TECHNICAL BRIEF

State-of-the-art approaches for evidence-based springshed management to increase resilience to climate change in Nepal

Key messages

- **A thorough understanding of spring systems is essential to design evidence-based springshed interventions. The necessary information can be collected by conducting hydrometeorological monitoring, hydrogeological assessments and isotope analysis.**
- **Springs are recharged by a combination of both surface water and groundwater sources that may extend beyond administrative and surface water boundaries. Identification of the nature and seasonality of springs provides a basis for prioritization of springs and design of interventions.**
- **Considering a broader landscape approach, integrating the management of forests, agricultural fields, soils and water systems over larger areas, is recommended for long-term springshed management and to ensure adequate water supplies under conditions of climate change.**

A team from the BCRWME project visiting the hydrological station set up at Shikharpur, Baitadi district, to measure water levels.

Context

- Springs are the primary source of water for the food and livelihood security of over 13 million people living in the upland hills and mountains of Nepal.
- Despite alarming trends in the drying up of springs in the last decade, a scientific understanding of mountain springs in the country has not been established.
- Interventions for enhancing the availability of spring water are designed with a poor understanding of springshed hydrology and leads to failures in preventing the drying of springs.
- Lack of integration and collaboration between agencies managing surface water, groundwater and land is a key challenge in springshed management.

Collaborators:

CGIAR Research Program on Water, Land and Ecosystems

Funding partners:

Nordic Development Fund

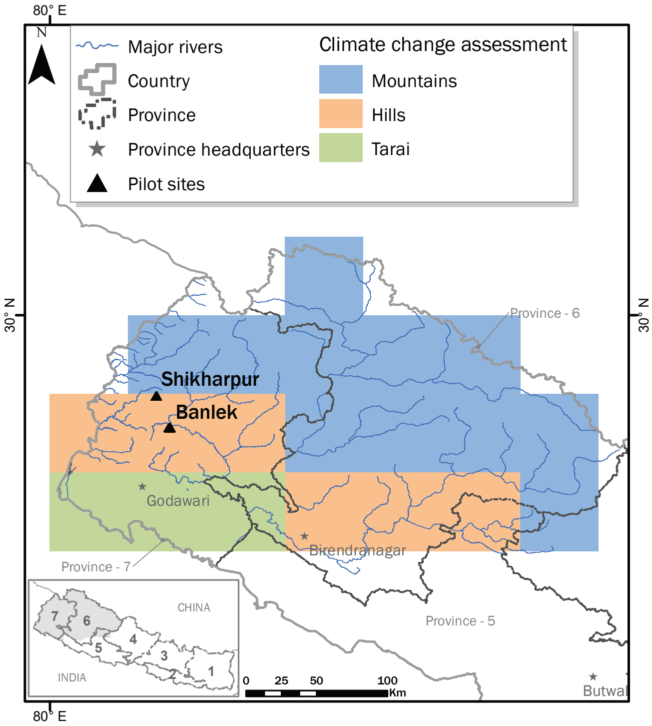
ADB Asian Development Bank

CIF Climate Investment Funds

The BCRWME project

The Building Climate Resilience of Watersheds in Mountain Eco-Regions (BCRWME) project is implementing various watershed interventions to provide 45,000 households in vulnerable mountain communities with access to a more reliable supply of water, and to combat the observed trends of the drying of springs. The International Water Management Institute (IWMI) is a knowledge partner leading a comprehensive research program characterizing mountain springs in western Nepal. The aim of the program is to identify effective interventions that can increase reliability and year-round water availability of spring water sources. Pilot studies incorporating state-of-the-art scientific methods were carried out in two mountainous watersheds – Banlek in Doti district and Shikharpur in Baitadi district – in Sudurpaschim province of Nepal. (Figure 1) The findings from the pilot studies are summarized here.

Figure 1. Pilot sites in Doti and Baitadi districts of western Nepal.



The climate is changing

Western Nepal is one of the most vulnerable regions to climate change. Projections from 19 Regional Climate Models (RCMs) show that the hills and Tarai may see the highest fluctuation in precipitation, while the mountains could see the highest increases in temperature, with these values being higher than projections for South Asia (Figure 2). Warmer temperatures, prolonged monsoon and sporadic rain events, even in drier months, are likely across all regions. There is a need for robust interventions that can cope with the high uncertainty in the direction and seasonality of changes in precipitation. Sustenance of springs can provide resilience against the fluctuations in surface water caused by climate change, by providing access to water stored in groundwater aquifers.

Figure 2. Changes in seasonal and annual average precipitation and maximum temperature values projected across nine meteorological stations in the mountains, hills and Tarai region of western Nepal.

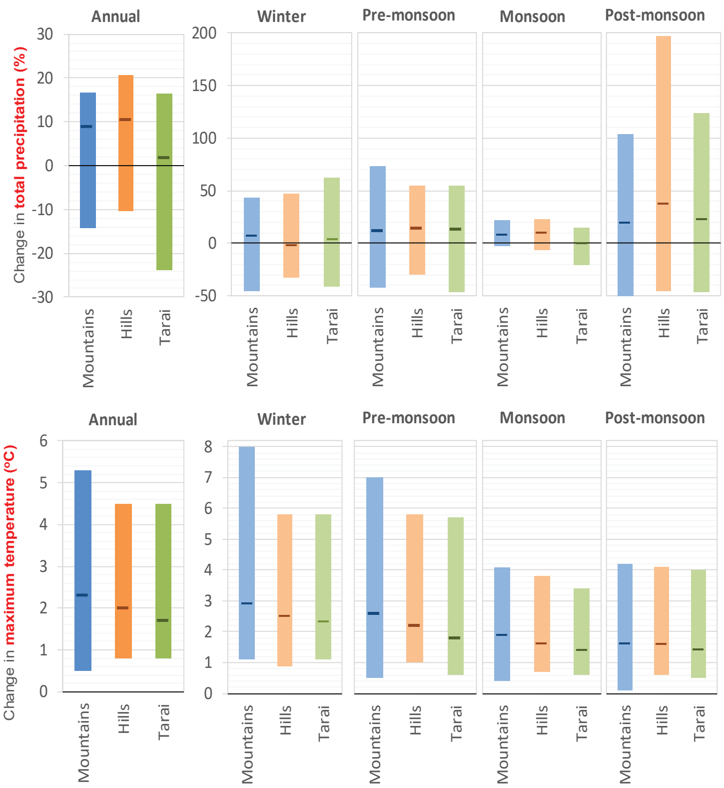


Figure 3. Ambika Khadka from IWMI manually measures discharge at one of the springs in Banlek, Doti district, Nepal.

Hydrometeorological monitoring

Intensive monitoring of climate (precipitation, temperature, relative humidity, solar radiation and wind speed) using two automated weather stations, and monitoring of discharge at eight springs using automated and manual measurements (Figure 3) revealed the following:

- The average response time of springs in Shikharpur to rainfall was 10 days. However, the response time varied even for springs along the same spring line and over short distances, which is common in the Himalayan region due to micro-climates.
- Varying responses to rainfall of individual springs suggest there is variability in their connectivity to surface water and different types of groundwater aquifers. Interventions should target the enhancement of such connectivities.
- Springs primarily fed by precipitation follow rainfall patterns. Other springs with stronger connections to groundwater have relatively low discharge that is sustained even in the dry season.
- Springs that sustain their flow in the dry season are important to ensure year-round water availability, while springs dominated by surface water may be key for use in irrigation in the post-monsoon seasons.
- Hydrometeorological data form the basis of rigorous analysis of springs, including baseflow separation, modeling the performance of springshed interventions and conducting climate change impact assessments.

Hydrogeological study

Success of springshed interventions depends on the nature of the subsurface geology. Use of a regional geological map, and conducting field visits and expert assessments helped characterize the local hydrogeology of the pilot sites to support the following conclusions:

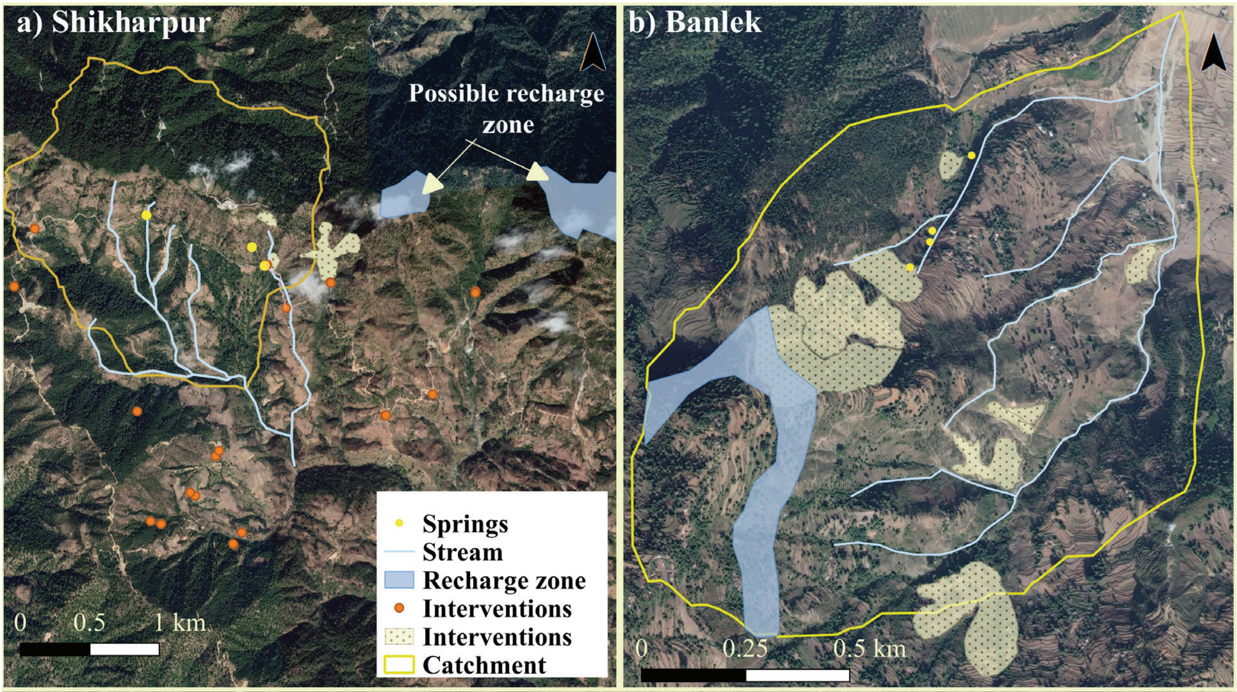
- Occurrence and emergence of springs depend on the type of geological layers and their arrangement in the subsurface. Both pilot sites have contact springs arising between the layers of varying porosity.
- Subsurface geology governs the connectivity of springs to surface water and shallow or deeper groundwater sources.

Isotope analysis

The BCRWME project is the first study to use stable isotopes to identify recharge zones for springs in Nepal. Isotope analysis helped to identify the relative contribution of surface water and groundwater to springs, recharge elevation zones for springs, and the recharge potential of springs, with a view to selecting effective interventions (Figure 4). The important lessons learned from the isotope analysis are given below:

- Springs are recharged by both surface water and groundwater.
- Seasonality in isotopic composition of rainwater suggests that different sources of water vapor cause rainfall in the monsoon and dry seasons to vary.
- Spring recharge areas can be broader than the immediate watershed boundaries defined by surface water hydrology.

Figure 4. Location of planned interventions and spring recharge zones estimated using isotope analysis combined with hydrometric and hydrogeological measurements in (a) Shikharpur, and (b) Banlek districts.



Conclusions and way forward

The nature of springs and potential for augmented recharge through watershed interventions can be complex due to the connectivity of springs to groundwater aquifers and surface water systems. Therefore, spring management projects should focus on a larger integrated landscape management approach that combines the management of forests, agriculture, soils and water systems to maintain healthy surface water and groundwater systems.

- Springs can be connected to aquifers and recharge areas crossing administrative and watershed boundaries. Thus, concepts of integrated watershed management, which limit interventions to a particular watershed, are not sufficient for successful management of springs.
- Given the wide range of climate projections across time and space, interventions should focus on springs primarily fed by groundwater which are less sensitive to climate change.
- Both pilot sites comprise of phyllite and quartzite formations, which facilitate smooth groundwater flow. The Karst limestone in Shikharpur, in particular, comprises of fractures and fissures that can support long-range subsurface connectivity across groundwater aquifers. Due to the possibility of such connectivity between surface and subsurface systems in springs, recharge interventions such as infiltration ponds, afforestation, source water protection and land use management, need to be applied to a larger landscape rather than individual and isolated watersheds.
- Spring conservation and management activities should use integrated landscape management approaches to synergize the positive linkages with livelihood practices (establishing bathing ponds for cattle that can also serve as recharge ponds, terrace farming, plantation for source protection, bio-fencing to prevent erosion, etc.), while preventing practices that have negative impacts (overgrazing, deforestation, creation of artificial gullies, haphazard road construction, over-extraction of springs, etc.).
- An integrated landscape management approach requires long-term collaboration among agencies responsible for forestry, water, agriculture, conservation, etc., and the government should move away from isolated, sectoral management of natural resources. Local communities must also be involved in such an approach.

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Dhaubanjar, S.; Pandey, V.P.; Bharati, L. Climate futures for western Nepal based on regional climate models in the CORDEX-SA. *International Journal of Climatology* (in review).

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The International Water Management Institute (IWMI) is a non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries. IWMI works in partnership with governments, civil society and the private sector to develop scalable agricultural water management solutions that have a real impact on poverty reduction, food security and ecosystem health. Headquartered in Colombo, Sri Lanka, with regional offices across Asia and Africa, IWMI is a CGIAR Research Center and leads the CGIAR Research Program on Water, Land and Ecosystems (WLE).

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