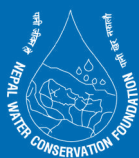


Mainstreaming Spring Revival in Hindu Kush Himalayas

# Status of Spring Research, Policy and Practice in Nepal



**Nepal Water Conservation Foundation (NWCF)**  
Chundevi, Maharaigunj, Kathmandu

December 2021

# Mainstreaming Spring Revival in Hindu Kush Himalayas

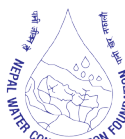
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December 2021

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### Published by

Nepal Water Conservation Foundation for Academic Research (NWCF)  
Chundevi, Maharajgunj, Kathmandu, Nepal  
and  
International Centre for Integrated Mountain Development (ICIMOD)  
Khumaltar, Lalitpur, Nepal

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### ISBN .....

**Photographs:** NWCF & ICIMOD, 2021

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### Citation

Adhikari, M., Gyawali, D., Bhattarai, C., Pokharel, G.S., Pokharel, A.K., Thapa, B., Tiwari, S., Sharma, B., Bhuchar, S., Dhakal, M., Agrawal, N.K., Shrestha, A.B., Shrestha, K., & Gupta, N. (2021). Mainstreaming Spring Revival in Hindu Kush Himalayas: Status of Spring Research, Policy and Practice in Nepal. Nepal Water Conservation Foundation for Academic Research and International Centre for Integrated Mountain Development. Kathmandu: Nepal

**Acknowledgement:** We duly acknowledge the local government officials, water users, and experts who provided invaluable information, feedback and cooperation especially during the survey, field visits and review.

### Editors

Dr. Chiranjibi Bhattarai, Bhumika Thapa and Sushma Tiwari

**Design & Layout:** Outline Graphics & Printing Support, Kathmandu

**Printed at** Anytime Printing Press, Buddhanagar, Kathmandu, Nepal

# Foreword

Springs are the lifeline for the millions of people living in the Himalayan region as they are the only source of water supply. In recent years, reports are pouring in from across the mountain towns and rural settlements that these sources are shrinking rapidly, either converted from perennial to seasonal or completely dried up. As a consequence, communities are facing unprecedented challenges in the forms of water stresses and associated disasters. This study undertaken by the Nepal Water Conservation Foundation (NWCF) in collaboration with ICIMOD is an essential step forward to fulfil the knowledge gaps specifically the inventory of springs and their statuses and trends. Although this edition has come with various shortcomings, we believe that this would serve as the reference for the future planning.

I take this opportunity to thank the Founding Member of NWCF cum Pragya Dipak Gyawali and Dr. David Molden, former Director General of ICIMOD for their shared vision that led to materialize this project. Dr. Chiranjibi Bhattarai, Dr. Mina Adhikari, Ms. Bhumika Thapa and the team of professionals from NWCF played crucial role to carry out the research and developing the draft report during the challenging time of COVID19 restrictions. The team of experts from ICIMOD including Dr. Sanjeev Bhuchar and Mr. Madhav Dhakal contributed greatly to finalize the draft into this present form.

As the study findings have clearly identified the linkages between causes and consequences, concerned communities, technical and elected officials may immediately use the information for planning mitigative and adaptive measures as appropriate. Nevertheless, further studies specific to the local contexts are imperative for executing the plans for which NWCF team would be available to offer necessary support.

**Ngamindra Dahal, Ph.D.**

Chairperson: NWCF

December 2021



## Executive summary

Spring water is used by communities living in the hills of Nepal for domestic use (drinking, washing, cleaning), irrigation, and other non-consumptive use (cultural value, ecosystem, river base flow). Springs also contribute to river base flow but the exact extent of this contribution is not known due to limited scientific studies in the mid-hills of Nepal. However, springs are disappearing, completely dried up in some villages while in many with discharge reduced. Perennial springs have become seasonal and seasonal are drying up.

The major issues contributing to springs drying up are mal-development practice, changing water use pattern, hill migrant influx in emergent towns and cities after the federalisation increasing water stress, limited know-how of the hydrogeology of springs, aquifers and recharge zones, as well as fluctuating weather anomalies and natural hazards.

Haphazard road construction without conducting proper engineering or environmental study has disturbed the ecology of the springshed area causing reduction in spring discharge, displacement and/or drying up. There is also a lack of understanding on the social, governance and ecological aspects of springshed management because most of the work is at the watershed level and some sporadic work at springs level.

Excessive extraction of groundwater in the valleys or excessive pumping from piedmont springs by burgeoning municipalities in the plains (as well as the tanker water supply industry in Kathmandu) with road access led to decline of groundwater level within the water tower, which might be another reason for declining water in the springs of the upper reaches. Deep boring-based lift water supply systems are among the major causes of reducing the groundwater table. Further, rampant use of such technologies may also have impacts on the groundwater table and possibility of premature failure of wells, due to over-abstraction.

Spring protection initiatives, though limited in scope, are critical for reviving and conserving springs in mountainous regions of the HKH. However, spring management is limited to either individual spring protection or protection at village ward levels. While watershed protection has been initiated in many places, with much more comprehensive efforts still left to be done, spring protection for managing and protecting springs is the next step necessary to be taken in spring revival and conservation, as springshed often overlap multiple watersheds.

Steps can be taken to fill in this knowledge gap including the developing a comprehensive mapping of springs, aquifers and recharge zones; translating policies into local strategies to promote effective management of springs as well as to building knowledge about underlying hydrogeology and meteorology integrating traditional knowledge; promoting community-led efforts on spring management approach and spring rejuvenation programmes based on a comprehensive campaign by national government to protect, conserve and restore springs across the country.



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# 1. INTRODUCTION

Water security is critical for sustaining the livelihood and wellbeing of around 240 million people of the Hindu-Kush Himalaya (HKH) region living in river basins of Afghanistan, Bangladesh, India, Nepal, Bhutan, China, Pakistan and Myanmar (ICIMOD, 2020). Communities use around 1597.8 km<sup>3</sup> (20.62%) of the total (7745.5km<sup>3</sup>) renewable water available at present (Scott et al., 2019). Apart from water availability; limited investment on water infrastructure, traditional ways of accessing water, topographic variability (mountain-hills-plains) preventing easy access to the available water and issues of water governance contribute to water scarcity in this region (Molden, 2020; Scott et al., 2019). Climate change, rapid population growth and water scarcity during the dry season coupled with inequitable access and increasing use of water would further escalate the water scarcity, making the communities more vulnerable to water security (Wester et al., 2019). Spring protection efforts are underway for addressing the challenges of water scarcity although these small-scale efforts pale in comparison with the size of the problem (Nepal et al., 2019; Scott et al., 2019; Singh et al., 2020). Though limited in scope, such efforts are critical for reviving and conserving springs which are the primary sources of water in mountainous regions of the HKH. This is especially critical for achieving SDG 6 that vows to '*ensure access to water and sanitation for all*'. The COVID-19 pandemic has also reinforced the critical importance of access to clean water and sanitation (ICIMOD 2020)

However, spring management is limited to either individual spring protection or multiple spring protection at village ward levels. While watershed protection has been initiated in many places, with much more comprehensive efforts still left to be done, the springshed<sup>1</sup> management approach is the next step necessary to be taken in spring revival and conservation.

A comprehensive account of the existing state of knowledge and practices regarding the status of springs and their management is an urgent task that is needed to advance further the hydro-geologically more challenging task of spring protection.

## 1.1. Springs in Nepal: Synopsis of the problem

Since ancient times till today, mountain communities have relied on spring water to meet most of their basic needs in the hills of Nepal (Mahamuni & Kulkarni, 2012). Springs are the primary source of water for domestic use, livestock care, agricultural, environmental uses and cultural value for the local communities (Molden, 2020; Poudel et al., 2020; Sharma et al., 2016; Upadhyaya, 2009a) Many piped water supply systems in Nepal are fed by springs, for instance, 17 out of the 18 piped gravity water supply systems in Chargare are linked to springs and the remaining one is supplied by river/stream diversion (Lamichhane et al., 2020). Springs are also major sources of non-snow-fed Rivers for maintaining base flows; which contribute to water supply for the communities and environment during the lean season.

1 A springshed is the area of land that contributes groundwater to a spring and springshed management is a term used to describe the process of planning, implementing and monitoring land and water use practices to protect and improve the quantity and quality of the spring water within a springshed by managing the use of land, surface water and groundwater resources in a comprehensive and inclusive manner.

However, local communities living in the hills often struggle to get enough water for consumptive use - drinking water, sanitation as they face the challenge to access water from rivers. Springs are the only easily accessible source of water for them. Unlike the hill communities, people living in plains and intra-mountain valleys such as Kathmandu can access water available in the form of surface water particularly rivers (Chinnasamy & Prathapar, 2016; Gurung et al., 2019) and groundwater which occurs in natural hydrogeological settings (Nepal et al., 2019). But in the Himalayas and hills, the towns and villages are located at the slope or top of the hills while river water flows in the valley. So, people have to work against gravity to get the river water. They rely on springs as the only option to collect water instead of going to rivers down streams (Molden, 2020). Consequently, they suffer from water scarcity despite a large volume of available water.

Springs-the only accessible source of water to hill communities are at the verge of drying up soon while some of them have already disappeared in the hills of Nepal (Poudel et al., 2020; Rijal, 2016; Singh et al., 2020). Springs drying up are a major cause behind water scarcity in the hills of Nepal (Gyawali et al., 2019). Several factors could be contributing to their disappearance: earthquakes; poorly examined development activities such as local construction by bulldozer drivers; encroachment and vegetation denudation of spring source areas; seasonality and variabilities in weather/climate with erratic rainfall pattern and decline of animal husbandry and concomitant disappearance of buffalo wallowing ponds, many of which have been filled over and developed for other purposes such as schools, bus parks, playgrounds etc. Recently, a survey conducted throughout Nepal covering 300 local governments concluded that more than 74% of local governments had incidences of dried-up springs within their areas. Dried out springs are pervasive from east to west and south to north of Nepal that affects Chure hills in the south of Nepal to the mid-hills, and the high mountains<sup>2</sup>.

This "slow cancer" also constrains the Government of Nepal to achieve the Water, Sanitation and Hygiene (WASH) related national targets under the Sustainable Development Goal (SDG 6). Consequently, villages were displaced due to water scarcity from dried up springs in various parts of Nepal. Such villages include Ram Prasad Rai Rural Municipality (RM) of Bhojpur, Shahid Bhumi RM and Mahalaxmi Municipality of Dhankuta, Dalome RM of Mustang, Manungkot of Vyas Municipality, Tanahu and Chhatreshwori RM of Salyan (Thapa et al., 2020b). People living in various parts of Nepal lack access to safe and clean drinking water and sanitation through access to safe and clean water is a basic right stipulated in the present constitution of Nepal (Government of Nepal, 2015, Constitution of Nepal, Art.35.4). The official figures for actual access to safe and reliable drinking water are questionable (Pokhrel, 2016).

There are also apparently water access and water quality issues. Disparities in access to water resources among different social groups by wealth, caste, etc. persists. Even though traditional caste-ethnic based discriminatory practices preventing the Dalits or so-called low caste people are considered non-existent Dalits and under privileged households are unable to exercise prior-use water rights due to their inability to mobilise social, political and economic resource and rights to access water (Shrestha, et al., 2020).

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2 Preliminary findings from "Survey of springs in the hills of Nepal" conducted with 300 municipal government representatives by NWCF-ICIMOD, 2020

Management of springs is confined to either single source protection or watershed conservation. Many water conservation programmes are built around the watershed “ridge-valley” concept that is supported by the Department of Soil and Water Conservation, Ministry of Forest (Tiwari et al., 2008). But it does not account for groundwater, which travels from one watershed to another through rock beds that dip towards an adjoining watershed. Further, there is little investment in infrastructure for spring management (Molden, 2020; Poudel et al., 2020). Communities still use traditional water systems, such as dug wells, tanks and ponds, and stone spouts to fetch spring water (Adhikari et al., 2020; Gurung et al., 2019). Thus, local communities pay attention to single or multiple source protection rather than considering watershed. There is a dire need to promote comprehensive spring protection efforts.

It is essential to have national policies, acts and programmes to enable springshed management in Nepal to curb malpractices which are adversely impacting springs and to provide incentives for springshed management. There is no or insufficient emphasis on springs and springshed management in the policy documents, or for that matter, the connection between springs and groundwater, or springs and river flows. The existing sub-watershed management planning guideline developed by the Department of Soil Conservation and Watershed Management (DOSCW, 2016) also does not include springshed management as part of the sub-watershed management planning process. These gaps in practice and policy limit concerted national response to springshed management in Nepal.

## **1.2. Purpose and objectives**

The purpose of this report is to record the empirical and practice-based knowledge of springs in Nepal. The specific objectives are to:

- Identify gaps in research, practice and policy for applying spring protection in Nepal
- Provide recommendations for mainstreaming spring revival in Nepal at various levels of policy-making from village administration to national agencies.

## **2. METHODOLOGY**

The report adopts a pragmatic approach to generate the existing knowledge base on springs in Nepal. Desk review and consultation with stakeholders were the primary sources of information to investigate the knowledge base on springs in Nepal.

### **2.1. Desk Review**

At first, a review of the literature was conducted to figure out the literature including peer-reviewed articles, working papers and grey literature on springs. An inventory of the literature was made and reviewed thoroughly to extract the information available. Along with the thorough review of available literature, a consultation with selected stakeholders was conducted to identify the information related

to the current spring protection practices and policies. A total of 50 articles were identified from Google scholar and webpage of different institutions about spring studies in Nepal. A thorough analysis of the selected literature was carried out to extract the available information about spring research in Nepal.

## **2.2. Consultation with stakeholders**

For conducting a stakeholder consultation via telephone and social media e.g. zoom meeting; a list of potential stakeholders engaged in spring protection including the local government representatives was prepared (see Annex A). Further, discussions were held with experts working at ICIMOD and other institutions on springs to explore information and validate the existing knowledge base. A survey conducted with local government officials throughout Nepal has also informed the report in addition to a policy scanning.

## **2.3. Survey of springs**

NWCF conducted a survey of springs to identify critical areas and affected communities due to declining spring sources. Using a synoptic approach of perception survey from the key informants, this study aims to contribute to building a broader knowledge base of the spring sources essential for policy planning and programmes. Of the 753 local level units in Nepal, this study covered 300 municipalities located in the hilly regions of Nepal. Based on the literature, Churia range lies below 1220 masl. Hence, the districts which fall under the Churia range were clipped by the elevation below 1220 m in ArcGIS. Of the 753 local level units in Nepal, 475 units (which comprise 63% of the total) lie in the Churia to the mountainous region. Municipal heads either elected or Chief Executive Officers were interviewed with semi-structured survey questionnaires focusing on the issues surrounding the spring sources. Altogether 306 municipal officials from 59 hill and mountain districts were interviewed between July to September 2020<sup>3</sup> (See Annex for list of municipalities surveyed and questionnaire).

## **2.4. Scope and limitation of the study**

Knowledge of Himalayan springs is limited due to the blind spot that continues to see springs just out there, eternal and inexhaustible. The defect is compounded by lack of mapping of spring sources, inadequate investigations of their nature (permanent or seasonal, copious or trickling, affected by earthquakes, road building etc or not etc.). There is also a lack of synthesis of existing information published in media reports and grey literature.

Literature focusing on issues of spring inclusive spring management and localised innovations to spring source management are negligible and scattered.

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3 Survey of springs report. NWCF-ICIMOD, 2020.

### 3. FINDINGS: STATUS OF SPRING

This study revealed that springs are a lifeline of communities in the hills of Nepal. Local communities relied on water available from springs for domestic use (drinking, washing, cleaning), irrigation, and other non-consumptive use (cultural value, ecosystem, river base flow). Springs also contributed to river base flow, but the exact extent of this contribution is not known due to limited scientific studies in the mid-hills of Nepal.

Some efforts to protect and manage springs are underway, but these efforts are scattered and do not provide a comprehensive knowledge of springs in Nepal: i) the extent of contribution of spring, ii) hydrogeology of springs and aquifer system, iii) spring source (aquifer) distribution and inventory, iv) spring protection efforts, v) direct and indirect factors contributing to drying up of springs and decreasing spring water quality. These issues are discussed in the next sections.

#### 3.1. Springs are the lifeline of mountain communities

Springs are the major source of water for various purposes in Nepal. Communities depend on consumptive and non-consumptive use of spring water in the middle hills of Nepal (Adhikari et al., 2020; Poudel et al., 2020; Sharma et al., 2016). Consumptive use of spring water includes drinking water, water for cooking and cleaning, water for feeding livestock, health and sanitation. While non-consumptive use extends to irrigation, livestock care, recharge ponds etc. For example, Thapa et al. (2020a) mapped 102 springs in Jhimruk River Watershed in Arghakhanchi, and found that 20% of the springs were used for drinking water, while 8%, 5% and 2% of them were used for washing and cleaning clothes, livestock feeding and irrigation. They claimed that a majority (52%) of the springs were used for multiple purposes whereas 14% of the springs were not used at all. Chapagain et al., (2017) in their survey of 305 springs, in Indrawati Watershed, Melamchi Region, confirmed 264 (87%) were utilized for multiple purposes including drinking, livestock feeding, and cleaning. Similarly, Poudel and Duex (2017) surveyed 41 springs in ThuliKhola Watershed, Nuwakot district, and confirmed that 78.1% of the springs surveyed were used for drinking water while the rest were used for irrigation and other purposes, such as fish ponds.

Aside from spring water use, springs also contribute to the base flow of rivers. Recent studies indicate the volume of annual yields close to 30 billion cubic meters per annum for the dry lean period only (Pokharel & Gyawali, 2021). However, the total contribution of spring water to the base flow is still unknown.

Springs not only provide communities with water but also anchor the entire ecological system. Springs offer habitat for aquatic invertebrate communities which act as ecotones at the groundwater to surface water and the aquatic to terrestrial interfaces (Reiss & Chiffard, 2017). Despite the significance of springs for human and ecosystem, there is negligible effort to understand the hydrogeology of springs and aquifers, distribution of aquifers and socio-economic and aesthetic values of springs. Some of these issues are discussed in greater detail in the following sections.

## 3.2. Hydrogeology, classification and distribution of springs

### 3.2.1. Hydrogeology of springs

Springs are a manifestation of water available on the earth subsurface which replenishes through precipitation (Matheswaran et al., 2019; Sharma et al., 2016; Upadhya, 2009a). Understanding the hydrological cycle is critical to understand subsurface water and springs. Hydrological cycle or water cycle contributes to the water availability on the subsurface of the earth.

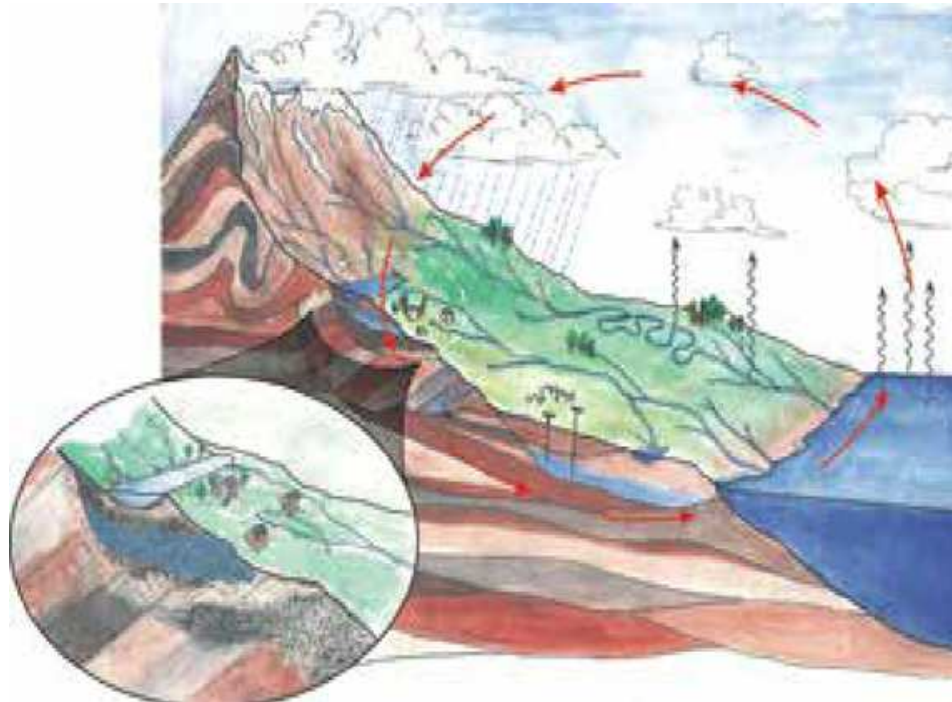


Figure 1 Hydrological cycle (Shrestha et al., 2018)

Figure 1 depicts the hydrological cycle and its contribution in spring recharge. The water in the form of rain, snow, surface water available in the atmosphere, gets infiltrated into the soil and thus percolates to the aquifer. Water available on the earth surface including soil moisture evaporates to the atmosphere. Plants and vegetation cover also transpire water to the atmosphere. Some amount of water from the earth surface and vegetation returns to the atmosphere in the form of precipitation. The cyclic process of shifting water from earth to atmosphere and then to earth contributes to the recharge of natural aquifers through infiltration. The discharge of groundwater stored in natural aquifers through fissures, fractures, foliation and rock cracks on the earthquake surface is attributed as spring (Poudel & Duex, 2017).

Several factors such as erratic rainfall, late snowfall, infrastructure construction on the discharge pathway, increase in impervious surface, might affect the process of the hydrological cycle and water discharge as springs (Chinnasamy & Prathapar, 2016; ICIMOD, 2015). However, the science behind the spring and aquifer hydrogeology that governs the occurrence and movement of water in

underground aquifers and springs is yet to be correctly understood in the hills of Nepal (Shrestha et al., 2018). There is an urgent need to understand the hydrogeology and aquifer system and potential natural recharge areas of springs for sustainable availability of water in the hills of Nepal.

### **3.2.2. Classification of springs**

Different authors have attempted to classify springs in various ways. Springs have been classified according to their different characteristics like geology, flow rates and discharge, etc.

#### **3.2.2.1. Flow-based classification**

Sharma et al. (2016) provided a classification of springs based on amount discharge from the springs. In their study conducted in Kavrepalanchok District, Nepal, they measured different flows and then later categorised that measurement of flows into five classes.

- i. **Survival minimum flow:** A spring discharge that yields up to 1 litre of water per day per person. This water is sufficient for bare survival, for drinking only, and represents an extremely water-stressed situation.
- ii. **Household low flow:** A spring discharge that yields up to 20 litres of water per day per household or a little more than 3 litres per person. This is the minimum quantity required for basic use; it is sufficient for drinking and some restricted cooking, but not for cleaning, washing, or sanitation, and represents the high water-stressed situation.
- iii. **Rural low flow with cattle:** A spring discharge that yields up to 100 litres of water per day per household. This is sufficient for drinking and cooking and to cover the needs of a cow or a pair of goats, with a limited amount available for washing, cleaning, and sanitation. It represents a water-stressed situation.
- iv. **Rural average flow:** A spring discharge that yields up to 40 litres of water per day per person. Water is sufficient for drinking, cooking, cleaning, washing, and sanitation, with some available for cattle and a small kitchen garden, and represents water restricted households.
- v. **Rural high flow:** A spring discharge that yields a total flow higher than the rural average requirement of 40 litres of water per day per person. Water is sufficient for all household uses including cattle and some irrigation; there is no water stress for a typical rural household. (Sharma et al., 2016, p. 10)

#### **3.2.2.2. Classification based on seasonality and nature of the discharge**

Sharma et al. (2016) used the concept of “water tower” as in Upadhya (2009a) to illustrate the availability of water at different portions of the hill slopes and their linkage to water availability

for classifying springs (Figure 2). They classified springs based on the seasonal variation on water availability and discharge into seasonal and perennial.

- i. **Perennial springs:** Springs that have regular discharge through the year even though the amount of discharge may vary in monsoon and dry season.
- ii. **Seasonal springs:** Springs that emerge during monsoon with variable discharge and disappear during the dry season.

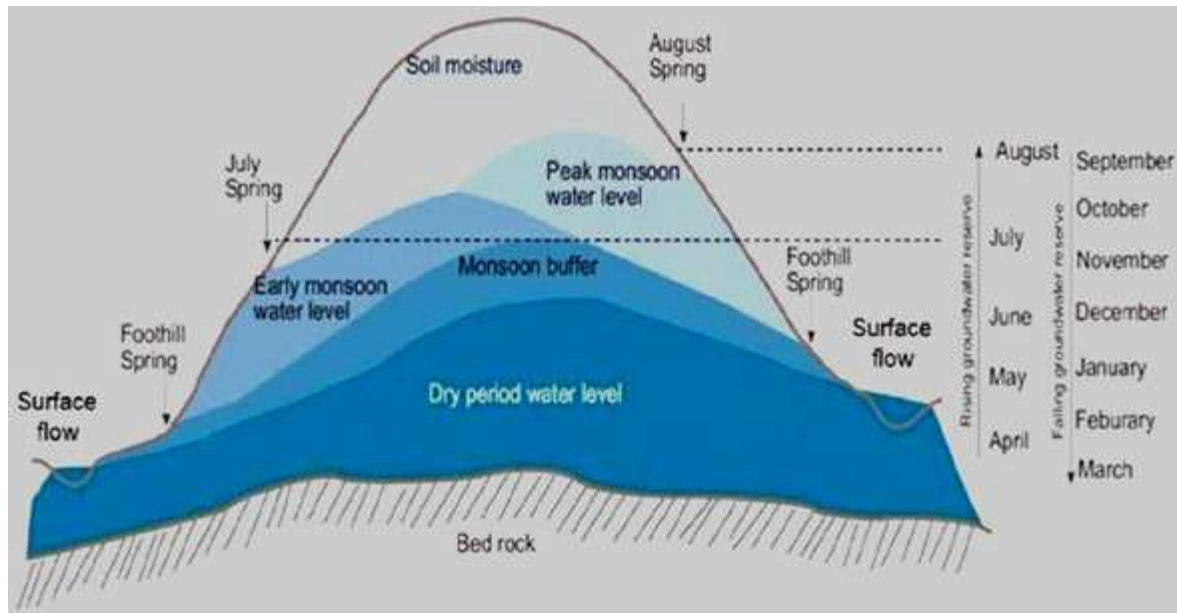


Figure 2 Water tower adopted from Sharma et al. (2016)

### 3.2.2.3. Classification of springs based on the purpose of use

Sharma et al. (2016) further classified springs or term '*mool*' in Nepali; into different forms based on purpose the springs into *dharo*, *kuwa*, well and *tyanki* as following:

- i. **Dharo (or dhara):** '*Dharo*' are free-flowing springs that emerge directly from the ground. In the past, water was usually conducted from the spring to a stone spout using a pipe made from cut bamboo; nowadays, polythene pipe is preferred.



Figure 3 Dara (Polythene pipe conducting

- ii. **Kuwa:** A ‘*Kuwa*’ is a shallow pit dug to collect water that doesn’t flow freely but seeps slowly out of the ground. When water is scooped out from the *Kuwa*, the water level drops and then slowly rises again. Kuwas are generally low yielding spring sources. Depending on the discharge, the water may deplete very quickly and rise again only slowly. Kuwas range from simple unlined holes in the ground, sometimes under an overhang, to elaborate structures lined with stones and enclosed by stone or brick structures. Enclosing keeps the source clean and reduces evaporation.



Figure 4 Kuwa (Collecting water from a kuwa enclosed by stone)

- iii. **Inar or well:** When the volume of water in a *Kuwa* goes down, people tend first to widen the pond and then to dig a deeper well called an ‘*Inar*’, which they line with concrete rings for collecting the spring water and stability.



Figure 5 Inar or well (Figure: A covered inar)

- iv. **Tyanki:** In some places, tanks (‘*Tyanki*’ in Nepali) are built instead of wells to serve a similar purpose to an *Inar*. (Sharma et al., 2016, p.3)

Figure 6 Tyanki (Tyanki at Thulo Dhara used for collecting and disbursing water from a spring)



#### 3.2.2.4. Classification based on geology

Chinnasamy and Prathapar (2016) adopted spring classification given by Fetter (1994) based on the nature of biology that groups springs into depression, contact, joint, fault, fracture and sinkhole springs. The classification is illustrated as following:

- i. **Depression springs:** Undulating topography intersects the water table to form depression springs.
- ii. **Contact springs:** When permeable rocks or sediments overlie less permeable units, infiltrated water flows laterally (due to higher hydraulic conductivity) rather than vertically due to gravity. Thus, preferential flow paths created at the contact of different geologic units with rocks of higher hydraulic conductivity are underlain by impermeable rocks. Water flowing through these flow paths emerges at the surface to form contact springs.
- iii. **Joint springs:** Many joints with high hydraulic conductivity may be present in low permeability rocks. When water flows in these joints, joint springs are formed.
- iv. **Fault springs:** When faults have higher hydraulic conductivity than the material in which they are embedded due to stress, movement or weathering, the faults can act as a regional boundary for groundwater movement and provide a preferential flow path for water. When water moves along the fault lines and discharges at the surface, fault springs are formed.
- v. **Fracture springs** – Because fractures have a higher hydraulic conductivity than adjoining rocks, water preferentially flows in these fractures, thus forming fractured springs.
- vi. **Sinkhole or Karst springs:** Limestones can have large conduits, cavities and channels created by the dissolution of limestone by flowing water (termed karst), which act as preferential flow paths for groundwater. When the water in these flow paths is under artesian pressure or cuts the slope, karst springs are formed. (Chinnasamy and Prathapar (2016)

Among different types of springs, depression springs are common in Himalaya where undulating topography intersects the water table to form depression springs (Chinnasamy & Prathapar, 2016; Upadhyay, 2009a). However, spring types may vary according to the geomorphologic conditions of the hills of Nepal. For instance, in Thuli Khola watershed, Nuwakot, contact springs were the most consistent, and productive, whereas the foliation or fracture springs had the smallest volume and depression springs showed the greatest variation in output (Poudel & Duex, 2017). Therefore, considering an extensive mapping of aquifers and springs of Nepal is vital to understand the nature and types of springs and their contribution to water security.

#### 3.2.3. Distribution of springs in Nepal

The analysis of the literature revealed that springs are distributed sporadically in remote locations. Distribution of springs varied by elevation, slope gradient and facing, and land cover types. Ghimire et al. (2019) found that the gentle slope class, low relative relief, high flow accumulation, north- and

east-facing slopes, denser lineament density, the altitude of 1500–2500 m, high vegetation density and forest demonstrated a higher likelihood of spring occurrences. Chapagain et al. (2017) found that spring density is higher in lower altitudes. They highlighted that more than two-thirds of the springs were in the mid-elevation (1500–2500 m) with moderate to steep slopes in the Melamchi region. Thapa et al. (2020a) also found that the 70% springs were situated in lower elevations of Bhumikasthan Municipality than the higher elevations of Malarani Rural Municipality of Arghakhanchi District.

The distribution of springs was also varied by land-use type. A large proportion of springs were located in forest areas followed by grassland, farmland and barren land (Chapagain et al., 2017). For example, Chapagain et al. (2017) in their study confirmed that 47% springs were located on forest land followed by 24% on bush/grassland; about 13% on agricultural land, and 4% on barren land in Melamchi Region. Similarly, Poudel and Duex (2017) also claimed that springs were located in the forest (53.6%), cropland (34.1%), and brush (12.3%) in ThuliKhola Watershed Nuwakot.

These studies provide a narrow and scattered view of the distribution of spring. So, the results cannot be generalised. These studies capture snapshots of site-specific detail on spring distribution. There is an urgent need to further investigate the distribution of springs Or a systematic mapping of springs which includes hydro-met, morphological, land use and demographic details and the factors influencing the distribution of springs in Nepal.

### **3.3. Spring protection efforts in Nepal**

Springs are integral for survival and livelihoods of hill populations in Nepal. As discussed above, there is limited information about spring management, nature and types of springs, distribution and their contribution to populations and ecosystems. These gaps arise partly from limited scientific knowledge about the nature of springs and spring water management. While limited policies and regulatory mechanisms for comprehensive management of spring sources including inclusive water access and utility also add complexity to better understanding spring management.

#### **3.3.1. Policy provisions and institutions on spring revival**

In this section, a quick scanning of the policy documents has been conducted searching provisions and statements that can be connected and utilized for spring revival programs in Nepal. In this regard, the constitution, some sectoral laws and policies have been captured.

The Constitution of Nepal enunciates fundamental rights to food security and sovereignty, health, drinking water and sanitation (Government of Nepal, 2015). In line with the Constitution, the state policies provide a framework to implement the right to access water, sanitation and health facilities, employment and dignified life to Nepali citizens. The Local Government Operation Act, 2017 is considered as a tool to implement the constitutional mandate, among others, for the formulation of environment protection and biodiversity-related policies, laws, standards and plans and implementation, monitoring and regulation (GoN, 2017, Section 11.2.j.12). Moreover, there are

sectoral legislations mainly the Water Resources Act, Environment Protection Act, Soil and Watershed Conservation Act, Forest Act and Land Use Act with direct as well as cross-cutting bearing with springs that can be utilized for the revival. Additionally, the Drinking Water and Sanitation Bill and Water Resources Bill are under consideration at the federal parliament which are directly linked to spring revival and management.

The policies like Water Resources Policy, National Wetlands Policy, National Forest Policy, Land Use Policy also cover sectoral conservation policies related to spring management that can contribute and support to spring revival programs if these policy statements are translated to practice.

All of these policies and statutory frameworks provide a basis for managing springs to the federal, provincial and local government of Nepal. The federal system has delegated powers and responsibilities to the local governments to provide basic drinking water and sanitation whereas health and services like drinking water and irrigation, forest, water use, environment, ecology and biodiversity are placed under the concurrent jurisdiction.

The federal government and provincial governments are responsible for carrying out larger-scale projects including water, watershed conservation, sanitation, and pollution prevention.

The local governments have the responsibility to make necessary arrangements for drinking water and sanitation facilities and manage and maintain those systems and services. They can also prescribe fees on such provisions, and formulate plans for spring conservation including wells, stone spouts, streams, rivers, forests, parks and open spaces.

The constitutional jurisdiction unbundling document has listed out the jurisdictions of three tiers of the state. It has assigned the responsibility of rural water resource management, small water resource structure reconstruction rehabilitation, maintenance and management to the local level. Likewise, the federal government is made responsible for land and watershed conservation and management, climate change and environment related policy, strategy, law and standard making, and conduct study, research, survey, demarcation and manage national databases. The provincial level is made responsible for land and watershed conservation, climate change mitigation and adaptation programs, and the local level is responsible for land and watershed conservation (The standard relating to classification and distribution of development programs and projects between the federal, provincial local level, 2076 BS).

Institutionally, the federal ministry of forest and environment is the responsible institution to look after the soil and watershed conservation, and a watershed and landslide management division under the forest and soil conservation department created. Under the division, six sections relevant to spring conservation are set up i.e., planning and information system section; critical watershed management section; wetlands conservation section; landslide management section; conservation technology development section; land use development and disaster mitigation section.

Similarly, for the water resources management at the federal level, two relevant departments i.e., department of water resources and irrigation, and department of hydrology and meteorology are provisioned under the ministry of energy, water resources and irrigation in addition to the water and energy commission secretariat (WECS), and water resource research and development centre. The department of water resources and irrigation consists of among others, watershed management and technology development section, geology research sector, and groundwater section. These federal level agencies have orientations in policy as well as technology development than of practice in the field. For instance, WECS helps GoN in law and policy making in water and energy sectors.

At the provincial level, the ministry of industry, tourism, forest and environment is responsible for the management of water sources and watersheds.

Moreover, the ward committees under the local governments are responsible to formulate local government's plans and policies about the protection and conservation of natural resources including the springs (Government of Nepal, 2017).

In line with the provisions, Suryodaya Municipality has enacted a law on drinking water management making the Municipality responsible for the conservation and protection of natural water sources, prohibiting drinking water pollution and conducting research on drinking water sources and sanitation (Section 8, Drinking Water Management Act of Suryodaya Municipality Act, 2020). Moreover, a notable fine punishment (NRs. 25,000) is provisioned against the offense of polluting drinking water sources and causing adverse impact to human health (Section 16).

Other local governments have also come forward proactively with spring revival programs with 'One Ward One Pond' programs and some with special programs and campaigns. For instance, Chaurpati RM, Accham has introduced a 'pond construction campaign' and conducts the campaign every year by calling people for voluntary labor contribution. Through this, a huge number of recharge ponds have been constructed there. Namo Buddha Municipality, Kavrepalanchowk has also introduced a pond construction program, and Suryodaya Municipality has included spring conservation programs under the "Drinking Water" heading of the major policies of town development plan where seven out of the 13 points deal with the spring conservation and protection. Conservation of springs by plantation, rainwater harvesting, construction of recharge ponds, and prohibition of pesticides and chemical fertilizers in and around the spring sources are the major provisions (Suryodaya Municipality Act, 2020, p.14).

Despite the exemplary efforts of local governments, a transition is still on in terms of policy implementation under the federal system along with the devolution of the state powers to the lowest unit. There are jurisdiction overlaps and uncertainties in relation to the responsibilities of various levels of the governments. There is a clearer disconnect between the policies and practice. Moreover, the policies indicate that either watershed or spring source protection and conservation are captured whereas springshed management is not envisioned.

### **3.3.2. Spring protection practices**

#### **3.3.2.1. Traditional approach to spring source protection**

In the Nepali society, cultural practices of conservation and protection of springs were very unique. Communities use religious values for protecting spring sources as pristine by relating to ‘Nag Dev’. They foster the value that if anyone pollutes spring sources ‘Nag Dev’ will punish them and teach their generation to conserve the spring sources. Communities also build the temple of powerful god/goddess in and around some spring sources so that people automatically obey the rule to conserve springs based on the religious belief that they would be cursed by the god. Cultural beliefs to protect springs have contributed to some extent to protect springs.

For example, Chhabis Pathibhara Rural Municipality (RM), Bajhang decided to conserve the water sources upholding traditional but religious practices and built a temple near the spring sources. After construction of the temple, the local people have started worshipping here, stopped grazing livestock around the sources, and the deforestation has gone down drastically. It protected the spring sources which were the only source for drinking water. The RM also found that the women and children were responsible mostly to collect firewood and fodder from the forests and would cut trees haphazardly as they did not know the importance of trees and forests. The RM realized the need to raise awareness among women and children for forests and water sources protection and conservation (*A. Dhami, personal communication, August 27, 2020*). But this approach focuses on a single source of spring protection. Besides the cultural approach to spring protection, there were efforts from the government to protect the springs.

#### **3.3.2.2. Government-led efforts to protect springs**

Since the 1970s, the Ministry of Forest and Soil Conservation promoted the agenda of conserving soil and water (springs) based on watershed (ridge to valley) approach and have attempted to manage watersheds jointly with local communities in different parts of Nepal (Tiwari et al., 2008). Watershed management approach has failed to consider the local and regional aquifers systems which are critical for spring management. However, some of the initiatives have increased the recharge of groundwater by increasing percolation, infiltration through soil and vegetation by controlling the disturbance in watersheds and protecting spring sources (Tiwari et al., 2008).

Another government-led initiative for conserving water and springs is the promotion of community forestry. Community forest user groups located in different parts of Nepal may have significantly contributed to protecting spring sources and aquifer recharge through community management. But their actual contribution for spring conservation is yet to be studied.

Recently few local governments have initiated some spring protection efforts. Some examples of the initiatives taken by the local government are presented.

**a. Identification of dry zone and promotion of pond construction in Suryodaya Municipality, Ilam**

Suryodaya Municipality of Ilam formulated plans and policies on water source protection and conservation that prevent the use of heavy equipment in construction works around the spring sources. Based on a study carried out at various springs, the Municipality declared some areas as “dry zones” where springs had dried up and introduced a one ward -one pond program/scheme. The Municipality also brought forth a scheme of providing support to construct ponds especially for fish farming, and a birthday plantation scheme that offers plant saplings as a birthday gift to the people on their birthday to encourage people to plant more and more trees in their locality. Additionally, the use of pesticides and deforestation in and around 50 meters of spring area are prohibited (*D.D. Bhattarai, personal communication, July 31, 2020*).

**b. Recharge Pond construction in Chaurpati RM, Achham**

In Chaurpati RM, Achham communities experienced drying up springs in the past and concluded that it was due to natural and artificial reasons such as road construction. In response, the RM decided to help save nature by making ponds for water recharge as well as minimize water shortage in the area and has been successful to construct around 2000 medium and small size ponds until now. Citizen scientists found that the structures built as recharge ponds have been successful to sustain the spring discharge now which used to dry up previously. As the community forests and public lands where the ancestors would graze animals have become barren and the rainwater is not accumulated, the RM has a plan to make land storage facilities and afforestation by making sure that the water from rain and ponds reaches up to the roots of the trees. Moreover, the RM has given the top priority to spring revival policy (*H.B. Saud, personal communication, August 30, 2020*).

**c. Recharge Kathmandu, Kathmandu Municipality**

Considering the depleting groundwater table of Kathmandu valley resulting from over-extraction of groundwater beyond the replenishing capacity, the Kathmandu Metropolitan City recently launched a scheme called “Recharge Kathmandu” (Ojha, 2020). The scheme focused on rainwater harvesting for groundwater recharge. Rainwater harvesting systems are being installed in government offices and then in the houses of government officials as piloting before scaling up to the general public (The Himalayan Times, 2019).

**d. Biodiversity conservation legislation enforced in Lumbini, Karnali and Sudurpaschim province for promoting spring protection.**

In Lumbini, Karnali and Sudurpaschim provinces, altogether 35 local governments of eight districts have already enacted and enforced the aquatic animal and biodiversity conservation legislation that covers spring conservation provisions. At first, this initiative was piloted in Chamunda Bindrasaini Municipality, Turmakand RM, Thantikand RM, Aathbish Municipality of Dailekh District and then extended to the other municipalities.

Likewise, environment-friendly rural roads construction guidelines have been adopted by various local governments in various parts of the three provinces. A section on management of planning and construction of environment friendly road construction guidelines requires that road construction should be carried out without damaging water sources, springs, streams, houses, other private or public structures. It also emphasises management of natural resources of water by identifying spring water sources before constructing roads in order to avoid adverse effects on it (Aathbis Municipality, 2019). The common provisions in all the local government's guidelines are that road construction should be started only after detailed study and extensive analysis on the positive and negative aspects of road construction on water sources, settlements, forests, places of historical and archeological importance. Provisions such as mandatory awareness program to users on environment-friendly road construction prior to construction, and the final payment shall be made only after ensuring that the road construction was environmentally friendly that is certified from independent evaluations (Aathbis Municipality, 2019). These policy initiatives were backed by the technical support of the USAID Paani Project (*N. Belbase, personal communication, November 14, 2020*).

While assessing the innovative efforts to conserve nature including water resources, a general tendency is evident that the practices focus on water source protection rather have not reached to the springshed approach of water resource management.

### **3.3.2.3. Community-led initiatives for spring revival and conservation**

Community-led initiatives for spring revival and conservation can also be found in some parts of Nepal. These efforts are a collective effort between local government, local communities, NGO and international organisations to promote spring protection for reducing water scarcity in the hills of Nepal. Some cases are discussed here.

#### **a. Community effort to protect springs**

The local community group of Namobuddha Municipality of Kavre which has been working for the revival of dried-up springs. The group conducted a mapping exercise to identify the dried-up springs within the last 10 years and potentially drying up springs in future. From that, it was found that 40 springs of their locality had dried up and the remaining springs were also likely to dry up if left unprotected. In response, a pond (*Pani pokhari*) was built in the area for piloting, and the dried-up spring revived after a few years. They also had conservation, disaster management, climate change-related activities including the capacity building of local users (*N. Ghatane, personal communications, October 11, 2020*).

#### **b. Collective between Renewable World, NWCF and local communities**

NWCF in collaboration with Renewable World conducted a spring conservation and water harvesting project in Surkhet District. This project has been designed to tackle water scarcity for drinking, irrigation, and other productive end-uses through solar-powered water pumping systems. It aims to

improve the community's health and hygiene, improve livelihoods through agriculture training, and protection and conservation of community water sources. The project has a plan to install 10 Solar Multiple Use Water Systems in five local governments of Surkhet district. Out of 10 Solar Water Systems, five have been installed and are functioning while two are under construction.

NWCF conducted an online telephone survey with the local governments to get a snapshot of the spring protection efforts in the hills of Nepal. The survey revealed that spring mapping and profiling, water source registration, dry zone declaration, recharge pond construction, plantation, water use master plan development have been included in policies and annual programs of various local governments (NWCF-ICIMOD, 2020).

These efforts underway at various levels including the local government and communities are critical for spring protection. But these efforts do not provide a clear idea of whether they are using a springshed management approach or not.

### **3.4. Issues in spring protection**

Many of the springs have reduced flow while others have dried up in recent years though some of the spring protection efforts underway in Nepal (as discussed in section 3.3.). Some cases of springs drying up in different parts of Nepal are: ICIMOD (2015) carried out a study of spring revival in Kavre and found that around 15% of the 70 springs mapped in Tinipale (area 14 km<sup>2</sup>) and 30% of the 174 springs in Dapcha (25 km<sup>2</sup>) have dried up within the last decade. Further, Poudel and Duex (2017) confirmed that of the 41 springs mapped in Thulokhola, 73% of the spring used as water sources had an observed decreased flow while 12.2% had dried up over the past 10 years or so. Similarly, Thapa et al. (2020a) found 102 springs in Malarani and Bhumikasthan area of Arghakhanchi District, 1% of that were dried up, 94% with decreased water volume and 5% as usual in terms of discharge for the last 10 years. The recent article published by Adhikari et al. (2020) shows the discharge trends of springs in five watersheds (Rangun, Thuligad, Middle Karnali, Bogdan-Lagam Karnali, and Jhimruk) of western Nepal where, 70.07 % of springs were decreasing their discharge, 1.57% of springs were dried up, 1.82% of springs were increased their discharge and 26.54% of springs were as it is in their discharge rate.

The causes for a decrease in spring discharge are attributed to increase in groundwater pumping, erosion of the topsoil, erratic rainfall patterns, climate change trends (especially in rainfall and temperature), land use land cover change, forest fires, over-exploitation of water and ill-planned development practices, haphazard road construction and growing disparity over water access and use (Adhikari et al., 2020; Chapagain et al., 2017; Gurung et al., 2019; Leder et al., 2019; Sharma et al., 2016). There seems to be an increased propensity to buy spring-located properties. For instance, in Chargare Village Development Committee (now part of Bidur Municipality) in the Mid-hills of Nepal, there has been an increased trend in the springshed to buy land that contains springs and other water resources. Such transactions are taking place mainly between people from different wards – specifically the downstream villagers are purchasing land in the upstream water-abundant area (Lamichhane et al. 2020).

The studies discussed above provide a narrow overview of the drying of springs in Nepal, and since they cover findings to specific study sites, they are not generalizable. To bridge this knowledge gap, NWCF conducted a telephone survey of 300 local governments of Nepal to explore the status of springs. The preliminary findings of the survey revealed that the road and other infrastructure development (51%), earthquake (46%) 2015, climate change (45%), deforestation (32%), floods and landslides (30%) and others (24%) as the causes for drying up of springs sources. These preliminary findings substantiated the findings related to the causes of spring drying up identified in the literature above. Some of these drivers contributing to drying up of springs are discussed in the next sections.

### **3.4.1. Changing water use pattern and population growth**

Nepal's population grew from under 10 million in 1961 to more than 25 million in 2011 and is projected to grow for many years with growth rates significantly higher in urban populations than in rural populations (Regmi, 2014). The larger population will probably need more water for drinking and domestic use, and urban water insecurity for drinking and other uses is likely to become a major problem (Leder et al., 2019; Pandey & Bajracharya, 2017). Springs are major sources of water for domestic and other purposes in the hills of Nepal. However, the declining spring water is likely to create severe water stress among the urban populations (Nepal et al., 2019; Vaidya, 2015).

With the federalisation of state, several towns and settlements developing in and around the new and existing municipalities have attracted populations migrating from the villages to these towns and cities. Population influx has increased the water demand in these emergent towns with a similar amount of water supply. The population growth has an indirect effect on spring drying up. The increased population increased the water demand but the available water sources are limited in the places which creates pressure on the water tower. To meet water demand, people practice different unsustainable ways of water extraction which deplete the groundwater table and thus contribute to drying up of spring sources (Dhakal et al., 2020, December 10). While this is an increasing trend, there are also communities like in Kavre who are taking up improved practices such as rainwater and waste water harvesting, mulching, drip irrigation etc. which help in water demand management (Nhemhafuki & Shah, 2021). However, new technologies have changed the practice of water use patterns than they used to in the traditional ways in Nepali society. People used to collect water only they needed but nowadays water is pumped and stored in tanks. So, they can use it as they wish. ICIMOD in its study on springs confirms:

Water use patterns are changing as a result of the availability of new technologies such as pumps, polythene pipes and PVC or cement tanks. Previously, social conventions decreed that water standing overnight was stale 'Basi' and this discouraged collecting more than needed. However, at present, water is pumped into the ground or overhead tanks and used unquestioningly after being stored. Agricultural practices are also changing, with entrepreneurial farmers changing to commercial vegetable farming using polytunnels and plastic greenhouses in place of dryland crops such as maize and millet, which increases water use significantly. (ICIMOD, 2015, p.3)

Besides the changing use pattern, ownership of the water sources affects the water access and conservation. The private springs are mostly distributed in the agricultural land and areas closer to settlements. In contrast, the publicly-owned springs are mostly confined to the forest and barren land (Chapagain et al., 2017). The springs available in agricultural land and settlements are protected while public springs located in barren land are likely to be destroyed or damaged by activities such as trampling, road construction, and disasters (Upadhyaya, 2009b).

#### **3.4.2. Mal-development practices**

The mal-development practice is another primary driver contributing to spring damage and disrupting spring discharge in Nepal. Development activities like hydropower development, irrigation channel, road construction as well as the construction of the building are without proper study of underlying geology and available water resources. So, these mal-development practices might damage and destroy sources of springs. For instance, non-engineered road construction has destroyed water pipes and channels of springs in the Extended East Rapti Watershed of Nepal (Adhikari, 2020, Manuscript submitted to New Angles). Studies have shown that the human activities also disrupt and destroy springs in various ways:

Springs located in barren land are more vulnerable due to open access where there is a higher concentration of human activities, i.e., grazing, collection of non-timber forest products. Local people have claimed that the water volume of many springs has decreased after the construction of these roads in the villages. The open grazing and no efforts on spring conservation have also led to water volume decreasing. (Chapagain et al., 2017, p.13)

However, drying up of springs is highly influenced by our common practices and activities. Some human activities accelerate the drying up of springs and some activities may support to conserve water:

Although declining rainfall, especially during the winter season, has been reported recently, the overriding drivers for springs drying up are poor management and technical and socioeconomic factors. For example, buffaloes used to be kept by many households and were an important source of income. Ponds were maintained for the buffaloes to wallow in, which provided comfort for the animals and also increased milk yields. At the same time, the ponds retained water after the monsoon and helped increase groundwater recharge, thus helping to sustain the springs. As animal husbandry has declined, the need for such ponds has disappeared and many have been abandoned, silted up, or filled for other uses. The acute shortage of domestic water has only been felt relatively recently, and the role of the ponds in recharge was not appreciated. (ICIMOD, 2015, p.2)

Aside from these activities, development activities like hydropower development, irrigation channel, and road construction, as well as the construction of the building without proper study of underlying geology and available water resources, also impact springs. Such activities may disconnect the spring channel in the springs leading to the drying and shifting of spring sources. This is especially true of

activities like small and medium-scale hydropower development as well as irrigation: the flow to their intakes in the streams and small rivers under the project are all dependent on springs in their upper catchment that are the ultimate source of water to their intakes. They have neither been mapped nor monitored for their flow health.

### **3.4.3. Natural drivers (natural hazards and climate change)**

The global climate scenario suggests that the impacts of climate change may be severe at high elevations and in regions with complex topography, as is the case in Nepal's mid-hills. As far as the issue of spring discharge caused by the climate change in Nepal is concerned there is no clear link established between climate change and declining spring discharge. However, the climate change scenarios for Nepal suggest a significantly wetter and warmer climate towards the end of the century. Both the average annual mean temperature and the average annual precipitation are projected to increase. But pre-monsoon precipitation is projected to decrease, and extreme precipitation events to increase (MoFE, 2019).

These changes are expected to affect the water sector, including springs (ICIMOD, 2015; Nepal et al., 2019). Many mountain cities are already facing the water scarcity problem. Many emergent urban areas in the mountains depend on springs and rivers (supplied through piped networks) groundwater. As these sources of groundwater are snow and glacier-fed, the impact of climate change may affect the quantity of water available from these sources (Singh et al., 2020, p.3).

Further, changes in weather-related parameters may exacerbate weather anomalies, droughts, floods, and other weather-related phenomena. Although the total annual rainfall remains more or less the same, high-intensity-short-duration rainfall, ones that are likely to result in disasters, have increased noticeably. In the hilly areas, such events trigger various forms of WID, including erosion and landslides; in the valleys and the flatlands, which cause severe flooding-all of which adversely affect the lives and the livelihoods of local communities (Adhakari, 2013; Baral, 2009; Wester et al., 2019).

Moreover, many of these natural hazards can affect infrastructure and water availability. For instance, hydropower especially can be impacted by landslides, floods and glacial lake outburst floods (GLOF). The glacial lakes situated at high-altitude can have an adverse effect on small and medium-size hydropower projects in the river course as in case of Sunkosi power station of NEA affected by GLOF many times in the past to Namche small hydropower project near Solu in 1985. Similarly, in 2014, Jure Landslide, brought down a huge landmass of the mountain and blocked the river and nearly 10% of the nation's electricity were impacted and washed out over 400 houses and killed over 200 people (Bhatt, 2017). Such landslides sweep away existing springs and reduce the chances of rainwater penetration to recharge downstream springs. Due to this, people have to face water scarcity and cross difficult terrain to fetch water for their cattle and other domestic uses (Upadhyay, 2009 a).

The 2015 earthquake impacted several water sources particularly springs. Some springs dried up while the discharge increased in some springs. Similarly, new springs appeared in some places while

some springs shifted from one place to the other (Chapagain et al., 2017). As a result, there might be an impact on water availability and communities dependent on springs might aggravate poverty and inequalities. Scarcity of water would have an impact on food security, health, and sanitation of the 30 million people living in Nepal.

However, uncertainty lies in the global models as these models provide a broad overview of the mountain environment. General climate models may provide a snapshot of the weather variability but it may not accurately represent the complex orographic pattern defined by the geographic, altitudinal and hydrogeological variabilities in Nepal.

Nepal has very diverse climatic conditions ranging from tropical in the south to alpine in the north. It has three distinct geographical regions-the snow-covered mountains, the mid-hills and the Tarai. The hydrology of Nepal is fed largely by the South Asian summer monsoon, but the relationship between the timing, volume of monsoon rainfall and the mountain landscape has not been understood well yet. An altitude gradient has resulted in pronounced orographic effects, effects which severely limit our ability to explain precipitation dynamics in Nepal. Another complexity is that the data set required to explain the processes is limited. There are few-just 280 monitoring stations across the entire country and hydro-meteorological data has been collected only since the late 1960s. With such a limited data set, it is impossible to adequately capture the temporal and spatial dynamics of precipitation. As a result, modelling works face fundamental limitations.

Within these limitations also, the preliminary indications of water scarcity due to weather anomalies and its cascading effect brought by natural hazards to water security is vital to acknowledge for managing springs-only easily accessible water sources of hill communities in Nepal.

#### **3.4.4. Issues of spring water management/governance**

To meet the increasing demand of water, communities and individuals often extract from deep boring and cement rings - *Inars*, and direct pumping from wells and springs (Pandey & Bajracharya, 2017; Sharma et al., 2016). This situation might make the water availability situation worse for others, and are not necessarily successful in the longer term even for the implementers (Pandey & Bajracharya, 2017; Sharma et al., 2016). Water extraction from springs and groundwater needs to be regulated to maintain a sustained water supply. However, there is a lack of both actions by authoritative regulatory bodies (such as elected rural municipalities), and an in-depth scientific understanding of the water endowment on a local scale.

Many formal and informal committees have been formed to manage natural resources at the local level, both permanent, like community forest user groups, and short-term, like construction committees, but water management groups that regulate springs and groundwater use are virtually non-existent (ICIMOD, 2015; Pandey & Bajracharya, 2017; Poudel et al., 2020; Tiwari et al., 2008).

Recently, some practices adopted by the local community to minimize the water scarcity in the hills of Nepal are emerging. For example, a local organization called community water forum is successful for water supply management in Dhulikhel. They have piloted the ten recharge ponds in four contours so far. The extraction rate and springs of discharge are monitored to investigate and confirm whether the recharge ponds will increase water yields in the future. Local stakeholders have owned the decision making, the selection of projects, and the implementation with a goal of long-term sustainability (Pandey & Bajracharya, 2017, p.306).

An important aspect of urban water management is decentralized governance and the devolution of power to local bodies and institutions managing water. A study of Tansen and Damauli, two small towns in Nepal, by Singh et al. 2020 shows that water institutions have played a very significant role in water supply management at the local level and that proper management can help avert critical water shortages. “In Tansen, infrastructural constraints and large-scale corruption in the systems have implications on water governance, while in Damauli; the systems have been well managed due to the involvement of local communities” (Prakash & Molden, 2020).

Some of these community and local led efforts to manage water resources in the hills of Nepal are critical. However, these sorts of initiatives are on a small scale. Thus, there is a need to invest time and resources for collective and collaborative efforts between government, communities and private sectors involved in water use and management.

#### **3.4.5. Inclusion and equity in water accessibility**

People living in the mid-hills are facing the scarcity of water directly affecting the livelihood of the community (Merz et al., 2004; Thapa et al., 2020a). Among many issues, poor sanitation and access to water supply systems were among the biggest issues affecting the health of children of the mid-hills of Nepal (Gurung et al., 2019; Sharma et al., 2019). Many villages were declared as open defecation free areas; however, the children were not given the basic rights to safe drinking water and sanitation facilities including hygienic toilets, soap for hand washing and so on. That was evident in public schools too where there were toilets but not used due to lack of water. This affected the girls the most.

The problem of water scarcity is that higher altitudes in poor, marginalized and disadvantaged communities are more severe than at hamlets located at lower altitudes. In some villages, disparities in access to water resources among different social groups by wealth, caste, etc. were visible as the Dalits or so-called low caste people were forced to use low quality water for drinking and other purposes. In many parts of the mid and far western region of Nepal, women during their menstrual cycle were not allowed to access the spring water in the name of cultural practice founded on the superstitions that they cannot touch the water because the springs become impure if they touch the water. Under such cultural landscapes, increased water scarcity affects women’s health and hygiene significantly.

Water scarcity issues have huge gendered effects. Generally, women being in charge of household chores, she is responsible to ensure water delivery at home. In villages, women fetch water from common springs and taps which involves time and physical effort. This activity of fetching water may have a significant health impact on women. For example, Sharma et al. (2016) in their study of springs conducted in Samundre Kuwa and Daraune Pokhari, Kavre District found that the female members hold the responsibility of collecting water for the family especially areas. Eighty percent women and 23% of men were involved in fetching water from natural springs. Similarly, Shrestha et al., (2019) confirmed that 85% of women and 9% of men walk up to 4.5 km by spending more than 4 hours fetching water in the Melamchi. This indicates that women are bearing the unfair burden of the water collection which increases vulnerability to the women.

## **4. GAPS: KNOWLEDGE, POLICY AND PRACTICE**

### **4.1. Gaps in knowledge**

#### **4.1.1. Spring hydrogeology**

The review of the literature indicates that there are a few studies that attempted to understand the hydrogeology of springs. It is crucial to understand the hydrogeology of springs for better utilising and protecting springs. However, the physical aspects of spring hydrogeology are still poorly understood so considerable research is needed. It is important to reveal how rainfall is stored inside a ‘water tower’, to determine the quantitative correlation between rainfall amount and spring flow as well as factors that affect recharge, and to evaluate how society would respond to recommendations made for water regulation. Advanced scientific methods such as tracer and geological drilling studies are more definitive and much needed, as are modelling exercises. Although they are very expensive, such studies should be carried at the micro-watershed level to establish firmer linkages between local hydrogeology, recharge ponds, and village springs. Whatever information and scientific data have been collected, they are of piecemeal character and have limited coverage as well as lack longitudinal data. This is feasible by enforcing policies and programmes such as college curriculum on springs and adequate capacity building to local government agencies and concerned stakeholders (e.g., user committees) for advancing scientific know-how about springs.

#### **4.1.2. Comprehensive spring, recharge zones and aquifer database**

There is an urgent need for a comprehensive map of springs used by the communities in the hills of Nepal. This will provide information on dependency on spring water. Further, springs are manifestations of discharge from aquifers, so it is vital to map regional and local aquifers and the recharge zones for comprehensive management of springs. Identifying the aquifer and recharge zone would contribute to managing springs. There is a need for creation of a web-enabled database/web portal on which all springs can be mapped/tagged where anyone, government, R&D institutions and NGOs working on springshed management can upload the data. An example of such an initiative

could be the Himalayan Spring Portal developed by ICIMOD. This could also lead to creation of a national registry on springs.

## **4.2. Gaps in policy**

At the highest political levels, the dominant narrative has been that "Nepal is rich in water resources", a scientifically questionable understanding since the country is rich in four monsoon months of flood and for much of the eight non-monsoon months in drought. This lopsided understanding of the ground realities of water availability has resulted in policy blindness regarding water scarcity (Gyawali et al., 2019). While many local politicians and authorities are aware of the growing problems of spring depletion and drying, given their inadequate understanding of the science and resource economics behind this phenomenon, their policy proclivity veers towards more deep boring pumping that only exports the problem to a not-too-distant future and compounds it for adjoining communities and spring sources in the springshed. Where there is mention in policy and planning documents of springs, it comes without strategy or program on what to do about it. Hence, the need for a more concerted effort at spring protection through research and advocacy is essential.

### **4.2.1. Policies promoting springshed management approach**

Some policies and processes provide the right to access water and the conservation of water sources including springs. However, these regulatory frameworks are to be translated into local policies and strategies that the decentralised local municipal governments can enforce to manage water resources in and adjacent to their jurisdiction. Recently, there have been a few attempts to enact policies and enforce conservation activities including the identification of water recharge zones and planning from local governments (discussed in section 3.3.). Though these efforts are vital, these are small in scale and local policies and strategies have been enacted and enforced without considering the hydrogeology of springs and aquifers.

Moreover, the water resource related policy instruments have adopted a traditional approach either of watershed management (ridge to valley) approach or source protection and conservation. Moreover, the Water Resources Policy has tried to go beyond the watershed level management to the river basin level. The springshed approach is yet to get legal and policy recognition.

### **4.2.2. Institutional arrangement for managing spring**

Over the centuries, spring management has been solely dependent on the communities managed by informal institutions. The formal institutional set up responsible to manage water, watershed, irrigation, forest, soil, land, wetlands, agriculture etc. had partially covered but lacked focus on the spring's management.

Under the new structure, local governments now have extended jurisdiction as well as responsibility that cover spring conservation and management. This new development can really be an instrumental

policy shift if a hamlet-level community management approach is upheld and encouraged through local governments and necessary support and backstopping by research and scientific organizations. At the same time, an institutional vacuum has been created as if the watershed, spring and springshed conservation is of no use since the institutions like Department of Soil and Watershed Conservation cease to exist under the federal structure and provincial and local institutions are yet to be set up, institutionalized and their capacity built from the springshed perspective.

### **4.3. Gaps in practice**

#### **4.3.1. Spring protection efforts**

Springs and water source protection and conservation efforts are underway in the hills of Nepal (as discussed in section 3.3.2) mainly focusing on source protection and conservation like cleaning the outlet, fencing, plantation, and recharge pond construction.

However, these efforts are scattered and limited with a focus on single spring or multiple spring protection. These efforts largely focus on watershed management (ridge to valley) approach, which does not capture the need to move to springshed management more in line with the nature of the underlying problems. It may be either due to inadequate knowledge and information on springshed management or lower level of willingness of the human resource involved in it. Moreover, these efforts have limited coverage and the intensity is low whereas the problem is severe and demands a massive campaign.

#### **4.3.2. Tapping traditional know-how**

Information on the neglected traditional way of managing and recharging ponds and conservation of spring sources will provide a faster way to design and implement spring conservation in the hills of Nepal.

This is an approach that combines traditional and scientific knowledge on spring hydrogeology, recharge zones, aquifers would enhance community appeal while providing a cost-effective way to implement and test the efficacy of the planned interventions.

Social issues and governance systems for spring revival and marginalisation of communities due to the caste-based system in some regions is a greater issue than just lack of technical measures. Therefore, this is also an area of further investigation for developing inclusive policies and practices.

## **5. RECOMMENDATIONS**

Springs are the lifeline of local communities in the hills of Nepal. Local communities rely on spring water for drinking water, cleaning and sanitation, livestock care, irrigation and other uses. However, springs are drying up in the hills of Nepal despite government and community-led small-scale and

scattered attempts to protect spring sources. Some of the factors leading to destroying and disrupting spring flow are mal-development practices, natural hazards, weather anomalies, increasing water demands in emergent towns and cities with the influx of hill migrant concentrations. Some of the approaches to reduce the looming water scarcity resulting from the drying of springs are discussed in the following section.

### **5.1. Research**

Comprehensive multidisciplinary research on mountain hydrogeology, geochemistry, and structural geology for understanding the spring origin, flow, aquifer system and recharge zones is critical. Further, investigating the changing water use and extraction pattern with the emergence of new towns and cities is vital for understanding socioeconomic, and ecological of the communities.

The absence of a comprehensive database of spring sources remains a major bottleneck for springshed conservation in Nepal. Given the ecological and socioeconomic dynamics of the chure, hills and mountain regions, the critical gap of real time data of spring sources cannot be over emphasized. The absence of a database was creating impediments for better policy decisions. An inventory of active spring sources and status of their performances are inevitable for understanding the issues and appropriate responses.

### **5.2. Policy**

Growing water demands for drinking water, sanitation (in the ODF context having at least a toilet at every household), livestock feeding and irrigation (at least for kitchen garden), crops if available, in rural, peri-urban and urban areas in the context of massive drying up of springs means greater water stress and scarcity. The inexorable ramifications of climate change with haphazard mal-development activities will place even greater pressure on the proper functioning of spring sources already inadequate to meet existing demands under the serious threat of drying up, the situation with climate change impacts and other disasters, we can expect serious consequences shortly.

Protecting and conserving existing spring sources with collective and concerted efforts through the formulation of policies based on the evidence generated from scientific studies and programs developed based on local capacities is the need of the hour. To further this existential cause, local communities especially of the spring areas, users and local governments should come together with the knowledge, will and commitment to protect and conserve existing springs and to rejuvenate dried up ones by implementing proactive measures.

As a result, local governments should take the lead in making policies, plans and programs, and local communities join hands together to translate springs conservation policy measures into reality for the sustainability of the springs. The power exercised by the 35 local governments of Lumbini, Karnali and Sudurpaschim provinces of western Nepal for aquatic animal and biodiversity

conservation legislation can be replicated in developing spring conservation and revival policies and implementation thereof, and showcased as spring policy piloting to mainstream springs conservation throughout HKH.

### **5.3. Practice**

#### **5.3.1. Springshed scale spring rejuvenation campaign**

For spring conservation, spring rejuvenation programs need to be launched as a massive campaign by involving local communities, government agencies, civil society organizations and other stakeholders based on the knowledge generated from the multidisciplinary research. It needs to be led by local government bodies and civic organizations but backed through policy support by higher authorities at province and national levels. It would involve the following four stages:

- 1) It must start with spring mapping at ward and hamlet levels, followed by measurement of their flows throughout the year, with the immediate post-monsoon flow representing the highest possible output and the flow in May/early June before the monsoon being possibly the lowest. The role of Winter Westerlies and their contribution to spring recharge must also be monitored.
- 2) Technical support must be provided to local bodies and civic groups involved in spring rejuvenation by national level government agencies and academia with knowledge of hydrogeology and springshed conservation. A starting point for this could be adopting processes identified in the “Recharge Pond Hand Book”(Government of Nepal, 2013) and eight step spring revival model can be a useful tool in this regard, which are summarised into six steps in Shrestha et al., (2018).
- 3) Proper EIA and development project planning must be enforced with continuous public consultations to ensure that mal-developments such as rampant, unengineered road constructions do not damage existing springs and other water bodies.
- 4) Because of the plethora of springs of different types and suitable for different purposes (seasonal irrigation only or year-round drinking water) in any small micro-watershed and the vicinity of hamlets, communities not only with knowledge of the nature of those springs but also their use must be the core foundation on which spring protection program must be built.

#### **5.3.2. Local community participation and capacity building**

Most importantly, local community participation (women, men) especially of women is must with decision-making powers at all stages of water and sanitation services from planning and construction to conservation and management. The engagement in local water management, spring conservation, and construction of recharge ponds has to start with grassroots institutions, and then work up to local municipalities and provincial government levels, first with sensitization on recharge science,

and then with the implementation of action research. Additionally, spring management could be introduced as an interdisciplinary course at a higher education level.

As per the local government officials, they have limited capacity on spring revival, so they need capacity building training (Thapa, et. al., 2020b). Therefore, capacity building programs on spring conservation, recharge and protection for water sustainability and climate change adaptation should be launched by developing a comprehensive as well as a flexible module for different level actors ranging from users to policymakers as springs are the only source of dependable water supply for a large number of mountain communities and they do not get the consideration they deserve.

In this context, one of the ways to increase water in aquifers is by augmenting natural system of water storage available from sources such as glacial melt, snowmelt, ablation, mountain springs, soil moisture and high-altitude wetlands through initiatives such as wetlands conservation and watershed management in the hills and mountains, groundwater aquifer recharge through infiltration ponds, Sabo dams in smaller gullies and flow channels, injection wells, channelling rainwater into ponds, flooding of agricultural lands during fallow periods (Poudel & Duex, 2017; Sharma et al., 2016; Vaidya, 2015), and even creation of small artificial glaciers (Vaidya, 2015) for convergence of spring management with watershed management.

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## Annex 1

### List of key informants interviewed

| S. No. | Name                      | Designation and affiliation                                                                      | Date               |
|--------|---------------------------|--------------------------------------------------------------------------------------------------|--------------------|
| 1      | Mrs. Durga Devi Bhattarai | Deputy Mayor , Suryodaya Municipality, Ilam                                                      | July 31, 2020      |
| 2      | Mr. Akkal Dhami           | Chairperson, Chhabis Pathibhara Rural Municipality, Bajhang                                      | August 27, 2020    |
| 3      | Mr. Harka Bahadur Saud    | Mayor, Chaurpati Rural Municipality, Achham                                                      | August 30, 2020    |
| 4      | Mr. Kaustuv Raj Neupane   | Researcher, South Asian Institute of Advanced Studies (SIAS), Kathmandu                          | September 23, 2020 |
| 5      | Mrs. Nanu Ghatane         | Local community leader, Namobuddha Municipality, Kavre                                           | October 11, 2020   |
| 6      | Mr. Vishnu Pandey         | Regional Researcher, International Water Management Institute (IWMI), Lalitpur                   | November 9, 2020   |
| 7      | Mr. Sanot Adhikari        | Chairperson, Youth Alliance for Environment, Kathmandu                                           | November 9, 2020   |
| 8      | Mr. Narayan Belbase       | Deputy Chief of Party/Senior Environmental Policy and Law Expert, USAID Paani Project, Kathmandu | November 14, 2020  |



**Nepal Water Conservation Foundation for Academic Research (NWCF)** is

a non-governmental, non-political and not-for-profit organization working on environment, climate change, water, energy, disaster and public interest protection through research, publications and engagement through public dialogues along with policy advocacy. Building on its core expertise of providing solutions on issues of rivers and watershed management, over the years, NWCF has expanded its portfolio with the inclusion of clean energy, climate change, gender issues and other significant environmental issues such as air pollution. NWCF works at federal, provincial, and local levels while being equally recognized with global recognition, and has carried out several projects ranging from climate change, water induced disaster risk management, rivers, water, energy, food, nexus and managed successfully.

**International Centre for Integrated Mountain Development (ICIMOD)** is

an intergovernmental knowledge and learning centre that develops and shares research, information, and innovations to empower people in the eight regional member countries of the Hindu Kush Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. We serve the region through information and knowledge generation and sharing to find innovative solutions to critical mountain problems. We bridge science with policies and on-the-ground practices. We provide a regional platform where experts, planners, policy makers, and practitioners can exchange ideas and perspectives towards the achievement of sustainable mountain development. We facilitate knowledge exchange across the region, help customize international knowledge and tailor it to the region's needs, and bring regional issues to the global stage.

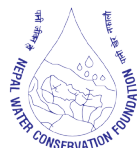
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**नेपाल पानी सदुपयोग फाउन्डेसन**

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