (EC), total dissolved solids (TDS), and potential hydrogen (pH). Some preliminary data on the location and type of springs, and socio-economic information such as dependent households were collected.

The springshed's boundary was demarcated on the basis of the "valley–ridge–valley" approach within the Charghare "water tower" for long-term monitoring (R.B. Shrestha et al. 2018). The recorded springs and digital topographic datasets were overlaid on the Google Earth platform and ArcMap to prepare respective maps.

2.3. Setting up a data-monitoring system

For this step, two manual rain gauges were installed in the springshed (see Table 1). In order to enable the local data collectors to read these gauges, a technical training programme was conducted. A monitoring mechanism and protocols were established to observe, measure and collect data on spring discharge and rainfall. As many as 31 springs were selected and categorized for the study.

Table 1: Rain gauge locations

SN	Place name/ward	Latitude	Longitude	Elevation (masl)
1	Khanigau/Ward 9	27.89781	85.128	757
2	Bhattagau/Ward 4	27.91364	85.10789	1,129

Five sets of criteria (see Table 2) were used to identify the 31 springs for long-term monitoring based on the spring revival protocol (R.B. Shrestha et al. 2018).

Table 2: Criteria for choosing springs

SN	Criteria	Number of springs
1	Dried up	6
2	High dependency and high discharge	6
3	High dependency and low discharge	6
4	low dependency and high discharge	6
5	Low dependency and low discharge	7
	Total	31

2.4. Socio-economic data

This step involved social survey and collection of both qualitative and quantitative data with the primary focus on assessing community perception regarding water resources, water use, changes in land use, development activities, and agriculture. The first stage included primary qualitative data collection to understand the social and governance aspects of spring water use; this was carried out through a series of interactions in the form of key informant interviews (KIIs) at both the spring and tap levels for a certain number of selected springs, and focus group discussions (FGDs) at the ward level. A socio-economic survey was also carried out to understand the dynamics and institutional systems at play in the use of spring water.

2.5. Hydrogeological study

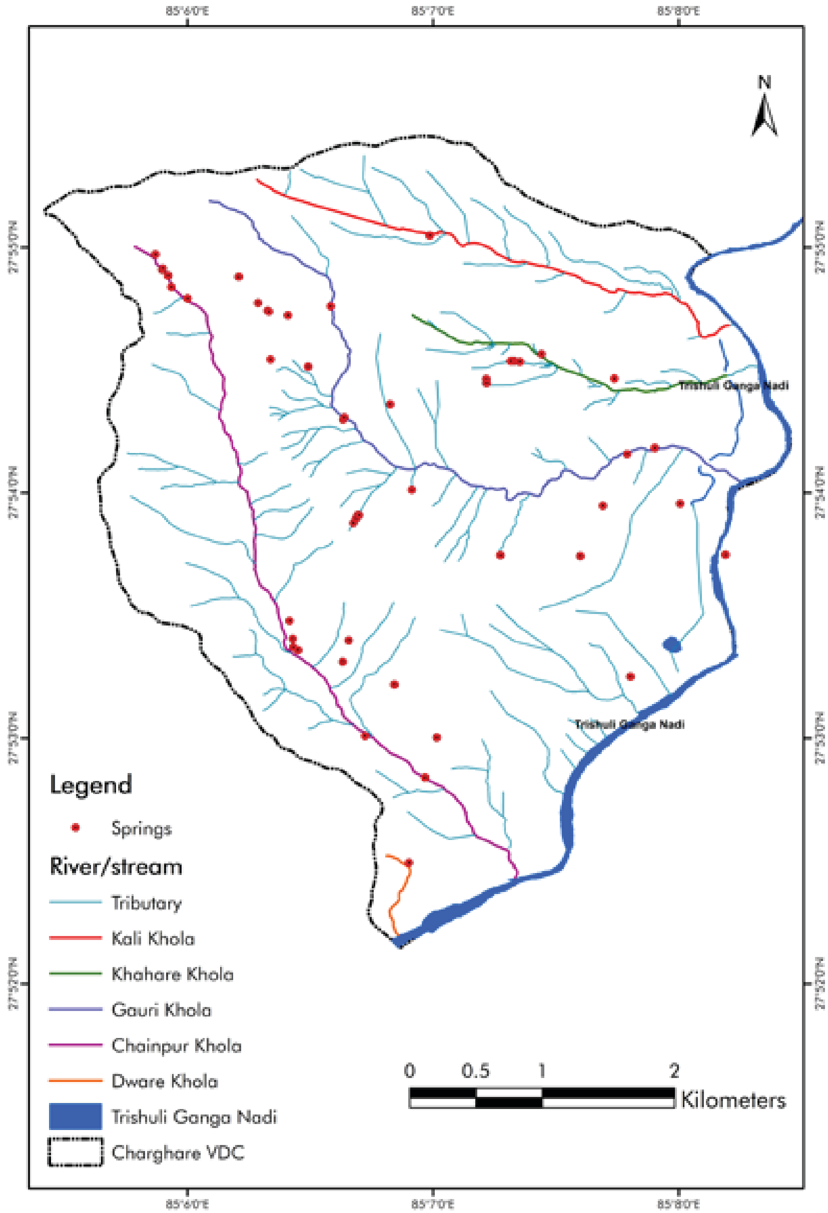
The field-based hydrogeological investigations in and around Charghare VDC involved the geological mapping of the Charghare VDC based on the criteria developed during previous reconnaissance visits and through social mapping tools. Following the collection of geological and hydrogeological data, conceptual layouts of the springs and their springshed were developed. A detailed hydrogeological study of four springs were conducted to identify the recharge area; these springs were: Ghatera Dhara spring, Bato Muni ko Mul and Bhalu Khola ko Kuwa, and Asine Mul.

3. Results

3.1. Delineation of springs and springshed

The springshed boundary is outlined by five major rivers and streams: Kali Khola, Chainpur Khola, Kafalbote Khola/Bhatta Khola, Gauri Khola and Naa Khola. Figure 1 shows the drainage of the area, while Map 2 shows the springshed boundary of Charghare VDC. As many as 69 springs were mapped in Charghare VDC (see Map 2), out of which 31 were regularly monitored. (For more information, see Annex I.)

Figure 1: Google Earth map showing drainage of the area



Map 2: Delineation of springshed boundary in Charghare VDC

3.2. Rainfall and discharge analysis

A total of 31 springs were selected for long-term monitoring based on five sets of criteria. The main objective of such a long-term monitoring was to get a sense of rainfall and discharge patterns during the various seasons (from rainy to dry seasons).

Figure 2 shows the rainfall data from the two rain gauge stations; the months of June to September are the peak monsoon period, with the highest daily rainfall (160 mm) recorded in August; the period between December to February can be described as dry, depicting almost negligible rainfall.

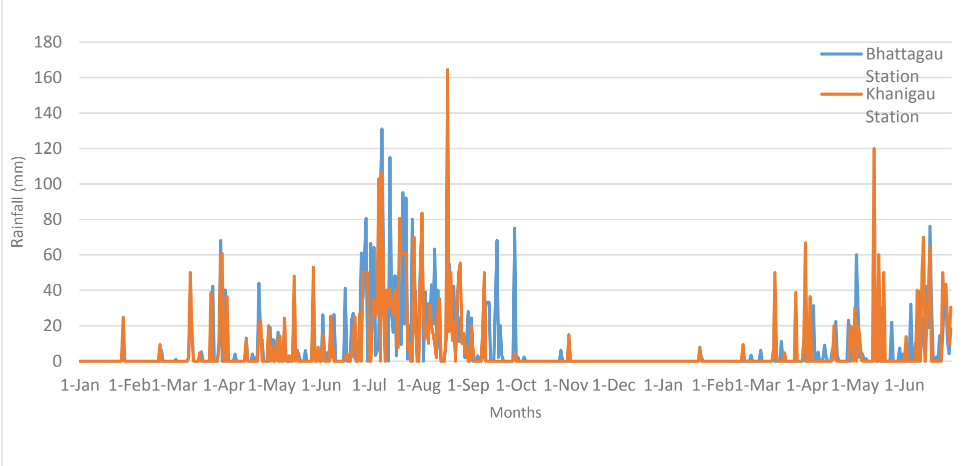


Figure 2: Rainfall data for the period January 2017–June 2018

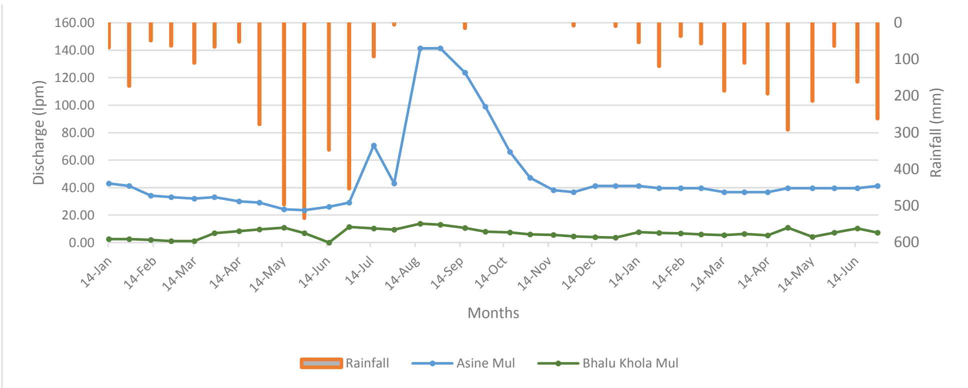


Figure 3: Hydrograph of Asine and Bhalu Khola springs

An analysis of the bimonthly discharge hydrograph shown in Figure 3 reveals that the discharge is measured in litres per minute (lpm), and the rainfall in millimetres. The graph shows that the maximum discharge in the Asine Mul is approximately 141.43 lpm, while the maximum rainfall is 533.6 mm. Bhalu Khola ko Mul shows regular flow through all seasons, while Asine Mul shows an increase in discharge during monsoon (from June to September). Asine Mul has a high dependency rate of around 85 HHs, while Bhalu Khola has 8 HHs dependent on it throughout the year.

Data acquired for the Asine and Bhalu springs contrast in terms of their discharge volume. While Asine Mul reflects high discharge throughout the monitoring period, Bhalu Khola Mul tends to discharge at comparatively lower volumes.

The hydrograph of the Asine Mul clearly indicates a delayed response to the monsoon. The discharge is seen increasing towards the middle of the peak monsoon period. The rise and decline in the discharge are fairly evenly spread over a period of almost six months. The Bhalu spring, on the other hand, does not reflect any such rise and decline in response to the monsoon. Both the Asine and Bhalu springs otherwise reflect similar behaviour during the other seasons. This clearly indicates that both the springs bear the same typology. Geological investigations also support the fact that both the springs are primarily "fracture springs". However, the noticeable deviation in the behaviour of Asine Mul in response to the monsoon indicates that there is some additional storage available there. This additional input to the Asine spring is gained from the combination of a separate aquifer (mostly the colluvial deposition forming a depression) and a fractured aquifer.

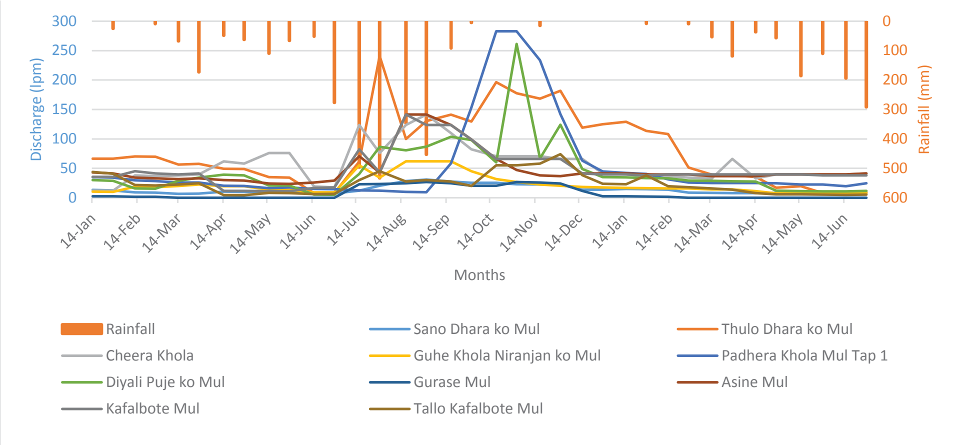


Figure 4: Hydrograph of bi-monthly spring discharge and rainfall of certain monitored springs

Figure 4 shows the long-term data collection (from January 2017–June 2018) from the monitored springs, and captures the springs' behaviour. Most of the springs show an increase in discharge from July–November due to the monsoonal rain, and the discharge is lower during the lean period. The maximum observed discharge is in Padhera Khola, with approximately 285 lpm.

3.3. Socio-economic findings

3.3.1. General

Charghare VDC is one of the 61 VDCs of Nuwakot district. The VDC comprises of nine wards and spreads over an area of 4–5 km². It is surrounded by Bidur municipality, Kalyanpur VDC, Gorysang VDC, and Khadgabhanjyang VDC. Charghare VDC consists of Chainpur, Munthala, Mulabari, Gauribesi, Bhaduwar, and Bhattagau.

According to a 2011 VDC-level report of the CBS, Charghare VDC has a population of 5,419, out of which 54.27 per cent are female (2,941) and 45.73 per cent male (2,478) who dwell in 1,190 HHs. The average HH size is 5, with a sex ratio of 84.26. (see Table 3).

Table 3: Demography of Charghare VDC

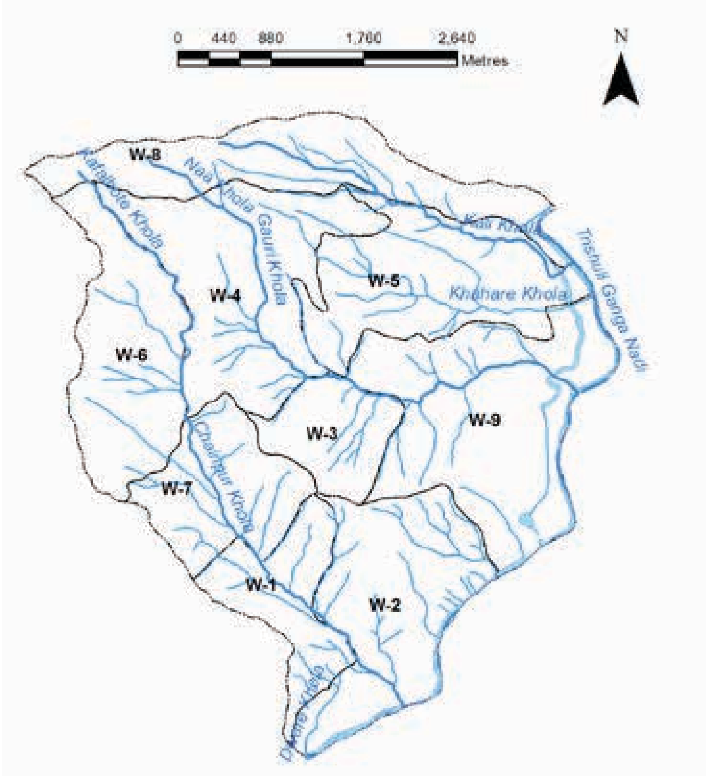
Number of HHs	1,190
Total population	5,419
Female	2,941
Male	2,478
Average HH size	5
Sex ratio	84.26

Source: CBS, 2011

3.3.2. Sources of water

I. Rivers

The major rivers and streams in Charghare are the perennial Trishuli River, Gauri Khola, Chainpur Khola, Kali Khola, Khahare Khola and numerous seasonal rivers and streams (see Map 3). In downstream settlements, rivers are a major source of water for drinking, domestic and irrigation purposes. Mostly, the drinking water supply system is based on river diversion, as long as such diversion is possible. For example, the Kali Khola is diverted to Ward 9, while the Chainpur Khola is diverted to wards 1 and 2 for drinking and domestic use. Uphill communities mostly depend on springs for drinking water and other purposes.



Map 3: Drainage map of Charghare VDC

II. Ponds and inars/drilled wells

The practice of having natural ponds in almost all the households in the area for daily water use, small irrigation and for domestic animals has dwindled and now there are only a few small ponds left. These ponds are mostly human-made and fed by streams and rainfall run-off. Due to the decline in rainfall and the subsequent drying up of the ponds, animal husbandry, which was practised when water was in abundance, has now decreased in the study area. Thus, the number of livestock has drastically reduced in the area.

As per the CBS data of 2011, only 0.1 per cent and 2.7 per cent of the total households are dependent on tube well and wells respectively in Charghare VDC. Artificial groundwater extraction in the form of deep boring is not popular here, which can be attributed to the hilly terrain and topography. However, the trend of commercial groundwater extraction has just started in the form of deep boring in Ward 1 along the Trishuli River, and three private inars or dug wells in Ward 2.

III. Rainwater harvesting

The distribution of natural water sources is not uniform across the study area. Therefore, rainwater harvesting (RWH) is practised here, especially in water-scarce areas. There is no proper infrastructure in terms of collection tanks, and water is collected in vessels such as *gagris* (metal vessels traditionally used to ferry and store water in Nepali households) and jerrycans at the household level. The collected water is used for washing, cleaning and feeding animals, but it only lasts for the first few days after the rains.

3.3.3. Water availability and uses

I. Domestic use

Natural springs and rivers are the major sources of domestic water in Charghare VDC. The other prominent sources of water for domestic use are:

- Piped water from springs
- Piped water from rivers
- Deep borewells and dug wells
- Rainwater harvesting

- Water supply through tankers (trucks)

An FGD held in the area revealed that sporadic tap and piped water from springs are the major source of drinking water for the majority of HHs in this VDC. It showed that for domestic use, 86 per cent of the households depended on 154 public taps; 8 per cent HHs relied on private taps; and 6 per cent HHs fetched water directly from the springs (see Figure 5). There were also a few households that extracted water from bore wells and dug wells, and a few that seasonally fetched water directly from the rivers and streams. In some cases, RWH was practised.

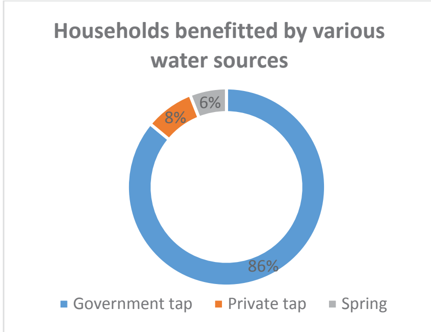


Figure 5: Households benefitted by various water sources

Source: Field data, 2016

II. Drinking purposes

Springs are the fundamental source of drinking water in the hills, as most of the HHs either fetch water directly from them or rely on spring-fed piped water supply. In Charghare, 17 out of the 18 piped gravity water supply systems are fed by springs, while the remaining one is supplied by river/stream diversion (see Table 4).

Table 4: Sources of drinking water: Household percentage

Sources of drinking water	No. of HHs
Tap/piped	95.3
Tube well/handpump	0.1
Covered well/kuwa	0.1
Uncovered well/kuwa	2.6
Water spout	1.6
River/stream	0.2
Others	0.0
Not stated	0.2

Source: CBS, 2011

III. Sanitation

It was observed during the field visits that a majority of the HHs had access to separate cemented toilets. The District Drinking Water Profile of Nuwakot for 2014/2015 stated that approximately 61 per cent of the households in Charghare VDC had well-managed toilets; but this decreased to 36.64 per cent following the 2015 earthquake.

In 2011, the CBS had reported a higher percentage of 74.6 households having toilet access.

The field data showed that an average of 45 litres of water was consumed for toilets by an average family size of 5 in Charghare VDC which is equivalent to 9 litres of water per person per day.

IV. Irrigation

Agriculture land in Nuwakot district covers an area of 32,996.5 hectares, out of which 58 per cent are rainfed, while 42 per cent are irrigated using water from sources such as rivers/lakes/ponds, reservoirs, and tube well/boring (CBS 2013). Rainfed traditional farming is dominant in this VDC as most of the agricultural land don't have access to other irrigation facilities. And amongst these facilities, rivers are the major source, and irrigation water flows down through an earthen temporary canal. When the rains don't arrive on time, the villagers have no other alternative than to leave their lands barren. The villagers also reported that the quantity of irrigation water has decreased over time due to the decline in rainfall and in river discharge.

3.3.4. Water collection and allocation for domestic use

I. Water collection

Mainly, women and girls are responsible for collecting and managing water in the households, while the men are more involved in the design and development of drinking water infrastructure.

Generally, people collect water two or three times a day, depending upon access, season, and availability. In the case of the controlled HH level piped water supply system, there is a fixed frequency and time period for water supply per day depending on the season and water availability, whereas, in the case of public taps, water supply varies with season. During the dry winter season, the supply is rationed, and water is available only for a certain duration in the morning and evening. During such lean seasons, water is collected on a turn-by-turn basis so that all the dependent HHs can have equal access.

During the wet season, the villagers get water directly at their house by connecting their own pipe to the public tap; during this time, there's no restriction on fetching water directly from the springs throughout the day.

On an average, a household consumes 80–100 litres (4–5 gagris) of water per day for domestic activities such as cooking, drinking, and cleaning. The quantity of water consumption varies depending upon the family size and the number of livestock.

The time taken to fetch water for household use is relative to the geographical location of the water sources, the type of water supply, and seasonality – for instance, it takes less time to fetch water during the wet season compared to the dry one. The villagers usually spend 15–30 minutes to fetch water from the public tap positioned near their houses.

II. Water allocation for different uses

Based on FGD data, on an average, the break-up of the water allocated for household use is thus: 13 per cent for drinking; 17 for dish washing; 10 for house cleaning; 19 for toilet; and 41 per cent for livestock (see Figure 6). Almost all of the households go to the water sources itself for washing clothes and bathing.

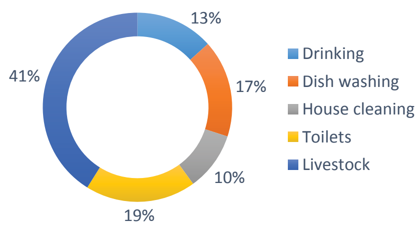


Figure 6: Percentage of water allocated for different HH uses

3.3.5. Land use and land cover

Overall, agricultural land accounts for just above half of the total area of Charghare VDC, while forests occupy nearly a quarter of the land (see Figures 7 and 8). The settlements cover slightly less than one-tenth of the land; from the field discussions, it was learnt that this share is increasing in the downstream area due to migration from the hills, especially after the 2015 Gorkha earthquake.

The rest of the land, less than 5 per cent, other than being used for grazing, is either abandoned or degraded (see Figure 7). Under the agricultural land category, the proportion of khets (flat, cultivable lands) is more than that of baris (sloping lands) as shown in Figure 8.

Figure 7: Land use types by percentage in the study area.

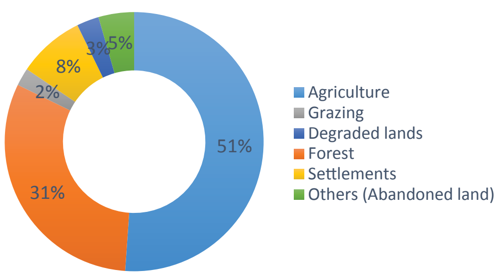
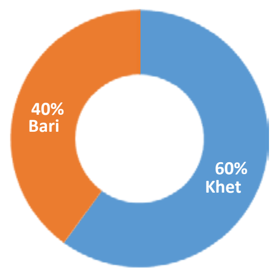
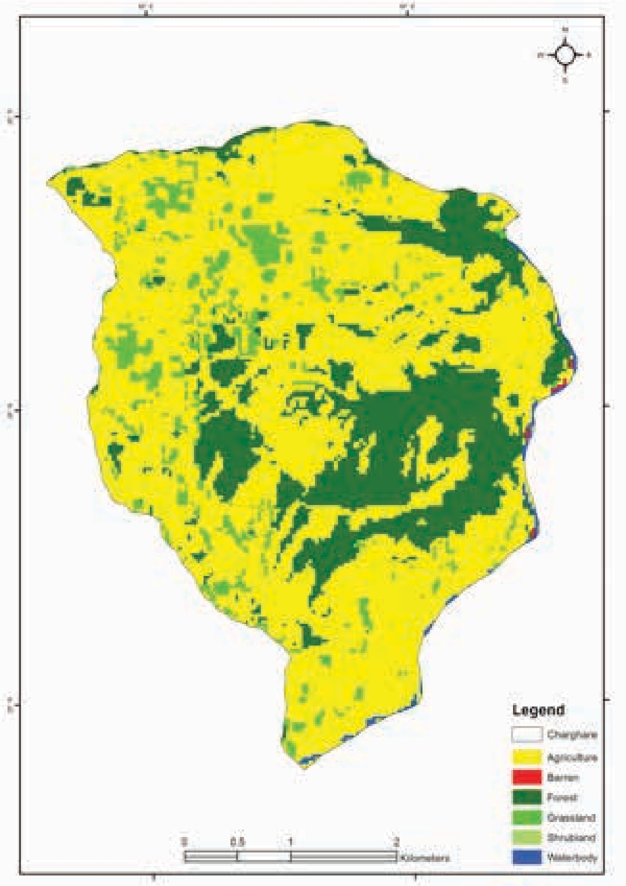


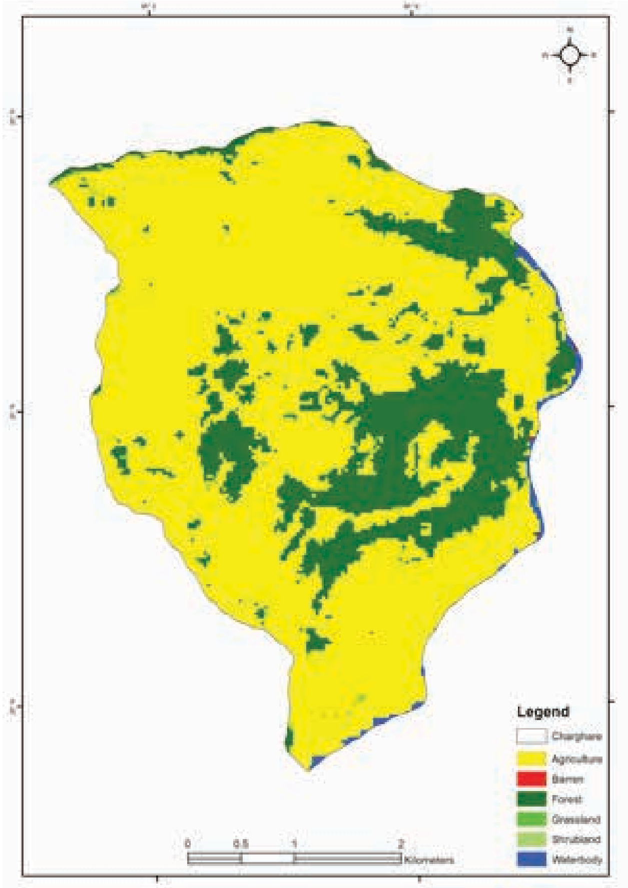
Figure 8: Proportion of different agricultural lands.



Source: FGD data, 2016



Map 4: Land use map of Charghare VDC, 2000



Map 5: Land use map of Charghare VDC, 2010

Source: ICIMOD land use and land cover maps of 2000 and 2010

From Maps 4 and 5, it is clear that there has been a change in land cover in Charghare VDC within a decade. There has been a substantial increase in agriculture land at the rate of 9.3 per cent over the last 10 years. And there has been a slight increase in the percentage of waterbodies in the area, and barren land has declined due to increase in settlements. A clear picture can be obtained from Table 5.

Table 5 Percentage of land cover in Charghare VDC in 2000 and 2010

SN	Land cover class	Area (in %) 2000	Area (in %) 2010
1	Agriculture	68.98	75.88
2	Barren	0.07	0.02
3	Forest	23.10	22.59
4	Grassland	7.27	0.74
5	Shrubland	0.01	0.00
6	Waterbody	0.57	0.77

Source: ICIMOD land cover data, 2000 and 2010

4. Institutions and governance

Various governmental and non-governmental organizations are involved in water resources management in Charghare VDC. The Nuwakot Drinking Water Supply and Sanitation Division, and other local bodies such as the DCC, VDC, and Water Users' Associations of various water supply systems are the main governing bodies actively working in the area of drinking water management. Similarly, various international, national and local organizations are involved in managing drinking water in this VDC, such as the Action Contre La Faim (ACF), Rupantaran Nepal, and Gerkhutar Yuwa Club.

There are altogether 18 piped water supply systems managed by the Government of Nepal (GoN) in Charghare VDC.

As regards spring water, it is used and managed in the following ways in the study area.

4.1. Privately-owned springs

Some spring sources are privately utilized by an individual or household in the village, and these come under the category of private property. This type of water use by an individual or household for personal and non-commercial purposes is not registered. Examples in this case are the Harkleos Pakha Mul and the Kali Kuwa Dandagau.

4.2. Community-owned springs

For such a water supply system, the community comes together and contributes the necessary resources and funds for its construction so that a group of households can lay exclusive claim to it. Most of the spring water supply systems are regulated by the Water Users' Committee. Based on the Drinking Water Regulation of 1988, a group of villagers or a community who wish to use a common spring water source or other forms of water sources should form a Drinking Water Users' Association/Committee, and register for collective use of water from one specific spring or water source (WaterAid 2005). After the registration of such a water users' committee, another users' committee shall not be registered within the scope of such an organization, as that would reduce the quantity of water utilized by this user committee. An example of this community-owned water supply system is in operation at Ward 2 in Munthale, and it is owned by 15 households.

5. Water and society

5.1. Water-related conflict and resolution

5.1.1. Intra-ward water conflict

There has been a major confrontation in Ward 8 regarding intra-ward water-sharing following the earthquake of 2015. Due to an increase in population and the drying up of springs or their diminishing discharge, the water demand has increased, which has resulted in severe water scarcity in the village, especially during the dry season. The residents of Ward 8 have to walk for one or two hours to fetch water from the nearby springs because of the significant decline in the Sano Padhera source. In this ward, the people are reluctant to share the available water source i.e. Irughari Mul which is mainly used by the Brahmin community with their fellow ward members, as they fear water insecurity in the future. This is a classic example of increasing intra-ward water conflict that might escalate in the coming days.

5.1.2. Inter-ward water conflict and water sharing

Ward 4 is comparatively water abundant. But when Ward 8 approached it with a request for an inter-ward water-sharing plan, the users' group of Ward 4 rejected the proposal fearing that their ward may suffer from water insecurity in the future. Even the intervention from the officials of the Nuwakot DWSSD proved to be unsuccessful. This led to a big conflict between the wards. The residents of Ward 4 even threatened the government officials when they were asked to agree to the water-sharing plan.

But this has not been the case between Wards 4 and 6. Ward 6 has shared the spring source, Jibjibe/Kafalbote Muhan with Bhattagau which is situated in Ward 4. For the last 25 years (from 1993), as much as 50 per cent of the water from Kafalbote Muhan is being diverted through a 25-mm pipe. This water supply system was designed by the GoN, and supported by it during the early years of its inception. In order to sustain continuous water supply, Ward 4 is seeking legal assurance, as they are worried about running short of water in the future. Thus, multiple meetings and negotiations have been held to get some written official assurance on continuing the supply in order to avoid future conflicts.

5.2. Local responses to the shortage of water

The drying up of major springs in the villages has increased the dependency on other nearby springs and water sources. During water shortages, the villagers have to search for alternative springs, which may be within or outside their villages. They have to travel longer distances and are allowed to fetch water only after the primary users have already collected sufficient water for themselves. As for other domestic purposes like cleaning and feeding livestock, people prefer to carry water from nearby streams and rivers or walk up to the source itself for bathing and washing clothes, mainly during the dry season. However, when water is abundant, the villagers fetch water from their springs and from the pipes in the community.

Case study

Ram Chandra Rimal, Ward 5

The Bhatta Khola, Diyali Puje Khola and Padhera Khola are the major sources of water for domestic and drinking purposes. Villagers have diverted water from the Bhatta Khola and Naa Khola to irrigate crops. The river discharge has considerably decreased over time, especially of the Padhera Khola, Diyali Puje Khola and Amchaur Khola. There has also been a decline in discharge from the springs near the rivers, such as the Padhera Mul, Deyali Puje Mul, and Amchaur Khola ko Mul. Earlier, they had to struggle to protect land along the riverbank from erosion due to high discharge. However, at present, even the bushes and grasses along the bank remain intact due to low discharge.

The Diyali Puje Khola used to be the prominent source of drinking water for communities in Nunchaur and Bhattagau. Discharge from the river has declined over the last 10 years, more so after the 2015 earthquake. The villagers have been diverting water from the Bhatta Khola as an alternative source as the Diyali Puje Khola (upstream of the Padhera Khola Mul) was unable to meet their increasing demand daily demand. People's water use behaviours have changed considerably as they now prioritize drinking water over other needs.

Therefore, the water sources that were earlier allocated for irrigation are now being used for drinking purposes, as in the cases of the Tallo Kafalbote Khani Kulo Muhan and the Bhatta Khola. In order to solve the problem of drinking water scarcity, the water diverted from Bhatta Khola is being collected and distributed through the existing water supply system.

5.3. Increased propensity to buy spring-located land

From the observations on the field, it has become clear that over the last two decades, there's been an increasing trend in the springshed to buy land that contains water sources. Although there are documents to prove such land transactions, the villagers are reluctant to talk about this openly even though it is a critical issue in terms of future water security in the VDC.

Such transactions are taking place mainly between people from different wards – specifically, the downstream villagers are purchasing land in the upstream water-abundant area. This is to ensure that water is available for drinking, as well as for domestic, agricultural and commercial uses. For example, the value of land that gets regular irrigation (such as khet) is higher than that of rainfed land (such as bari).

5.4. Discrimination against specific groups and individuals

5.4.1. Dalits and water access

The Dalits still face deprivation and discrimination when it comes to access to natural resources. They are considered untouchables and aren't allowed to fetch water from the springs that the upper castes use. Traditionally, they have been allocated separate springs, but many of these have dried up post-earthquake, which have rendered them without adequate water sources. Although Charghare VDC consists of people from all castes, the lower castes have been facing stigma for decades, and they are excluded from accessing basic necessities such as water.

During the FGDs, it came to light that there are still upper-caste people in the area who believe that if the lower castes touched their utensils, it made them impure and unfit to be used for kitchen chores or religious activities. And when the lower castes are allowed to fetch water from the same source as the others, they have to wait till the upper castes fill their vessels.

Case study

Dhungetar (Ward 1 of Charghare VDC), a predominantly Dalit upstream village, serves as an interesting example of water conflict among the hill communities. The villagers of Dhungetar have been challenged in their ownership right to the stream water in their area by the adjoining downstream Brahmin community in Munthala (Ward 2). The Brahmin community allegedly bought around 1,017.44 m^2 (2 ropanis) of land bordering the local stream in Dhungetar Ward 1. According to Ram Bikka, an aged villager of Dhungetar, the spring in the Brahmin community land had dried out, so the community diverted the stream water and claimed it as spring water to be used for domestic purposes in their downstream settlement. As a result, the local Dalit community faces water shortage, especially in the dry months. This has spread discontent among the Dalits in Dhungetar. The community is waiting for government intervention in water management.

5.4.2. Gender

Women are mostly responsible for carrying out chores such as fetching water for domestic purposes. In Charghare VDC, it was found that most of the men have migrated to different places for work, and so it is entirely left to the women to handle household activities. (The men would return to the village during the paddy plantation season, and involve themselves in ploughing and harvesting.)

It was found that piped water doesn't reach all the households in the VDC, and so women have to walk for miles to fetch water from the spring or river sources. This takes them on an average 25–30 minutes to fetch water and get back home, adding to their stress level.

During the dry period, the situation gets worse, as they would have to wait in a queue for an entire day to fetch a few gagris of water. This is because of reduced discharge, and so the supply becomes limited and controlled. Thus, women spent most of their productive time in the collection of water.

Case study

Sushmita Biswakarma told the study team that while both men and women carry water in her village, it was mostly left to the women and children to manage water for domestic use. In most of the houses, the men were not present as they had migrated for work. So, the burden almost entirely fell on the women. Like in the case of Sushmita, whose husband has been away in Saudi Arabia for the past three years. Even when the men were in the village, they could exercise the choice of carrying or not carrying water, but for women, such a choice didn't exist.

6. Impact of the 2015 earthquake on springs and water supply systems

On 25 May 2015, an earthquake of a moment magnitude of 7.8 hit central Nepal; this was followed by more than 300 aftershocks, including one of 6.8 magnitude the next day (Kargel et al. 2016). As many as 31 of Nepal's 75 districts were affected by the quake, and Nuwakot was categorized as a "severely hit" district, along with five other districts of Gorkha, Dhading, Rasuwa, Sindhupalchowk, and Dolakha (Maharjan, Prakash, and Goodrich 2015). The earthquake caused huge physical destruction and casualties. Besides these visible direct losses, the earthquake had a severe indirect impact on the spring and ground water system of the affected areas – it changed the hydrological flow regimes of the groundwater due to the disturbed geology underneath the earth. These impacts range from drying up of major springs, change in the nature of spring from perennial to seasonal, the emergence of new springs, and the increase in the yield of a few springs in the downstream areas.

A report by the On-Site Operations Coordination Centre (OSOCC), during the post-earthquake initial assessment, pointed to a 19.24 per cent decrease in households getting piped water. As information is available for just a few specific locations at the ward level, it is not clear the degree to which this is representative of Nuwakot district. According to an initial assessment, about 50 per cent of the improved water sources in Ward 9 were functional. Initially, the water was muddy, and even though the quality of water has visibly improved, it needs to be tested. Presently, the toilet facilities are limited, as many of them were damaged, and open defecation has been reported in both wards 5 and 9. In Ward 5, it has been reported that no safe drinking water is available and that residents are using water from the river, which is a 30-minute walk from the village. A major water system in Bidur municipality was damaged in the earthquake, limiting the population's access to clean drinking water. Here, 87 per cent of the population had access to tap or piped water in pre-earthquake times (Cluster 2015).

The drying up of the major springs on which the villagers depended heavily have made it difficult for them to access safe drinking water; this has put high pressure on the nearby alternative springs and rivers; there's also increased competition for water; and all this has added to the drudgery of the women, as they are the ones responsible for fetching water to fulfil household needs. The struggle for water turns acute during the arid winter season when the seasonal springs and rivers dry up; lack of normal rainfall too contributes to the woes. Matters become worse when the perennial streams and springs start yielding less than what they usually did.

Perhaps the biggest damage the earthquake has done is to the water supply infrastructure. Water collection tanks have developed cracks and are leaking; and pipelines are in a broken state. While the water supply system in the mid-hills has always faced challenges, the earthquake has exacerbated the situation.

7. Climate change and adaptation strategy

The study tried to understand the people's perception about the major changes in their local weather and climate over the last 10 years. During the discussions, it emerged that both the temperature and rainfall patterns have changed significantly in the study area. The villagers felt an increase in the overall temperature – meaning, hotter summer and warmer winter. They pointed out that this change in temperature has led to an increase in the occurrence of mosquitoes in uphill settlements where they rarely used to exist. They also made the observation that the rainfall has decreased and that there has been a change in the time of the onset of monsoon; they said that while earlier, springs used to yield water soon after the start of the monsoon in mid-June and July, now there's a delay in this discharge. This correlates with findings from the Thulokhola watershed in Nuwakot (Poudel and Duex 2017).

The villagers also said that due to the decline in rainfall, the area that could be irrigated has reduced, as has also the river flow, which have led to an overall slump in agricultural production. This slump has also got to do with the fact that the villagers are forced to leave their land barren because of untimely rainfall or change in the rainfall pattern.

However, the perception of the local communities about the impacts of climate change on springs is rather vague. They attribute the cause of drying up of springs more significantly to the earthquake than to the changing climate; they say it's largely because of the earthquake that there has been a drastic reduction in spring water discharge. Additionally, though the communities have perceived climate change impacts, they are unable to understand them in terms of springs due to a lack of awareness about the springshed dynamics. They reported changes in water availability, and have observed pronounced shifts in water use and access. The impacts of climate change will put further strain on the existing water availability and access, and complicate the socio-economic dynamics of the community, affecting the poor and the marginalized more than the others.

Hill communities have employed several adaptation pathways to cope with the pressing issue of water scarcity which range from seeking alternative springs and streams to buying of land containing springs. The dry season is very severe on the hill communities in term of water availability – the level of perennial rivers starts to drop, the seasonal streams and groundwater dry up, the discharge of persistent springs decline simultaneously, and even rainfall is very nominal in this season. The people augment their declining spring's discharge with water from nearby rivers and streams to meet their demands. When the springs dry up completely and there are no other alternatives, the villagers depend directly on rivers to meet their household water requirements. The water supply system fed by river diversion ranges from small- to very large-scale systems. The wards without any major source of groundwater depend on the large-scale lift water supply system which is either constructed by the community or funded by the GoN.

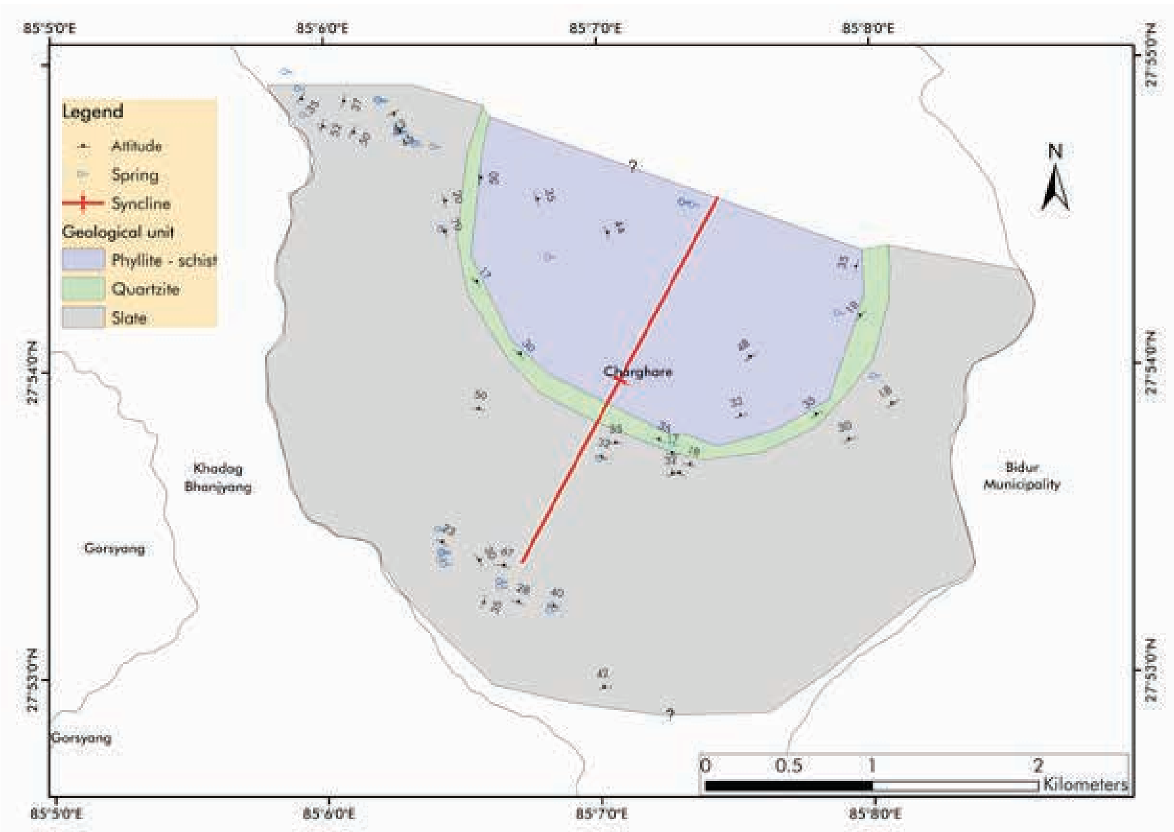
During water-scarce winters, the villagers carry drinking water from the hydropower reservoir tank; this is also done during the rainy season when the flow from their primary source is intermittent and turbid due to the mixing of flood and spring water.

8. Hydrogeological study

8.1. Geology

The springs in the study area are located on the flanks of the NNW–SSE trending ridge, west of Battar, across the Trishuli River, and this ridge has been defined as the Charghare water tower. The ridge slopes eastward towards the Gauri Khola river valley and westward towards the Chainpur Khola river valley. In the south, it is bounded by the Trishuli River itself. Field visits were made to the Charghare water tower, and hydrogeological data were collected for four springs (see Map 6). Lithologically, the ridge mostly comprises of phyllites with a sequence of low-grade, grey slaty phyllites, overlain by white quartzites in the north and north-western part of the study area. Grey schistose phyllites or phyllitic schists and gritty phyllites with quartz veins and lenses are present in the south and south-eastern parts of the study area. The rocks are highly fractured and deeply weathered. Generally, these rock formations follow a north-dipping pattern, but the dips of the rocks change locally and exhibit undulations. There are different sets of fractures trending in different directions: one set is dipping towards NE, and dipping moderate to high in general; another set is dipping steeply towards SE or SW; and the third set of fractures is vertical or semi-vertical, striking in the NW–SE or E–W direction.

Based on the collected field data, hydrogeological conceptual layouts were developed. Of the four springs that were mapped, one spring is exclusively of the depression type, two others are fracture springs, while one of them is a combination of fracture and depression.



Map 6: Geological map and springs distribution of Charghare VDC, Nuwakot

Table 6: Criteria used for selection of springs for hydrogeological investigation

SN	Spring name	Ward no.	Criteria	Remarks
1	Ghattera Dhara Spring	1	Low dependency and low discharge	100% Dalit dependency; located in post-earthquake reconstruction area
2	Bato Muni ko Mul Spring	9	Dry spring after earthquake	Transformed from perennial to seasonal seeps (spring) after the Gorkha earthquake
3	Bhalu Khola Ko Kuwa	9	High dependency and high discharge	Used as an alternative water source by the Tamang community of Khanigau, Ward 9, as the discharge from their primary source – the Kali Kuwa – is very nominal during the dry season.
4	Asine Mul	4	High discharge and low dependency	User dependency increasing on this spring as the earlier primary source (Gurase Mul) has dried up after the earthquake

8.2. Hydrogeology of springs and identification of recharge area

8.2.1. Ghattera Dhara

The area adjacent to the Ghattera Dhara spring as exposed in the Chainpur Khola is constituted of NE-dipping durable and consistent rocks – grey laminated phyllites with quartz lenses, with dips in the range of 20° to 30°. However, the springshed itself is covered by the softer, weathered colluvial debris. Both the areas below and above the spring are cultivated terraces. The spring emerges on the SE-facing slopes from the unconsolidated loose sediments distributed over the river terrace. It emerges well and truly from the weathered debris, indicating a shallow, unconfined aquifer within the loose deposit. Hence, it is classified as a "depression spring". The conceptual hydrogeological layout for the Ghattera Dhara spring is shown in Figure 9.

While the spring emerges from what is the discharge zone of the weathered, loose colluvial sediments, its recharge zone lies at the top, further upslope. The recharge and discharge zones of the aquifer are exposed on the same slope. In other words, the recharge zone is on the same slope as from where the spring emerges.

The Ghattera Dhara spring is a typical example of a "depression spring" found emerging out of loose colluvial material. The hills adjacent to this spring display slaty phyllites, which dip towards NE. The whole area around the spring is covered with river colluvial material deposited in the river terraces of the valley. The Chainpur Khola is towards the east of the spring. Thus, the potential aquifer for the Ghattera Dhara is formed in this loose colluvial material which will need some recharge strategy. The probable recharge area could be big due to the large extent of colluvial material in the valley; thus, it will be difficult to demarcate the exact recharge area. The area above the spring consists of cultivated terraces and a village. The average slope of the area ranges between 15 and 20%. If non-cultivated land is available, a percolation pond can be designed. In the case of the cultivated area, terraces can be raised from the front to facilitate recharge to the system. Plantation activity can be carried out in the valley to ensure less erosion during the monsoon and to provide good infiltration in that particular area.

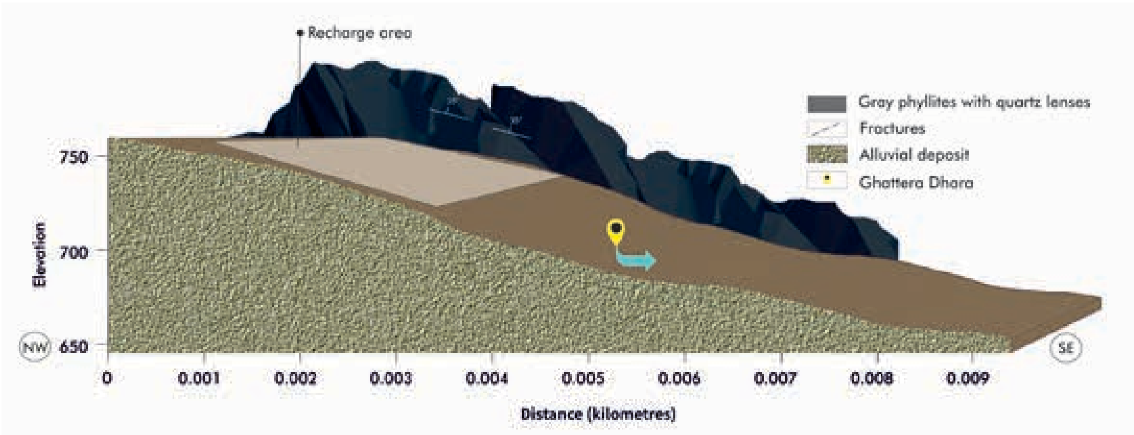


Figure 9: A conceptual hydrogeological layout of Ghattera Dhara showing the recharge area

8.2.2. Bato Muni ko Mul

The Bato Muni ko Mul spring is located on the left bank of the Gauri Khola, further upstream from the confluence of the Gauri Khola and Trishuli River. Geologically, the area around the spring as exposed in the Gauri Khola is constituted of NW-dipping rocks, with moderate (18° to 35°) dips. The springshed is primarily composed of fractured, crystalline grey quartzites and grey, banded phyllites with quartz lenses. The springshed itself is covered by colluvial materials above the more durable and hard grey quartzite with bands of grey laminated phyllites. These grey phyllites also consist of quartz lenses. There are three different sets of fractures around the spring and the springshed area. These fractures provide secondary porosity, forming a potential aquifer that can feed this spring. On the basis of this hydrogeological information, a potential recharge area was identified. This spring source is found on the slope facing the NE direction (see Figure 10), and the spring emerges primarily from the fractures in the rocks. Thus, it is classified as a "fracture spring".

The potential recharge area lies on the ridge in the SE direction which forms the escarpment slope. The escarpment slope area that falls under the recharge area can be treated with staggered contour trenching, depending on the slope characteristics (Chinnasamy and Prathapar 2016). This trenching activity should be restricted to the upper reaches of the slope. Plantation activity should accompany the trenching activity on the same slope in order to prevent soil erosion. Preventing soil erosion will ensure good infiltration into the underlying aquifer system.

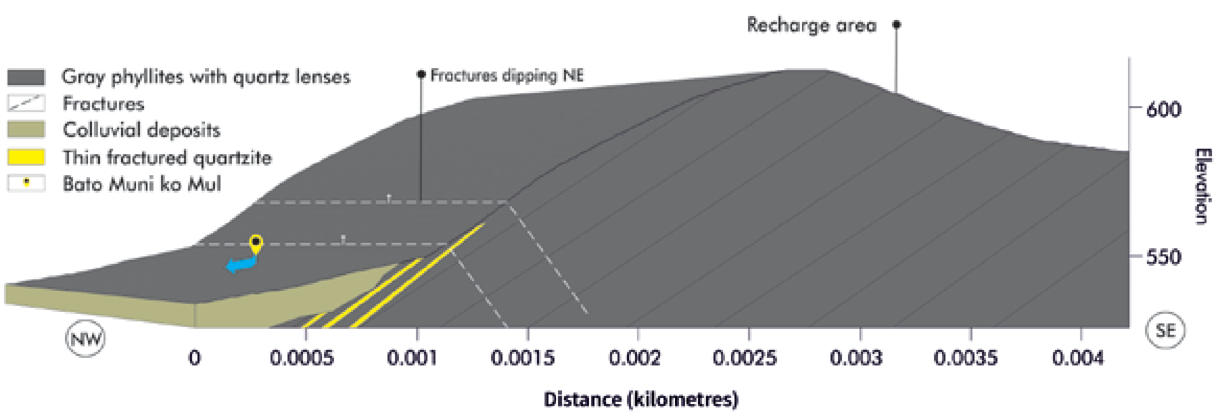


Figure 10: A conceptual hydrogeological layout of Bato Muni ko Mul showing the recharge area

8.2.3. Bhalu Khola ko Kuwa

The area around the springshed of the Bhalu Khola ko Kuwa spring is constituted of northerly dipping rocks, which are consistent with the regional geology of the ridge. The dip direction swings locally from NW to NE, with dips in the range of 15° to 25°. The main lithology is grey laminated as well as banded phyllites with quartz lenses. Grey, gritty phyllite bands are present within the dominant grey phyllites. The spring is located on the dip slope.

Fracturing is quite prominent in the form of two major sets. The main fracture zone along which the spring emerges trends NW–SE, dipping towards NE, along with another set trending NE–SW, dipping towards SE. The fracture openings at the surface are wide and it is obvious that the movement of groundwater stored in the phyllitic aquifer has a preferential direction in concurrence with the trend of the NE-dipping fracture zone and/or bedding openings. The Bhalu Khola ko Kuwa spring is found on the northern slope of the region. The thick, weathered phyllites show a dip slope with clear foliation-related openings indicating this aspect. The spring is found emerging out of the fracture, and is thus classified as "fracture spring" (see Figure 11).

Thus, the potential recharge area for this aquifer is possibly on the escarpment slope and some portion of the ridge area on the dip slope. The escarpment slope is quite steep (50 per cent on an average) and therefore planning any physical activity would be challenging. The area on the escarpment slope is quite densely vegetated and thus can be protected. If required, some additional plantation activity can be carried out. The dip slope also seems to be a bit less steep than the escarpment slope. Staggered contour trenching can be planned with more distance between two trenches. The details provided in "Dhara Vikas" will be useful in this context too (Vikas and Vikas, n.d.). Further down the slope, where the cultivated terraces are to be found, these can have raised bunds to facilitate some additional recharge to the aquifer system below.

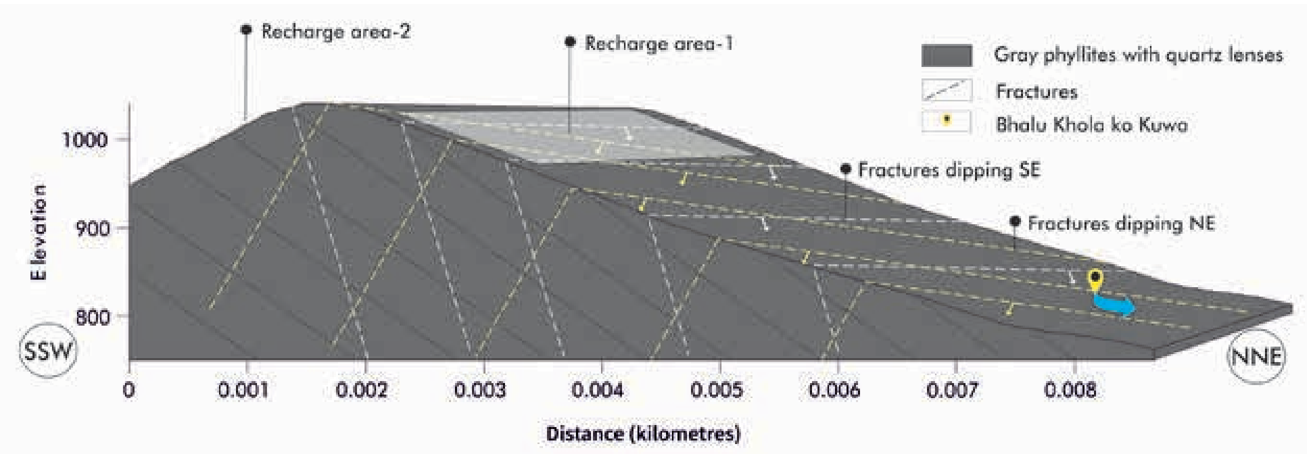


Figure 11: A conceptual hydrogeological layout of Bhalu Khola ko Kuwa showing the recharge area

8.2.4. Asine Mul

The Asine ko Mul spring is located on the upper reaches of the Chainpur Khola, on the slope facing the southern direction. Most of the exposed rock around the Asine ko Mul spring along Chainpur Khola is constituted of SE dipping rocks, with dips in the range of 35° to 50° with average dips of 45°. These rocks are grey, dark grey slaty phyllites. Quartz lenses are also present in these grey slaty phyllites. Bands of white crystalline quartzites too are exposed in the areas adjacent to the spring. The springshed itself is covered by weathered colluvial debris which overlies the more durable and consistent grey, well-bedded and banded slaty phyllites (see Figure 12). There are two prominent fracture sets: one striking NE–SW (F1), dipping towards NW; while the other one striking NW–SE (F2), dipping towards SW. The spring emerges from the fractured rocks, but there is a contribution from the unconsolidated colluvial sediments above these bedrocks as well. The spring is hence classified as "a combination of fracture and depression spring".

The Asine Mul spring is found emerging noticeably through the fracture set F2 and thus the recharge area identified falls on the same slope on which the spring is found, but a little to the left of the spring location (see Figure 12). The approximate slope of the recharge area is around 30 per cent. Considering the land use/cover pattern, staggered contour trenching is feasible for recharge activity. The trenching activity should accompany plantation in order to mitigate soil erosion activity for better infiltration into the aquifer system below. If there is any agricultural practice taking place, a small-dimension deep trench at the corners of the terraced fields can be structured for recharge.

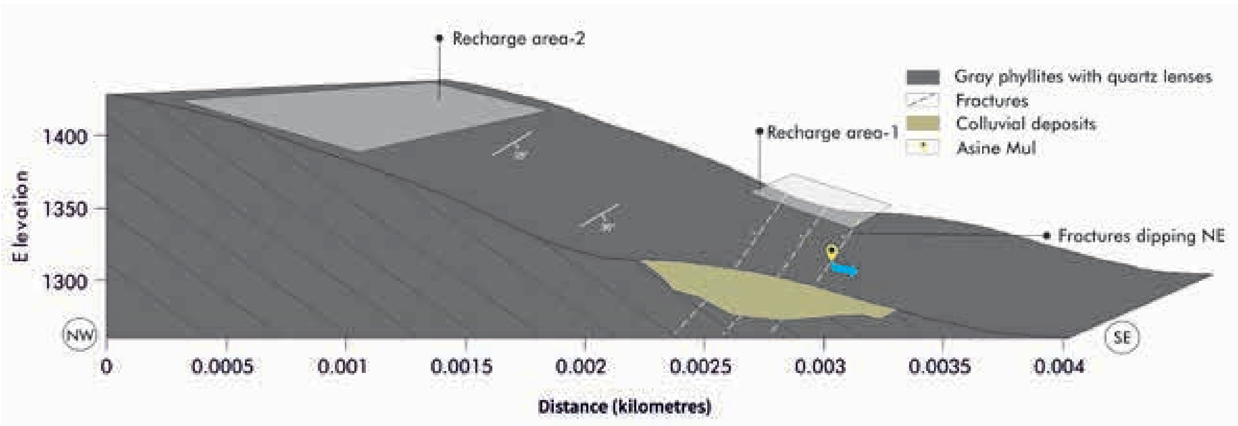


Figure 12: A conceptual hydrogeological layout of Asine Mul showing the recharge area

9. Conclusions

Water availability is very much defined by the prevalence of natural water sources in and around villages. Lack of water storage infrastructure, the challenging geographical setting, and variations in storage capacities amongst villages lead to one being more water scarce than another in Charghare VDC. For example, out of 69 mapped springs, a maximum of 20 springs (nearly 30%) are located in Ward 4.Water scarcity is reported in most of the villages during the dry season. The Gorkha earthquake of 2015 has dried up the major springs in the villages; it has led to a decline in the discharge from springs; springs have shifted location; and all of this will be further exacerbated by the changing climate scenario. One of the fallouts of this long-term as well as seasonal water scarcity has been formal and informal transactions in land containing springs. This has led to conflict over the right to use this water source.

There are no formal rules governing water extraction from the springs in the study area. The rules that exist are ad hoc in nature. Usually, the households that are dependent on the springs are responsible for their upkeep. The rule regarding the amount of water that a household can fetch is applied only during the dry season – both for springs and piped water – so that all the water users have an equal share of the water resources. In terms of the overall management of the water sources, it has to be said that a proper system is not in place; there are infrastructural problems regarding collection tanks, pipes, distribution, etc. Water conflict is prevalent in the springshed – this ranges from minor arguments among the users to major confrontations at the intra- and inter-ward levels.

Similarly, among 31 monitored springs, four were selected for a detailed hydrogeological study. A potential recharge area was identified with recommended recharge measures to be conducted for spring revival.

10. Recommendations for springshed development

In order to conserve the existing spring sources across the entire VDC, it is crucial to develop a robust springshed management and governance protocol. This will help in identifying the springs that need to be conserved and also in undertaking potential recharge measures. Similarly, a springshed governance plan should be developed in consultation with the local communities in order to ensure better management.

Spring revival activities can be carried out on the monitored springs through structural, vegetative, agronomic or forest management measures so as to preserve the recharge area and to improve the discharge rate.

For these technical measures to succeed, community engagement and the participation of all the stakeholders are crucial. The community members should be well aware and trained in spring research activites. A team of parahydrologists can be developed at the community level who can monitor and effectively implement the springshed management plan.

Water is a basic human right, and all communities and households should have equal access to the resource. Hence, it is vital that while conducting springshed management activities, the social and political aspects of water resource management are given top priority. Awareness and legal interventions can go a long way in supporting and establishing water rights for all social groups within the community.

More thorough research and monitoring of the springs in the area is important to measure impacts. A systematic study and formation of a springshed management plan can help improve the springs' condition and lead to better management, which will be beneficial to the communities at large. This can be achieved by involving all the stakeholders – governmental and non-governmental – and other organizations such as development partners, research organizations, and academia in this springshed development project.

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Annex I: Spring data sheet

Baseline data collected on springs during comprehensive spring msapping (Step-1)
SPRING DATASHEET- HI-AWARE RC3
Date: 24–29 May 2016

Name of spring	Spring code	Latitude(N)	Longitude(E)	Elevation (masl)	Discharge (L/S)2	Spring type	Location of spring	Depen-dency	PH	EC	Salinity	Water quality
Rainguage1												
Kot Padhera	S1	27°55" 12.9'	85°8" 45.7'	959	DRY AFTER EARTH-QUAKE	PERENNI-ALLY DRY	MULABARI	80 HH				
Falche Khola	S2	27°53" 53.8'	85°6" 41.2'	860	0.028	PERENNIAL FRACTURE SPRING	MULABARI		8.5	267	128	
Patale Mul	S3	27°53" 53.8'	85°6" 41.7'	842	0.043	PERENNIAL CONTACT SPRING	MULABARI	20 HH	7.82	313	151	POTABLE
Dhai Jhok Padhera	S4	27°53" 54.6'	85°6" 41.9'	944	DRIED AF-TER EARTH-QUAKE	KUWA	MULABARI	80 HH				
Muse Kuwa	S5	27°54" 6'	85°6" 43.4'	787	0.022	PERENNIAL	MULABARI	7 HH	8.17	350	25.2	POTABLE
Ghimire Padhera	S6	27°54" 6'	85°6" 54.8 '	778	0.0026	SEASONAL	MULABARI	8 HH	6.52	51.9	31.8	POTABLE
Sim Pani Mul	W2S1	27°53" 15.1'	85°7" 48.2'	475	DRIED	SEASONAL	MANDRED-HUNGA					
Kali Khola Intake	W9S1	27°53" 0.2'	85°7" 0.9'	691	1	PERENNIAL	KALIKHOLA	30 HH	7.7	42.2	36	POTABLE
Kahare Khola ko Mul	W9S2	27°54" 28'	85°7" 44.3'	570	0.11	PERENNIAL	KHAHA-REPARI PAKHA	50 HH	8.04	45.1	27.8	POTABLE
Bato Muni Ko Mul	W9S3	27°54" 11'	85°7" 54.2'	575	DRIED AF-TER EARTH-QUAKE	DRIED AF-TER EARTH-QUAKE	GAURIBESI	7 HH				

Name of spring	Spring code	Latitude(N)	Longitude(E)	Elevation (masl)	Discharge (L/S)2	Spring type	Location of spring	Depen-dency	PH	EC	Salinity	Water quality
Mul Pani ko Mul	W9S4	27°53" 57.4'	85°8" 0.4'	462	0.077	PERENNIAL	GAURI BASI	25 HH	7.03	48.7	29.2	POTABLE , POPULAR WATER FOR DRINKING
Kali Kuwa Khatrigau	W9S5	27°53" 56.9'	85°7" 41.5'	648	VERY NOMINAL	PERENNIAL, DRIEDAFTER EARTH-QUAKE	KHATRIGAUN	15 HH	7.55	53.9	34.4	POTABLE
Kali Kuwa Khanigau	W9S6	27°53" 44.6'	85°7" 36'	819	0.011	PERENNIAL, BUT VERY NOMINAL DIS-CHARGE	KHANIGAU	52 (30 HH EARLIER)	7.4	50.4	15.9	POTABLE
Bhalu Khola ko Kuwa	W9S7	27°53" 44.8'	85°7" 16.5'	737	0.044	PERENNIAL	KHANIGAU	25 HH	8.37	44.9	38	POTABLE
Saune Khola ko Mul	W9S8	27°54" 32.1'	85°7 " 21.2'	689	0.125	PERENNIAL	FEDHIPAKHA MUL CHARGHARE	10 HH	8.11	95.7	49.2	BIT TURBID
Dhankute Pakha Mul/ Personal	W9S9	27°54" 32.3'	85°7" 19.8'	720	0.052	PERENNIAL	CHARGHARE BADHUWAR	1 HH	5.89	23.1	18.6	CLEAR
Dhankute Pakha Mul-ii	W9S10	27°54" 32.3'	85°7" 19.1'	721	0.1	PERENNIAL	CHARGHARE BADHUWAR	7 HH	6.26	41.3	25.8	CLEAR
Thulo Dhara ko Mul	W9S11	27°54" 27.9'	85°7" 13'	816	DRIED	SEASONAL	CHARGHARE W9	60 HH				CLEAR CLEAN
Sano Dhara ko Mul	W9S12	27°54" 26.9'	85°7" 13.1'	802	0.04	PERENNIAL	CHARGHARE W9	12 HH EARLIER, 60 HH NOW	5.8	49.1	29.1	TURBID
Sansari Ba-jra Dhungo (Gauri Khola)	W9S13	27°54" 18'	85°6" 38'	741	DRIED AF-TER EARTH-QUAKE	DRIED AF-TER EARTH-QUAKE	W3	7 HH				
Gauri Khola	W9S14/ W5S1	27°54" 18.5'	85°6" 38.3'	764		PERENNIAL	W3	7 HH				CLEAR
Gado Khola	W5S3	27°54" 21.7'	85°6" 49.5'	794		PERENNIAL	W5 GAD-OKHOLA	20 HH	7.5	69.4	38.1	CLEAR
Irughari Mul	S2	27.9162222°	85.0978333°		PESENNIAL, DRIED OUT	DRIED	TALLO JAMUNA	7 HH				CLEAN

Name of spring	Spring code	Latitude(N)	Longitude(E)	Elevation (masl)	Discharge (L/S)2	Spring type	Location of spring	Depen-dency	PH	EC	Salinity	Water quality
Gurase Muhan	S1	27°54" 52.9'	85°6" 12.5'	1165	DRIED SINCE FEB	PERENNIAL EARLIER THIS YEAR	JAMUNE KO GURAS, COMMUNITY	10 HH				
Asine Mul	S3	27°54" 54.6'	85°5" 53.8'	1258	0.2	PERENNIAL	KAFALBOTE COMMU-NITY	82 HH	8.52	157	78.4	CLEAN
Kafalbote Mul	S4	27°54" 54.9'	85°5" 54'	1126	0.2	PERENNIAL	BHATTAGAU					CLEAN
Tallo Kafal bote Mul	S5	27°54" 54.9'	85°5" 55.3'	1165	0.01	PERENNIAL	BHATTAGAU		7.9	206	98	
Kafalbote Khani kulo Muhan	S6	27°54" 50.1'	85°5" 50.1'	1154	FOR IRRIGA-TION ONLY	PERENNIAL	BHATTAGAU					
Bhatta Khola	S7	27°54" 47.6'	85°6" 0'	1125	0.333	PERENNIAL	BHATTAGAU COMMU-NITY	27 HH	8.69	86.9	45.9	
Amchaur Khola ko Dharo	S8	27°54" 45.7'	85°6" 35'	1033	DRIED	DRIED 3 YEARS BACK	BHATTAGAU	0 HH				
Delhibhuje Dharo	S9	27°54" 46.5'	85°6" 17.2'	1130	0.076	PERENNIAL,,SLOWLY DRIED UP IN 2 MONTHS	BHATTAGAUN	37 HH	7.6	25.1	19	
Padhera Khola	S10	27°54" 44.6'	85°6" 19.6'	1086	0.166	PERRENIAL	BHATTAGAUN COMMUNITY	27 HH	6.42	35.6	23.1	OPEN
Padhera Khola Mul	S11	27°54" 44.4'	85°6" 19.9'	108	0.083	PERRENIAL (DE-CREASED DIS-CHARGE DUE TO EARTH-QUAKE)	BHATTAGAUN COMMUNITY	27 HH	6.45	21.2	17.8	OPEN
Gado Khola fed ko Mul/ Gado Khola Charghare Drinking Water Sup-ply/ Vheera Khola Mul	S20	27°54" 30.9'	85°6" 29.5'	884	1	PERENNIAL, DEPRES-SION	CHARGHARE (W-5)	50 HH	7	47	27.8	CLEAN

Name of spring	Spring code	Latitude(N)	Longitude(E)	Elevation (masl)	Discharge (L/S)2	Spring type	Location of spring	Dependency	PH	EC	Salinity	Water quality
Guhe Khola Mul/ Niranjan ko Mul	S21	27°54" 32.7'	85°6" 20.3'	977	0.09	PERENNIAL DEPRESSION	MULABARI W-3	1 HH	6.1	20.5	17.2	
Naa Khola ko Mul	S22	27°54" 43.5'	85°6" 24.5'	988		PERENNIAL DEPRESSION	FOR IRRIGATION NOT DIVERTED FOR DRINKING	0 HH	6.2	24.3	19	
Karamphedi Mul/ Khatri ko Padhera	S1	27°53" 24'	85°6" 37.9'	616	0.03	PERENNIAL	ARCHALE	6 HH	7.4	64.9	36.7	CLEAN
Salphedi ko Mul	S2	27°53" 24'	85° 6" 39.4'	635	INACCESSIBLE	PERENNIAL	ARCHALE	15 HH				CLEAN
Bhalu Khola ko Mul	S3	27°53" 13.2'	85°6" 50.4'	651		PERENNIAL	ARCHALE	8 HH	6.9	57.6	33.1	CLEAN
Rame ko Khet ko Mul	S5	27°53" 24.4'	85° 6" 694'	623	0.015	PERENNIAL DEPRESSION	DHUNGENTAR W-1	11 HH	6.8	49.1	29	
Padheri Khet ko Mul	S6	27°53" 21.6'	85° 6" 27'	622	DRIED AFTER EARTHQUAKE	PERENNIAL	MUNTHALA	30 HH				
Munthale Mul	S7	27°53" 21.7 '	85°6" 25.8'	594	0.111	PERENNIAL DEPRESSION	MUNTHALA W-2	22 HH	7.34	30.3	9.8	
Afno Khet ko Mul	S1	27°53" 28.8'	85°6" 24.9'	694	0.015	PERENNIAL DEPRESSION	CHAINPUR W-1&W-6	4 HH	6.6	35.9	23.8	

Annex II: Questionnaire and checklists

1. General

Area:	
VDC:	
Ward no.:	
Village/settlement:	
No. of households:	
Average family size:	
Total population:	
Male–female ratio:	

2. Water resources by type

2.1 Rivers

2.1.1 What are the major rivers and streams in the area?

River/stream name	Location and ward/name of the place	Water availability (seasonal, permanent)

2.1.2 Have the flows of rivers changed over the past 10 years? (increased, decreased, or remained the same)

2.1.3 If water availability has decreased, how do you cope with it? (in terms of drinking, washing, cleaning, irrigation, livestock)

2.2 Ponds

2.2.1 How many ponds exist in the area (ward number-wise) and how are they distributed geographically?

Name/location*	Permanent	Seasonal	Completely dry

*Location can be up or down, east, west, north or south, depending on the cluster

2.2.2 For what purposes are the ponds used (religious, recreational, providing water for animals, fishery, washing, cleaning, and groundwater recharge)?

2.2.3 Which of the ponds mentioned above have performed well in terms of water availability and what is the reason for this?

2.2.4 Please give the location of those ponds that may be contributing to the recharge of the springs downstream.

2.2.5 How have ponds changed in the past 10 years in terms of number, water depth, quality, etc.? Why?

2.2.6 Do you think there is a connection between ponds and springs? Please give examples.

2.2.7 Do you have any plans to construct ponds for the purpose of recharging the springs in your locality in the near future?

2.2.8 Which areas are suitable for the construction of ponds?

2.3 Inars and drilled wells (deep boring)

2.3.1 Are there inars in your ward/VDC? If so, how many, and since when have they been in existence? What purposes are they used for?

2.3.2 Do you use deep boring for water? If so, how many? When was the first deep boring drilled? Who owns it? How much does it cost? What purpose is it used for?

2.3.3 If yes, how many borings are in use, and how are they distributed geographically?

Name/location*	Permanent	Seasonal	Remarks
	Yes		

*Location can be up or down, east, west, north or south, depending on the cluster

2.3.4 Are they reliable sources of water for drinking? Which is better?

2.3.5 How does the depth of water fluctuate between the dry and wet seasons? (Units: foot, metre, haat, bitta, others specify…)

2.3.6 Is the quality of water fit for drinking purposes from these sources?

2.3.7 Do you get sufficient water for all your needs? If not, how do you prioritize?

2.3.8 Has the number of bore wells/inars increased or decreased in the past 10 years? What about the water table? Why?

2.4 Rainwater harvesting

2.4.1 Is rainwater harvesting done in your locality?

2.4.2 When was the first rainwater harvesting scheme introduced?

2.4.3 Who brought that idea for the first time? (an institution or any one from the community)

2.4.4 Is there any support in this regard from any organization? If so, what kind of support?

2.4.5 How many households in this ward use this practice now?

2.4.6 Has the number of households using this practice increased over the past 10 years?

2.4.7 What kind of water-harvesting system is commonly used (collection in drums and buckets, open storage tank, closed storage tank, plastic pond, groundwater recharge, etc.)?

2.4.8 Does any household have a permanent rainwater harvesting structure (with all its components)? If yes, how many households have it?

2.4.9 What is the average capacity of a household-level rainwater collection container

2.4.10 What are the preferred uses of water from this source (rainwater harvesting)?

2.4.11 Is your household water demand fulfilled by rainwater harvesting?

2.4.12 For how many months are the harvested water sufficient?

2.4.13 What is the level of acceptance for the rainwater harvesting system? Do you think this is a sustainable source of water for household use?

2.4.14 What are the main problems in rainwater harvesting and its usage?

3. Sources of water for various uses

3.1 For domestic use

3.1.1 What are the major sources of water for domestic use?

System	Number	Beneficiary households	Quality	Change in the past 10 years	
				Quality	Quantity
Tap water (government)					
Tap water (community water supply system)					
Spring water (mul, dhara, kuwa)					
Inar (dug well) and bore well					
River/stream					
Tanker					
Rainwater harvesting					
Pond					
Hydropower reservoir					

3.1.2 Is the quantity of water sufficient (from the above sources) for all your domestic needs?

3.1.3 What changes in the quantity and quality of water from these different sources (mentioned above) have you noticed in the past 10 years?

3.1.4 If there has been a decline, how have you been coping with it?

3.2 Sanitation

3.2.1 Is sufficient water available for all your sanitation needs? If not, how do you cope with it?

3.2.2 Does your household treat water before drinking it?

3.2.3 If yes, which method of water treatment does your household use?

3.3 Irrigation

3.3.1 Major sources of irrigation

Source	Type (permanent, seasonal)	Irrigated area (ropani)	Beneficiary households	Trend (increasing/ decreasing)
River/stream				
Spring (*mul, kuwa, dhara*)				
Pond				
Canal/channel/*raj kulo*				
Rainwater harvest				
Inar/deep boring				
Others				

3.3.2 Methods of irrigation

Method	Trend (increasing/ decreasing)	Source	Remarks
Flooding			
Polythene pipes			
Sprinklers/drip			
Others			
Ridge furrow (e.g.: potato)			
Pitcher			

3.3.3 Is the quantity of water sufficient for all your agricultural needs (including for irrigation and livestock)?

3.3.4 How are the irrigation systems managed (in terms of institution – formal/informal, such as user groups; rules and regulations)?

3.3.5 What changes in the quantity and quality of water for agricultural use have you noticed in the past 10 years?

3.3.6 If there has been a decline in quantity, how have you been coping with it?

3.4 Other users

3.4.1 Who are the other users of water in this area (e.g., hotels, industry, etc)?

3.4.2 What are the sources used to run these other users and what is the situation regarding sufficiency, quality, etc.?

3.4.3 What is the impact on water availability for locals/community due to the other users using the same water sources?

3.4.4 Are there any specific rules on water use for the other users?

4. Land use and land-related activities

4.1 Land use

Land use	Estimated area (%)	Notes and remarks
Agriculture		
Forest		
Grazing		
Settlements		
Degraded land/ barren land		
Others specify		

4.2 Agricultural practices

4.2.1 What are the proportions of khet and bari lands? (in %)

4.2.2 What are the major crops and cropping patterns?

4.2.3 What changes have taken place in the past 10 years in:

Land use?

Crops?

Cropping patterns?

Production and yields?

Use of pesticides and chemical fertilizers?

4.3 Forests

4.3.1 What are the natural forest species?

4.3.2 What are the species used in afforestation? (in the past 10 years)

4.3.3 How have forests changed over the past 10 years in terms of:

Area under forests?

Forest condition?

Species of trees and other vegetation?

4.3.4 Have you observed any changes in water availability after planting any particular plants/ species in the locality? (in the past 10 years)

4.3.5 In your experience, which species of plant is good or bad for water restoration?

4.3.6 What are the water resources available within the forests?

4.3.7 How are the water resources in the forests utilized?

5. Water collection and allocation for domestic use (Preferably to be asked to women)

5.1 Who fetches water for household use (men, women or children)?

5.2 How much water does one person collect per day?

5.3 How many times does one have to collect water per day?

5.4 How much water does one household use per day?

5.5 How much time does it take to fetch water for household use?

5.6 How is water allocated for household use?

6. Institutional and governance aspects

6.1 Which institutions are involved in managing water resources?

6.2 Have you noticed any conflicts regarding water use/distribution in your locality?

6.3 How are the conflicts resolved?

7. Upstream areas

7.1 In what conditions are the upstream areas of water resources used by the community?

7.2 Have there been any major changes over the past 10 years in terms of infrastructure, housing, and land use?

7.3 Are there any plans for development and land use changes in the upstream areas in the near future?

8. Climate change

8.1 Over the past 10 years, have there been any major changes (in terms of degree and timing) in:

Temperature?

Rainfall?

Occurrence of extreme events like floods, droughts, hailstones, landslides, cloudbursts, etc.?

8.2 How did they impact the water sources in the area?

8.3 How did people cope with the impacts?

9. Groundwater recharge (GWR) practices

9.1. Are you aware (directly/indirectly) of GWR?

9.2. Have you ever implemented any such technique?

9.3. What kind of techniques have you practised so far?

10. Migration

10.1. Has anyone migrated from your area/village?

10.2. If yes, what was the reason for the migration? How many households have migrated? Where did they migrate to?

10.3. Has any household or community migrated due to water shortage in your locality? If yes, where did they migrate to?

11. Tendency of buying land containing springs

11.1. Is there a practice of buying land containing springs in your village?

11.2. If yes, when did it start? Why?

11.3. Is the trend of buying such land increasing or decreasing in your village?

11.4. Please give us a specific instance of such a land transaction. (Which spring, who bought, who sold, and for how much money?)

11.5. Who are buying such lands?

i. Outsiders (from other VDCs or from other districts)

ii. People from the same locality

iii. Anyone else

11.6. For what purpose is the land with springs used?

i. Drinking and domestic use

ii. Irrigation

iii. Commercial farming

iv. Building construction

v. Factory

vi. Any other reasons

11.7. What is the cost difference (range) in terms of lands without springs and with springs?

11.8. What happens when a private person buys a land where a spring is located in terms of others having access to the water? Are others allowed to fetch the water?

12. Impacts of the 2015 earthquake

12.1 Have you observed any impacts of the earthquake on springs?

12.2 If yes, how has the earthquake been affecting the springs at present?

12.3 Have you perceived any other factor that has impacted springs besides the earthquake – such as road construction, change in rainfall pattern, landslide, flood, fire, etc.?

12.4 When the springs dry up or the discharge decreases, how do you cope? Or, what happens when the spring discharge increases?

Other comments/remarks concerning spring sources in the area (if any):

List of participants

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