

A

Report on

**Hydrogeological Investigation of springs around Gangajamuna
Rural Municipality Wards 1 and 2, Dhading, Nepal**



Submitted to

Rotary Club of Dhading

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Executive Summary

Springs serve as the primary sources of potable drinking water and small-scale irrigation in the Nepal Himalaya, providing essential groundwater discharge where piped supplies and large-scale systems remain limited. In agricultural landscape of Nepal, the lack of reliable irrigation networks constrains farmers ability to boost crop productivity and transition to commercial agriculture, particularly for coffee, tea, and medicinal herbs in suitable terrain. To tackle these issues, the Dhading Rotary launched an action plan for a systematic irrigation system in Gangajamuna Rural Municipality, Wards 1 and 2.

The study spans the Lesser Himalayan zone in Dhading District, inventorying six perennial springs: Gortha Khola (100 lps) and Kelsyong Khola (5 lps) in Ward 1, plus Kalshyong Khola (32.5 lps), Tawal Khola (16 lps), Kimru (3.5 lps), and Lakuridada (7 lps) in Ward 2. Geologically, the Kuncha Formation is dominated by greenish grey phyllite interbedded with metasediments, featuring fractured joints (apertures up to 5 cm) and colluvial deposits that facilitate recharge via vegetated slopes. Traditional canals and pipes currently harness these flows for limited irrigation, with surplus sustaining downstream rivers like Ankhu Khola, although post-2015 earthquake declines shifted some to piped use.

This assessment details the hydrogeological conditions and geology to enable efficient spring utilization, water quality excellence (low SAR 0.04–0.22, safe RSC 0.30–0.98 meq/L, SSP 8.66–27.20%), and a climate-resilient network. Recommendations emphasize recharge protection through afforestation, pipelines from high-discharge sources reserving 20–30% for environmental flow, and monitoring to support year-round, high-value crop irrigation.

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1. Introduction

1.1 Background

Nepal is an agricultural country with extensive mountainous regions, where many communities depend on spring water as their primary source of irrigation. The Gangajamuna Rural Municipality in the Dhading District is one of the many local units that rely on springs and streams for drinking water and irrigation. Wards 1 and 2 of Gangajamuna Rural Municipality, where 90% of the population depends on agriculture, are well-known for their suitable climate and terrain, which are conducive to coffee, medicinal herbs, and tea farming. Despite this agricultural potential, the area lacks a systematic and reliable irrigation system, which has become a major constraint in scaling up commercial coffee farming and ensuring year-round crop productivity. Establishing an efficient irrigation network in these wards requires a comprehensive hydrogeological investigation to identify viable water sources, assess springs and streams, and evaluate water extraction sustainability.

In response to this need, Integrate Earth System (IES) Consult was assigned by Rotary Dhading to undertake detailed hydrogeological studies in this area. As part of this, IES Consult conducted field assessments, geological mapping, and groundwater evaluations to generate essential hydrogeological information for Wards 1 and 2. The findings of this study provide a scientific basis for utilizing springs for long-term agricultural development, particularly in coffee and tea cultivation, within the municipality.

1.2 Objectives

This study aimed to investigate the proposed spring hydrogeological conditions of four springs in Ward 2 and two springs in Ward 1 of the Gangajamuna Rural Municipality, with an in-depth understanding of the geology of the study areas. The specific objectives are as follows:

- Identify and map potential spring and surface water sources in the target villages.
- Measure discharge rates, seasonal flow variations, and recharge potential.
- Evaluate water quality for irrigation and household use.
- Determine the feasibility of water extraction and conveyance through pipelines.

- Provide technical data to design a sustainable and climate-resilient irrigation system that ensures a year-round water supply for coffee and high-value crops.

1.3 Study area

1.3.1 Demographic information

In the Gangajamuna Rural Municipality, a population of 25,872 people is spread across 5,718 households, with 13,280 males and 12,592 females (Table 1).

Table 1. Demographic information of Gangajamuna Rural Municipality.

Ward	Households	Population			Average family member
		Male	Female	Total	
1	652	1288	1137	2425	3.7
2	650	1467	1392	2859	4.4
3	675	1430	1347	2777	4.1
4	653	1629	1533	3162	4.8
5	938	2238	2185	4423	4.7
6	1078	2576	2366	4942	4.6
7	1072	2652	2632	5284	4.9
Total	5718	13280	12592	25872	4.5

Source: Household Survey 2076, Gangajamuna Rural Municipality

1.3.2 Physiographical and geological setting

The study was conducted in the Lesser Himalayan region of Nepal, specifically within wards 1 and 2 of the Gangajamuna Rural Municipality in the Dhading District (Figure 1). The study area is located approximately 57 km (aerial distance) northwest of Kathmandu. This region represents a typical mid-hill physiographic setting characterized by rugged terrain, steep slopes, and deeply incised river valleys. The area experiences average daytime temperatures ranging from about 20 °C during the winter months to about 36 °C in summer, reflecting a climatic regime that transitions from subtropical to moderately temperate conditions.

The location and geological setting make the area particularly significant for hydrogeological investigations related to spring resources, water availability, and rural-water-supply planning. The investigation covers two spring sources: Gortha Khola and Lakuridada spring, located in Ward 1, and four spring sources: Kelsyong Khola, Kalshyong Khola, Kimru Khola and Hullu

Syong in Ward 2 of Gangajamuna Rural Municipality (Figure 2), which was conducted in November of 2025.

Geologically, the study area lies within the Kuncha Formation of the Lesser Himalayan Belt, which is composed of lower grade metamorphic rocks. The terrain is extensively characterized by phyllite interbedding with metasandstone, which forms the dominant lithological unit throughout the region. These rocks play a significant role in controlling the hydrogeological behavior of springs, influencing groundwater occurrence, storage, and discharge characteristics.

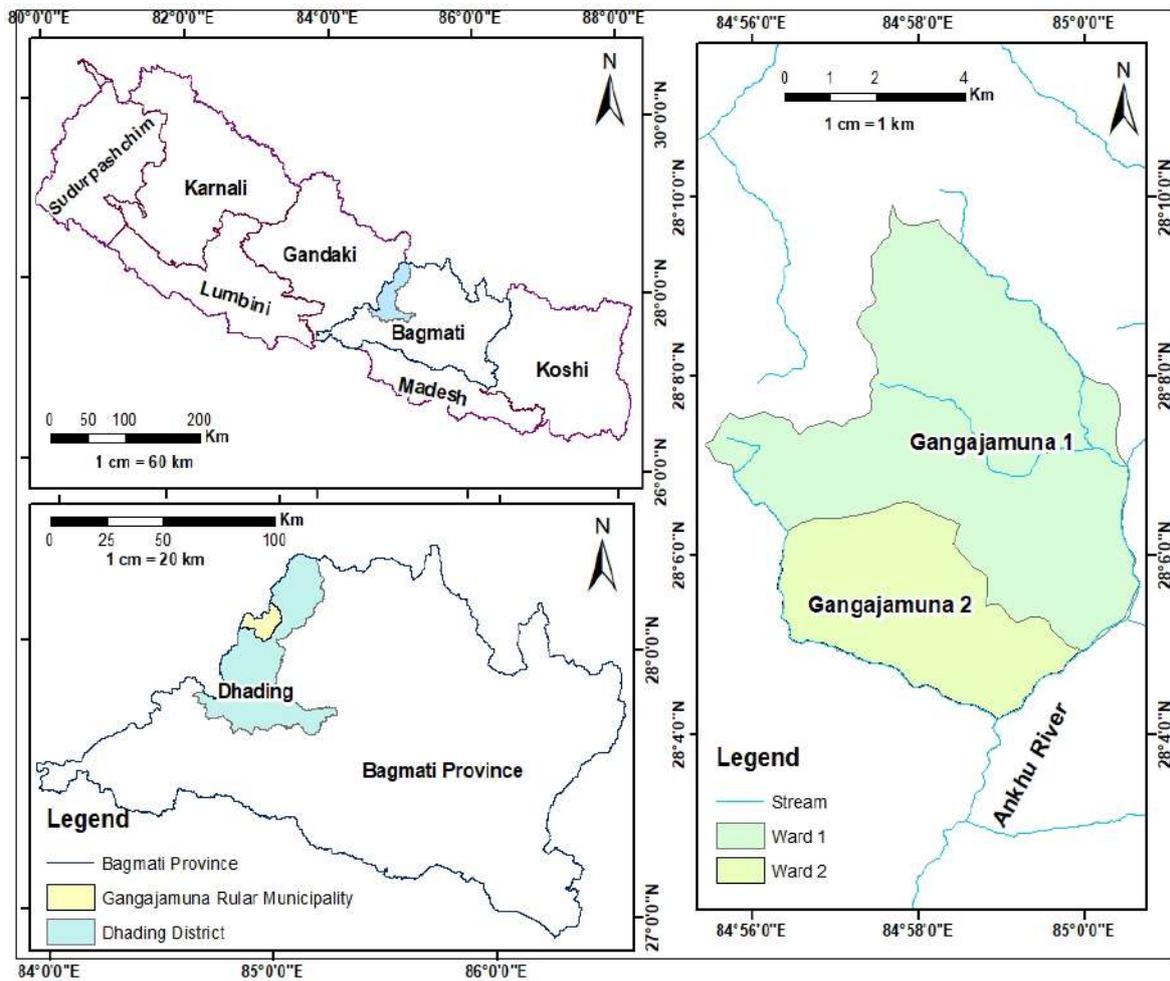


Figure 1. Location map of Ward 1 and 2 of Gangajamuna Rural Municipality.

2. Materials and Methods

2.1 Materials

Various instruments and equipment were used to obtain the necessary hydrogeological and spatial data. The primary tools used during the survey are described in the following sections. GPS was used for identifying and monitoring investigation sites by recording their geographic coordinates. The device operates by receiving signals from multiple satellites, allowing it to calculate precise positional information. In field-based studies, this capability ensures accurate site verification, spatial mapping, and reliable navigation even in remote terrain. This instrument was used for the determination of bearings and azimuthal directions by referencing the Earth's magnetic field. In geological fieldwork, it is utilized to measure the attitudes of structural features, including bedding surfaces, foliation, joints, and other rock discontinuities.

A geological hammer is an essential tool for fracturing and chipping rock samples in the field. It is primarily employed to expose fresh rock surfaces, allowing for interpretation of lithology, mineral composition, material properties, and geological history, as well as to make preliminary assessments of rock strength. A measuring container is utilized during spring-discharge measurements to quantify the volume of water available for subsequent water-budget analyses. It was employed to collect representative water samples for comprehensive laboratory-based analyses of water quality parameters. High-resolution imagery of the study sites was systematically acquired using smartphones, enabling detailed documentation of site morphology, spring conditions, and associated geomorphological or anthropogenic features.

Field work was conducted to collect data related to the geological aspects of the areas, such as rock type, morphology, and the presence of water bodies. A detailed survey was conducted in the field work to quantify the available water resources and assess water quality. The underlying geological formations and discontinuities associated with the water bodies were characterized to understand their influence on groundwater occurrence and surface water dynamics. Field traverses were conducted to locate potential rock outcrops, lithological variations, and to evaluate land cover and land-use patterns. Local community resource persons were engaged throughout the survey to provide logistical guidance, site access, and contribute indigenous knowledge regarding hydrological features and landscape.

2.2 Methods

Hydrogeological mapping of springs within Gangajamuna Rural Municipality 1 and 2 was initiated by establishing the study objectives and implementing a structured data-collection method in coordination with local government representatives and community resource persons. Spatial data, including the geographic coordinates of spring points, lithological exposures, and land-cover conditions, were acquired using handheld GPS instruments.

The functional status and discharge condition of each spring were assessed in the field, while preliminary socio-economic characteristics were documented based on community consultations. Photographic records of spring sites and associated geological features were systematically captured during the survey period. The discharge of selected sources in liter per second (lps) were estimated using bucket-stopwatch and area-velocity methods where appropriate.

Water samples of springs were collected to assess laboratory physico-chemical parameters. The irrigation suitability of water samples was evaluated using key indicators such as Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), and Soluble Sodium Percentage (SSP). These parameters were computed based on laboratory-analyzed concentrations of Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Chloride (Cl^-), and Bicarbonate (HCO_3^-) ions. The mathematical expressions for these suitability indices are given as follows:

$$SAR = \frac{Na^+}{\sqrt{\frac{(Ca^{2+} + Mg^{2+})}{2}}}$$
$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$
$$SSP = \frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100$$

All ionic concentrations are expressed in milliequivalents per liter (meq/L). These calculated indices provide a basis for assessing the chemical suitability of groundwater for irrigation purposes, reflecting its potential influence on soil permeability, sodicity, and long-term agricultural productivity.

3. Results and discussion

3.1 Topography and drainage

The hydrogeology of six spring sites of Ward 1 and Ward 2 of Gangajamuna Rural Municipality, Dhading were observed (Figure 2). Among six sites, four lie in Ward 2 and remaining two lies in Ward 1 of Gangajamuna Rural Municipality. The study area lies in the Midlands surrounded by Mahabharat Range to the south and the Himalaya Range to the north. The study area encompasses a prominent hill massif characterized by pronounced vertical relief and varied slope gradients.

The base of the hill, or the Aakhu Khola, is located at an elevation of about 750 m above mean sea level, and the summit of the massif reaches a height of about 2300 m. Reegaun is situated at an intermediate elevation of 1,900–1,950 m, occupying a subdued mid-slope position. The drainage pattern of the study area is dendritic in nature, and the stream shows high gradient, flowing from the west to the east direction.

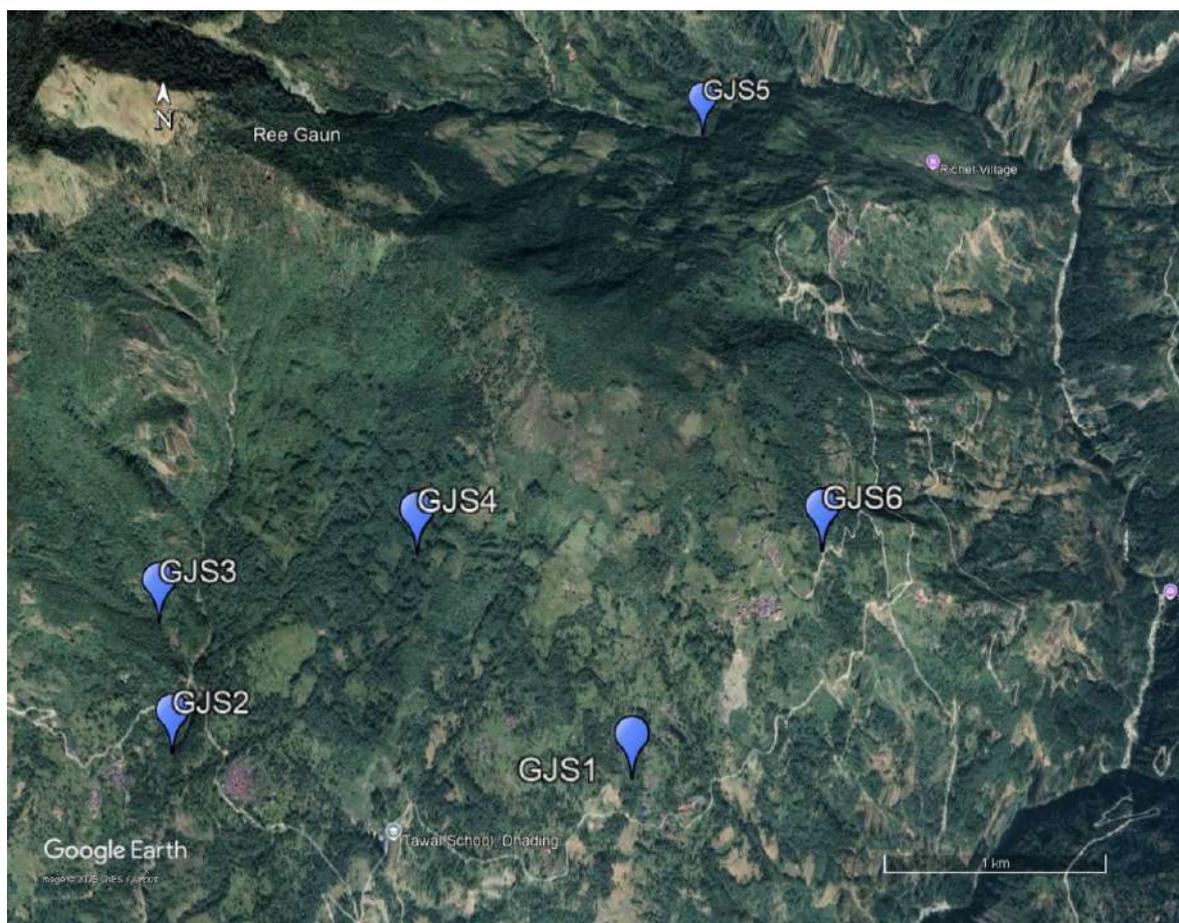


Figure 2. Distribution of springs on Google Earth imagery in the study area.

3.2 Hydrogeology of the area

Regionally, Gangajamuna Rural Municipality entirely lies within the Kuncha Formation of the Lower Nawakot Group of Nawakot Complex (Figure 3). This geological formation, the oldest unit of the Himalaya is characterized by a uniform lithological composition consisting greenish grey phyllite, quartzitic phyllite, phyllitic metasandstone, gritstone, micro-conglomerate, and black schist, which sometimes exhibits amphibolite bands.

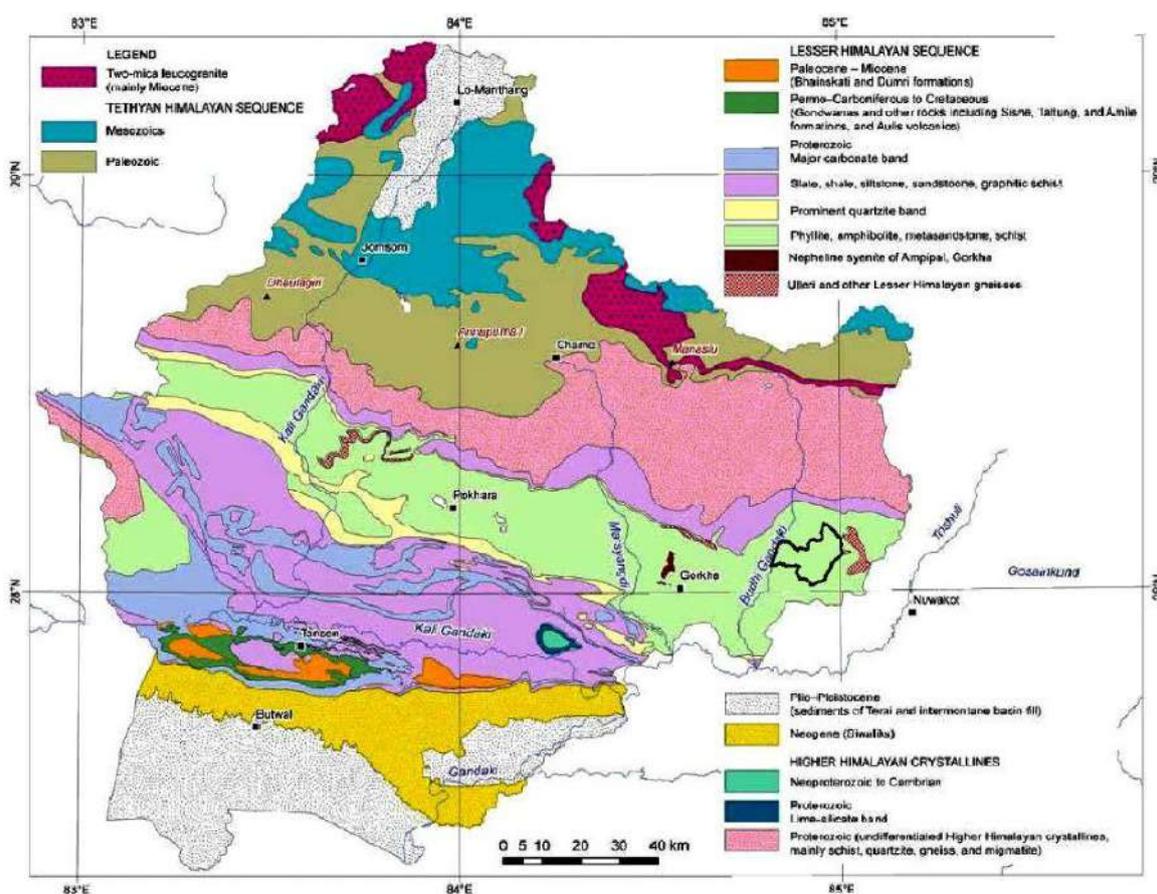


Figure 3. Gangajamuna Rural Municipality with a small dark black outline in simplified geological map of Gandaki Region (Dhital 2015).

The study area has significant groundwater resources which naturally come up to the surface through springs and seepages. These springs provide fresh water all the time which recharges for streams. These streams including springs are partially utilized by local people for drinking water, irrigation, other household purposes and the remaining portion are left for environmental flow; confluence to the Aakhu Khola. Hence, this groundwater is found to be significant for the health of the ecosystem downstream.

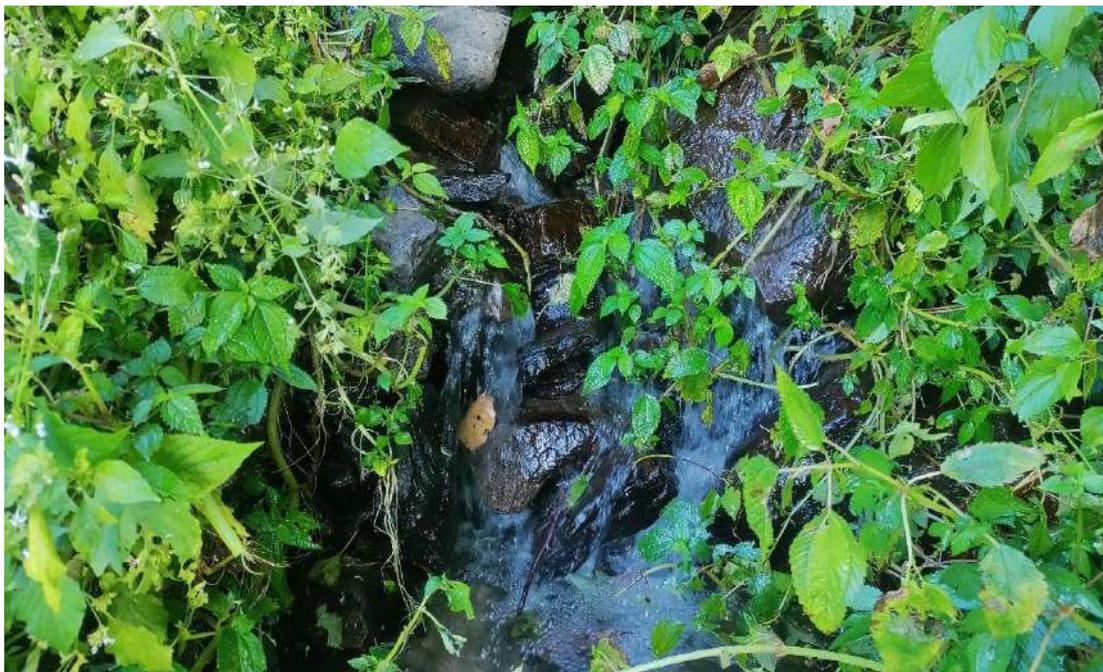
The hydrogeology of six particular springs in the region will be examined in the sections ahead. Detailed accounts and illustrative diagrams will be presented so that the distinctive features of each groundwater system can be highlighted, and the mechanisms of groundwater recharge can be clearly identified.

3.3 Spring inventory

The spring inventories of 6 spring locations (GJS1, GJS2, GJS3, GJS4, GJS5 and GJS6) were conducted in Ward 1 and Ward 2 of Gangajamuna Rural Municipality. These sources are lifeline of the residing communities for household as well as irrigation purposes. Additionally, these springs are contributing to the environmental flow and maintain ecosystem of the region (Annex 1). The laboratory physico-chemical analysis of 4 samples GJS1, GJS4, GJS5, GJS6 were carried out to perform irrigation suitability such as Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), and Soluble Sodium Percentage (SSP) of water samples (Annex 2).

3.3.1 Kelsyong Khola (Salleri), Gangajamuna Ward 1 (GJS1)

The source is located near Salleri village (Photograph 1). It is a stream which originates at about 200 m uphill from the observation site (Figure 4). Colluvial deposits with the vegetation cover with mostly Utis trees at both banks of the stream were observed (Photograph 2). The estimated discharge of GJS1 was 5 lps.



Photograph 1. Kelsyong Khola flowing over fractures rocks in Salleri.

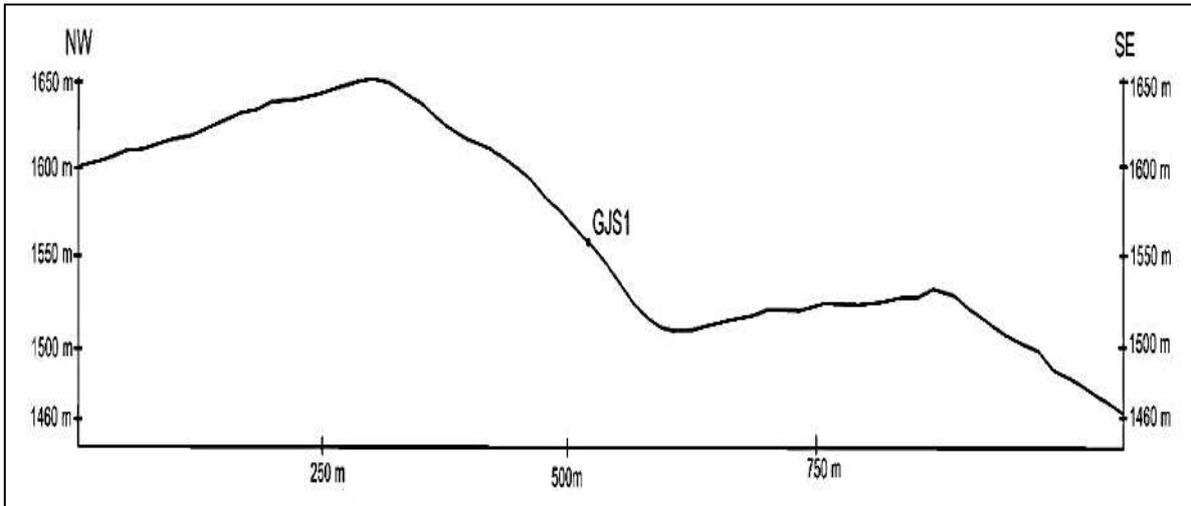


Figure 4. Elevation profile of Kelsyong Khola (Salleri).

At about 40 m away from the right bank of the stream, the rock exposure was observed (Photograph 3). Slightly to moderately weathered greenish grey phyllite interbedded with metasandstone was seen. The exposure was highly fractured. The orientation of the foliation and joint sets of the rock exposure were noted. The aperture of about 2 cm to 5 cm was seen at joint set 2.



Photograph 2. Highly fractured phyllite, interbedded with metasandstone, is exposed near Salleri Khola.



Photograph 3. Vegetation overlying colluvium deposits along the Kelsyong stream indicates a potential groundwater recharge zone.

3.3.2 Kalshyong Khola (Tawal besi), Gangajamuna Ward 2 (GJS2)

It is located near Tawal Besi Village. It is a stream, flowing with high gradients (Photograph 4). In the observation site, it was seen that two streams are converging to form a bigger stream. This stream originates at about 400 m uphill from the observation site (Figure 5). The estimated discharge of GJS2 was 32.5 lps. Cliff is observed at both banks of the stream at downstream whereas at upstream, vegetation cover with trees were seen.

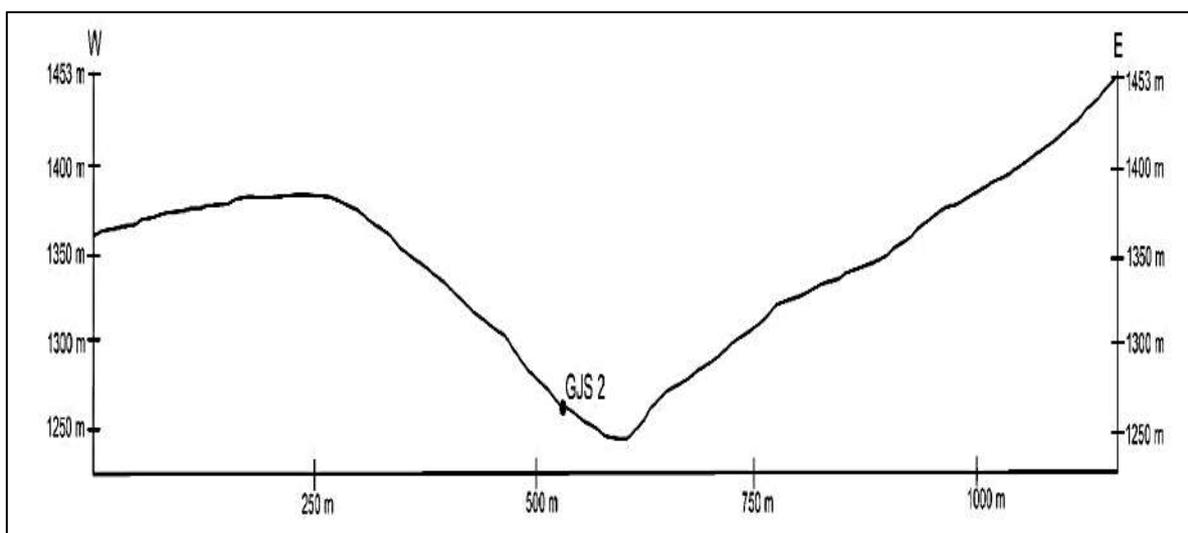


Figure 5. Elevation profile of Kalshyong Khola (Tawal besi).

Geologically, rock exposure of slightly to moderately weathered greenish grey phyllite interbedded with metasandstone was observed near spring (Photograph 5). Quartz vein of thickness 3 cm to 8 cm was also present in the phyllite which is almost parallel to its foliation. The thickness of the phyllite bed is up to 3 cm whereas the metasandstone has the thickness up to 15 cm. The groundwater condition of the rock exposure is drippy. The orientation of the bed including two joint sets were noted. The aperture of joint set 1 was about 2 cm to 4 cm.



Photograph 4. Kalshyong stream near Tawal Besi Village



Photograph 5. Rock exposure observed near Kalshyong Khola.

3.3.3 Tawal Khola (Tawal), Gangajamuna Ward 2 (GJS3)

The observation site lies close to Tawal village (Photograph 6). The origin of the source is a stream where the cliff is observed at both sides of the stream, covered with vegetation (Figure 6). The estimated discharge of GJS3 was 16 lps.

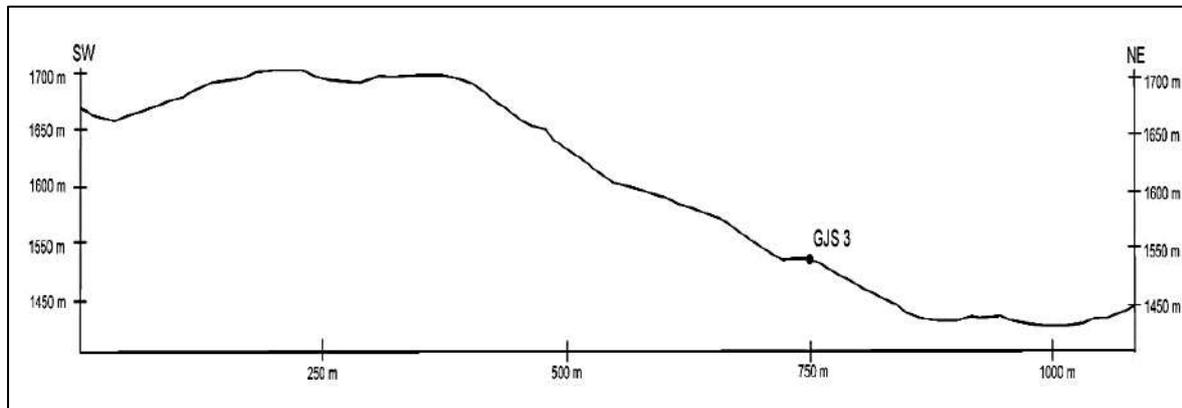


Figure 6. Elevation profile of Tawal Khola (Tawal).

The rock exposure was observed near the observation sites at about 10 m away from the left bank of the Tawal Khola (Photograph 7). It consists of slightly to moderately weathered phyllite interbedded with slightly weathered fine grained metasandstone with the presence of the quartz vein in phyllite. Metasandstone was about 2 cm to 15 cm thick. The condition of ground of the rock exposure was wet. The orientation of three discontinuities including bedding (foliation) seen in rock exposure was also taken.



Photograph 6. Tawal Khola in the vicinity of Tawal Besi



Photograph 7. Metasandstone interbedded with phyllite near Tawal Khola.

3.3.4 Kimru spring, Gangajamuna Ward 2 (GJS4)

Kimru spring is situated near Reegaun (Photograph 8). A study of the Kimru spring identified it as a colluvial spring, providing fresh water year-round, though its discharge markedly decreases during the dry season. The estimated discharge of GJS4 was 3.5 lps.

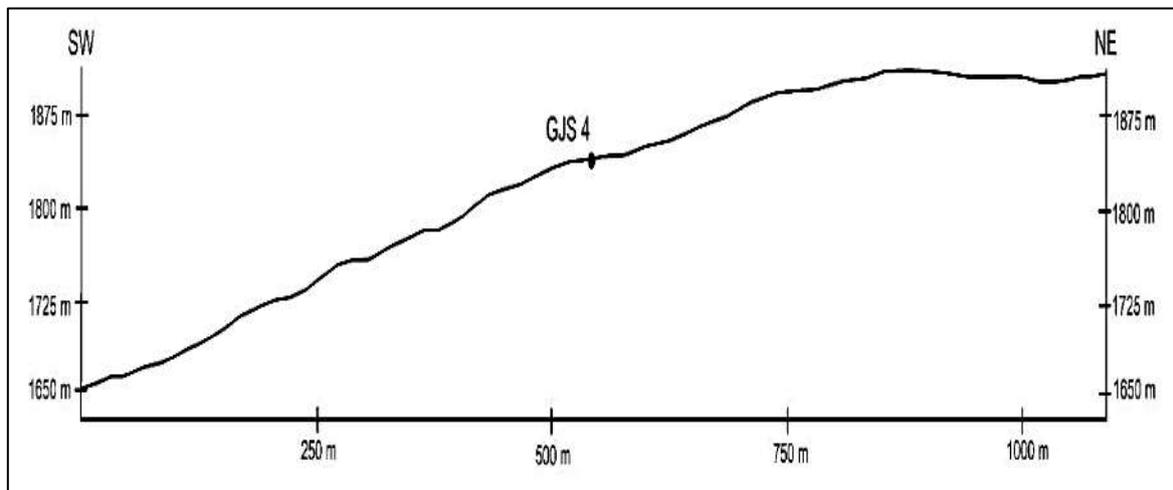


Figure 7. Elevation profile of Kimru Spring and surrounding.

Gravel and boulders of phyllite, metasandstone, quartz, etc. can be seen around the spring. Vegetation covers around the spring and terrace of cultivation land about 10-13 ropani at about 10 m uphill from the slope can be observed. This spring seems to emerge at the ground surface along the contact between a thin, permeable colluvial cover and an underlying low permeability phyllite and metasandstone bedrock.



Photograph 8. Krimu Mul, a colluvium spring near the farmland at Reegaun.

3.3.5 Gortha Khola (Richet), Gangajamuna Ward 1 (GJS5)

The observation site is situated in the vicinity of Richet Village (Photograph 9). It is a stream that converges with the Aakhu Khola. The estimated discharge of GJS5 was ~100 lps. It is a perennial stream whose discharge decreases during the dry season (Figure 8). The exposed rock formation near the Gortha Khola consists of slightly to moderately weathered greenish grey phyllite with an undulating surface. Quartz veins can be observed in phyllite.

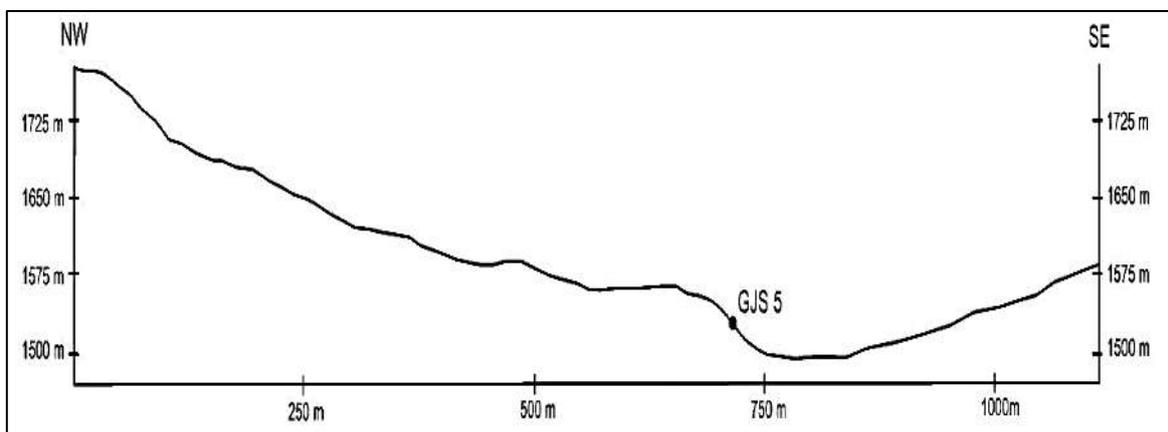


Figure 8. Elevation profile of Gortha Khola Richet.



Photograph 9. Gortha Khola near Richet Village.

3.3.6 Lakuridada Spring (Reegaun), Gangajamuna Ward 2 (GJS6)

The source is located near Reegaun. The investigation reveals that the spring is colluvial (Figure 9). The estimated discharge of GJS6 was 7 lps. The area is covered with the loose sediments of gravel to boulder sized phyllite, metasandstone and the vegetation, making it difficult to locate the rock exposure during the visit (Photograph 10). The spring originates from these loose sediments. However, analyzing water flow data suggests that the perennial springs throughout the region are fed by deep fractures of underlying phyllite and metasandstone rock.

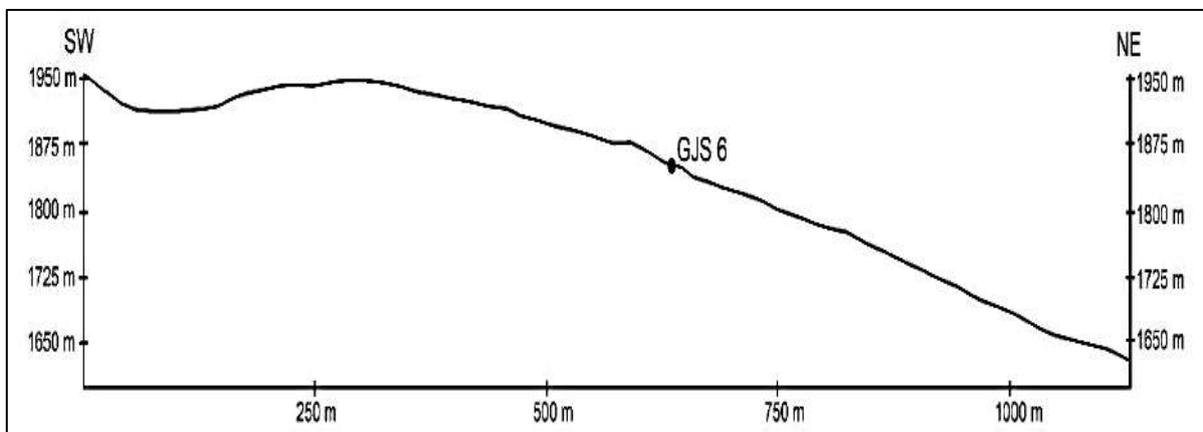


Figure 9. Elevation profile of Lakuridada Spring (Reegaun).



Photograph 10. Lakuridada spring near Reegaun, locally known as Tanki Khola.

4. Conclusions and recommendations

The study area in Gangajamuna Rural Municipality, Wards 1 and 2, lies within the Kuncha Formation of the Lesser Himalayan Belt, characterized by lower-grade metamorphic rocks dominated by greenish grey phyllite interbedded with metasandstone, quartzitic phyllite, gritstone, and occasional amphibolite bands. These lithologies exhibit high fracturing and jointing, with apertures up to 5 cm, facilitating groundwater storage and seepage along discontinuities such as foliation (e.g., 183°/20°N at Kelsyong Khola) and joint sets. Colluvial deposits of gravel and boulders overlying the bedrock further enhance recharge zones, particularly where vegetation-covered slopes promote infiltration, as observed near Salleri and Reegaun villages.

Spring discharges vary significantly across the six inventoried sites (GJS1–GJS6), all perennial and supporting household use, irrigation, and downstream environmental flow into Ankhu Khola. Notable rates include Gortha Khola (GJS5) at 100 lps, Kalshyong Khola (GJS2) at 32.5 lps, and Tawal Khola (GJS3) at 16 lps, while colluvial springs like Kimru (GJS4, 3.5 lps) and Lakuridada (GJS6, 7 lps) show dry-season reductions. These streams follow dendritic drainage patterns on steep gradients (elevations 750–2300 m), originating from uphill fractures in phyllite-metasandstone contacts, with post-2015 earthquake declines noted at some sources shifting from canal to pipe irrigation.

The sodium hazard of the spring waters is very low, and they can be categorized as excellent for irrigation based on SAR. For instance, all measured SAR values (0.04–0.22) are well below the commonly cited upper limit of 10 for irrigation water, which indicates minimal risk of soil permeability or structural problems associated with excessive exchangeable sodium (Ayers & Westcot, 1985; Richards, 1954). Under such conditions, these waters are considered suitable for long-term use on a wide range of soil textures without the need for specific sodicity mitigation measures (Ayers & Westcot, 1985).

Residual sodium carbonate values (0.30–0.98 meq L⁻¹) also suggest that the spring waters are safe to marginally safe for irrigation. RSC thresholds of 1.25–2.5 meq L⁻¹ are often used to flag potential alkalinity and infiltration problems, and values below this range imply a favorable balance between carbonate–bicarbonate and divalent cations, reducing the likelihood of Ca–Mg precipitation and subsequent sodium accumulation on exchange sites (Eaton, 1950; Gupta,

1983). Thus, with respect to RSC, these spring waters are not expected to create significant alkalinity or infiltration constraints for most irrigated soils (Ayers & Westcot, 1985).

Soluble sodium percentage values for the samples (8.66–27.20%) are well below the commonly adopted threshold of about 60% for acceptable irrigation water. Low SSP indicates that sodium represents a small fraction of total cations, which reduces the risk of soil dispersion and maintains favorable soil structure under irrigation (Doneen, 1964; Michael, 2008). Considering SAR, RSC, and SSP together, the spring waters can be classified from excellent to good for irrigation use, with negligible sodium-related hazards for most crops and soil types under typical management conditions (Ayers & Westcot, 1985; Richards, 1954).

Conservation measures align with study objectives of mapping sources, assessing recharge, and designing climate-resilient irrigation for coffee and high-value crops. Protect vegetated recharge zones (e.g., Utis tree covers at Kelsyong Khola) through community-managed afforestation to sustain perennial flows and mitigate dry-season declines. Implement pipeline conveyance from high-discharge springs like GJS5, reserving 20–30% surplus for environmental flow, alongside regular monitoring of discharge and fractures to prevent over-extraction. These steps ensure efficient utilization while enhancing groundwater recharge in the Kuncha Formation.

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Annex 1: Springs of RIDP project studied in the Reegaun, Dhading

ID	Long	Lat	Elev (m)	LULC	HHs	Source name	Origin	Lithology/Remarks
GJS1	84.98504	28.08639	1510	Vegetation covers with some trees (Utis) at both sides.	30	Kalshyong Khola (Salleri)	Stream	No exposure seen. Colluvial deposit of gravel and boulder around stream. Discharge after earthquake 2015. Earlier before earthquake, water flow so enough that water was channelized through canal to irrigation. But after earthquake, small pipes are used for irrigation.
GJS2	84.96459	28.08758	1243	At right bank, about 15m height cliff is present. At left bank, sloppy hill; all cover with vegetation with some trees	45	Kalshyong Khola (Tawal besi)	Stream	Slightly to moderately weathered greenish grey phyllite interbedded with metasandstone. Quartz vein of thickness of 3cm to 8cm is present, almost parallel to foliation. Exposure is in drippy condition. Phyllite thickness = up to 3cm, Metasandstone thickness = Up to 15cm: Aperture of J1 = 2cm to 4cm.
GJS3	84.9641	28.09226	1388	Cliff with vegetation in both bank	49	Tawal Khola	Stream	Slightly to moderately weathered greenish grey phyllite with slightly weathered thickly bedded fine grained metasandstone with quartz vein. Metasandstone thickness = 2 to 13 cm, Groundwater condition = wet, aperture = tight to partly open, opening less than 1 cm.
GJS4	84.97584	28.09417	1850	Vegetation covers all sides. Cultivation land of 12 ropani at 10-20 m uphill	60	Krimru Spring	Colluvial	Gravel and boulder of quartz, phyllite, metasandstone, etc. around spring, max boulder size = 0.8*0.4*0.2m. No exposure seen
GJS5	84.98823	28.11526	1184	Cliff/steep hill at both banks with vegetation cover.	40	Gortha Khola	Stream	Slightly weathered greenish grey phyllite with undulation surface with quartz vein.
GJS6	84.99303	28.09453	1825	Vegetation covers all sides	45	Tanki Khola	Colluvial	At about 5m uphill, intake tank for drinking purpose

Annex 2: Physico-chemical parameters of springs in the Reegaun, Dhading

S.No.	Sample no.	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	HCO ₃ (mg/l)
1	GJS1	0.26	0.06	1.7	0.52	9.94	40
2	GJS4	0.32	0.076	2.3	0.64	8.52	70
3	GJS5	1.56	0.083	2.5	0.76	8.52	30
4	GJS6	0.78	0.065	2.1	0.68	9.94	60