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(2025-2027)



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EDITORIAL

It is our great pleasure to present the 11th Bulletin of the Nepal Hydrogeological Association (NHA). Reaching this important milestone is a matter of pride for the Association and reflects our continued commitment to promoting hydrogeological knowledge, professional development, and sustainable water-resource management in Nepal.

This issue brings together valuable contributions from senior hydrogeologists, researchers, and professionals working in different areas of hydrogeology and water resources. The articles cover diverse topics, including groundwater exploration, water-resource management, sustainable development, climate resilience, and emerging approaches to hydrogeological investigation. We hope these contributions will provide useful knowledge and practical insights to professionals, researchers, students, policymakers, and all those interested in hydrogeology and water resources.

We extend our sincere gratitude to all the authors and contributors for sharing their knowledge and experiences, and to the reviewers for their valuable time and constructive suggestions in maintaining the quality of this publication. Our special appreciation goes to all advertisers and advertisement providers whose valuable support has contributed significantly to the publication of this bulletin. We are equally grateful to our sponsors, financial supporters, institutional partners, professional organizations, members, well-wishers, and individual supporters for their continued trust, encouragement, and cooperation. Their support has been instrumental in strengthening the activities and vision of the Nepal Hydrogeological Association.

We sincerely thank the Executive Committee for its guidance and encouragement, and the Editorial Board members for their dedication, teamwork, and valuable contributions in bringing this 11th Bulletin to fruition. The Editorial Board is pleased to have successfully published Volume 3 of the research journal alongside this bulletin.

We hope this bulletin will serve as a useful source of knowledge and a valuable record of the Association's continuing journey and contribution to the development of hydrogeology in Nepal. We look forward to continued collaboration and collective efforts to promote scientific knowledge, professional excellence, and sustainable management of Nepal's precious groundwater and water resources.

Warm Regards,

The Editorial Board
Nepal Hydrogeological Association (NHA)

Bhadra, 2083 B. S.

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MESSAGE FROM THE PRESIDENT OF SEVENTH EXECUTIVE COMMITTEE ON FIFTEENTH AGM

नेपाल हाइड्रोजियोलोजिकल एसोसिएसन (NHA) भूमिगत जलको उपयोग, आवश्यकता र उपादेयतालाई ध्यानमा राखी यसको संरक्षण, उपयोग तथा व्यवस्थापन सम्बन्धमा विभिन्न गतिविधिहरू गर्दै आइरहेको भूमिगत जलस्रोतसंग सम्बन्धित विज्ञहरूको संगठन हो । यसको स्थापना २०६७ मा भएको थियो । स्थापना काल देखि नै आफ्नो उद्देश्य अनुरूप सरकारी, निजी निकायहरूमा भूमिगत जलस्रोतको अध्ययन अनुसन्धान, विकास तथा व्यवस्थापन सम्बन्धमा आवश्यक राय परामर्श समेत उपलब्ध गराउने र देशको आम नागरिकमा भूमिगत जलस्रोत सम्बन्धि जनचेतना मुलक कार्यहरू (Talk program, Seminar) गर्दै आइरहेको देखिएको छ ।

नेपाल हाइड्रोजियोलोजिकल एसोसिएसनले मिति २०८२ भद्र ४- ५ The First Nepal Hydrogeological Conference - 2025 विषयको सम्मेलन सम्पन्न गरेको थियो जसमा नेपाल लगायत विदेशका ख्यातिप्राप्त भूमिगत जलस्रोतको अध्ययन अनुसन्धान, विकास तथा व्यवस्थापनसंग सम्बन्धित विज्ञ तथा नेपाल सरकारका विभिन्न निकायहरू, त्रिभुवन विश्वविद्यालय, गैरसरकारी संस्था र सरोकारवाला संस्थाहरूमा कार्यरत करिब १५० भू-वैज्ञानिक, भूमिगत जल विज्ञ, इञ्जिनियर, वातावरणविज्ञ र विभिन्न क्षेत्रमा कार्यरत प्रतिनिधिहरूको सहभागिता रहेको थियो । जसमा ३४ गोटा भूमिगत जल संग सम्बन्धित कार्य पत्र पेश भएका थिए ।

जलस्रोत तथा सिंचाई विभाग को सन्दर्भमा भन्नु पर्दा आर्थिक वर्ष २०८०/८१ बाट भूमिगत जलको अध्ययन अनुसन्धान गर्ने भूमिगत जल स्रोत विकास समिति खारेज भएपछि अनुसन्धान सम्बन्धि कार्य जल तथा शक्ति आयोगबाट र पूर्वाधार सम्बन्धि कार्य जलस्रोत तथा सिंचाई विभागबाट हुदै आएका छन् । यसका साथै तराइका २२ जिल्लाहरूमा भूमिगत जल सतह मापन कार्य समेत यसै विभागबाट संचालन हुदै आएको छ ।

बढ्दो शहरीकरण, बसाई सराई, उद्योगधन्दा तथा कृषि प्रणालीहरूमा उपलब्ध भूमिगत जलस्रोतको अत्याधिक उपयोग भईरहेको अवस्था र उद्योगधन्दाबाट जथाभावी रूपले भूमिगत जलस्रोतको दोहन तथा प्रदुषण गर्ने कार्य पनि गरिरहेको हुँदा अब यो बहुमूल्य प्राकृतिक स्रोतको उचित रेखदेख, नियमन, नियन्त्रण तथा अनुमति लिएर मात्र उपयोग गर्ने व्यवस्था गर्न नितान्त जरूरी भएको छ ।

देशमा ठुलो संख्यामा भूमिगत जलसंग सम्बन्धित भूमिगत जल विज्ञ रहेको र राज्यले उनिहरूमा रहेको विज्ञताको भरपुर प्रयोग गर्न सकेको खण्डमा सजिलै देशले दिगो विकास मार्फत समृद्धिको फड्को मार्ने देखिन्छ । नागरिकको पहिलो आवश्यकता खानेपानीको सहज आपूर्ति तथा देशको आर्थिक समृद्धिको मुल आधार मानिने कृषिमा भूमिगत सिंचाइको प्रयोग र औद्योगिक प्रयोजनबाट भूमिगत पानीको जल भण्डारणमा कमि आउन नदिनको लागि अध्ययन तथा अनुसन्धान जस्ता कार्यहरू वैज्ञानिक तथ्यहरूमा आधारित भई अगाडि बढाउनु आजको आवश्यकता रही आएको छ यस सन्दर्भमा नेपाल हाइड्रोजियोलोजिकल एसोसिएसनले खोज तथा अनुसन्धान केन्द्रित कार्यक्रम संचालन गरि त्यस बाट प्राप्त निष्कर्षहरू प्रदेश तथा नेपाल सरकारका सम्बन्धित निकायहरूलाई प्रदान गरी देशमा देखिएको भूमिगत जलस्रोतको समस्याको दीर्घकालीन समाधानका साथै समग्र देश विकासको लागि महत्वपूर्ण भूमिका खेल्ने विश्वास लिएको छ । अन्तमा यस नेपाल एसोसिएसनको नया कार्यकारिणी समिति (आठौ कार्य समिति) लाई सफलताको हार्दिक शुभकामना व्यक्त गर्न चाहन्छु ।

१५ औं वार्षिक साधारण सभामा महासचिव अनिल खत्रीको प्रतिवेदन:

नमस्कार,

यस नेपाल हाइड्रोजियोलजिकल एसोसिएसन (NHA) का अध्यक्ष तथा सभाका सभाध्यक्षज्यू, यस एसोसिएसनका पूर्व अध्यक्षज्यूहरु, एसोसिएसनका पधाधिकारीज्यू तथा सम्पूर्ण सदस्यज्यूहरु। यस NHA को १५ औं वार्षिक साधारण सभामा उपस्थित सम्पूर्ण आजिवन सदस्यज्यूहरु तथा अतिथिज्यूहरुलाई स्वागत गर्न चाहन्छु।

आज मिति २०८२ आश्विन २४ गते शुक्रवार यस NHA को पन्ध्रौ वार्षिक साधारण सभामा महासचिवको हैसियतले आ.ब. २०८१/८२ मा यस एसोसिएसनबाट भएका गतिविधिहरु प्रस्तुत गर्न पाउँदा मलाई ज्यादै खुशी लागेको छ।

समस्त जीवन र जगतको अस्तित्व रक्षा गर्ने प्रकृतिप्रदत्त वरदानका रूपमा रहेको भूमिगत जलको महत्व संरक्षण र दिगो प्रयोगका बारेमा जनचेतना अभिवृद्धि गर्ने यस संग सम्बन्धित विशेषज्ञहरुको हक हित को संरक्षण तथा भूमिगत जलश्रोतको संस्थागत बिकास गर्ने उद्देश्यसहित स्थापना भएको यस एसोसिएसनबाट गत आ.वमा भएका कार्यहरुको विवरण यहाँहरु समक्ष प्रस्तुत गर्न गईरहेको छु।

१. विगतका वर्षहरुमा भैं यस वर्षपनि यस एसोसिएसनको वार्षिक गतिविधि तथा Research Articles हरु समावेश भएको 10th Edition of Bulletin प्रकाशन भएको जानकारी गराउँदछु।
२. महत्वपूर्ण लेखरचना सहित यस संस्थाबाट Scientific Journal प्रकाशन गर्ने कार्यलाई बिशेष प्राथमिकता दिइएको छ।
३. NHA को Website लाई आवश्यकता अनुसार update गरिएको छ र महत्वपूर्ण तथ्यांक तथा लेख रचना एबम सूचना सामग्रीलाई समयानुकुल upload गरिएको छ।
४. यस अवधिमा भूमिगत जलश्रोतको क्षेत्रसँग सम्बन्धित बैज्ञानिक अनुसन्धान तथा खोजमुलक विषयमा Groundwater Talk Program सम्बन्धी कार्य संचालनको लागि उच्च प्राथमिकता दिइएको थियो।
५. मिति 7th October २०२४ मा Basics and Applications of Stable Isotopes on Water Resources Studies बिषयमा Half day Workshop संचालन गरिएको थियो जसमा Dr. Chidambaram S., Research Scientist, Water Research Center, Kuwait Institute for Scientific Research Kuwait बाट कार्यपत्र प्रस्तुत भएको थियो।
६. Talk Program लाई निरन्तरता दिने क्रममा यस एसोसिएसन र जलश्रोत अनुसन्धान तथा विकास केन्द्रको संयुक्त आयोजनामा talk program संचालन गरिएको थियो जसमा Prof John A. Cherry, र Prof Jimmy Jao, Department of Earth Science Hongkong बाट कार्यपत्र प्रस्तुत भएको थियो।

७. भूमिगत जलस्रोतको अतिदोहन र शहरी क्षेत्रमा निर्माण गरिएका पक्की संरचनाका कारण पुनर्भरणमा अवरोध उत्पन्न भएका कारण जमिनमुनिको पानीको सतह निरन्तर घटिरहेको देखिरहेको साथै, अव्यवस्थित मानव वस्ती र बढ्दो औद्योगीकरणका कारण भूमिगत जलस्रोत प्रदूषित हुँदै गएको छ । गत असारमा तराईका जिल्लाहरूले सामना गर्नु परेको सुख्खा तथा खडेरी जस्तै भविष्यमा आउनसक्ने जलसंकटको चुनौतीलाई मध्यनजर गर्दै भूमिगत जलस्रोतको पुनर्भरणका लागि जलाधार क्षेत्रहरूको संरक्षण गर्ने तथा भूमिगत जलस्रोतको आम नागरिकमा जनचेतना जगाउन अत्यावश्यक देखि नेपाल हाइड्रोजियोलोजीकल एसोसियसनले गत भाद्र ४-५, २०८२ मा “परिवर्तित संसारमा मानिस तथा पर्यावरणको लागि भूमिगत जलको स्थायित्व र पर्यप्तता” Groundwater for People and EcosystemsM Sustainability and Resilience in the Changing World भन्ने नारा सहित २ दिने प्रथम हाइड्रोजियोलोजीकल सम्मेलन (1st Nepal Hydrogeological Conference, २०२५ Hydrogeology of Nepal Himalaya and adjacent Region) आयोजना गरेको थियो । उक्त सम्मेलनमा स्वदेश तथा विदेशबाट करिव १५० जना सहभागीहरू उपस्थिति रहेका थिए । सम्मेलनमा स्वदेशी तथा बिदेशी गरि जम्मा ३४ ओटा बैज्ञानिक कार्यपत्र प्रस्तुत भएको थियो ।
८. आजका मिति सम्म यस एसोसिएसनका आजिबन सदस्यहरूको संख्या बढेर १८६ पुगेको व्यहोरा जानकारी गराउन चाहन्छु ।
९. उर्जा जलस्रोत तथा सिंचाइ मन्त्रालयका सचिव, जलस्रोत तथा सिंचाइ बिभागका महानिर्देशक लगायतका ब्यक्तित्वहरूसंग हाइड्रोजियोलोजिष्ट तथा भूमिगत जलस्रोतको संस्थागत बिकास सम्बन्धि विषयमा छलफल गरिदै आएको छ ।
१०. यस बाहेक यस संस्थाले वार्षिक रुपमा गर्ने नियमित गतिविधिहरू जस्तै संस्थाको प्रशासनिक काम, लेखा परिक्षण, संस्था नविकरण, बैंक खाता नविकरण जस्ता महत्व पूर्ण कार्यहरू सम्पन्न भएको छ ।

यो एसोसियसनको सातौ कार्यकारिणी समितिको दुई बर्षे कार्यकालमा आ-आफ्नो ठाउँबाट विभिन्न भूमिकामा रहेर यस कार्यकारिणी समितिलाई सफल बनाउन सहयोग गर्नुभएकोमा हार्दिक धन्यवाद दिन चाहन्छु ।

महासचिव

NHA ACTIVITIES OF THE YEAR 2082/083

Nepal Hydrogeological Association (NHA) represents all groundwater specialists from all disciplines working on various areas of groundwater resources and development throughout Nepal. Since its inception, it has consistently pushed for the advancement of professionals working in the groundwater sector in Nepal, with a primary focus on groundwater investigation, exploration, regulation, and management. Professional activities include the organization of various discussions, talk programs, seminars, and conferences. In the year 2082/083 NHA had Organized various talked program and workshops which are summarized below.

ONLINE INTERACTION PROGRAM

Date: Magh 8, 2082 (Jan 22, 2026)

Title of Interaction Program: **“Groundwater Depletion During Drought, what is actually happening? And What should be our one door view.”**

The context of the discussion

Every pre-monsoon season, as the terai faces dry spells, the media narrative surrounding groundwater depletion reaches a fever pitch. While the public’s concern is valid, the resulting havoc is often fueled by unauthentic views and lack of scientific context. As a representative body of Nepal’s groundwater specialists, the Nepal Hydrogeological Association (NHA) organized a critical interactions program with its members in the google meet platform. The main objective of the program was to move beyond the headlines, convey the real scenario of groundwater level in Terai and emerge with a unified professional view to inform the public and nation. More than fifty participants were presented during the interaction program and expressed their views.

SYMPOSIUM

Date: Magh 23, 2082 (Feb 6, 2026)

Title of Interaction Symposium: **“Landslide Hazard and Bio-Engineering Approaches for Slope Stability in Nepal.”**

The half day symposium was organized by NGS in which the NHA was the collaborative partner. The symposium was conducted in the meeting hall of Department of Water Resource and Irrigation. The symposium included presentations from senior geologist, geotechnical engineer and bio-engineering expert and a very comprehensive panel discussion. The panelist included were:

- 1) Mr. Dineshg Bhatt (CE, NDRRMA)
- 2) Dr. Bijaya Jaisi (DG, DoR, GoN)
- 3) Dr. Santosh Kaini (DDG, DWRI, GoN)
- 4) Mr. Dilip Kumar Sadaula (Senior Geologist)
- 5) Dr. Manita Timalisina (Geotechnical Engineer)

And the panel discussion was moderated by Prof. Dr. Tara Nidhi Bhattarai.

Advancing Himalayan Geoscience for a Resilient, Sustainable and Resource-Secure World

12th NEPAL GEOLOGICAL CONGRESS NGC-XII, 2026 Nov 19-21, Kathmandu

NGS Symposium on Landslide Safety

“Landslide Hazard and Bio-engineering Approaches for Slope Stability in Nepal”

ORGANIZER
NGS

IN COLLABORATION WITH
Department of Water Resource and Irrigation
Geohazard Technical Working Group
DPNet Nepal

VENUE AND DATE
Department of Water Resource and Irrigation
Jawalakhel, Lalitpur
February 6, 2026 (Magh 23, 2082)
13:30-17:45

TECHNICAL WORKSHOP ON PRACTICAL CHALLENGES IN GROUNDWATER DEVELOPMENT

Date: Chaitra 5, 2082 (March 19, 2026)

Nepal Hydrogeological Association in collaboration of Nepal Geological Society (NGS) and Nepal Geological Student Society (NGSS) organized a half day workshop on practical challenges in Groundwater Development on the occasion of National Water Week 2026 in the hall of Central Department of Geology (CDG), TU, Kirtipur. Representatives from different municipalities of Kathmandu Valley, Central Department of Geology and NARC along with students from Central Department of Geology were the participants. Senior hydrogeologists namely Mr. Surendra Raj Shrestha, Mr. Surendra Maharjan and Mr. Aravind Kumar Mishra presented the very effective and fruitful presentations regarding the practical challenges in groundwater development.

NATIONAL WATER WEEK 2026 – PROFESSIONAL DIALOGUE SERIES



Technical Workshop on Practical Challenges in Groundwater Development

Presentation-I

Challenges in Groundwater Extraction: Aquifer Response, Well Interference and Sustainable Yield



Mr. Surendra Maharjan, Hydrogeologist

**Venue: Central Department of Geology
Tribhuvan University, Kirtipur**

Date: 2026-03-19, Thursday

Time: 14:00-15:00

Organizer



NATIONAL WATER WEEK 2026 – PROFESSIONAL DIALOGUE SERIES



Technical Workshop on Practical Challenges in Groundwater Development

Presentation-II

Groundwater Exploration and Resource Estimation: Methods and Field Challenges in Nepal



Mr. Surendra Raj Shrestha, Hydrogeologist

Venue: Central Department of Geology

Tribhuvan University, Kirtipur

Date: 2026-03-19, Thursday

Time: 15:00-16:00

Organizer



NATIONAL WATER WEEK 2026 – PROFESSIONAL DIALOGUE SERIES



Technical Workshop on Practical Challenges in Groundwater Development

Technical Training Session

Fundamentals of Well Design and Pump Selection for Groundwater Development



*Mr. Aravind Kumar Mishra, Hydrogeologist
President, NHA*

Venue: Central Department of Geology

Tribhuvan University, Kirtipur

Date: 2026-03-19, Thursday

Time: 16:00-17:00

Organizer



SYMPOSIUM ON GROUNDWATER MATTERS” SECURING WATER FUTURES FROM BENEATH OUR FEET”

Date: Chaitra 6, 2082 (March 20, 2026)

On occasion of National Water Week 2026 NHA in collaboration with NGS and NGSS organized a half day symposium in the meeting hall of Department of Irrigation and Water Resources, Jawalakhel, Lalitpur. During the symposium senior Hydrogeologist duo Mr. Pratap Singh Tater and Mr. Nir Shakya presented about the evolution of groundwater studies in Nepal and Dr. Moti Lal Rijal presented about Springs of Nepal: Water -Energy-Food-Ecosystem Nexus and their Management Strategy. After the two very effective presentation panel discussion was conducted on the topic “Future of Groundwater in Nepal: Science, Policy and Pathways for Sustainable Management. Panelist included the academic personality, government officials from Department of Water Resource and Irrigation and Department of Water Supply and Sewerage Management and WASH Expert. The panel discussion was moderated by senior Hydrogeologist Mr. Surendra Raj Shrestha. Bodh Narayan Shrestha (member of Parliament) had confirmed his presence for the panel discussion but could not join at the last moment. The detail of the panelists is given below:

1. Prof. Dr. Dinesh Pathak (HOD, Central Department of Geology, TU)
2. Dr. Er. Sanjeev Bickram Rana (Ex Executive Director, Kathmandu Valley Water Supply Management Board/ WASH Expert)
3. Er. Surat Bam (PD, WSGISM/Joint Secretary, GoN)
4. Mr. Dev Kumar Syangbo (PD, TMGIP/Joint Secretary, GoN)

NATIONAL WATER WEEK 2026 – PROFESSIONAL DIALOGUE SERIES

Symposium on Groundwater Matters
Securing Water Futures from Beneath Our Feet

Key Presentation I

Springs of Nepal: Water-Energy-Food-Ecosystem Nexus and Their Management Strategy

Assoc. Prof. Dr. Moti Lal Rijal

Venue: Department of Water Resources and Irrigation
Jawalakhel, Lalitpur

Date: 2026-03-20, Friday
Time: 14:30-15:15

Organizer





NATIONAL WATER WEEK 2026 – PROFESSIONAL DIALOGUE SERIES

Symposium on Groundwater Matters

Securing Water Futures from Beneath Our Feet

Key Presentation II

Evolution of Ground Water Studies in Nepal: At a Glance

Mr. Pratap Singh Tater, Senior Hydrogeologist



Venue: Department of Water Resources and Irrigation
Jawalakhel, Lalitpur

Date: 2026-03-20, Friday

Time: 15:15-16:00

Organizer



NATIONAL WATER WEEK 2026 – PROFESSIONAL DIALOGUE SERIES

Symposium on Groundwater Matters

Securing Water Futures from Beneath Our Feet

Panel Discussion

Future of Groundwater in Nepal: Science, Policy and Pathways for Sustainable Management



Hon. Besh Narayan Shrestha
Member of Parliament
Panelist



Prof. Dr. Dinesh Pathak
HeD, CDG, TU
Panelist



Eng. Dr. Sanjeev Bickram Rana
Former ED, KUVSMB
Panelist



Er. Surat Bam
PD, WSGISM/Joint
Secretary
Panelist



Mr. Dev Kumar Syangbo
(PD/TMGIP)/Joint Secretary
Groundwater
Panelist



Mr. Surendra Raj Shrestha
Senior Hydrogeologist
Moderator

Venue: Department of Water Resources and Irrigation
Jawalakhel, Lalitpur

Date: 2026-03-20, Friday

Time: 16:00-17:50

Organizer



TALK PROGRAM

Date: Asar 16, 2083 (June 30, 2026)

Title: Water And Soil Pollution: The role of Hydrogeology in Remediation Plans

Speaker: Dott.Geol. Claudio Galli

This talk program was conducted on the Google meet platform. The presentation was very informative, almost new and neglected field in Nepal which focus with the practical cases personally followed, the various phases of remediation process, focusing attention on great role that geology and hydrogeology play.



**NEPAL
HYDROGEOLOGICAL
ASSOCIATION**

TALK PROGRAM

WATER AND SOIL POLLUTION:

THE ROLE OF HYDROGEOLOGY IN REMEDIATION PLANS

SPEAKER: DOTT. GEOL. CLAUDIO GALLI
GEOLOGIST – HYDROGEOLOGY EXPERT



DATE
Tuesday,
30 June 2026



TIME
6:30 – 8:00pm
Time zone: Asia/Kathmandu



ORGANIZED BY
NEPAL HYDROGEOLOGICAL
ASSOCIATION

ABSTRACT

This presentation aims to provide a summary of the ways in which soil and groundwater pollution problems are addressed in Europe and specifically in Italy.

The presentation aims to show, with the help of practical cases personally followed, the various phases of a remediation process, focusing attention on the great role that geology and hydrogeology play.

From the initial site characterization phase, with the execution of a suitable number of geognostic investigations and the collection of soil and groundwater samples, to the verification of the actual environmental impact and risk to people and the environment, up to the adoption of site remediation actions—which can use very different technologies—the role of geology and hydrogeology is fundamental to properly size the interventions and achieve an acceptable result without waste of economic resources and time.

In particular, the use of numerical hydrogeological models and specialized software can be very helpful in making projections on the development of pollution over time and on the remediation times of the aquifers.

SPEAKER



**DOTT. GEOL.
CLAUDIO GALLI**
GEOLOGIST – HYDROGEOLOGY EXPERT

Dr. Claudio Galli is an Italian environmental geologist and geotechnical specialist with more than 30 years of professional experience. He earned his degree in Geological Sciences from the University of Milan in 1991 and currently serves as Chairman, Technical Director, and Senior Environmental Geologist at G&T S.r.l., Italy. His work focuses on environmental investigations, contaminated land remediation, geotechnical studies, and hydrogeological assessments, with extensive project experience across Italy.



GOOGLE MEET JOINING INFO
Video call link: <https://meet.google.com/jmd-gekk-udy>



nepalhydrogeologicalassoc@gmail.com



info@nha.org.np



<https://nha.org.np/>

TALK PROGRAM

Date: Shrawan 13, 2083 (July 29, 2026)

Title: From Hydrogeology to Water Security: Insights from Mid Hill Springs of Nepal
Speaker: Dr. Gunanidhi Pokhrel

Google platform was used for the online talk program. This talk program include the some outcomes of the PhD research of the presenter. The talk program provide us the good insight about significance of springs in mid hills, why springs are critical for water security in mid hills and challenges to maintain the natural flow of the springs in the changing environment.

TALK PROGRAM
FROM
HYDROGEOLOGY
TO
WATER SECURITY:
Insights from Mid-Hill Springs of Nepal

DATE: 2083 Shrawan 13, Wednesday
29 July 2026

TIME: 6:30 PM

SPEAKER:
Dr. Gunanidhi Pokhrel
Hydrogeologist

Ph.D. in Geology from the Institute of Science and Technology, Tribhuvan University, Nepal (2026)

Expert in Groundwater, Springs and Water Resources

FREE ONLINE SESSION
Open to All

OPEN TO ALL
Hydrogeologists, Geologists, Researchers, Students, Water Professionals and Anyone Interested

JOIN US ON
Google Meet

DISCOVER. LEARN. SHARE.
Together for Water Security in Nepal

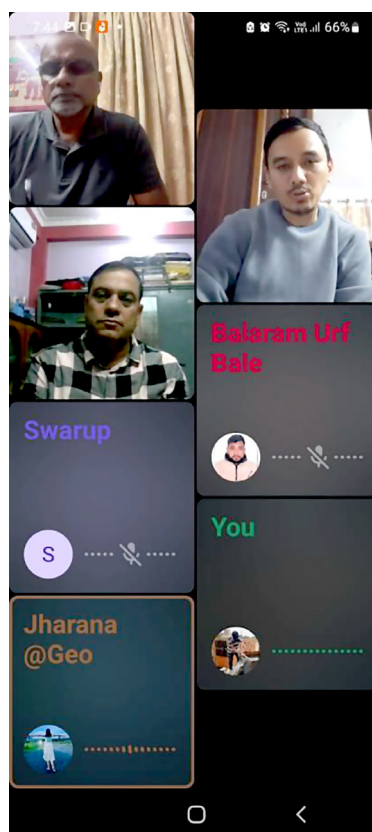
JOIN THE SESSION:
<https://meet.google.com/pmd-madz-oxe>

nepalhydrogeologicalassoc@gmail.com | <https://nha.org.np>

MEETING PHOTOS



Joint Meeting of Seventh and Eighth Executive Committee and Handover



Online and physical meeting with Technical and advisory Committee and Chief Editor

PHOTOGRAPHS OF TALK PROGRAM











6:41 PM | jmd-gekk-udy

NEPAL HYDROGEOLOGICAL ASSOCIATION

TALK PROGRAM - Tuesday, 30th June 2026

WATER AND SOIL POLLUTION: the role of hydrogeology in remediation plans

G & T Via Galvani 6/A Spresiano (TV) - ITALY

Dott. Geol. Claudio Galli

Claudio Galli (Presenting)

Aravind Kuma... Bzen Shaky... Pratap... Nepal Hydrogeo... Khila Nath Dahal... 10 others... Shahid Muslim

THE ROLE OF HYDROGEOLOGY: ENVIRONMENTAL CHARACTERIZATION

ENVIRONMENTAL CHARACTERIZATION

1. EXISTING DATA AND PRELIMINARY CONCEPTUAL MODEL
2. INVESTIGATION PLANS (boreholes, trenches, sampling, chemical analysis on soils and groundwater, FINAL CONCEPTUAL MODEL)

Geological and Hydrogeological framework of the area

Ruled use of the area (residential, industrial, rural...)

Assessment of the most useful positioning of sampling points of investigation (statistical or next to the main hazardous sites...)

Legend: TS-P28, PZ8, PZ5, SC13, SC9, PIEZOMETRO, SONDAGGIO VISIVO, SONDAGGIO, TRINCEA, TOP SOIL, limite area

Claudio Galli Nir Shaky... Pratap Sing... Khila Nath Da... Bzen Shaky... Nepal Hydrog... 10 others... Shahid Muslim

Claudio Galli

Nir Shaky...

Pratap Singh Tater

Bzen Shaky...

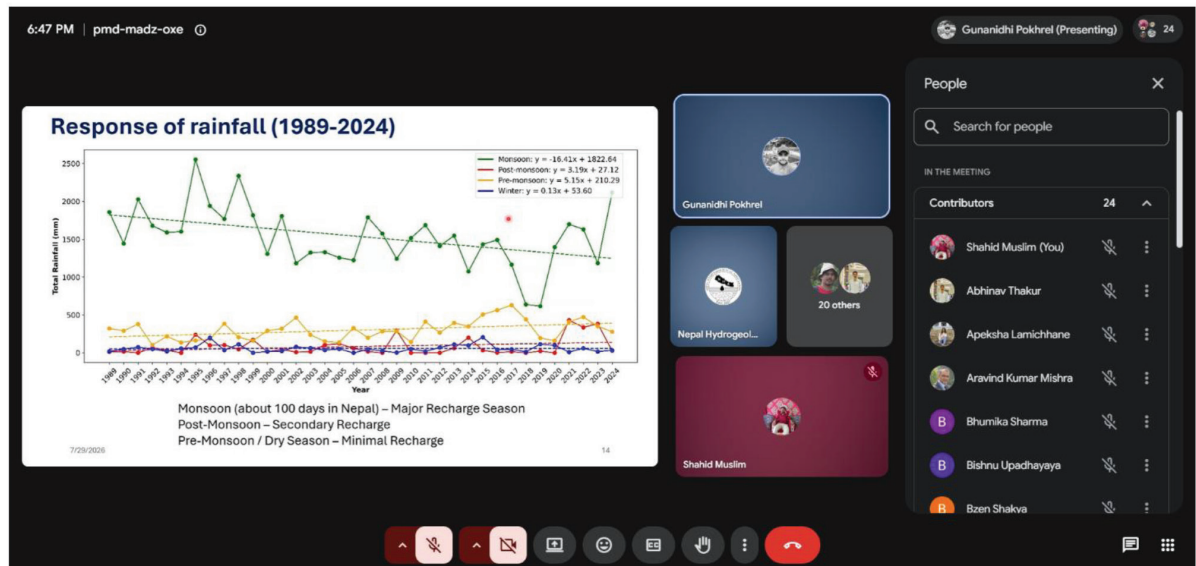
Nepal Hydrogeological Associati...

Khila Nath Dahal

Aravind Kumar Mishra

12 others

Shahid Muslim



6:46 PM | pmd-madz-oxe

Socio-economic and governance

Current status
Old tap standing in grass representing supply system

Notice/Report
Gathering recharge area information from planning notice

Interaction
During gathering to fetch clean water

Transect walk
with locals on springs status and utilization

Site visit
understand spring water supply system

7/29/2025

Gunanidhi Pokhrel (Presenting)

People

Search for people

IN THE MEETING

Contributors 23

Shahid Muslim

15 others

prasanika malla

Narendra...

Aravind Kumar Mishra

Ramesh Gautam

Nepal Hydrogeol...

Gunanidhi Pokhrel

PANDIT & ASSOCIATES

(Reg. Auditors)

Auditing License No. 0114 "B"

Firm's Regd. No. - 2654

PAN No. 500082436

☎ 5-357781 (Maitighar)

Independent Auditors' Report to Chairman of M/S. NEPAL HYDROGEOLOGICAL ASSOCIATION

Opinion

We have audited the financial statements of M/S. NEPAL HYDROGEOLOGICAL ASSOCIATION, which comprise the statement of financial position as at Ashad 32, 2082, and the statement of comprehensive income, statement of cash flows for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements present fairly, in all material respects, the financial position of the Company as at Ashad 32, 2082, and its financial performance and its cash flows for the year then ended in accordance with Nepal Accounting Standards.

Basis for Opinion

We conducted our audit in accordance with Nepal Standards on Auditing (NSAs). Our responsibilities under those standards are further described in the *Auditor's Responsibilities for the Audit of the Financial Statements* section of our report. We are independent of the Company in accordance with the ICAN's *Handbook of Code of Ethics for Professional Accountants* together with the ethical requirements that are relevant to our audit of the financial statements in Nepal, and we have fulfilled our other ethical responsibilities in accordance with these requirements and the ICAN's *Handbook of The Code of Ethics For Professional Accountants*. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Key Audit Matters (KAM)

Key audit matters are those matters that, in our professional judgment, were of most significance in our audit of the financial statements of the current period. These matters were addressed in the context of our audit of the financial statements as a whole and in forming our opinion thereon, and we do not provide a separate opinion on these matters. We have determined the matters described below to be the key audit matters in our report.

Responsibilities of Management and Those Charged with Governance for the Financial Statements.

Management is responsible for the preparation and fair presentation of the financial statements in accordance with Nepal Accounting Standards, and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the Company's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Company or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the Company's financial reporting process.

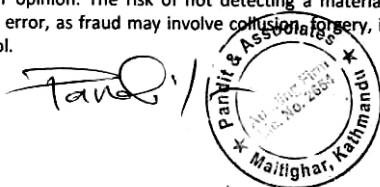
Auditor's Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with NSAs will always detect a material misstatement when it exists.

Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with NSAs, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.



- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Company's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.
- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Company's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Company to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit. We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards.

Report on Other Legal and Regulatory Requirements

As per the requirements of Section 115 of the Companies Act, 2063 (First Amendment 2074), we further report that:

- a) We have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit.
- b) In our opinion the Company has kept proper books of account as required by law so far, as appears from our examinations of those Books
- c) The financial statements are in agreement with the books of account.
- d) In our opinion and to the best of our information and according to the explanation given to us, the financial statement the said Balance Sheet, Income Statement and Cash Flow Statement, read together with the notes forming part of the accounts give the information required by the Companies Act 2063 (First Amendment 2074) in the manner so required and give a true and fair view:
 - i. In the case of Balance Sheet, of the state of affairs of the Company as at Ashad 32, 2082; and
 - ii. In the case of Income Statement, of the results of operations of the Company for the year ended on Ashad 32, 2082; and
 - iii. In the case of the Cash Flow Statement, of Cash inflow and outflow of Company for the year ended on that date.
- e) Neither we have come across any of the information about the misappropriation of fund by the directors or any of the representative or company's staffs during the course of our audit nor have we received any such information from the management.
- f) No accounting fraud has been observed during the course of our audit.

For Pandit & Associates
Registered Auditor

Place: Kathmandu, Nepal

Date: 2082/06/26


Bhakta Bdr Pandit
Membership No: B 14
Place: Kathmandu, Nepal
UDIN: 

251012RA00384nCbgH

NEPAL HYDROGEOLOGICAL ASSOCIATION

Babarmahal, Kathmandu

STATEMENT OF FINANCIAL POSITION

As at end of of Asadh 2082

PAN : 304960556

SOURCE OF FUNDS	Annex no.	CURRENT YEAR	PREVIOUS YEAR
Fund	1	293,256.82	95,681.00
Retained Earnings	2	96,701.05	73,914.00
Current Liabilities	3	77,083.46	15,300.00
<i>Total:</i>		467,041.33	184,895.00

APPLICATION OF FUNDS	Annex no.	CURRENT YEAR	PREVIOUS YEAR
Fixed Assets	8	-	-
<u>Current Assets:</u>			
Cash & bank balance	4	449,390.36	184,059.00
Pre-paid a/c	5	-	-
Deposit	6	-	-
Advance, Debtors & Receivables	7	17,650.97	836.00
<i>Total Current Assets:</i>		467,041.33	184,895.00
<i>Total:</i>		467,041.33	184,895.00

As per attached our report.


Treasurer




Chairperson



NEPAL HYDROGEOLOGICAL ASSOCIATION

Babarmahal, Kathmandu

STATEMENT OF INCOME

From : 2081/04/01 to 082/03/32 (2024/025)

PAN : 304960556

PARTICULARS	Annex	CURRENT YEAR	PREVIOUS YEAR
1.Income:			
Received from Resources	9	278,031.18	273,269.00
Membership Fee		15,500.00	-
Financial Income		7,287.05	4,573.00
		300,818.23	277,842.00
2.Direct Expenses:	10		
Project Cost Expenses		-	
Total:		-	-
3.Operating Profit		300,818.23	277,842.00
		300,818.23	277,842.00
4.Indirect Expenses:			
Administrative expenses	11	278,031.18	273,269.00
Depreciation charged	8	-	
Total:		278,031.18	273,269.00
5.Net Surplus/Deficit before tax		22,787.05	4,573.00
Tax provision		-	-
6.Net Surplus/Deficit after tax		22,787.05	4,573.00

As per attached our report.


Treasurer




Chairperson


Auditor


NEPAL HYDROGEOLOGICAL ASSOCIATION

Babarmahal , Kathmandu

CASH FLOW STATEMENTFrom : 2081/04/01 to 082/03/32 (2024/025)

PAN : 304960556

PARTICULARS		AMOUNT
Opening Cash & Bank balance		184,059.0
<u>Add:</u>		84,570.5
Net Profit of current year	22,787.05	
Depreciation charged	-	
Increase in current liabilities	61,783.46	
Total:	84,570.51	
Total Cash In flow		268,629.5
<u>Less:</u>		17,651.0
Tax & Tds paid	-	
Increase in pre-paid expenses	-	
Increase in advance income tax & Deposit	-	
Increase in Advance, Debtors & Rceivables	17,650.97	
Increase in fixed assets	-	
Total:	17,650.97	
Closing cash & bank end of Asadh, 2082		250,978.5
Total:		268,629.5

Accountant

Chairperson

Auditor



NEPAL HYDROGEOLOGICAL ASSOCIATION

Babarmahal , Kathmandu

DETAIL OF INCOME

F.Y.2081.082

PAN : 606831420

Annex no. 9

S.N.	Particulars	F.Y.2081.082
1	For Program Help	278,031.18
	Total:	278,031.18

DETAIL OF COST OF PROGRAMME

Annex no. 10

S.N.	Particulars	F.Y.2081.082
1	Wages (Volunteer)	
3	Program exp.	
	Total:	-

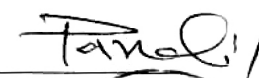
DETAIL OF ADMINISTRATIVE EXPENSES

Annex no. 11

S.N.	Particulars	F.Y.2081.082
1	Printing & Stationery	37,430.00
2	AGM & Meeting (Fooding)	119,974.19
3	Audit fee	15,000.00
4	Renew Expenses	1,500.00
5	Refreshment Expenses	389.99
6	Bulletin Expenses	101,587.00
7	Office Exp	2,150.00
	Total:	278,031.18




 Treasurer  Chairperson



 Auditor



NEPAL HYDROGEOLOGICAL ASSOCIATION

Babarmahal, kathmandu

Annexure parts of the Balance Sheet for the F.Y.2081/082 (2024/2025)

S. No.	Particulars		Current Year
1	Fund	Annex no. - 01	293,256.82
	Total :		293,256.82
2	<u>Retained Earnings</u>	Annex no. - 02	
a)	Surplus upto previous year		73,914.00
b)	Add: Surplus of current year		22,787.05
	Total :		96,701.05
3	<u>Current Liabilities</u>	Annex no. - 03	
a)	Audit fee Payable		15,000.00
b)	Other Payable		62,083.46
c)	TDS Payable		-
	Total :		77,083.46
4	Cash & Bank balance : Cash in hand NMB Bank Ltd (A/C:0667300011)	Annex no. - 04	
			-
		Total:	449,390.36
5	Pre-paid a/c	Annex no. - 05	0.00
		Total:	0.00
6	<u>Deposit</u>	Annex no. - 06	
b)	Deposit		0.00
		Total:	0.00
7	<u>Advance, Debtors & Rceivables</u>	Annex no. - 7	
	TDS Receivable		17,650.97
		Total:	17,650.97



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NEPAL HYDROGEOLOGICAL ASSOCIATION
Babarmahal , Kathmandu

Details of Depreciation Charged on Various Assets
F.Y.2081/082 (2024/025)

GRP	PARTICULARS	QTY	PREVIOUS	CURRENT	PUR. DATE	TOTAL	RATE	DEP. AMT	CAPITALIZED	BALANCE	Annex no.8
KA.	<u>Land and Building</u>										
	Sub Total:		0.00	0.00		0.00	5%	0.00	0.00	0.00	
KHA.	<u>Furniture & Office Goods</u>										
	Furniture /Fixture					-	25%	-		-	
	Office Printer					-	25%	-		-	
	Electric Goods					-	25%	-		-	
	Glass Door					-	25%	-		-	
	Sub Total:		-	-		-		-	0.00	-	
GA.	<u>Vehicle</u>										
	Sub Total:		0.00	0.00		0.00	20%	0.00	0.00	0.00	
GHA	<u>Machine & Equipment</u>										
	Musical Instrument					-	15%	-		-	
	Carpet/Curtain					-	15%	-		-	
	Sub Total:		-	-		-		-	0.00	-	
	Grand Total:		-	-		-		-	0.00	-	



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CONGRATULATIONS

Promotions/Appointments/Academic Award

Nepal Hydrogeological Association proudly congratulates the following members on their achievements and extends best wishes for a successful tenure ahead.

Appointment



Dr. Champak Babu Silwal (LM 132)

Assistant Campus Chief of
Tri-Chandra Multiple Campus.

Date: 2082/06/11



Dr. Kabi Raj Paudel (LM61)

Deputy Controller of The office of the Controller
of Examinations (OCoE) Tribhuvan University.

Date: 2082/07/02



Dr. Vishnu Prasad Pandey (LM 134)

Executive Director, Center for International
Relations, Tribhuvan University.

Date: 2082/07/01



Mr. Dev Kumar Syangbo (LM 68)

Joint Secretary (First Class), Technical
Stream, under the Nepal Engineering Service,
Government of Nepal.

Date: 2082/09/25



Mr. Birat Shrestha (LM 189)
Level 7, Geologist Officers at the
Nepal Electricity Authority, Nepal.
Date: 2082/10/27



Mr. Mukunda Raj Paudel (LM 178)
HOD of Geology ,
Tri-Chandra Multiple Campus.
Date: 2082/11/4



Mr. Madhav Lamsal (LM 190)
Under Secretary (Second Class),
Technical Stream (Geology–Hydrogeology),
Nepal Engineering Service,
Government of Nepal.
Date: 2083/01/14



Mr. Ajay Raj Adhikari (LM 52)
Joint Secretary (First Class),
Technical Stream (Geology)- Engineering
Geology under the Nepal Engineering Service,
Government of Nepal.
Date: 2083/03/18

Promotions



Mr. Anil Khatri (LM 37)

Under Secretary, Technical Stream (Geology),
under the Nepal Engineering Service,
Government of Nepal.

Date: 2082/09/28



Dr. Ranjan Kumar Dahal (LM 148)

Professor of Central Department of
Geology, Tribhuvan University.

Date: 2082/11/03



Mr. Saroj Niraula (LM 73)

8th Level Assistant Manager (Technical –
Geology) at the Nepal Electricity
Authority (NEA).

Date: 2082/12/21



Mr. Bhim Bahadur Rana (LM 164)

The Gazetted Third Class Hydrogeologist
position under the Hydrogeology Sub-group
of the Nepal Engineering Service.

Date: 2082/12/22

Award



Dr. Gunanidhi Pokhrel (LM 113)

Phd on " Investigation of Groundwater Potential of Dolomite Rock
in Lesser Himalaya of Nepal, Kushma–Syangja Area"

Tribhuvan University, Insitute of Science and Technology,
Central Department of Geology,
Kritipur, Kathamandu.

Date: 2082/11/4



आयो टप्प टिप्प्यो, लग्यो, मिति पुग्यो टारेर टर्दै न त्यो,
इन्द्रे बिलि गरुन् भुकेर पदमा त्यो बिलि मान्दै न त्यो।

भावपूर्ण श्रद्धाञ्जली



जन्म मिति:
बि.स. २००७/०८/१० गते



स्वर्गारोहण:
बि.स. २०८२/०८/१० गते

स्व. महेन्द्र राज सिंह श्रेष्ठ

हाम्रो नेपाल हाइड्रोजियोलोजिकल एसोसिएसन (आजिवन सदस्य नं.३१)को
सदस्य स्व.श्री महेन्द्र राज सिंह श्रेष्ठ ज्यूको तेह्रौं पुन्य तिथिमा उहाँको चीरशान्तिको कामना
गर्दै भावपूर्ण श्रद्धाञ्जली अर्पण गर्दछौं।

आयोजक

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मिति २०८३/०३/१० गते रसुवा जिल्लाको
भोटेकोशी नदीमा आएको विनाशकारी बाढी तथा विपद्का
कारण भएको ठुलो मानवीय तथा धनजनको क्षतिप्रति
नेपाल हाइड्रोजियोलोजिकल एसोसिएशन
गहिरो दुःख व्यक्त गर्दछ।



यस प्राकृतिक विपद्मा परी ज्यान गुमाउनुहुने सम्पूर्ण
मृतकहरूका आत्माको चिर शान्तिको कामना गर्दै
भावपूर्ण श्रद्धाञ्जली अर्पण गर्दछौं। साथै, यस कठिन घडीमा
शोकमा डुब्नुभएका सम्पूर्ण शोकाकुल परिवारजनप्रति
हार्दिक समवेदना प्रकट गर्दै घाइतेहरूको शीघ्र
स्वास्थ्य लाभको कामना गर्दछौं।



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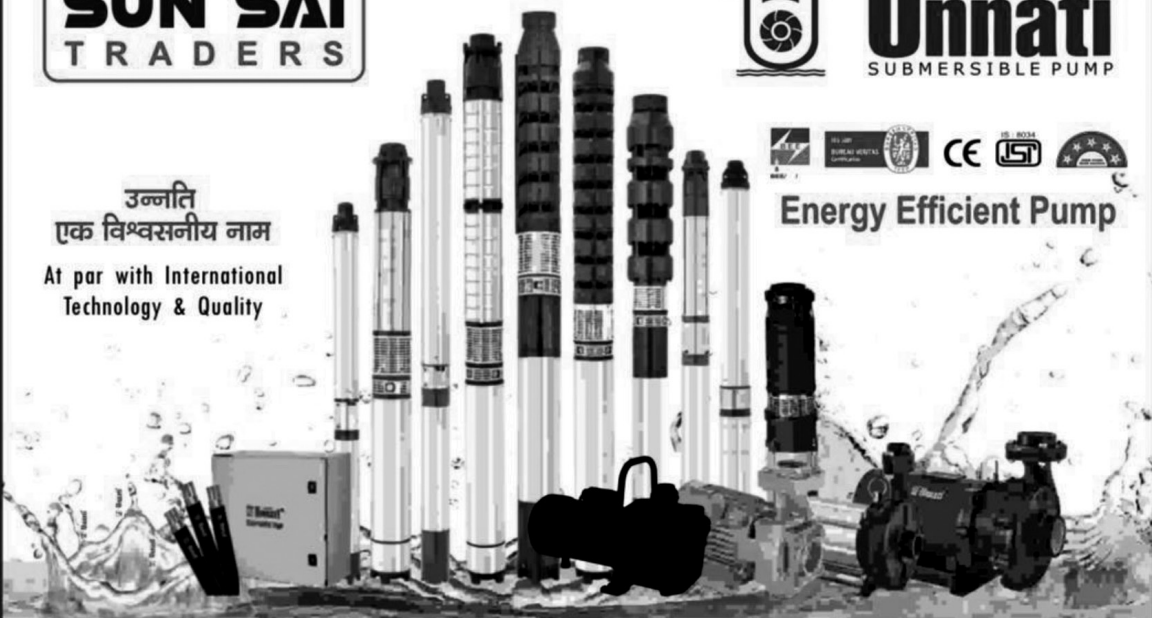




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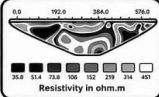
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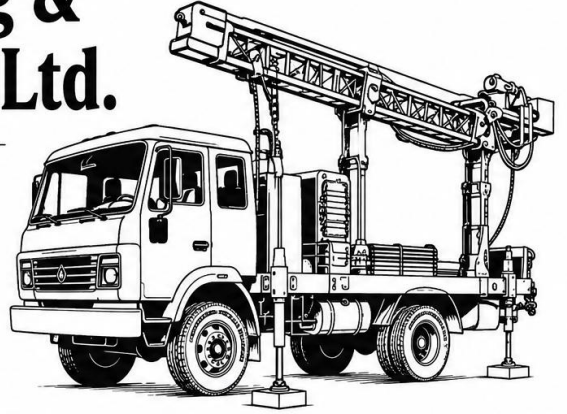
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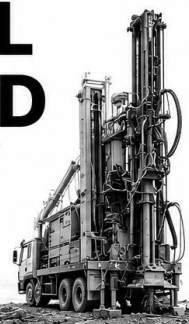
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- वर्षातको पानी ढलमा नमिसाई खाल्डो खनी पुनर्भरण गरौं ।
- सबैले वर्षातको पानी संकलन गर्ने प्रविधि जडान गर्ने गरौं ।
- भूमिगत पानीको उपयोग गर्दा अनिवार्य रुपमा यस बोर्डबाट अनुमती पत्र लिने गरौं ।
- खानेपानीको महशुल नियमित रुपमा भुक्तानी गर्ने गरौं र जरिवाना तथा वक्यौताबाट छुटकारा पाउँ ।
- काठमाण्डौ उपत्यका भित्र भूमिगत पानीको दुरुपयोग, भूमिगत श्रोतको अनाधिकृत दोहन आदीको बारेमा थाहा पाएमा यस बोर्डलाई जानकारी गराऔं ।



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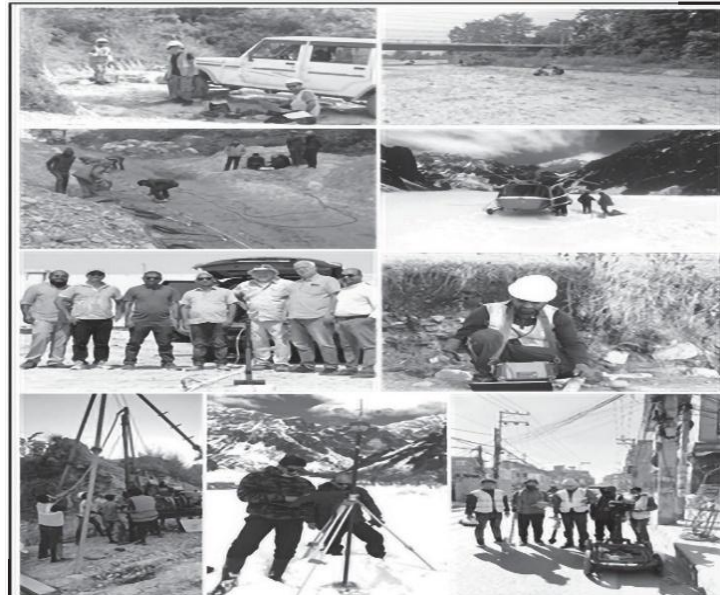
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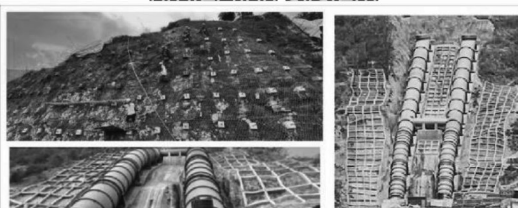
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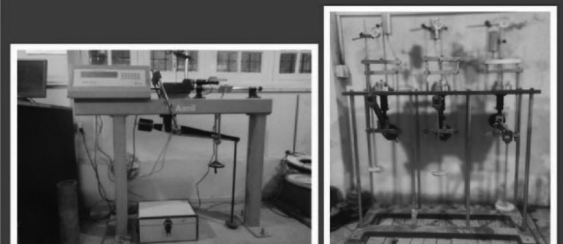
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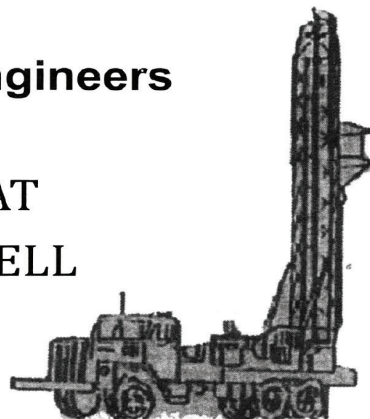


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अमृत खड्का
९८४३०५४६५८



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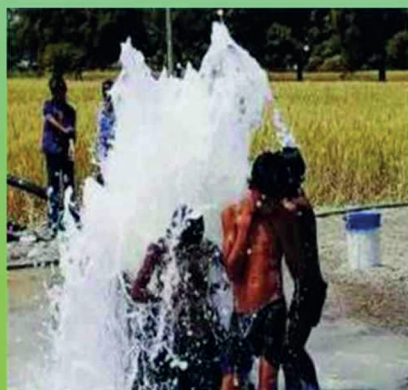
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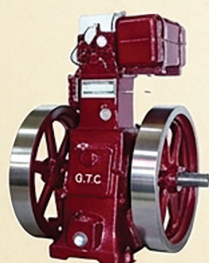
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ARTICLE SECTION

WATER WELL FAILURES IN DIRECT CIRCULATION MUD FLUSH ROTARY DRILLING

Causes, Field Experience & Preventive Measures

A Practical Guide for Hydrogeologists, Drilling Contractors and Groundwater Development Agencies

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ABSTRACT

This technical note comes from many years of planning, supervising, and evaluating water-well construction, mostly in the alluvial plains of Nepal. Over and over, field experience has shown that wells producing good discharge at the time of completion lose efficiency within a few years. In most cases, the aquifer was not to blame. The real causes lay in drilling practices and well completion.

Many of these problems begin during drilling but remain unnoticed until the well is already in service. An undersized mud pump, poor hole cleaning, the wrong bit, excessive rotary speed, poor drilling-fluid management, an improperly designed mud pit, and poor filter-pack placement may each appear to be minor shortcomings. Together, they can significantly reduce the working life of a well.

This technical note explains these failure mechanisms in simple engineering language and relates them to field conditions observed over many years. Rather than presenting new research, it brings together practical field experience and lessons learned from water-well construction. It is intended for hydrogeologists, drilling contractors, supervising engineers, project managers, and government agencies involved in groundwater development, with the hope that it will contribute to the construction of better and longer-lasting wells.

The scope of this technical note is limited to drilling practices and well completion. Well development, well design, filter-pack design and selection, and pumping tests are beyond its scope.

Keywords: *Well failures, mud flush, rotary drilling, well development*

INTRODUCTION

Direct circulation mud rotary drilling is the method most widely used for water wells in unconsolidated formations such as sand, gravel, and silt.

A new well that gives a strong discharge on the day it is completed is often assumed to be a good well. Field experience tells a different story. Many wells with excellent initial yields lose efficiency within a few years, and the cause is almost always something that happened during drilling, not in the aquifer.

Poor hole cleaning, careless drilling-fluid management, an undersized mud pump, excessive rotary speed, weak

well design, and insufficient development all lower a well's hydraulic efficiency from the day it is finished, even when nobody notices at the time. A well should therefore be judged by its performance over years, not only by its first pumping test.

FIELD EXPERIENCE

On many drilling projects in Nepal, rigs capable of reaching good depths were fitted with undersized mud pumps. Drilling was completed without difficulty, but poor hole cleaning reduced the long-term performance of the wells. In several cases, missing drill collars or spare parts further affected drilling quality.

1. Site Selection and Rig Package

Good well construction begins before the rig starts turning. Site selection should account for groundwater availability, expected geology, target aquifer depth, access for equipment, availability of drilling water, and adequate working space. A poorly chosen site complicates drilling, development, and later maintenance.

The rig itself should be selected to match the requirements of the well, not just its rated drilling depth or engine power. A complete drilling package needs a mud pump of adequate discharge and pressure, properly sized drill collars and drill pipe, essential spare parts for the mud pump, mud-testing equipment, and a properly designed mud pit. An undersized mud pump, in particular, leads to poor hole cleaning, excessive mud solids, a thicker filter cake, difficult well development, and reduced well efficiency: problems that surface later even if drilling itself goes smoothly.

2. Hole Cleaning: the Most Important Process in Water Well Drilling

Hole cleaning is one of the important processes in water-well drilling. Borehole stability, filter-cake formation, gravel placement, well development, and long-term performance all depend on how effectively cuttings are removed while drilling. Many problems that show up during development, or even a few years later, actually began with poor hole cleaning at the drilling stage.

As the bit cuts the formation, it produces cuttings continuously, and these must be removed from the bottom of the hole before the bit turns again. If they are not removed quickly, they accumulate beneath the bit, get crushed repeatedly instead of forming fresh cuttings, and turn into fine particles that overload the mud with solids and build a thick filter cake on the borehole wall. This chain of events begins within minutes of poor cleaning, but it may not become obvious until the well has been in service for a few years.

Engineering Principle: A drill bit should always cut new formation, not re-grind old cuttings. Every revolution should produce fresh cuttings while the drilling fluid carries the earlier cuttings to the surface.

If cuttings stay at the bottom, drilling efficiency drops and well quality starts to deteriorate, even though this is invisible at the time.

Annular Velocity (Up-hole Velocity)

Drilling fluid carries cuttings upward through the annular space between the drill pipe and the borehole wall. This upward speed is called the annular velocity, or up-hole velocity (UHV), and is calculated as:

$$\text{UHV (m/min)} = 1274 \times Q \text{ (L/min)} \div (D^2 - d^2)$$

where UHV = annular velocity (m/min), Q = pump discharge (L/min), D = borehole diameter (mm), d = drill pipe outside diameter (mm).

This equation makes an important point: as borehole diameter increases, the annular area increases rapidly, and if pump discharge stays the same, annular velocity falls. This is why a mud pump that works well for an 8½-inch pilot hole often becomes inadequate once the hole is reamed to 12¼, 14, or 17½ inches. Many drillers overlook this and keep drilling without reducing the rate of penetration or increasing pump capacity.

Slip Velocity

Every cutting tends to settle downward under gravity, at a rate called its slip velocity, which depends on particle size, particle density, mud density, and mud viscosity. Large gravel particles settle faster than fine sand; fine clay settles very slowly.

FIELD EXPERIENCE

This is probably the most common drilling problem observed on production wells in Nepal. Larger bit sizes are often selected for pilot-hole reaming without checking mud-pump capacity. Drilling continues, but the fluid no longer has enough velocity to lift coarse cuttings. Most of them settle back to the bottom or get re-ground into the fluid.

Good hole cleaning occurs only when annular velocity is greater than slip velocity. If the fluid moves upward faster than particles fall, cuttings reach the surface. If it moves slower than particles settle, cuttings stay in the hole, and that is where poor hole cleaning begins.

This relationship is often expressed as the Cutting Transport Ratio ($CTR = \text{annular velocity} \div \text{slip velocity}$). A CTR greater than 1 is needed to lift cuttings out of the hole, and higher values give more efficient hole cleaning.

What Happens When Hole Cleaning Becomes Poor

Cuttings settle near the bottom → the bit strikes the same cuttings repeatedly → coarse particles turn into fine ones → the mud becomes overloaded with fine solids → mud density rises → a thick filter cake forms → well development becomes difficult → the finished well has low hydraulic efficiency.

This sequence explains why many wells lose efficiency even when the aquifer itself is good.

Mud Pump Selection

Many contractors buy a rig capable of drilling deep boreholes but fit it with a mud pump that is too small for the job, or whose rated speed (the jack-shaft speed) is mismatched to the job. The result is lower annular velocity, poor bottom-hole cleaning, more fine solids in circulation, a thicker filter cake, longer development time, and lower well efficiency. For this reason, the mud pump is one of the most important components of the drilling system.

FIELD EXPERIENCE

A common response to slow drilling is to increase bit RPM. This may speed up penetration briefly, but it also produces more cuttings than the fluid can carry, and the mud quickly becomes overloaded with fine solids, making hole cleaning worse. The problem is hydraulic, not mechanical. A larger mud pump does not drill the hole faster; it drills the hole cleaner. A clean borehole is easier to develop, produces a thinner filter cake, accepts gravel more uniformly, and results in a more efficient well.

For water wells drilled with water-based mud: keep annular velocity between 15 and 40 m/min, measure actual pump discharge in the field rather than relying on the manufacturer's rated capacity, and recalculate annular velocity every time the hole diameter changes.

3. Mud Pit Design and Solids Control

Contractors often invest heavily in the drilling rig but pay comparatively little attention to the mud pit. In reality, the mud pit is one of the most important parts of the drilling system. A well-designed pit removes drilled solids from the circulating fluid so that relatively clean fluid returns to the pump. If the pit is too small or poorly designed, solids keep circulating, get carried back to the bottom of the hole, and are crushed again by the bit, adding more fine particles to the mud and, eventually, reducing well efficiency.

A properly designed mud pit lets solids settle, supplies cleaner fluid to the pump, helps keep mud properties stable, reduces pump wear, improves hole cleaning, and produces a thinner, more permeable filter cake. It should be treated as part of the drilling equipment, not just an excavation beside the rig.

Retention Time

The most important design parameter of a mud pit is retention time, the average time the fluid stays in the pit before returning to the pump. If retention time is too short, sand has too little time to settle, fine particles keep circulating, mud density gradually rises, the filter cake thickens, and hole cleaning suffers. For most water-well drilling, provide a minimum retention time of 30–40 minutes.

Example: If the mud pump delivers 300 L/min and the required retention time is 30 minutes, the required pit volume is $300 \times 30 = 9,000$ litres. A pit holding only 4,000 litres returns fluid to the pump before enough solids have settled.

Layout

A good mud pit should have several compartments connected in series. The first compartment, called the sampling pit, receives the drilling fluid directly from the borehole. Cutting samples are collected here for lithological logging. The fluid then flows into the larger second compartment, the settling pit, where most of the cuttings settle. As the flow slows further, even the finer particles settle before the fluid enters the final compartment. The suction pit, which is the final compartment, should contain the cleanest drilling fluid in the system, and the mud pump should draw fluid only from this pit.

FIELD EXPERIENCE

On many sites, only one shallow pit is excavated beside the rig, and fluid flows almost directly from the borehole to the pump without enough settling time. Drilling continues normally, but the same sand and fine particles circulate repeatedly, one of the main reasons for poor mud quality during drilling.

As a general guideline, the required pit volume should be divided into sampling pit : settling pit : suction pit = 10 : 60 : 30.

Example: If the required pit volume is 9,000 litres, the sampling pit should have a capacity of 900 litres, the settling pit 5,400 litres, and the suction pit 2,700 litres.

Sand Content

Sand content is the simplest and most useful field indicator of borehole condition, and should be checked regularly. As a guideline, sand content in the annulus should stay below 5%, and in the suction pit below 2%. If these limits are exceeded, reduce the rate of penetration, improve hole cleaning, and clean the mud pit before continuing.

FIELD EXPERIENCE

Many contractors add more bentonite whenever the mud becomes thick, assuming this will improve performance. In most cases the opposite is true: the real problem is excessive drilled solids, not too little bentonite. Adding more only raises viscosity and thickens the filter cake further. The correct fix is better solids removal, not more bentonite.

4. Drilling Fluid Properties and Mud Management

Drilling fluid, commonly called mud, removes cuttings, supports the borehole wall, cools and lubricates the bit, and forms a thin filter cake that limits fluid loss into the formation. It should be treated as an engineering material, with its key properties measured and controlled throughout drilling; poor mud management can reduce well efficiency even when drilling itself goes well.

Key Properties



SAND CONTENT KIT



Density provides hydrostatic pressure against the borehole wall. Too low, and the hole may collapse or formation water may enter; too high, and mud invades the aquifer, building a thick filter cake that makes development difficult. The rule is to use the lowest density that keeps the borehole stable.

Viscosity governs how well the fluid transports cuttings. Too low, and cuttings settle rapidly and hole cleaning suffers. Too high, and the filter cake thickens, pump pressure rises, and development takes longer. Higher viscosity does not always mean better drilling.

Gel strength keeps cuttings suspended when circulation stops. Too low, and cuttings settle fast, risking a stuck drill string when circulation resumes. Too high, and the fluid becomes hard to circulate, fine particles stay suspended instead of settling in the pit, and pump pressure rises unnecessarily.

Sand content, as noted above, indicates how much drilled material remains in the fluid; a high value means the mud pit is not removing solids effectively or the drilling rate is too fast.

The Filter Cake

A thin filter cake is desirable; a thick one is not. Its only purpose is to limit fluid loss and stabilize the borehole wall. A thick cake plugs aquifer pores, makes development harder, raises entrance losses, and lowers well efficiency. Many poorly performing wells can be traced to a thick filter cake that was not completely removed during well development.

FIELD EXPERIENCE

Many crews believe that any local clay can be used to make a good, thick drilling fluid. In practice, good mud comes from proper drilling-grade additives, not raw clay dug from the site.

Additives

Bentonite is the most common additive: it raises viscosity, improves borehole stability, forms the filter cake, and suspends cuttings. But excessive bentonite produces a thick cake that is hard to remove, so more bentonite does not necessarily mean a better well.

Barite raises mud density and should only be added when extra hydrostatic pressure is genuinely needed. For normal water-well drilling in unconsolidated alluvial formations, it is rarely required.

Polymer (CMC, carboxymethyl cellulose) promotes efficient cuttings transport, cause less formation damage, form a thinner filter cake, and dissolve more easily during development than bentonite-based drilling fluids. For these reasons, polymer-based fluids are often preferred within the producing aquifer.

The goal with any additive is not the thickest possible mud, but a fluid that cleans the borehole efficiently, keeps it stable, and can be removed easily during development.

5. Bit Selection, Rotary Speed, Weight on Bit and Rate of Penetration

The drill bit is the only part of the system that actually cuts the formation, and its performance depends on bit type together with three operating parameters: Weight on Bit (WOB), Rotary Speed (RPM), and Rate of Penetration (ROP). These must be balanced against drilling hydraulics; increasing RPM or drilling faster cannot make up for poor hole cleaning, and often makes the finished well worse.

Bit Selection

Drag bits work well in soft, very thick, uniform formations such as clay and fine sand, but are not suited to formations that change frequently with depth, as commonly happens in Terai alluvial deposits; under

these conditions they wear unevenly, produce crooked boreholes, and are more likely to regrind cuttings. Tricone (rock) bits are generally more suitable for water wells in these settings: they handle mixed formations better, produce straighter boreholes, maintain better hole geometry, and perform more reliably as geology changes. They cost more, but usually produce a better well.

Rotary Speed

RPM is easy to change and often misused. Many drillers raise it whenever drilling slows, which usually makes things worse: higher RPM produces cuttings faster than the fluid can remove them, so cuttings stay beneath the bit and get crushed repeatedly into fine particles. For water wells, keep RPM between 60 and 100, using lower values for larger bit diameters and reducing RPM as depth increases. Increasing RPM only increases the rate at which cuttings are produced. It does not improve the hydraulic capacity of the drilling fluid to transport them. If the additional cuttings cannot be carried to the surface, hole cleaning becomes poorer rather than drilling becoming more efficient.

Weight on Bit

WOB is the downward force on the bit. Too little reduces drilling efficiency; too much overloads the bit, increases wear, and can damage the borehole. In practice, though, this level of overload is rarely reached; most rigs simply cannot generate enough pull-down force to genuinely damage a properly sized bit. The correct value depends on bit diameter, bit type, formation hardness, and bottom-hole cleaning. Properly set, WOB lets the bit cut fresh formation without excessive vibration or grinding.

Rate of Penetration

Faster drilling is not always better. Every metre drilled produces a fixed volume of cuttings, and if drilling outpaces the fluid's transport capacity, cuttings accumulate in the annulus. Good drilling is not the fastest drilling; it is drilling at a rate that allows continuous cuttings removal. In practice, keep sand content below 5% in the annulus and 2% in the suction pit; if either is exceeded, reduce the penetration rate and improve circulation rather than simply raising RPM.

FIELD EXPERIENCE

Fast drilling is often seen as a sign of good performance. In reality, drilling too fast usually produces more cuttings than the mud system can carry, overloading the fluid with sand and reducing bottom-hole cleaning. The well may be finished quickly but perform poorly over its service life.

The Regrinding Cycle

Drilling seems slow → RPM is raised → more cuttings are produced than the pump can remove → cuttings stay beneath the bit and are ground repeatedly into fine particles.

From there, the sequence is the same one described under Hole Cleaning: rising fine solids, a thickening filter cake, harder development, and falling well efficiency. This cycle is behind many premature well failures.

6. Drill Collars and Bottom Hole Assembly

FIELD EXPERIENCE

On several projects, rigs capable of high hydraulic pull-down force (especially rotary-cum-DTH rigs) were run without enough drill collars. Drilling continued, but penetration was irregular, bit wear increased, and boreholes deviated more. After adequate collars were installed, drilling became smoother and more stable even with rotary speed unchanged, proof that correct weight distribution matters more than simply applying more force.

When a DTH-cum-rotary machine is used, drill rods intended for DTH drilling are sometimes used for direct rotary drilling as well. However, DTH and direct rotary drilling use different flushing methodologies. DTH drilling generally uses externally flushed drill rods, with flushing nozzles or ports at the tool joint, whereas direct rotary drilling uses internally flushed drill pipes, in which the drilling fluid flows through the pipe bore. Drill rods are intended for DTH drilling and drill pipes for rotary drilling. The difference is not merely nomenclature; the construction of DTH drill rods and rotary drill pipes is also fundamentally different.

The drill collar is a thick-walled, heavy steel pipe installed just above the bit. Its job is to supply the required Weight on Bit while keeping the drill pipe in tension, not to drill the hole itself. Without enough drill collars, the bit cannot cut efficiently no matter how powerful the rig is, and relying instead on the rig's hydraulic pull-down or on drill-pipe weight leads to inefficient drilling, excessive vibration, and poor borehole quality.

Drill pipe is built to transmit rotation, drilling fluid, and tensile load, not heavy compressive load. If WOB is applied through the drill pipe instead of the collars, the pipe can buckle, the borehole can go crooked, torque and vibration increase, bit performance drops, and pipe wear increases. Good practice keeps the drill pipe in tension and lets the collars supply WOB.

The number and size of collars needed depends on bit diameter, required WOB, borehole depth, and formation type; large production wells need heavier collars than small pilot holes. Beyond supplying WOB, collars also stabilize the borehole: their stiffness reduces drill-string vibration and lateral movement, helping keep the hole straight, which in turn simplifies casing installation, gravel packing, and development.

7. Formation Damage Mechanisms

Formation damage is any reduction in the aquifer's natural permeability caused during drilling and construction. A productive aquifer can permanently lose part of its hydraulic conductivity before the well is even finished, through several mechanisms:

- **Filter cake invasion:** fine clay particles invade aquifer pores, reducing permeability and raising entrance losses.
- **Mud solids invasion:** poor hole cleaning creates excess fine solids that migrate into the formation.
- **Clay swelling:** freshwater mud can hydrate expandable clay minerals, narrowing pore throats and lowering conductivity.
- **Particle migration:** high development velocities can mobilize fine particles that lodge deeper in the aquifer.
- **Biological plugging:** poor sanitation lets bacteria colonize the well, and biofilms clog pore spaces.

- **Chemical precipitation:** iron, manganese, and calcium carbonate can gradually clog the aquifer and screen openings.

These mechanisms link almost everything discussed earlier into one chain of cause and effect. Poor hole cleaning starts the same sequence described earlier (rising fine solids and a thickening filter cake), which then continues into the aquifer itself:

...thickening filter cake → formation invasion → reduced hydraulic conductivity of filter pack → difficult well development → lower specific capacity → premature well failure.

Prevention

Maintain adequate annular velocity, control mud properties, use low-solids drilling fluids in producing zones, minimize filter-cake thickness, develop the well thoroughly, and verify improvement using specific-capacity measurements.

8. Borehole Logging and Well Design

Borehole logging is one of the most important stages of construction; it provides the information needed to select screen intervals. Mistakes made here are difficult to correct once casing is installed.

Logging should measure the thickness of water-bearing zones, identify the zones with the highest conductivity within the aquifer, locate clay and silt layers, guide screen placement, and support filter-pack design. Geophysical logs should always be interpreted together with drilling records and lithological samples; neither should be relied upon alone.

Lithological samples, collected at regular depth intervals or whenever the formation changes, should be washed carefully and examined immediately. These samples provide valuable information about the subsurface formations. Poor or incomplete logging often results in screens being placed opposite clay layers, productive aquifers being left uncased, excessive sand production, and reduced well yield.

Screens should be set opposite the most productive and stable aquifer zones, avoiding clay, silt, and unstable

formations, with enough blank casing left between separate aquifers to limit vertical mixing. The gravel pack, the transition zone between aquifer and screen, should use gravel that is clean, well sorted, rounded, and properly sized for the aquifer material; a good pack keeps formation sand out, supports the borehole wall, reduces entrance losses, and improves well efficiency.

9. Borehole Conditioning, Well Completion and Well Development

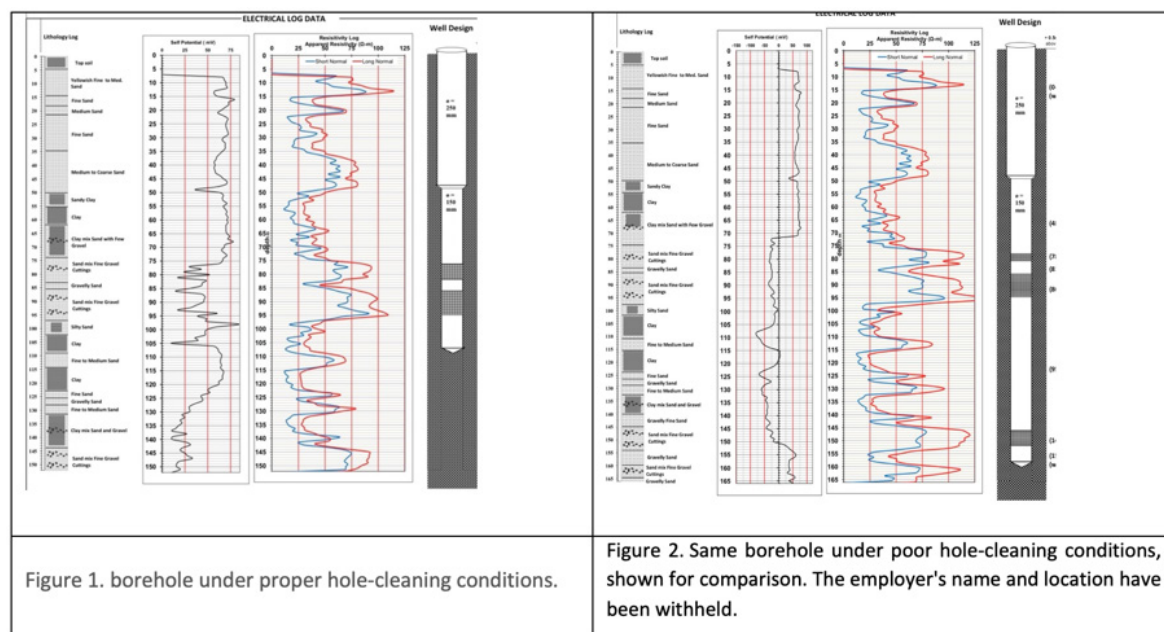
Reaching target depth completes the drilling, but not the well. Construction is finished only once the borehole is properly conditioned, the gravel pack correctly selected and placed, and the well thoroughly developed; these final steps largely decide the finished well's hydraulic efficiency.

Before lowering the casing and screens into the borehole, the proposed well assembly should be laid out on the ground in the exact order of installation. The length of each casing and screen should be measured and compared with the proposed well assembly drawing. Minor differences in length (a few millimetres or fractions of a centimetre) may be ignored but should be recorded so that the final well construction record is accurate. Each casing and screen should be numbered in the order of placement. Pipe No. 1 should be lowered first, followed by the remaining pipes in sequence. This simple procedure greatly reduces the chances of errors during installation.

FIELD EXPERIENCE

Many contractors stop development as soon as the water looks clear. Clear water alone does not mean the well is adequately developed; development should continue until sand production is negligible and specific capacity stops improving.

Before casing installation, remove any settled cuttings from the bottom of the borehole, condition the drilling fluid, stabilize the borehole, and confirm that the planned drilling depth has been reached. Skipping these steps often leads to bridging and uneven distribution of the filter pack during placement.



The filter-pack material should be placed slowly and continuously, preferably through a tremie pipe, with frequent checks of the gravel level to avoid segregation, bridging, and incomplete filling of the annular space. Poor filter-pack placement is one of the major causes of sand pumping in water wells.

Well development removes the filter cake, fine particles, residual drilling fluid, and formation damage caused during drilling. It should continue until the water runs clear, sand production becomes negligible, and specific capacity stabilizes; stopping early leaves the well partly clogged from the day it goes into service. Common methods include air lifting, surge-block development, mechanical surging, high-velocity jetting, and pumping; a combination usually gives the best result.

10. Practical Field Checklist for Water-Well Construction

For every production well:

Before Drilling

- Select the rig and complete drilling system for the final borehole diameter, not only drilling depth.
- Verify mud-pump capacity and measure actual discharge in the field.

- Check drill collars, drill pipe and other essential drilling equipment.
- Ensure mud-testing equipment and necessary spares are available.
- Confirm adequate mud-pit capacity and settling arrangements (30–40 minutes retention time, with suction drawn only from the final compartment).

During Drilling

- Maintain adequate annular velocity (15–40 m/min) and recalculate it whenever borehole diameter changes.
- Ensure the bit cuts fresh formation rather than regrinding settled cuttings.
- Monitor mud density, viscosity, gel strength and sand content.
- Keep sand content below 5% in the annulus and 2% in the suction pit.
- Control ROP according to cuttings-transport capacity rather than drilling speed alone.
- Do not increase RPM simply to compensate for poor hole cleaning; keep RPM moderate (60–100), lower for larger bits and greater depths.
- Use drill collars to provide WOB and keep drill pipe predominantly in tension.

- Monitor hole-cleaning performance continuously.

Borehole Logging, Well Design and Completion

- Maintain complete drilling records and lithological logs.
- Interpret lithological and geophysical information together.
- Confirm screen intervals from the identified productive and stable aquifer zones.
- Avoid placing screens opposite clay, silt or unstable formations.
- Verify casing and screen lengths and installation sequence before lowering them.
- Condition the borehole before casing and screen installation.
- Place gravel slowly and continuously and check for bridging or incomplete filling.

Well Development and Verification

- Develop the well thoroughly to remove filter cake, residual drilling fluid and formation fines.
- Do not stop development merely because the water appears clear.
- Continue until sand production becomes negligible and specific capacity stabilizes.
- Record discharge, drawdown, turbidity and sand content during development.
- Confirm improvement using specific-capacity measurements.

Conclusions

A water well is a long-term engineering asset. Its performance depends not only on the aquifer but on the quality of its construction. Successful wells come from careful planning, sound drilling hydraulics, effective hole cleaning, good drilling-fluid management, accurate well design, and thorough development. Every stage of construction influences the next, and shortcomings introduced during drilling usually remain with the well throughout its service life.

By following the engineering principles and practical recommendations in this publication, hydrogeologists, drilling contractors, and supervising engineers can reduce premature well failures, improve well efficiency, and extend the productive life of water wells.

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SPRINGS OF NEPAL: WHY ARE THEY DRYING UP?

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ABSTRACT

Springs are the lifeline of Nepal's hills and mountains, where nearly 90% of the rural population depends directly on them for drinking water, irrigation, and domestic use. This article synthesizes current understanding of why springs across Nepal are drying up, drawing on hydrogeological principles, field observation, and secondary literature. It examines the different types of springs found across Nepal's physiographic regions, the geological and land-use factors that control their occurrence, and the combined role of deforestation, unplanned urbanization, infrastructure development, groundwater overuse, and climate change in reducing spring discharge. The article further discusses how the 2015 Gorkha earthquake altered subsurface flow paths in parts of the mid-hills, disrupting long-standing spring systems. Impacts on drinking water security, agriculture, women and children's workload, public health, and local ecosystems are outlined, followed by practical, community-centered conservation measures. The article concludes that reviving Nepal's springs requires coordinated scientific monitoring, spring-shed protection, and, above all, active participation of local communities.

1. Introduction

"Pani Khanu Mul, ko Jodi Rojnu kul ko" so goes an old Nepali saying, reflecting the deep, generations-old reliance of Nepali communities on spring water. A spring is a natural point where groundwater discharges at or near the Earth's surface, forming a visible flow. It occurs when the underground water table intersects the ground surface, or when sufficient hydraulic pressure pushes water upward through overlying rock and soil.

Springs represent that portion of precipitation which infiltrates the ground and percolates downward through unconsolidated sediments and bedrock openings until it reaches the water table. Their emergence at the surface is governed by two broad categories of discharge mechanisms: those driven by gravitational forces and those governed by non-gravitational forces. The location, yield, and behavior of a spring in any given area are shaped by a combination of geology, geomorphology, soil composition, rock type, and geological structures, among other factors.

Across the hills and mountains of Nepal, springs are far more than a hydrological curiosity they are the primary and often the only reliable source of fresh water. Groundwater, defined as water present below

the water table in the zone of saturation, is one of the country's most heavily utilized natural resources. In the Himalayan region specifically, springs sustain both highland and lowland communities alike, meeting drinking, irrigation, and domestic needs. It is estimated that nearly 90% of the population in Nepal's hilly and mountainous regions depends directly on springs for their water supply. Yet in recent years, many of these springs have begun to dry up or show a marked decline in discharge, triggering water shortages across numerous hill and mountain communities that have depended on them for generations. What was once considered a dependable, perennial resource is now, in many villages, an increasingly uncertain one raising urgent questions about what is driving this change, and what it means for the future of water security in Nepal's highlands.

2. Scope of the Article

This article takes a national-level view of spring drying, covering Nepal's three broad physiographic settings the Siwalik (Churia) hills, the Middle Hills (Mahabharat range and Lesser Himalaya), and the High Mountains as well as rapidly urbanizing valley towns. It draws together hydrogeological principles, patterns reported in field studies and community consultations,

and observations following major disturbance events such as the 2015 Gorkha earthquake. The intent is to present, in accessible language, why springs behave differently across these landscapes, what is driving their decline, what this means for the communities and ecosystems that depend on them, and what practical steps can support their revival.

3. Types of Springs and Their Geographical/Geological Setting

Not all springs behave the same way, because they are fed by different subsurface pathways. Broadly, four types are commonly recognized in Nepal's terrain, each associated with particular geological conditions and regions:

Spring Type	Geological Setting	Common in Nepal	Vulnerability to Drying
Depression (water-table) springs	Water table intersects a low point in the land surface	River valleys, terraced mid-hill slopes	High — sensitive to seasonal rainfall and land-use change
Contact springs	Permeable layer overlying an impermeable layer forces water to emerge along the contact	Siwalik and Mahabharat foothills	High — disturbed easily by excavation, road-cutting
Fracture / fault springs	Water travels along joints, fractures, or fault planes (e.g. near MBT, MCT)	Lesser Himalaya, mid-hills, tectonically active zones	Very high — flow paths can shift after seismic activity
Artesian / confined springs	Water under pressure in a confined aquifer rises to the surface	Scattered, deeper valley and basin settings	Moderate — more stable but vulnerable to deep extraction

Field reports and community observations suggest that contact springs and fracture/fault springs in the Siwalik and Middle Hills are drying most visibly, largely because these are also the zones facing the heaviest deforestation, road-cutting, and settlement expansion. High-mountain springs, though comparatively less disturbed by construction, are increasingly affected by changing snowmelt timing and glacial retreat, which alter the seasonal rhythm of recharge even where the source itself has not disappeared.

Hot spring within the Himalaya

Alongside the cold-water springs discussed above, Nepal is also home to numerous hot springs, locally known as *tatopani*. These form when groundwater percolates deep along fault planes and fractures often associated with major tectonic structures such as the Main Central Thrust (MCT) where it is heated by the Earth's natural geothermal gradient before rising back to the surface along the same fracture pathways. Their locations are therefore not random: hot springs are geological markers of active or historically active

fault zones, and their distribution helps geologists trace subsurface fault structures across the Himalaya. Well-known examples include Tatopani (Myagdi), Jhinu Danda (Annapurna region), Chandeswari, and Gorkha's Tatopani, all of which lie along or near major thrust systems. Beyond their scientific value, these hot springs hold cultural and religious significance, and support local tourism-based livelihoods.

4. Causes of Spring Drying

Several interlinked factors are responsible for the drying up of springs across Nepal, though their relative importance differs between urban and hilly areas. In rapidly growing towns and cities, the dominant cause is land-use change: as open ground is paved over with concrete, roads, and buildings, rainwater can no longer seep into the soil and recharge the groundwater beneath. This loss of open, permeable surface area means that even normal rainfall increasingly runs off instead of infiltrating underground, starving nearby springs of the water they depend on.

In the hills and mountains, by contrast, the picture is shaped more strongly by deforestation and climate change. The clearing of forests removes the vegetation cover and root systems that would otherwise slow rainwater and allow it to soak into the ground, while shifting rainfall patterns including delayed monsoons, more intense but shorter bursts of rain, and longer dry spells reduce the steady, gradual infiltration that springs

need to stay recharged. Other contributing factors, present in both settings to varying degrees, include rapid and often poorly planned road construction and infrastructure development, which can disturb underground water flow paths, and the overuse of groundwater through excessive extraction, which lowers water tables faster than they can naturally replenish.

Setting	Primary Cause	Secondary Contributing Factors
Urban / peri-urban areas	Concretization — loss of open, permeable recharge surface	Road construction, groundwater overextraction
Hills and mountains	Deforestation and shifting rainfall patterns (climate change)	Road-cutting, land-use change, seismic disturbance

Taken together, these factors are pushing many of Nepal's springs toward decline, with urban concretization and hill-region deforestation and climate variability standing out as the two most significant drivers in their respective landscapes.

5. Why Springs Matter — and Their Link to Climate Change and Disasters

Springs are not only a water source; they are an indicator of the health of the wider landscape. Their discharge reflects the cumulative condition of forests, soils, and rainfall in the surrounding recharge area, which makes them an early and sensitive signal of environmental change.

Global climate change is altering the timing, intensity, and distribution of the monsoon across the Himalaya, along with accelerating glacial retreat in the high mountains. These large-scale shifts filter down into local hydrology as delayed monsoon onset, shorter but more intense rainfall events, and longer dry seasons conditions that reduce the slow, steady infiltration that most springs depend on. Locally, land-use decisions such as deforestation, road construction, and unplanned settlement expansion compound these global trends by degrading the immediate recharge zones that feed individual springs.



Fig. 1: Springs at Sipapokhare VDC, Sindhupalchok District, showing post-earthquake changes in discharge. Source: ICIMOD

Disasters add a further layer of disruption. The 2015 Gorkha earthquake is widely reported to have altered subsurface fracture and fault patterns across parts of the mid-hills, in some cases causing established springs to dry up abruptly while new springs emerged elsewhere as underground flow paths shifted. Post-earthquake landslides and ground fissures have also disturbed recharge areas in several districts, illustrating how seismic events can reshape a community's water security within moments, with effects that may persist for years. Together, these global and local pressures show that protecting springs cannot be separated from broader efforts on climate adaptation and disaster resilience.

6. Impacts on Communities

The drying up of springs has far-reaching consequences for the communities that depend on them, touching nearly every aspect of daily life. The most immediate impact is on drinking water supply, as households that once relied on a steady, nearby spring must now search for alternative sources, often traveling much farther or paying for water they previously received for free. Agriculture and livestock rearing, both central to hill and mountain livelihoods, also suffer, as irrigation becomes unreliable and livestock struggle to find adequate drinking water, threatening crop yields and household income alike. The burden of this change falls disproportionately on women and children, who are traditionally responsible for fetching water in most Nepali communities; as nearby springs dry up, they are forced to walk longer distances over difficult terrain, spending hours each day on a task that leaves less time for schooling, income-generating work, or rest, and can affect their overall health and wellbeing.



Fig. 2: Women/children collecting water, or a dried-up spring source

Public health and sanitation are affected as well, since reduced water availability makes it harder for families to maintain basic hygiene, increasing the risk of waterborne and sanitation-related illnesses. Finally, local ecosystems that depend on spring-fed streams and wetlands including forests, wildlife, and downstream agricultural systems face degradation, disrupting the delicate ecological balance that has sustained these landscapes for generations.

7. What Can Be Done? Conservation Measures

Reversing the decline of Nepal's springs requires a combination of scientific understanding and community action, rather than any single fix. Protecting spring recharge areas, the upslope zones where rainwater infiltrates the ground before eventually emerging as spring flow is a foundational step, as disturbing these areas through construction, quarrying, or unplanned land-use change can cut off a spring's water source entirely. Closely linked to this is the need to plant trees and conserve existing forest cover, since forested land absorbs and retains rainwater far more effectively than bare or degraded slopes, allowing it to percolate slowly into the ground rather than running off the surface.

At the household and community level, promoting rainwater harvesting can ease pressure on natural sources by capturing rain for direct use, while the construction of recharge ponds and infiltration trenches in strategically chosen locations can actively direct rainwater back into the ground, replenishing the aquifers that feed local springs. Underpinning all of these efforts is the need for scientific spring mapping and monitoring, which helps identify a spring's recharge area, discharge patterns, and vulnerability, allowing interventions to be targeted where they will have the greatest impact. Ultimately, though, none of these measures can succeed without strong community

participation in spring conservation, since it is local communities who best understand their landscape, depend most directly on its springs, and must sustain any conservation effort over the long term for it to remain effective.

8. Results and Discussion

Bringing these strands together, three broad patterns emerge.

- Spring drying in Nepal is not a single phenomenon but a regionally differentiated one: urban and peri-urban springs decline mainly due to concretization and loss of recharge surface, while hill and mountain springs decline mainly due to deforestation, changing rainfall patterns, and, in places, earthquake-related disturbance of subsurface flow paths.
- Certain spring types particularly contact springs and fracture/fault springs common in the Siwalik and Middle Hills appear disproportionately vulnerable, since they depend on relatively shallow, easily disturbed flow pathways.
- The consequences of drying extend well beyond water supply itself, cutting into agriculture, public health, gender equity, and ecosystem stability, which underscores why spring conservation deserves attention as a cross-cutting development priority rather than a narrowly technical issue.

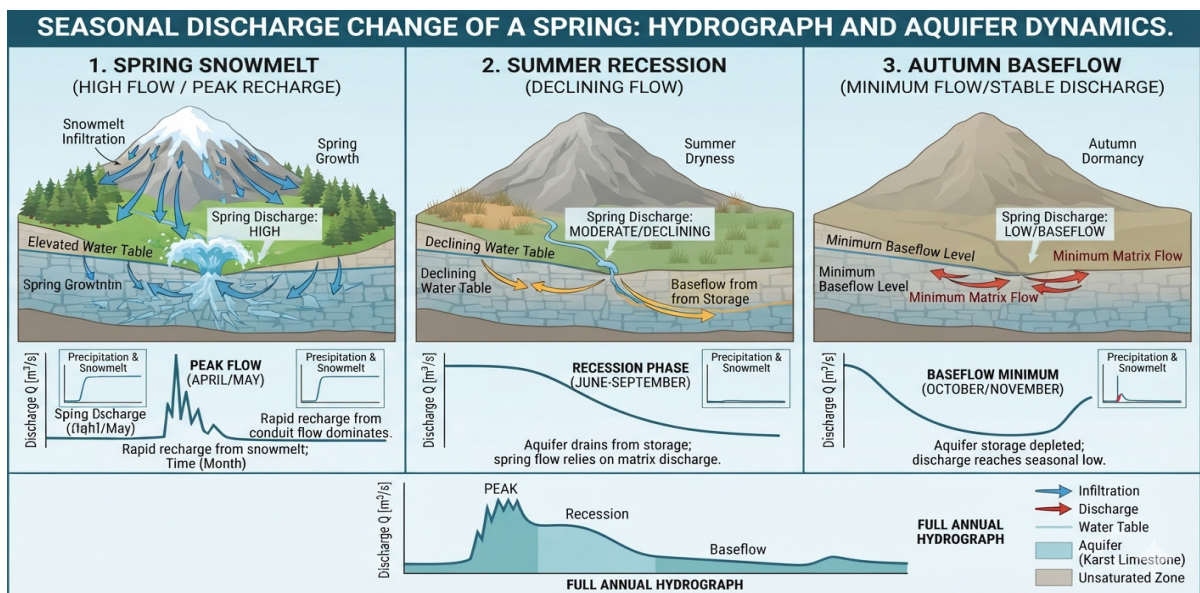


Fig. 3: Infographic illustrating the three seasonal phases of spring discharge and aquifer dynamics over a full annual hydrograph. (Source: Google image)

A recurring limitation is the lack of a comprehensive, up-to-date national inventory of spring discharge, type, and status. Strengthening systematic, long-term spring monitoring potentially through partnerships between local governments, research institutions, and community spring-users' groups would substantially improve the ability to target conservation interventions where they are most needed.

9. Conclusions

Springs remain one of Nepal's most valuable natural water resources, sustaining millions of lives across the hills and mountains where no other reliable alternative exists. Yet their steady decline driven by deforestation, climate change, unplanned urbanization, and overextraction threatens the very foundation of rural water security. The path forward lies not in any single solution, but in a combined effort: protecting and restoring forest cover, managing groundwater resources wisely and sustainably, and, above all, involving local communities as active stewards of their own water sources. With coordinated action today, Nepal's springs can be revived and safeguarded, securing water for generations yet to come.

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INVENTORY AND PRESENT STATUS OF FREE-FLOWING ARTESIAN TUBEWELLS IN THE WESTERN TERAI OF NEPAL: EVIDENCE FROM BANKE AND BARDIYA, DISTRICTS

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ABSTRACT

Flowing artesian tubewells are a familiar but poorly documented feature of Nepal's Terai plain, where confined-aquifer pressure occasionally pushes groundwater to the surface without pumping. Left uncapped, such wells wastewater, waterlog the surrounding land, and in some cases eventually lose their flow altogether. This paper compiles and interprets a field and secondary-data inventory of flowing deep across two districts Banke & Bardiya. GPS referenced field visits, cross checked against departmental irrigation records and mapped in a GIS, documented several dozen individually described flowing wells together discharges ranging from well under 1 liter per second to about 20 liters per second. Applying a three-tier classification wells that have already stopped flowing, wells with modest and locally useful discharge, and wells with strong, largely unregulated flow shows a recurring pattern across these districts with usable well-level data: a substantial share of wells recorded as flowing at the time of drilling, in some cases decades earlier, had slowed markedly or stopped altogether by the time of the survey, while a smaller number continue to discharge at rates that justify a regulating valve. The findings support capping high-discharge wells, leaving moderate-discharge wells in local use, and folding tubewell status into a standing, GIS-linked groundwater monitoring record rather than treating the inventory as a one-off exercise.

Keywords: *Artesian tubewell, free-flowing well, Terai aquifer, groundwater inventory, Nepal, GIS*

1. Introduction

In number of places worldwide, groundwater is being drawn down faster than it recharges. In some parts of the Kathmandu Valley, groundwater levels have been dropping for many years. This is a result of groundwater being pumped out while not enough is being replaced through natural recharge.

Numerous tubewells across the plains are flowing without a pump, because they tap a confined aquifer under enough pressure to push water above the surface. These free-flowing, or artesian, wells are common enough that they rarely draw attention until a field turns to swamp because the discharge has nowhere planned to go, or a well that supplied a household for years stops flowing with no obvious explanation.

A free-flowing well is not, in practice, a free resource. Uncapped discharge waterlogs the surrounding land,

and over time, unregulated loss of pressure can shorten the useful life of the aquifer zone the well taps water and pressure that a future user, or the same user's neighbor, might otherwise have drawn on. Agencies responsible for irrigation and groundwater management have a direct stake in knowing where these wells sit, not simply to record curiosity but to decide, well by well, whether it should be capped, left alone, or investigated for possible rehabilitation.

This paper draws on an inventory of flowing tubewells across the Banke and Bardiya districts, originally prepared by the Groundwater Division of the Department of Irrigation (DOI) and updated with data from the Groundwater Irrigation Development Division in Nepalgunj. The inventory was undertaken to locate deep tubewells drilled for irrigation, drinking water, or investigation and to compile their details in a district-level geographic information system (GIS) database for future planning. The present paper reorganizes and

re-examine checks inventory as a research contribution rather than a project deliverable: it synthesizes the well-level findings into a consistent classification, checks the underlying records against one another, and draws out what the pattern of flowing and now-quiet wells implies for aquifer condition and for management.

The distinction between an “inventory” and a “survey” is worth a sentence here, since the underlying fieldwork used both terms loosely. The U.S. Fish and Wildlife Service treats inventory as a survey conducted to determine the presence, relative abundance, status and distribution of a resource at a particular point in time (USFWS, Policy on Inventory and Monitoring, 701 FW 2). Other authors draw a sharper line between the two activities (Elzinga et al., 1998; Pokorny et al., 2006), though both agree that either exercise fixes the location and condition of a resource as of one survey period rather than tracking it continuously.

2. Study Area

The study covers two districts of Nepal's western part, Banke and Bardiya (Fig. 1). These two districts sit along the Nepal–India border and share the broad Terai hydrogeological setting, a belt of Quaternary alluvium banked against the Siwalik (Churia) hills to the north, thickening southward toward the Gangetic plain.

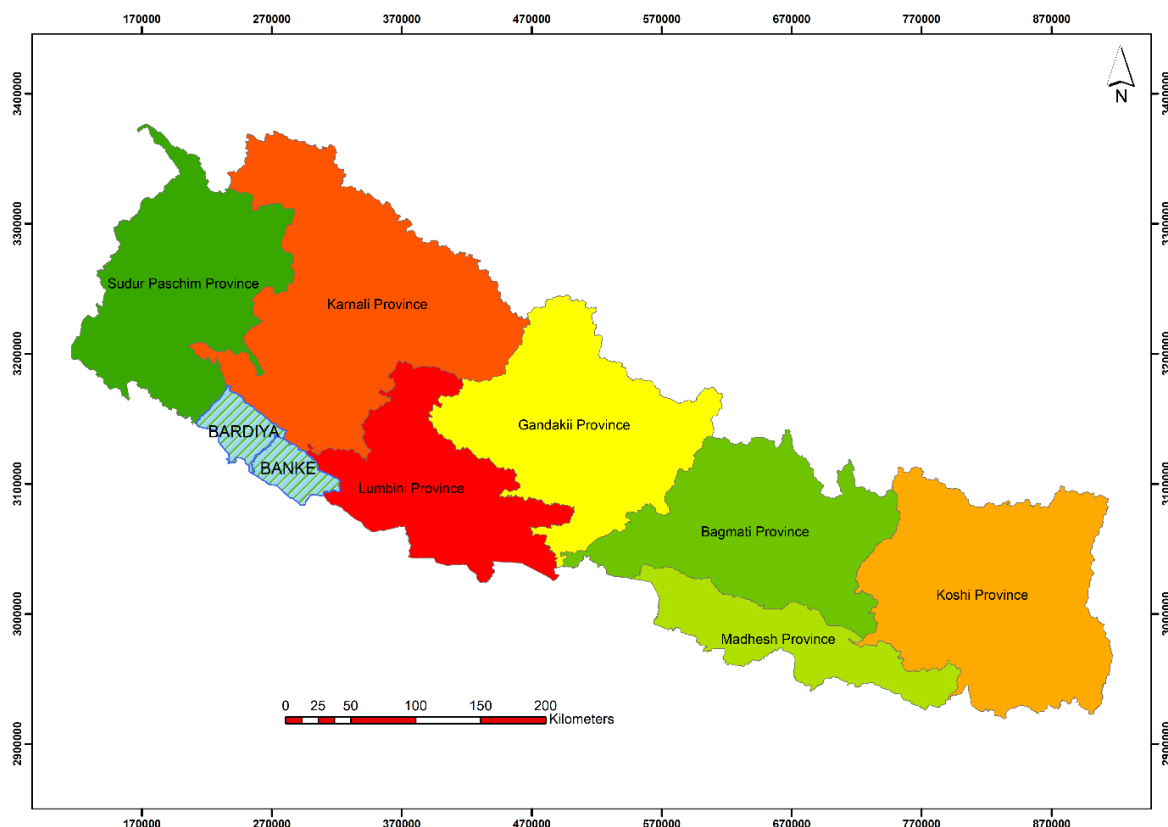


Fig. 1: Location of the study districts.

Banke, drained mainly by the West Rapti River with the Babai River forming much of its western boundary, lies adjacent to the Churia Hills. In Banke, the land changes from the coarse Bhabar–Churia zone in the north to the flat alluvial plains of the Terai in the south. The aquifers generally become thicker towards the southern part of the district. Bardiya is drained by the Karnali, Babai and Geruwa rivers. The district has a thick and continuous aquifer made up of connected layers of sand, gravel and pebbles.

Table 1. Basic profile of the study districts.

District	Area (km ²)	Population (2021 census)	Headquarters	Major rivers
Banke	2,337	603194	Nepalgunj	West Rapti, Babai
Bardiya	2,025	459900	Gulariya	Karnali, Babai, Geruwa

3. Materials and Methods

The inventory was prepared mainly from secondary information available at the Ground Water Irrigation Development Division (GWIDD), Nepalgunj and Department of Irrigation. Collected and reviewed available records includes topographic, geological, land-use, and hydrogeological maps, and well construction records. These existing documents provided the foundation for the inventory and helped identify the sites that required field verification.

After the desk review, wells listed in the departmental records were visited to check their present condition and collect any missing or revised data. The physical condition of the well was also observed, and free-flow discharge was measured wherever possible. If a well was capped, damaged, or inaccessible, discharge information was collected from local users and compared with departmental records to ensure that the information was as reliable as possible. Finally, all information was entered into a Geographic Information System (GIS) to prepare district-level well location maps and finalize the inventory.

For interpretation, individual flowing wells are grouped into three condition categories, following the classification scheme used in the original departmental study:

Category I — wells that flowed at some point (often at installation) but showed no free flow at the time of the survey;

Category II — wells flowing at a modest, locally useful rate, taken here as roughly 0.5 to under 5 litres per second;

Category III — wells flowing at 5 litres per second or more, a rate large enough that unregulated discharge represents a meaningful and largely unused loss.

These thresholds are approximate rather than hydraulically derived, they follow the practical

distinction the original survey drew between wells worth leaving alone, wells worth capping, and wells already beyond the point of concern and are applied here only to wells for which the source material gives a specific discharge figure or an unambiguous qualitative status.

4. Results

4.1 Banke District

Banke falls hydrogeologically within the Terai (Indo-Gangetic alluvial) belt directly south of the Churia hills. Three aquifer zones are recognized in departmental hydrogeological mapping: a northern alluvium in the Bhabar zone (transmissivity roughly 230–3,050 m²/day, specific capacity around 3.6 L/s per metre of drawdown), a Gangetic alluvium further south with the highest recorded transmissivity (510–1,640 m²/day, specific capacity around 3.8 L/s/m) and the district's greatest groundwater potential along the Nepal–India border, and a central Churia formation of comparatively low potential (transmissivity around 210 m²/day, well yield around 28 L/s). The Churia basement sits at shallow depth across much of the central district, which limits aquifer thickness away from the southern border strip.

Available irrigation records list 113 deep tubewells developed for irrigation in Banke as of fiscal year 2082/83, together covering roughly 2260 hectares of command area. Of the 11 individually recorded flowing tubewells (Table 2), eight were flowing at the time of the field survey, with discharge from roughly 0.5 L/s at the weaker Bankatuwa-area wells up to about 10 L/s at Udain; three including a well at Kohalpur and one at Mahadevpuri had already stopped. A separate cluster of roughly a dozen shallow tubewells around Naubasta, each discharging on the order of 2 L/s, was reported by local users to run dry seasonally, typically by May or June, and is not itemized individually in Table 2.

Table 2. Individually recorded flowing tubewells, Banke District.

Well / location	Drilled depth (m)	Diameter (mm)	Free flow (L/s)	Status at survey
1/8, Udain (Buchapur)	184.5	150/150	10.6	Flowing
2/11, Kohalpur	457.5	150/150	no measurable flow at survey	not flowing
Golcha Housing Complex, Ram Nagar-8	200	200/200	5	Flowing
Kohalpur Medical College	200	200/200	>5	Flowing
BK-3, Bankatuwa	53	100	1	flowing (weak)
BK-4, Channahawa	50	100	1	flowing (weak)
BK-5, Thapawa	42	100	0.5	flowing (weak)
BK-20, Mahadevpuri	65	100	0	not flowing
Naubasta-8, Baniyabhar	50.3	100	2.5	Flowing
Naubasta-2 (private), Pitmari	36.5	100	up to 10	Flowing

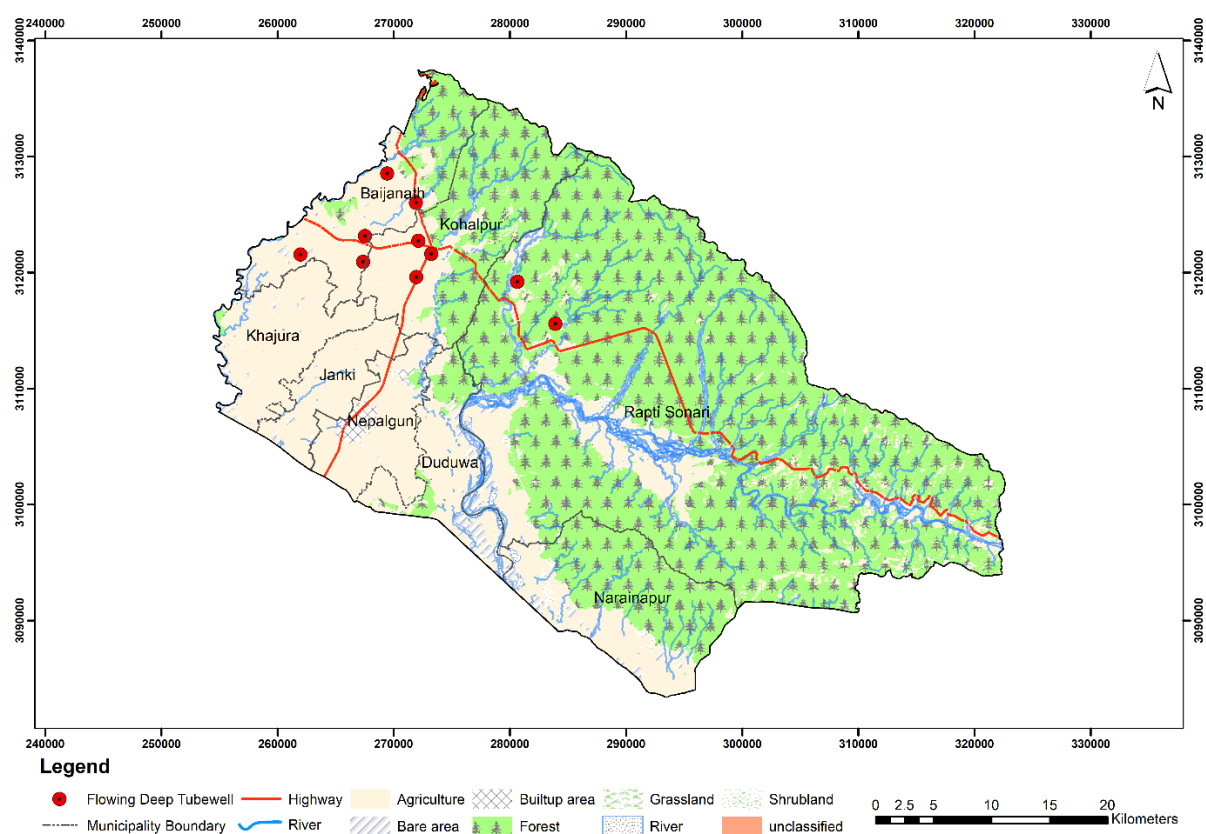


Fig. 2: Location of flowing tubewells in Banke district

4.2 Bardiya District

The aquifer systems in Bardia are an indeterminate stack of interconnected sand, gravel and pebble lenses intercalated with silt and clay with transmissivity reported across a wide range (roughly 200–8,000 m²/day). Static water levels in shallow tubewells vary from about 0.5 to 15 m below ground.

Seventy-seven deep tubewells were recorded for irrigation in Bardiya as of fiscal year 2082/83, covering about 1540 hectares. Only six flowing wells carry full technical detail in the departmental record (Table 3), and the record itself is not fully consistent: the summary table lists small positive free-flow values for the Thumini, Samaj Sudhar, Madaha and Jabdahawa wells (0.5 and 2.5 L/s respectively), while the accompanying field narrative describes both as having already stopped flowing by the time of the visit. That contradiction is reproduced in Table 3 rather than resolved, since the original source gives no basis for preferring one figure over the other; either the table records a historical value while the narrative reflects the moment of the visit, or one of the two was transcribed in error. Beyond these four wells, the field narrative also reports roughly ten shallow tubewells flowing at about 2 L/s each around Belwa-7, and a further eleven near Ranjha — drilled about a decade before the survey with support from CARE Nepal — flowing at around 5 L/s and serving as the area's only irrigation source.

Table 3. Individually recorded flowing tubewells, Bardiya District.

Well / location	Drilled depth (m)	Diameter (mm)	Free flow (L/s)	Status at survey
3/8, Madaha	305	150/150	0.5	Inconsistent
5/5, Jabdahawa	93.6	150/150	0.25	inconsistent
BD-1, Betahni (private)	40	100	2.5	Flowing
Pvt-1, Ranjha, Belwa-7	33.5	100	7	Flowing
Bansgadhi 8, Bathuwa	133		2.5	Flowing
Thumini, Bansgadhi 9	140	250/150	2	Flowing

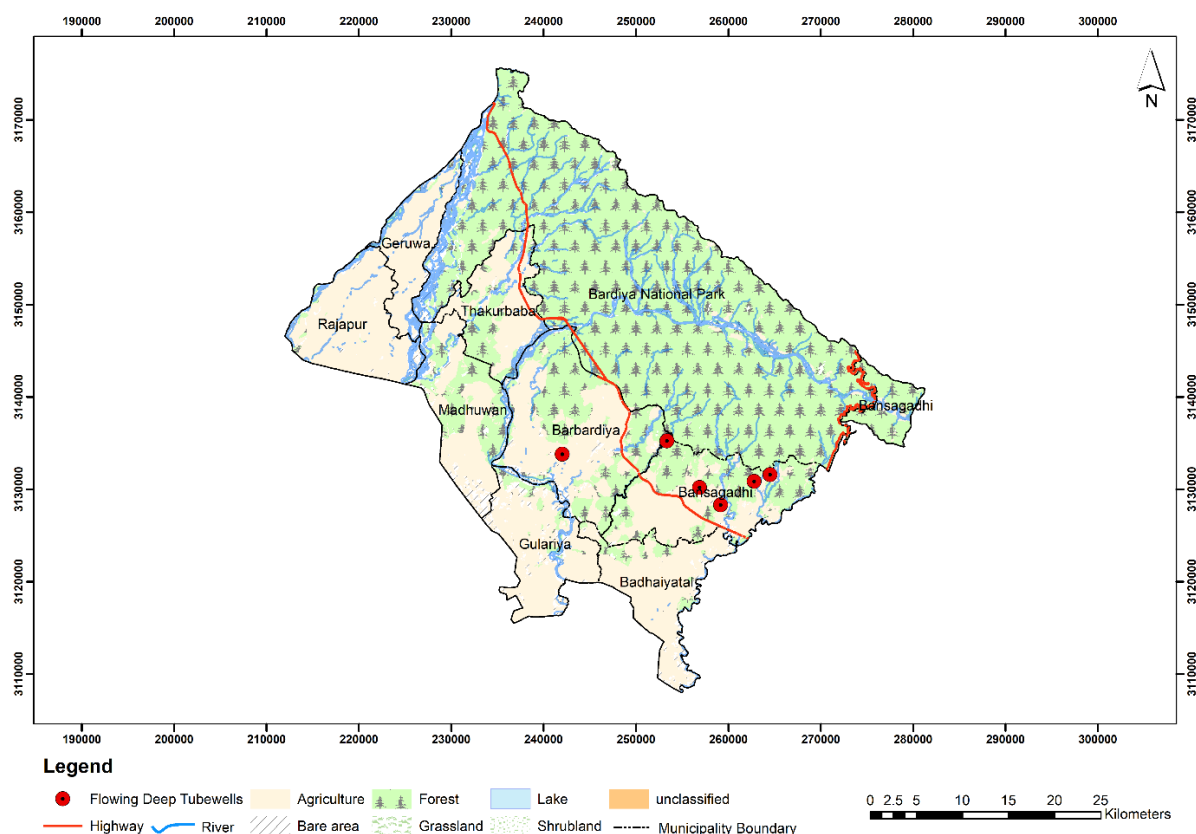


Fig. 3: Location of flowing tubewells in Bardiya district

4.5 Synthesis across districts

Table 4 draws together the three-tier classification from Section 3 for the wells in Banke and Bardiya where the source material gives an unambiguous current and the handful of Bardiya wells with directly conflicting table and narrative entries (Section 4.2), which are reported separately above rather than forced into a single category. Read across the three districts, the pattern is consistent: a meaningful minority of wells recorded as flowing — sometimes decades earlier — had stopped by the time of the survey, a smaller set continue at a modest rate that local users already rely on.

Table 5. Approximate distribution of flowing wells by condition category, Banke and Bardiya districts.

District	Category I — no longer flowing	Category II — 0.5–<5 L/s	Category III — ≥5 L/s
Banke	2	6	2
Bardiya	0	5	1

5. Discussion

These tubewells flow naturally because they tap a confined aquifer that is under sufficient hydraulic pressure. The aquifer is recharged mainly in the higher areas. This creates pressure within the aquifer. When a tubewell is drilled into the confined aquifer, the groundwater rises inside the well due to this pressure. If the water level, or potentiometric level, rises above the ground surface, water comes out of the well naturally without pumping. Such wells are known as flowing artesian tubewells. In simple terms, the natural flow occurs when the hydraulic head in the confined aquifer is higher than the ground elevation at the well site. The flow continues as long as sufficient pressure is maintained in the aquifer.

A substantial fraction of the wells recorded as flowing at the time of drilling, no longer flow. This pattern is evident in both study districts. In Banke, three of the ten individually documented wells had ceased flowing by the time of the survey. Although the evidence points to a decline in the number of active flowing wells, the reasons are not always clear. A well that no longer flows is not necessarily evidence of declining confined aquifer pressure but mechanical failure, wellhead damage, or blockage can also interrupt free flow. Because the present inventory represents a single visit to each site rather than repeated monitoring over time, it cannot reliably distinguish between hydraulic decline and well-specific mechanical problems. The inventory should therefore be regarded as the starting point for long-term monitoring rather than a definitive assessment of aquifer condition. The flowing tubewells located in both districts, categorized according to their respective free flow, are presented in the figure 4.

The three-tier classification adopted in Section 3 provides a practical framework for prioritizing management actions. Most of the wells that continue to flow in both Banke and Bardiya fall within the moderate-discharge category, supplying water at rates that are already incorporated into local domestic use or small scale irrigation. Closing or capping these wells would remove a useful local resource while recovering relatively little additional water. By contrast, a smaller number of high-discharge wells—particularly those exceeding 5 L/s, including the Udain and private Naubasta wells in Banke and the Belwa-7 well in Bardiya continue to discharge substantial volumes of water with limited evidence of active regulation. These wells represent the greatest opportunity for reducing unnecessary water loss through the installation of appropriately sized regulating valves or flanges, an approach consistent with the recommendations contained in the original departmental inventory.

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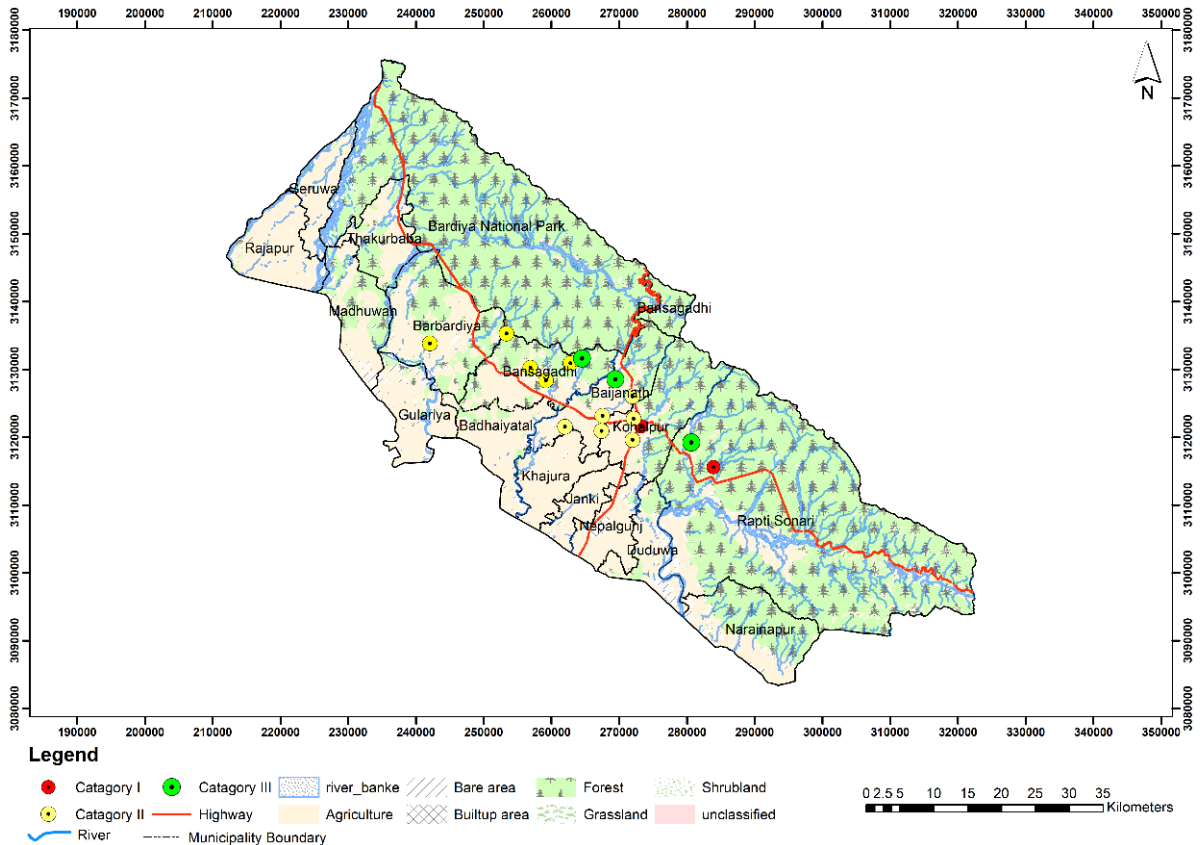


Fig. 4: Map showing Categorized Location of flowing tubewells in Banke & Bardiya

A second theme appearing from the study concerns the quality and consistency of the underlying records. More broadly, the inventory demonstrates that groundwater information remains fragmented between district offices and central departmental records. A continuously maintained, GIS-linked database that records changes in well condition over successive inspections would provide a more reliable basis for groundwater management than periodic standalone inventories. Such a system would enable changes in artesian flow to be tracked directly through time instead of being inferred retrospectively from isolated field surveys.

6. Conclusions and Recommendations

The flowing artesian tubewell population in Banke and Bardiya is neither static nor uniform. A meaningful proportion of wells recorded as flowing at installation had ceased flowing by the time of the survey, while discharge among the remaining active wells ranges from less than 1 L/s to approximately 10 L/s. Most active wells fall within a moderate-discharge range that supports existing domestic and irrigation uses, whereas a smaller number continue to discharge at rates where unmanaged flow represents a measurable loss of groundwater. Based on the classification developed in Section 3, three management recommendations follow directly from the results:

- **Category III wells (≥ 5 L/s)** should be equipped with regulating valves or appropriately sized flanges to reduce unnecessary continuous discharge while maintaining access to groundwater when required.
- **Category II wells (approximately 0.5–<5 L/s)** should generally remain in their present condition where local communities already depend on them for domestic supply or small-scale irrigation, as the recoverable water volume is relatively limited compared with the disruption that capping would create.
- **Category I wells (no longer flowing)** should be evaluated individually before management decisions are made. Where the well structure remains intact, rehabilitation may restore artesian flow if the confined aquifer continues to provide sufficient pressure. Where structural damage or blockage is responsible for flow cessation, rehabilitation may not be technically or economically justified.

Beyond individual well management, the inconsistencies identified within the Bardiya records highlight the need for improved groundwater information management. Establishing a single, continuously updated GIS database jointly maintained by district/province offices and the central groundwater authority would improve record consistency, facilitate repeated monitoring of individual wells, and provide a stronger evidence base for future groundwater planning and management. Such a system would allow changes in artesian well condition to be documented prospectively rather than reconstructed retrospectively from isolated inventories.

Repeated monitoring is important because artesian groundwater conditions can change between seasons. The flow of a tubewell may decrease during the dry season and increase again after the monsoon when groundwater recharge takes place. Therefore, a single measurement cannot show whether a decrease in flow is only a seasonal change or a long-term decline in aquifer pressure. For this reason, the same wells should be monitored regularly during both wet and dry seasons over a number of years. Recording discharge and the physical condition of the well will help identify the actual trend. Such regular monitoring will provide a better basis for determining whether the change is seasonal or indicates a long-term change in the artesian groundwater condition.

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THE MESMERIZING JOURNEY OF GROUNDWATER HYDRAULICS:

From Darcy's Sand Column to Artificial Intelligence

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ABSTRACT

Groundwater hydraulics has evolved from a simple laboratory experiment into a cornerstone of sustainable water resource management. This article traces that evolution—from Henry Darcy's 1856 sand column experiment on steady flow, through C.V. Theis's 1935 formulation of transient well mechanics, to the digital revolution brought by MODFLOW, GIS, and modern artificial intelligence. It highlights how advances in computing power turned idealized hand calculations into three-dimensional simulations of complex aquifer systems. Yet, even as supercomputers and machine learning reshape predictive hydrogeology, modern modeling remains firmly anchored in the physical principles established nearly 170 years ago.

Introduction:

Groundwater is Earth's largest readily accessible source of freshwater, hidden beneath our feet in the pores and fractures of rocks and sediments. While ancient civilizations engineered remarkable systems like qanats and stepwells to collect groundwater, these early feats relied on observation rather than physical laws. Yet the scientific understanding of groundwater flow and aquifer behaviour is surprisingly young. The modern understanding of groundwater hydraulics began with a simple sand column experiment in 1856. Over the past 170 years, that modest experiment has evolved into one of the most sophisticated branches of earth science, where mathematical equations and powerful computers help scientists understand, predict, and sustainably manage the aquifers that support billions of people.

filter beds to purify raw water before it entered the distribution system.

At first glance, the task appeared straightforward. Yet Darcy, being a meticulous engineer, was not satisfied with relying solely on experience. Had he been asked to build a bridge, centuries of accumulated knowledge would have guided him through established designs, proven materials, and well-tested construction methods. Curiously, no such scientific foundation existed for designing something as seemingly simple as a sand filter for water purification.

To determine the dimensions of the filter bed, Darcy first needed to know how rapidly water would move through different types of sand. He soon discovered that no established engineering method existed for measuring water flow through porous media.

Birth of Groundwater Hydraulics:

The year 1856 marks one of the most significant milestones in the history of groundwater hydraulics. It was in that year that Henry Philibert Gaspard Darcy (1803-1858), a French civil engineer, was charged with improving the water supply system of the city of Dijon. Part of the project involved constructing sand

Rather than relying on trial and error, he designed a physical model consisting of a vertical sand column connected to two water reservoirs, one above and the other below the column. By maintaining different water levels in the two reservoirs, he was able to control the hydraulic head and accurately measure the rate at which water flowed through the sand under carefully controlled conditions.

The experiments revealed a remarkably simple but profound relationship. Darcy found that discharge (Q) through the sand column was directly proportional to the cross-sectional area (A) of the column and the difference in hydraulic head between the two reservoirs, while being inversely proportional to the length of the flow path (L). More importantly, this relationship could be expressed as a simple mathematical equation by introducing a proportionality constant, K , which Darcy interpreted as a measure of the permeability of the sand.

While Darcy's law emerged directly from laboratory measurements, its mathematical form echoed Fourier's 1822 heat conduction equation, reflecting the strong foundation in continuum physics Darcy received during his studies.

For nearly eighty years after its publication, Darcy's Law remained the only mathematical model available to describe groundwater flow through porous media. Yet, despite its remarkable success, it contained one important limitation. It described how groundwater flows, but not how it is stored within an aquifer.

While Darcy's law emerged directly from laboratory measurements, its mathematical form echoed Fourier's 1822 heat conduction equation. Just as heat flows from high to low temperature proportional to thermal conductivity, water flows from high to low hydraulic head proportional to permeability. This striking physical parallel reflected the strong foundation in continuum physics Darcy received during his studies at the École Polytechnique in Paris, establishing that the movement of fluids, heat, and electricity across porous media all obey identical mathematical principles.

From Steady Flow to Transient Flow: The Theis Revolution

Darcy's Law successfully described how groundwater flows through porous media, but it left one important question unanswered. It explained groundwater movement under steady conditions but did not account for the vast quantity of water stored within an aquifer or how groundwater levels change with time.

This limitation becomes obvious when we consider the plumbing of a house. When every tap is closed, water no longer flows through the pipes, yet the pipes remain completely full of water. Likewise, an aquifer is not merely a pathway for groundwater flow; it is also a vast underground reservoir capable of storing and releasing enormous quantities of water as hydraulic pressures change.

The solution to this problem was found by borrowing mathematical concepts from thermodynamics. During the nineteenth century, the rapid development of steam engines prompted physicists like Joseph Fourier (1768–1830) to formalize the mathematics of heat conduction and heat storage.

In 1935, hydrogeologist Charles Vernon Theis recognized that Fourier's thermal equations could be adapted to groundwater systems. Just as Darcy's steady-state equation had echoed Fourier's work on heat conduction decades earlier, Theis realized that non-steady heat equations held the key to transient groundwater flow. By replacing thermal variables with their hydrogeological equivalents—substituting hydraulic head for temperature, and storativity for heat capacity—he derived the first analytical solution for transient groundwater flow. His equation made it possible to predict how groundwater levels decline with time and distance from a pumping well.

The impact was profound. Hydrogeologists could now analyze pumping tests to determine aquifer transmissivity and storativity, evaluate groundwater responses to pumping and recharge, and assess water resources quantitatively. Darcy provided the foundation for quantifying groundwater flow; Theis transformed it into a predictive science.

In the decades following 1935, hydrogeologists like H.H. Cooper Jr. and C. E. Jacob, M.S. Hantush, S.P. Neuman and J.G. Ferris expanded upon Theis's foundation, deriving analytical solutions for simplified field calculations, leaky aquifers, and unconfined water-table conditions, and

bounded systems, respectively. However, these formulas still required simplified geometries and uniform geology. To model irregular, real-world groundwater basins with complex stratigraphy, the discipline needed a tool that could solve thousands of equations simultaneously—a leap that arrived with the digital computer revolution.

From Analytical Solutions to Numerical Models:

While the analytical formulas provided invaluable insights for individual pumping tests, applying them across entire regional basins presented an insurmountable obstacle. Closed-form mathematical solutions required assuming a homogeneous, isotropic aquifer of infinite extent, tapped by a fully penetrating well with constant pumping rates. Real groundwater systems are far more complex. Geological formations are heterogeneous and anisotropic; aquifers are bounded by rivers, faults, impermeable rocks, and recharge areas; and groundwater development often involves multiple pumping wells operating simultaneously. Analytical solutions could describe only simplified situations.

To simulate these complex, heterogeneous systems, hydrogeology underwent a fundamental paradigm shift during the 1960s, moving from analytical solutions to numerical modeling. The rise of electronic computing provided a way forward. Instead of seeking exact analytical solutions, hydrogeologists began solving the groundwater flow equation numerically using finite difference methods. The aquifer was divided into thousands of small computational cells, and the governing equations were solved step by step for each cell. Although the calculations were far too laborious to perform manually, computers could complete them rapidly and accurately.

For the first time, groundwater models could represent real aquifer systems rather than idealized ones. Numerical modeling made it possible to simulate complex geological conditions, variable recharge, irregular boundaries, interacting rivers,

multiple pumping wells, and changing groundwater stresses.

The Computational Revolution: From Supercomputers to AI

The transition from idealized hand calculations to digital, finite-difference grid modeling—exemplified by MODFLOW—fundamentally transformed hydrogeology. Unlocked from paper constraints, hydrologists gained the ability to represent vast, complex, and heterogeneous underground formations in software. Integrated with Geographic Information Systems (GIS), these numerical models enabled resource managers to evaluate climate impacts and design sustainable extraction strategies across entire regional aquifer systems.

As technology advanced, high-performance supercomputers expanded these capabilities to an unprecedented scale. By solving millions of simultaneous matrix equations in minutes, supercomputers made it possible to simulate intricate, multi-layered aquifer networks in full three-dimensional detail—tasks that would have once taken years of manual calculation.

Today, the field is entering its next major evolution by coupling artificial intelligence with these supercomputer simulations. While the supercomputers process the core fluid mechanics, machine learning algorithms analyze satellite data and automated field sensors to optimize parameter estimation and spot subtle anomalies. Together, they form dynamic digital replicas that continuously update their forecasts as live field data arrives.

Conclusion:

The evolution of groundwater hydraulics is one of the most remarkable stories in Earth science. It began with Darcy's simple sand column experiment in 1856, advanced through Theis' pioneering work on transient groundwater flow, and evolved into sophisticated numerical models capable of simulating complex aquifer systems. The advent of modern computing transformed the field.

Today's supercomputers can simulate regional groundwater systems containing millions of computational cells, performing calculations that would once require years of manual effort. As computing power continues to grow, emerging technologies such as machine learning are beginning to complement traditional groundwater modeling by improving parameter estimation, forecasting groundwater levels, and supporting decision-making.

The most advanced supercomputer simulations still rely fundamentally on the fluid continuity equation and Darcy's Law—which combine the conservation of mass with hydraulic gradient principles established nearly 170 years ago.

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THE STUDY OF GROUNDWATER USE AND ITS EFFECT IN THE AREA OF MANAMAIJU AND SOLATEE MOD OF KATHMANDU VALLEY

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ABSTRACT

The study to investigate the hydrogeological, geological, and geotechnical effects of extensive groundwater extraction in the Manamaiju and Soaltee mod areas of the Kathmandu Valley was conducted. Hydro-geologically, Manamaiju features a three-tier aquifer system within the Tokha Formation, where heavy abstraction by water from private water vendors (~4 million liters/day) has caused localized well interference, declining water levels causing decrease of discharge in shallow wells during dry spell. In Soaltee mod area, the aquifers have been tapped in deep tubewells found to be of coarse sand/silt horizons embedded within the low-permeability of Kalimati Formation and deep bedrock boundary. There is no evidence of widespread land subsidence in Manamaiju, whereas continuous silt pumping was observed from a commercial deep well in Soaltee mod indicating localized ground settlement and structural cracking in an adjacent residential property. The study shows no installed piezometer monitoring networks, poor well-spacing of tubewells, tubewell construction without specific guidelines, and no sealing in unused open wells.

Keywords: *Groundwater extraction, hydrogeology, tube well interference, subsurface erosion, Kalimati formation, Kathmandu valley*

INTRODUCTION

Groundwater is the one of the major sources of drinking water in Kathmandu valley. It is mostly extracted from dug wells and tube wells and fed springs and streams of the valley. Along with the drinking purpose, groundwater in the valley is use for industrial and recreation purpose also. Aquifers in the valley are associated with alluvial/sediments deposits and fractured rock. Most of the shallow aquifers are recharged from rain, river and springs whereas deep aquifers might have been recharged from northern peripheral boundary of the valley.

The use of groundwater is increasing every passing year due to higher water demand. The ground water mostly used through deep tubewells are licenced by the government agencies and monitored to some extent whereas shallow tubewells are the private property and the users are not entitled to take permission from the government.

Groundwater extraction can lead to several significant problems if not managed properly. Over pumping can interfere within wells and lower the groundwater table, making it difficult for sustainable use. It can also affect the quality of water. As the water table lowers, pumping may require more energy resulting in the increment of operational cost of individuals/ communities and the government. Furthermore, aquifers can become more susceptible to contamination from pollutants like agricultural runoff or industrial waste.

To mitigate the ground water use problems, sustainable groundwater management practices are essential. These include water conservation, rainwater harvesting, groundwater recharge, and regulations to limit extraction and monitor water levels. By adopting these measures, sustainability of groundwater resources can be insured.

Mandate of the Study

Manamaiju Area:

The mandate of the research team was to study extraction of groundwater by water tanker supply companies/ vendors and to determine whether there is the case of unsustainable extraction or not. The users committee expressed their concern over the declining of groundwater levels and drying of upper aquifers in the shallow tubewells due to the excessive withdrawal of groundwater from shallow/deep tubewells for commercial supply. The committee also raised concerns about the potential long-term impacts of continued overexploitation, including groundwater depletion, reduced water availability for local residents, and the drying of the aquifer. The committee emphasized to prevent further deterioration of the groundwater resources in the Manamaiju Area

Soaltee mod Area:

Similarly in the Soaltee mod area study was focused to understand the effect of the silt pumping from deep tube well in the surrounding civil structures and area. During the field visit cracks in the boundary wall, ground settlement in the nearby building were observed.

LOCATION AND ACCESSIBILITY

Manamaiju area of Tarkeshwor Municipality-9 & 10 and surrounding area of deep tube well of Grand Hotel at Soaltee Mod of Kathmandu Metropolitan City-13 were under the investigation. The Manamaiju area lies in the North western part around 2 km north from Gangabu bus park. whereas the Soaltee Mod area lies in the 3 km east of Kalanki of the Kathmandu Valley. The location map of the study area is shown below in Google Image.

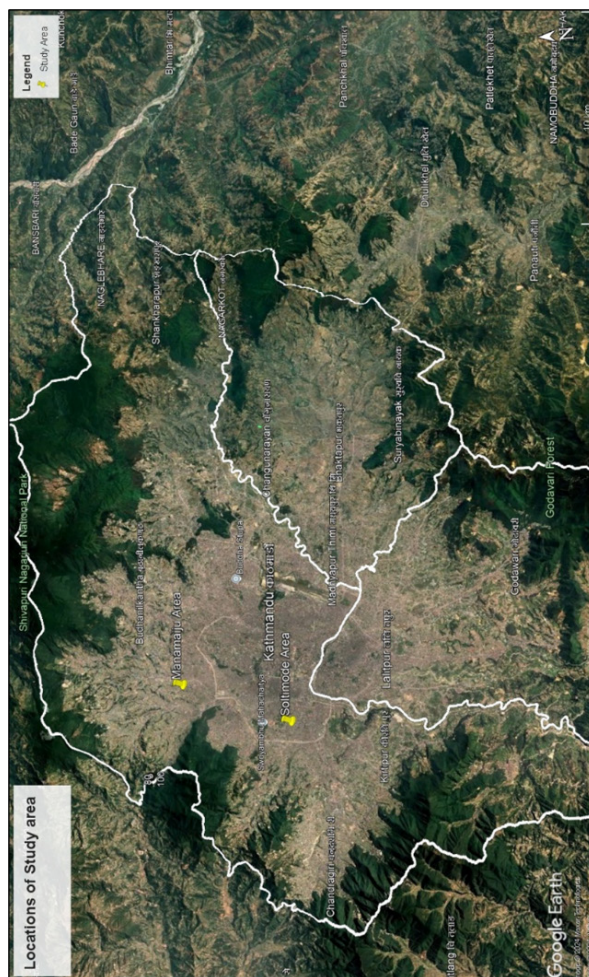


Fig. 1: Location map of Study area

GEOLOGY AND HYDROGEOLOGY OF KATHMANDU VALLEY

Kathmandu Valley is the large intermontane basin existed in the central Nepal, Lesser Himalaya region. The Northern and North Eastern parts of the basin is underlain by the basement rocks of granite, gneisses, schist, migmatites of the Shivapuri Gneiss. This injection zone show greater degree of weathering and thus gives rise to large amount of alluvial and colluvial in the form of cone and fan. Stratigraphy of the Kathmandu valley is divided into two groups i.e. Phulchowki group and Bhimphedi Group (Stocklin and Bhattarai, 1977). The bed rock within the valley consists of the Paleozoic succession of Tistung Formation, Sopayang Formation, Chandargiri

Limestone, Chitlang Formation and Godavari Limestone. The Kathmandu valley basin consists of fluvial and lacustrine sediments of Plio- Pleistocene to Holocene Epoch. It mainly constitutes unconsolidated to semi-consolidated sand, gravel, peat, silt, clay and carbonaceous black sticky clay locally known as Kalimati lying unconformably to the Paleozoic rocks of Phulchowki group and partly of the Bhimphedi group of Kathmandu Complex. The Quaternary sediments in the region consist of black carbonaceous lacustrine clay deposits and alluvial deposits composed of fine to coarse sand and gravel (Shrestha, 2008).

Case I: Manamaiju Area

Geology and Hydrogeology of Manamaiju Area

The present study area of Manamaiju lies in Tokha Formation. The Tokha Formation is mostly high permeable and mainly consists of dark grey clay, brownish grey sand and poorly sorted sub-angular to rounded sandy gravel. Peaty clay and lignite layers is also present in the area. Thickness of the formation is about 200m. or more. (as per available lithologs of nearby)

Detail information of the deep tube wells of the study area were taken from the webGIS platform of Kathmandu Valley Water Supply Management Board (www.geonep.com.np) and other information like the nearby well of KUKL/PID and Community were collected during field visit. Location of the wells considered in the study are shown in Figure 2.

LOCATION MAP OF WATER VENDORS, KUKL AND COMMUNITY WELLS

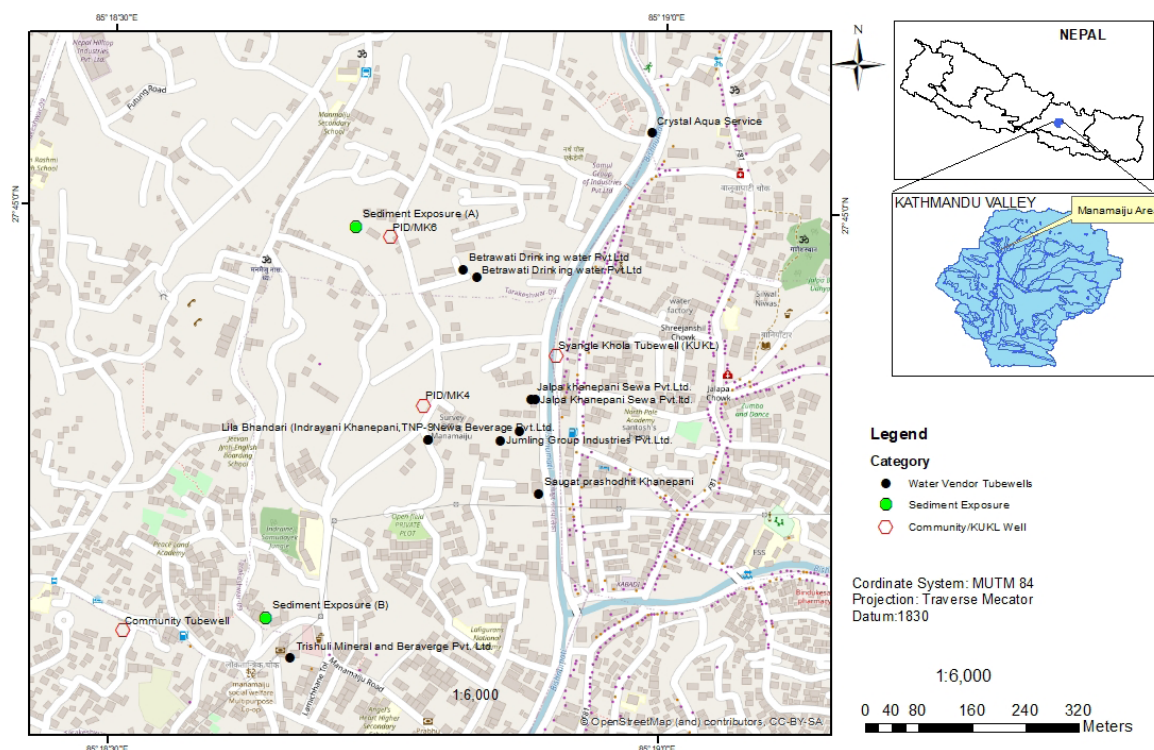


Fig. 2: Location Map of Water Vendors, KUKL/PID well and Community Wells of Manamaiju Area
Based on the study of the lithologs data of the deep tube wells of the study area and literature review the
aquifer system of the area is categorized into three different major systems.

a) Upper shallow aquifer system:

Generally, exists upto 15-20 meters below ground level consisting of fine sand/silt. Dug wells, hand pumps are generally tapped water from this aquifer. Piezometric level of this systems is found 6 meters(bgl).

Table 1: Details of Water Vendors Tubewell (Source: KVWSMB)

License No.	Owner Name	Depth (m)	Size of the TWs	Max. permitted Q(l/s)	Date of permission	Power of the Pump (HP)	Latitude	Longitude	Functioning/ non-functioning	Discharge (l/s)
48	Crystal Aqua Service	30.48	4"	100000	2.31.068	3.5	27.75108	85.31653	Functioning	4
191	Jalpa Khanepani Sewa pvt.ltd.	70	4"	100000	1.4.2069	3	27.74747	85.31481	Functioning	2.5
192	Jalpa khanepani Sewa pvt.Ltd.	70	4"	100000	1.4.2069	5	27.74747	85.31475	Functioning	2.5
199	Ajima Khanepani Supplier Pvt. Ltd.	21.3	4"	100000	2.1.2069	2.5	27.74703	85.31458	Sealed (NF)	-
277	Newa Beverage Pvt.Ltd.	21.34	4"	20000	10.8.2069	5	27.7469	85.3132	Functioning	0.55
339	Lila Bhandari (Indrayani Khanepani, TNP-9	100	6"	108000	5.10.2075	5	27.7469	85.3132	Functioning	3
435	Betrawati Drinking water Pvt.Ltd	70	4"	300000	3.19.2080	5	27.7491	85.3139	Functioning	3
436	Betrawati Drinking water Pvt.Ltd	70	4"	300000	3.19.2080	5	27.7492	85.3137	Functioning	3
438	Jumbling Group Industries Pvt. Ltd.	60	4"	120000	4.15.2080	7.5	27.7469	85.3143	Functioning	1.5
60	Saugat prashodhit Khanepani	30.5	4"	200000	4.12.2068	2	27.74619	85.31489	Functioning	0.55

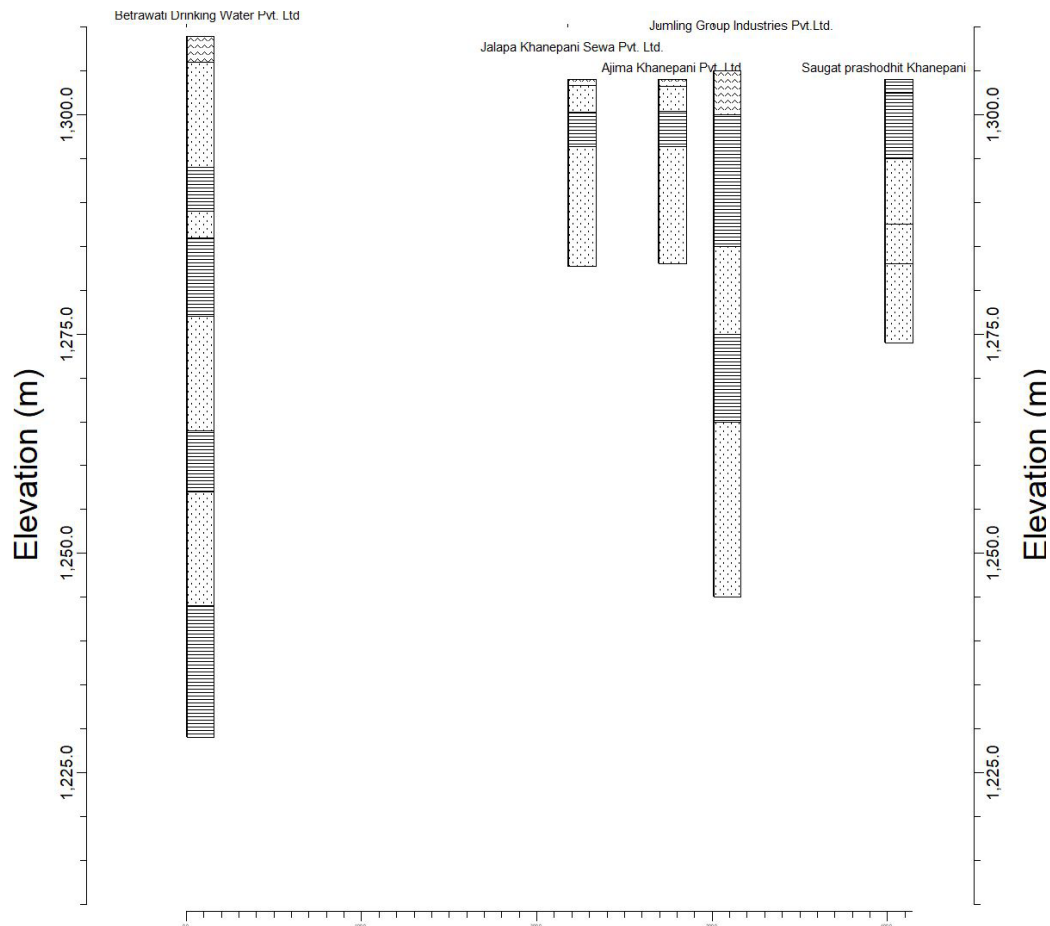


Fig. 3: Lithologs of different Locations at Manamaiju area

b) Lower shallow aquifer system:

Unconfined to mainly semi-confined aquifers generally exist at the depth greater than 50 meters consists of medium to coarse sand with occasional fine sand and silt. Generally, water vendors of the areas are abstracting the ground water from these aquifers. Water level in the tubewells varies from 13.59 to 14 meters.

c) Deep aquifer system:

The deep aquifer system in the study area consist of sand and mostly of confined to semi-confined in nature. Drinking water for TNP 9 and 10 (KUKL/ DTWs) that is at Shanti Nagar, TNP-9 (MK-6) and Loktantrik Chowk (MK-3), TNP-10 are the main source of drinking water supply in the area which tap this deep aquifer system.

The lithology of tube wells of water vendors is shown in Figure 3 and tabulated below in Table 1 (Source: KVWSMB).

During the field visit, construction work of new tube well was in progress drilling, where cow dung was used for the lifting of cuttings material. Similarly, water level was also measured in the old TW near to the well under construction. The water level was measured at 14.09 meters (BGL), which is similar to July 2023 data.

Observations & Findings.:

Hydrogeological & Yield Observations

The field investigation included visits to KUKL/PID deep tube wells MK-3, MK-4 (abandoned), and MK-6, a community tube well located within the Ward No. 10 office compound, and the KUKL deep tube well at Sangle Khola. Information collected from KUKL operators indicated that the MK-3 deep tube well is currently supplying water to the surrounding area, while the MK-6 well produces approximately 15–20 L/s. The Baniyatar Panitanki deep tube well near the left bank of Sangle Khola has a reported discharge of about 15 L/s and supplies water to Tokha Municipality Wards 8, 9, and 10 on a rotational basis. Field observations revealed significant geological exposures in the area. A vertical bed of highly weathered peaty clay was observed near the MK-6 deep tube well, while excavation at a nearby residential building exposed approximately 4 m of sticky black clay underlain by coarse sand. A nearby 35 m deep shallow tube well has remained operational for more than 15 years, indicating that the shallow tubewell is still supplying domestic water demand. In addition, a 180 ft (100 mm diameter) tube well at Trishuli Minerals and Beverage Pvt. Ltd and continuously supplying water for mineral water production. Discussions with local residents, water vendors, and field observations indicate that groundwater generally flows toward Sangle Khola (Stream). The shallow aquifer appears to receive recharge from the stream; however, there is concern that groundwater quality may be vulnerable to contamination from industrial effluent discharged upstream. Groundwater level measurements were limited because pumps are permanently installed in most of the wells. However, the static water level measured in a 30 m deep well at Jumbling Group Industries Pvt. Ltd. found 13.59 m below ground level.

Well Construction & Drilling Practices

The field survey further showed that most domestic tube wells consist of 100 mm PVC casing fitted with manually slotted screens and installed using hand-sludge drilling methods using Cow dung as a drilling fluid, whereas commercial wells generally use 150 mm mild steel casing and screens using mechanical drilling methods. It was observed that one tubewell was under construction at Jumbling Group Industries

Pvt. Ltd., where cow dung was being used as a drilling additive/ fluid to facilitate the removal of drill cuttings. Many wells were found to have inadequate or poorly installed gravel packs, increasing the likelihood of screen clogging and reduced well efficiency. Newly drilled wells commonly use locally manufactured PVC screens with limited open area, which may further affect long-term performance

Community Feedback & Resource Stress

Local residents reported that private water vendors collectively extract approximately four million liters of groundwater per day, which might have exceeded the extraction limit. Even though flow meters are installed in most commercial wells, pumping records are poorly maintained or unreliable, making the actual volume of groundwater abstraction difficult to verify. The Residents and committee members reported declining of groundwater levels and reduced well yields over the past several years. Consequently, shallow tube wells originally constructed to a depth of 30–40 m have increasingly been replaced by deepening to 50–60 m, particularly for commercial water supply. Similar replacement of 100 mm wells with large diameter (150 mm) wells in several commercial water supply Industries. Interference between closely spaced commercial and domestic tube wells were frequently reported, especially during the dry season (Baisakh–Jestha). Residents stated that pumping from nearby commercial wells significantly reduced the discharge from their domestic wells, indicating hydraulic interference within the shallow aquifer. Local residents also reported that many domestic tube wells have failed because of declining water levels, clogging, or sediment accumulation, forcing households to install new wells in every few years. In several cases, replacement wells were drilled without investigating the actual cause of failure of the existing wells

Geotechnical & Structural Status

Despite the intensive groundwater extraction in the study area, no evidence of land subsidence, ground settlement, structural cracks, or damage to roads and buildings. Based on these observations, no visible geotechnical impacts associated with groundwater abstraction were identified in the Manamaiju area.

Case II: Soaltee Mod area near Grand Hotel

Geology and Hydrogeology of the Soalteemod area.

Soaltee mod area lies at Kalimati formation. The formation is exposed in the central part of the valley around the main cities of Kathmandu, Lalitpur and Bhaktapur. It consists of grey to dark silty clay and clayey silt. This formation shows purely a lacustrine facies and acts as an aquiclude or aquitard material having extremely low permeability.

The lithological section across the Soalteemod area—spanning Hyatt Palace, Red Cross Society, Grand Hotel, and Hotel Soaltee—shows a subsurface environment heavily dominated by thick, impermeable sticky clay (the regional *Kalimati* clay) and interbedded

fine sand/silt in the upper 150 to 200 meters. Primary potential aquifer horizons composed of coarse-to-medium sand are concentrated in the deeper strata, mostly between 150- and 250-meters depth at Hyatt Palace, Red Cross, and Grand Hotel, whereas Hotel Soaltee exhibits significantly fewer coarse sand layers and is dominated by clay almost throughout. Bedrock (diagonal hatching) is encountered around 230 to 260 meters depth (~1,030–1,050 m elevation) in the first three locations, but dips deeper to over 280 meters depth at Hotel Soaltee, indicating that productive deep tubewells in this zone rely on tapping these deep coarse sand layers directly overlying or embedded within the deeper bedrock boundary. The location map of Grand hotel and Surrounding tubewell and Complainants Residence is shown in Figure 4. The litholog tubewells of Grand hotel and Surrounding is shown in figure 5.

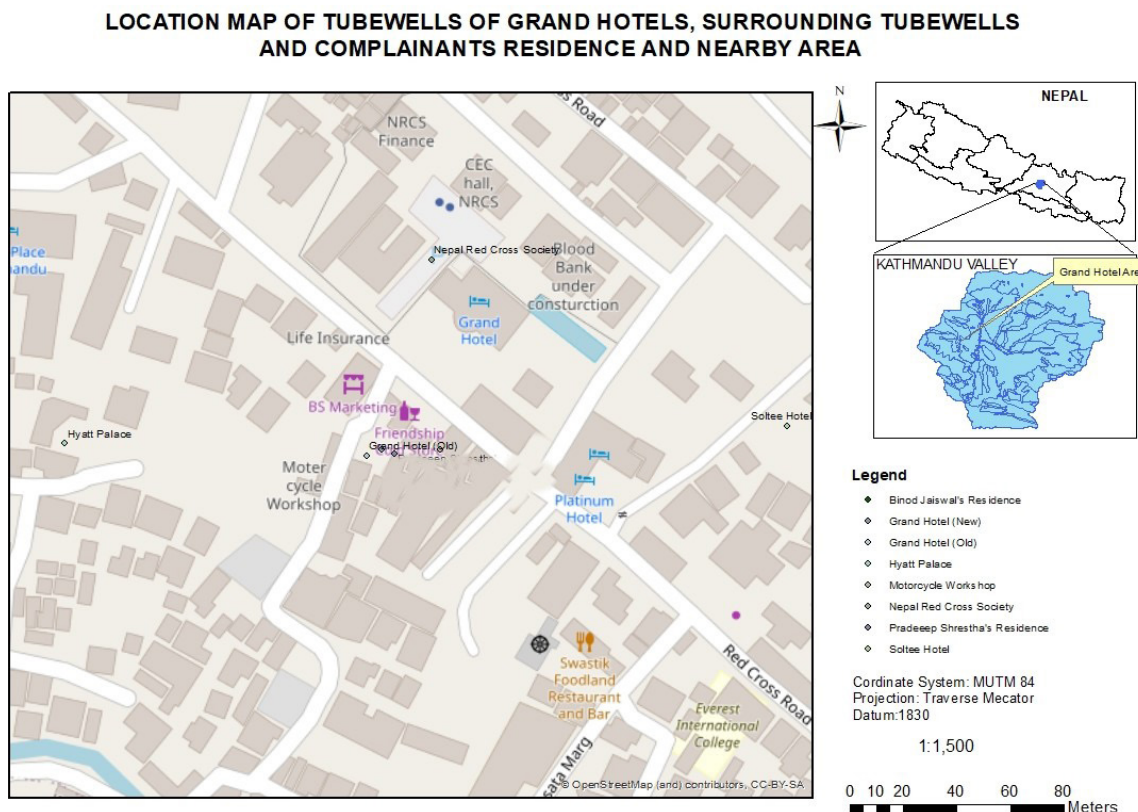


Fig. 4: Location Map of Grand hotel and Surrounding tubewell and Complainants Residence

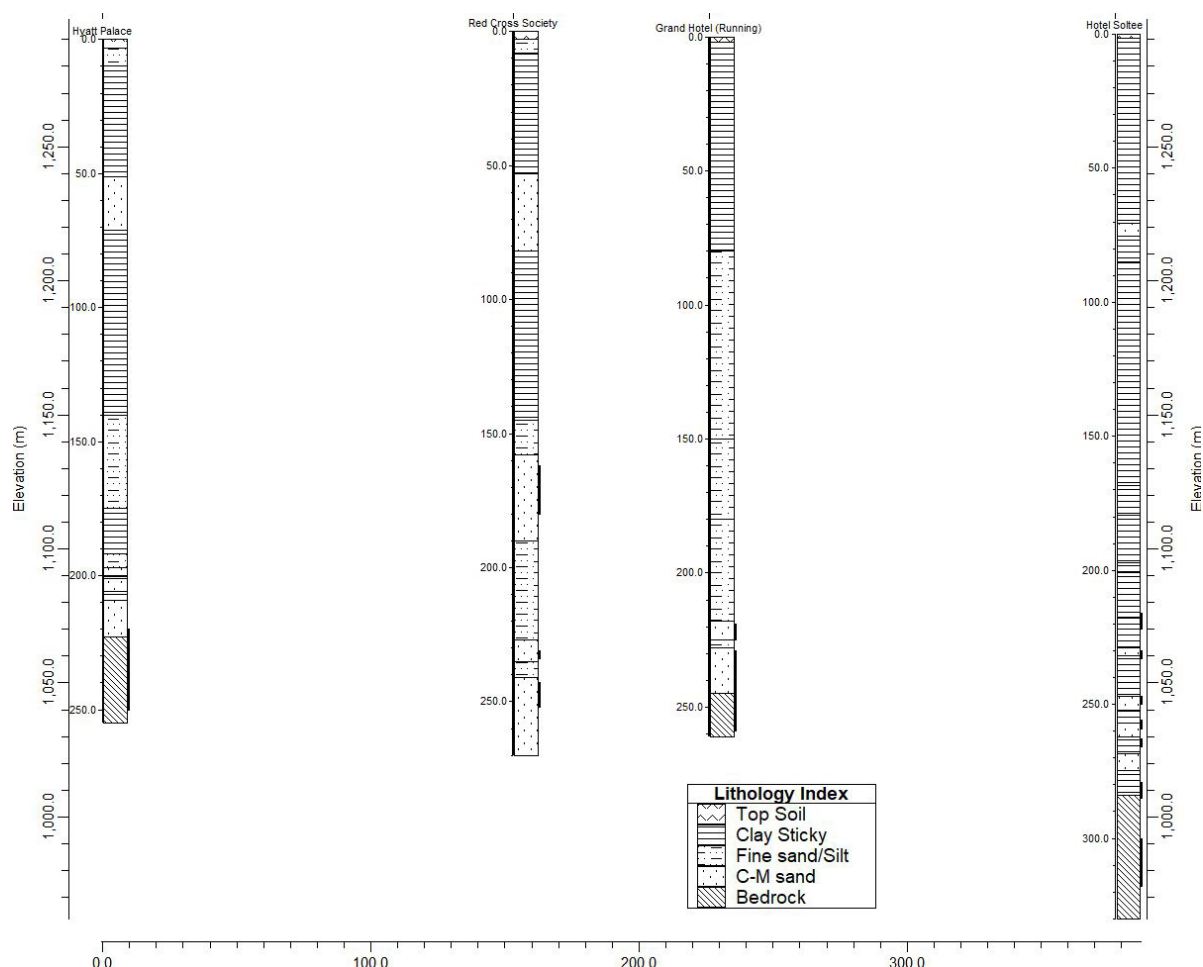


Fig. 5: Lithologs of different Locations at Soaltimode area

Observations & Findings

Deep Tubewell Operations & Sediment Management

A 150 mm diameter deep tube well located south of Hotel Grand was found to be in operation for water supply of the hotel. Another 150 mm diameter deep tube well within the same premises at a distance of 5m was observed which is abandoned and left open. The operating well had a measured discharge of approximately 2 liter per second where the silt content in the water is very high. A three-stage settling ditch system has been constructed to remove silt from the pumped water before it enters the hotel's filtration plant. During the field visit, the silt concentration in the discharged water was found to be low (approximately 3

mg/L), indicating that the settling system is effectively reducing suspended sediments. Two additional deep tube wells were observed near the Grand Hotel area, including one at Hotel Hayat Palace, which is currently operational, and another within the Red Cross premises. No evidence of ground cracks, land subsidence, or silt pumping was observed around these wells

Localized Geotechnical & Structural Impacts

In contrast, the operating deep tube well located adjacent to the property of Local resident was reported to discharge noticeable amounts of silt during pumping. Which might have created cracks and localized ground settlement within their property, observed by the team. Field observations confirmed the presence of cracks in the boundary wall, compound area, and in the ground

floor of local house. However, no similar damage was observed in neighboring buildings, nearby roads, or the other adjacent properties.

Socio-Economic Considerations & Institutional Governance

Ground water for drinking water is particularly associated with social security and status. Hence the problems arise for its proper distribution. Everyone tries to control and takes its ownership. Therefore, the problems occur to have the ground water in their vicinities. Therefore, everyone tries to dig out without knowing its consequences at the time of construction which is the case in most of the rural as well as urban area for example Manmai ju and Soaltee Mod area. There are many cases of conflict for water in particular ground water in Kathmandu valley. Therefore, to minimize the conflicts and problems, clear guidelines regarding its availability, mode and quality of construction with expert supervision needed to be addressed through one umbrella organization

Recommendations for Sustainable Groundwater Management

Ground water for drinking water is particularly associated with social security and status. Hence the problems arise for its proper distribution. Everyone tries to control and takes its ownership. Therefore, the problems occur to have the ground water in their vicinities. Therefore, everyone tries to dig out without knowing its consequences at the time of construction which is the case in most of the rural as well as urban area for example Manmai ju and Soaltee Mod area. There are many cases of conflict for water in particular ground water in Kathmandu valley. Therefore, to minimize the conflicts and problems, clear guidelines regarding its availability, mode and quality of construction of the tube wells. The location of the tubewells must be decided on the basis of the existing monitoring wells and expert suggestions. All the tubewell related data must be submitted to a dedicated organization under the government of Nepal for further GW management and sustainable development in the area.

Acknowledgements

We would like to express our gratitude to Kathmandu Valley Water Supply Management Board (KVWSMB) for their valuable support. Appreciation is also extended to the local residents, Tole Sudhar Committees, water vendors, tube well users, and the representatives of Hotel Grand for their cooperation and valuable information during the field study.

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GROUNDWATER MONITORING IN NEPAL: FROM PERIODIC MEASUREMENTS TO CONTINUOUS AQUIFER MONITORING

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ABSTRACT

Groundwater is a major source of water for drinking, irrigation and other uses in Nepal, but information on how groundwater changes over time has remained limited and scattered. Increasing water demand, urban growth and drought have made regular monitoring more important than ever. Nepal has a long history of groundwater investigations, but monitoring was mostly manual and project-based. Recent work is changing this through continuous monitoring, rainfall and surface-water observations, and community participation. The use of clustered, single-screen tubewells has also made it possible to observe different aquifers separately and better understand their response to rainfall and pumping. Early observations show clear daily and seasonal groundwater fluctuations that are often missed by occasional measurements. These initiatives provide a useful foundation for a coordinated national monitoring system. Long-term government ownership, common monitoring standards, reliable data management and wider coverage will now be essential to turn groundwater monitoring into practical support for groundwater sustainability.

Background

Groundwater is one of Nepal's most important resources, yet it remains largely out of sight. It supplies drinking water, irrigation, industries, and ecosystems across the country, and worldwide it makes up the great majority of the planet's accessible freshwater (UNESCO & UN-Water, 2022). Despite this, Nepal lacked coordinated system to track groundwater levels and quality over time. Rising droughts, fast urbanization, and increasing groundwater use have made the need for proper monitoring more urgent than ever, particularly as the country's water resources face growing pressure from climate variability (World Bank, 2022). The water crisis in Birgunj in 2023 and the drought that hit Madhesh Province in 2025 both showed how badly the country needs reliable groundwater data to plan for water security and prepare for future droughts.

A Brief History

Groundwater monitoring in Nepal began with hydrogeological studies for irrigation in the late 1960s. It later grew into a broader effort covering drinking water safety, water quality, and resource management (Shrestha, 2022). After the Groundwater Resources Development Board (GWRDB) was set up in 1976, the

country started systematically tracking groundwater levels, aquifer conditions, water chemistry, and geophysical features across the Terai (GWRDB, 2024a, 2024b).

Through the 1990s and 2000s, as groundwater became the main source of drinking water for much of the country, monitoring expanded to cover water quality as well. National programs run by the Department of Water Supply and Sewerage (DWSS), GWRDB, UNICEF, and other partners tested for arsenic, iron, manganese, and bacterial contamination, helping identify unsafe areas and safer aquifers for water supply.

Even with these efforts, groundwater monitoring in Nepal stayed largely project-based and disconnected (Shrestha, 2022). Most water-level readings were taken manually, once a month for groundwater level or once a season for water quality, which made it hard to understand how groundwater actually behaves day to day, reaction to rainfall and recharge, abstraction affects, and others. Data ended up scattered across separate institutional databases with little standardization or sharing. Rainfall, surface water, groundwater use, and climate data were rarely looked at together. All of this pointed to one clear need: a coordinated national

monitoring network, built on standard protocols, real-time technology, and a shared national database, a gap also flagged in global reviews of groundwater degradation and sustainability (Foster & Chilton, 2003). Generalized timeline of groundwater monitoring history is shown in Figure 1.

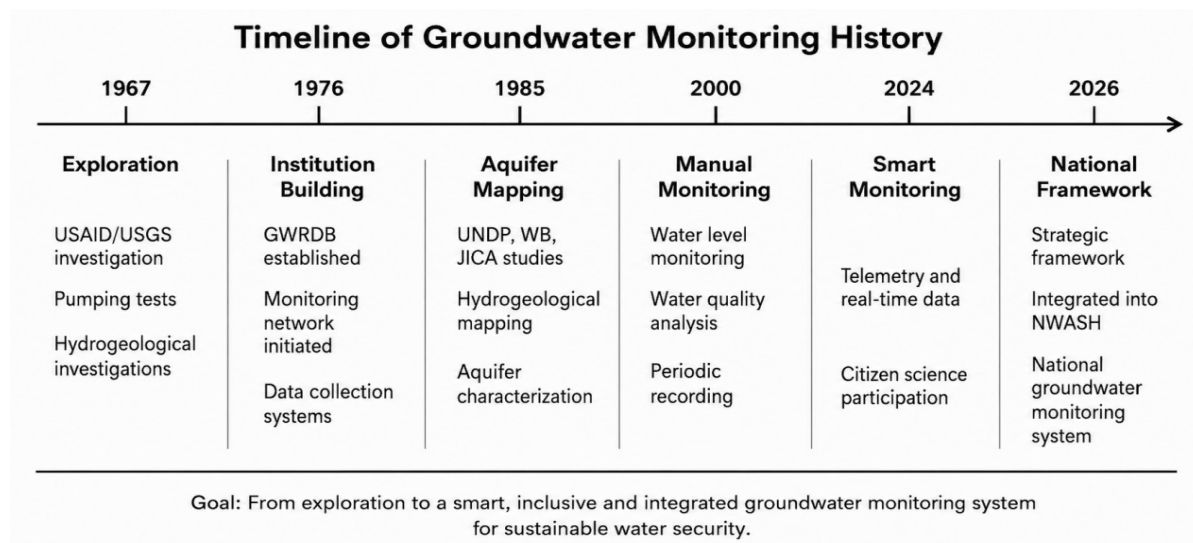


Fig. 1: Generalized timeline of groundwater monitoring history.

Observations from Past Studies

Government reports, research studies, and development projects have repeatedly flagged the same problems: limited long-term groundwater records, data scattered across institutions, weak monitoring of water quality and abstraction, and no standard protocols to follow. Most monitoring work was tied to specific projects and stopped once the project ended. As a result, Nepal still lacks a clear picture of multi-aquifer long-term groundwater trends, developing early warning systems, defining how aquifers respond to climate change, and sustainability based on the current water practice and future water demand, all of which makes evidence-based planning difficult. However, there are the multiple way forwarded recommended by various reports and studies and are one line summarized in Table 1.

Table 1. Challenges from the past studies and way forward for each challenge.

Challenge	Way Forward
Fragmented groundwater data	A national groundwater database
Manual, project-based monitoring	Continuous, real-time monitoring
Limited data sharing	Standardized data management
Short-term projects	Long-term institutional monitoring
Separate agency databases	An integrated national groundwater information system (NGIS)

Recent Progress

Despite these gaps, Nepal has made real progress in recent years by modernizing groundwater monitoring through climate-resilient management initiatives, working alongside local governments and development partners.

In 2024, the country's first municipal-level groundwater monitoring network was set up in Hansapur Municipality, Dhanusha, combining groundwater level monitoring with rainfall and surface water observation (UNICEF Nepal, 2025). Similar efforts have since been piloted in Golbazar and Karjhana in Siraha (WHH, 2025), and in Godavari and Dhangadhi in Kailali (IFRC-BRC, 2025), building a better picture of groundwater behavior in both the eastern and western Terai. The program has since expanded to Surunga Municipality (Saptari), Birgunj Metropolitan City (Parsa), and Banganga Municipality (Kapilvastu), creating a wider monitoring network across different hydrogeological settings, led by UNICEF Nepal with support from the FCDO (UNICEF, 2026) (Figure 2). The Asian Development Bank has also carried out significant arsenic monitoring across the Terai (ADB, 2026).

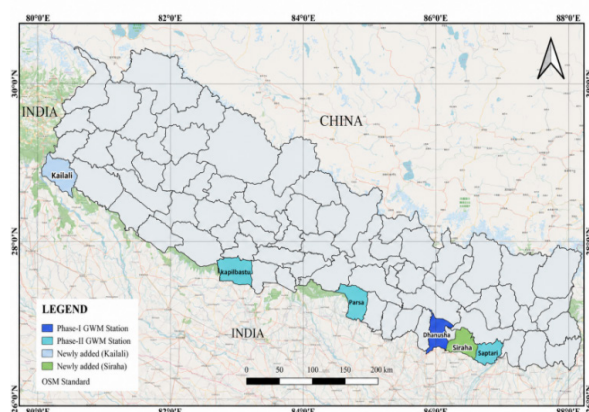


Fig. 2: Clustered monitoring tubewells installed at Saptari (UNICEF), Siraha (WHH), Dhanusha, Parsa (UNICEF), and Kailali (IFRC-BRC).

One of the biggest advances has been the introduction of automatic groundwater monitoring systems using telemetry-based digital water-level loggers. These loggers are installed in clustered tubewells: a group of separate wells drilled close together at the same site, each drilled to a different depth and single screened and gravel pack at only one specific horizon (Figure 3). This design lets each well in the cluster monitor a distinct aquifer layer independently, rather than mixing water from multiple depths together, giving a much clearer picture of how shallow, intermediate and deep

groundwater behave differently. However, the depths for each well are chosen based on regional and local aquifer along with screen zone mapping from the irrigation and drinking water wells mapping.

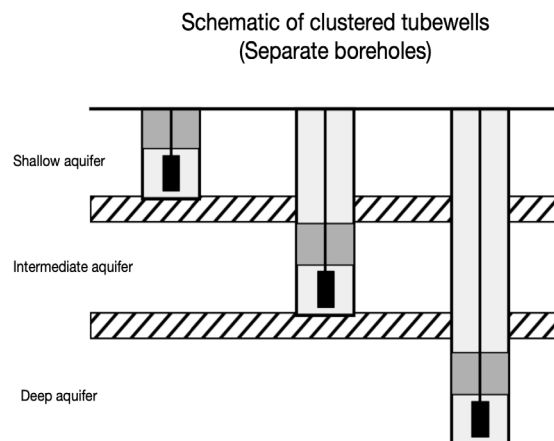


Fig. 3: Schematic diagram of clustered tubewell

Clustered single screened tubewell monitoring represents an important early application for continuous water level monitoring while it isn't new to Nepal. DWSSM with USGS constructed clustered tubewells of single screened in Nawalparasi for only arsenic testing (ATFGLP, 2004), however no water level data were measured from those. Monitoring wells screened at different depths provided the information on individual aquifers rather than an averaged response from multiple groundwater horizons. This particularly is important in the Terai, where shallow and deep aquifers may have separate recharge pathways, groundwater quality, and responses to rainfall and pumping.

This continuous monitoring has revealed clear daily fluctuations from pumping for domestic and irrigation use, followed by recovery once pumping slows down. Seasonal records show groundwater levels dropping through the dry season and gradually recovering after the monsoon, while drought years show delayed recharge and longer stretches of low groundwater levels (Figure 4).

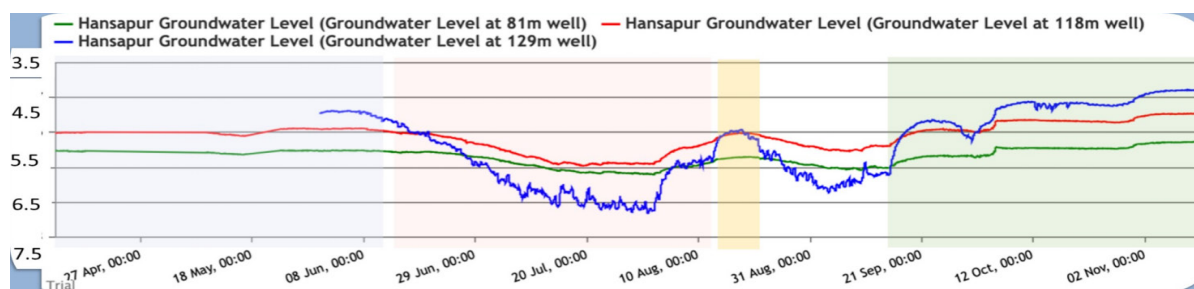


Fig. 4: Real-time groundwater fluctuation data obtained from three different aquifer layers using clustered tubewell at Hansapur, Dhanusha (UNICEF-Nepal, 2025)

Recommendation

Even though coverage is still limited, these automatic systems provide continuous, reliable data that manual measurements simply can't match, and community involvement has proven to be a practical, sustainable way to keep observations going and build local stewardship (Nath & Kirschke, 2023). The clustered tubewell design has made it especially clear that shallow and deep aquifers need to be monitored separately, since they respond differently to rainfall and pumping expanded aquifer-specific monitoring is required. Going forward, standardized monitoring protocols, centralized data management via. NGIS, and better coordination between institutions will be essential to make groundwater information accessible for planning and decision-making (Shrestha, 2022), for which groundwater monitoring framework guideline is important. As a future priorities, sustained government investment and long-term institutional commitment will be key to expanding this monitoring nationwide and strengthening Nepal's resilience to drought, its early-warning systems, and its ability to meet growing water demand under a changing climate.

Conclusion

Recent groundwater monitoring initiatives mark an important shift in Nepal from occasional measurements towards continuous observation of groundwater conditions. The experience from Hansapur and other municipalities shows that automatic monitoring, hydrogeological investigations and community participation can work together to provide much better information on groundwater behaviour. The use of clustered, single-screen tubewells is particularly useful

because shallow and deeper aquifers do not always respond in the same way to rainfall and pumping. However, installing monitoring equipment alone will not solve Nepal's groundwater information gap. The network needs clear standards, regular maintenance, quality control and long-term institutional responsibility. Groundwater-level and quality data should also be linked with rainfall, surface water, abstraction and climate information so that they can support actual decisions. The priority now should be to build on the recent pilots and establish a coordinated national monitoring system that can support drought preparedness, sustainable groundwater use and long-term water security.

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SPRINGS OF NEPAL HIMALAYA AT RISK: DRIVERS, IMPACTS, AND PATHWAYS TO RESILIENCE

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ABSTRACT

Springs are the lifeline of communities living in hills and mountains of Nepal, supplying water for drinking, cooking, farming, and livestock, and sustaining livelihoods that have depended on them for generations. But across the country, springs are changing flowing less, running dry for part of the year, or disappearing altogether. Studies from different parts of Nepal have documented widespread declines in spring discharge and increasing spring drying. The causes are rarely singular: shifting rainfall patterns, land-use change, road and infrastructure development, growing water demand, and the region's active geology all interact to disrupt the groundwater systems that feed springs. Because a spring is only the visible outlet of a much larger, hidden system, the real drivers of decline often lie far upslope, in the recharge areas that replenish groundwater, within the springshed-the landscape that captures, stores, and transmits water to the spring. When springs fail, the costs go beyond water scarcity; longer water-collection journeys that fall disproportionately on women and girls, reduced crop and livestock production, ecological loss, and mounting economic pressures on households with limited capacity to adapt. This article argues for a shift from protecting springs in isolation to managing entire springshed-the landscapes that feed them through monitoring, local knowledge, and locally appropriate recharge and conservation measures. With no universal solution and much about spring systems still poorly understood, the priority is to act while springs can still be understood and protected, rather than after they have gone dry.

Keywords: *Springs, spring drying, Nepal Himalaya, springshed, water security*

Background

For many people living in the hills and mountains of Nepal, water begins with a spring. A spring may look small-a trickle of water emerging from a slope, a stone spout beside a village, or a simple collection point along a trail. Yet for the households that depend on it, that small flow can support almost every part of daily life. In Nepali, springs are commonly referred to as *mul*, *muhan*, *dharo*, *dhungedhara* or *kuwa* (*Photograph 1*), depending on their form and outlet. Spring provides water for drinking, cooking, washing, livestock, and farming. They also feed streams, wetlands, and vegetation downstream. Across Nepal's hills and mountains, springs have supported communities for generations. People have developed their own ways of protecting springs, sharing water, and maintaining traditional water sources. In many places, these practices are closely connected with local knowledge, culture, and community life.

But something is changing. In many parts of Nepal, people are noticing that springs do not behave as they once did. Some springs now produce less water. Others flow for only part of the year. Some have disappeared altogether. For a community that has depended on the same spring for decades, even a gradual reduction in flow can have serious consequences. Spring decline is not entirely new, and it cannot always be attributed to one factor. What is changing is the combination of pressures acting on these water systems. Climate change, land-use changes, infrastructure development, increasing water demand, geology and seismic activity, and changes in groundwater recharge are interacting in ways that are often difficult to separate. The question, therefore, is not simply whether springs are drying. It is why they are changing, what this means for mountain communities, and what can be done before the problem becomes more difficult to reverse.



Photograph 1: Different forms of spring (a) mul/muhan, (b) kuwa and (c) dhungedhara. (Source: Goma Khadka)

The Nepal Himalaya and its springs

The Nepal Himalaya spans diverse elevation zones, from the Middle Hills to the high mountains. These are home to thousands of springs that have traditionally served as important sources of water for rural communities. Springs occur in a wide range of geological, topographic, and climatic settings. Hydrogeologically, spring form where groundwater reaches the ground surface. Their flow depends on how water enters the ground, moves through soil and rock, is stored underground, and eventually emerges. That process is largely hidden from view. This is one reason springs can be difficult to understand and manage. When the flow at a spring decrease, the problem may not be at the spring itself. The changes may have occurred much farther upslope, within the area where water enters and replenishes the groundwater system.

For local communities, however, the importance of a spring is much more visible. One spring may supply an entire settlement. It may irrigate agricultural land, provide drinking water for livestock, and keep a nearby stream flowing during the dry season. A spring can therefore be much more than a point on a map. It can be part of the economic, social, and cultural life of a community.

Are springs drying?

Evidence from different parts of Nepal suggests that declining spring flow is a widespread concern, although its extent and causes vary considerably between locations. An assessment of springs across the country found that nearly 60% were experiencing a decline in discharge, with about 16% having stopped flowing altogether- a pattern attributed largely to declining rainfall, haphazard infrastructure development, and overexploitation of spring resources (Chauhan et al., 2023). Similar patterns emerge from the mid-hills, where Sharma et al. (2016) documented springs, whose output had fallen over time, some shifting from year-round to seasonal flow and others ceasing to flow at all; they linked this pattern to land-use change and other human pressures. Perception-based data tell a comparable story in a nationwide survey of local-government units, 74% reported spring drying in their area, and nearly half of these (44%) characterized the decline as moderate to severe (Thapa et al., 2023). Respondents in this survey pointed to a mix of drivers behind the trend, including road and infrastructure development, the 2015 earthquake, climate change, deforestation, floods, and landslides. A more localized study in far-western Nepal, working at the watershed scale, found reduced discharge in 73% of the springs surveyed and complete drying in 2% (Pandit et al., 2024). The same study tied this decline to land fragmentation, rising temperatures, more frequent high-intensity rainfall, population growth, and unplanned road expansion. Declining spring flow and spring drying have also been documented in other parts of Nepal by Chapagain et al. (2017); Poudel and Duex (2017); Gurung et al. (2019); Shrestha et al (2019); and Molden (2020).

People often notice the change before there is any formal measurement. An older resident may remember that a spring once flowed throughout the year but now becomes weak during the dry season. A farmer may notice that irrigation water is no longer sufficient. A household may find that the spring takes longer to fill a container than it did in the past. These observations are important because spring decline is often gradual.

A spring does not necessarily disappear overnight. It may first become less reliable. Its discharge may decrease during the dry season, its period of flow

may become shorter, or the timing of peak flow may change. In some cases, the spring may eventually stop flowing. For households with few alternative water sources, these seemingly small changes can have major consequences. When a nearby spring becomes unreliable, people may have to walk farther to collect water. Some communities invest in pipelines, storage tanks, or pumping systems. Others shift to another spring or water source. These responses require time, labour, money, and, in some cases, new infrastructure.

Why are springs drying?

There is rarely one simple answer. A spring is part of a groundwater system, and that system is influenced by climate, geology, topography, vegetation, land use, and human activities. Changes in any one of these factors can influence how much water reaches the groundwater system and how that water moves underground.

• A changing climate

Climate change is altering the conditions under which mountain water systems operate. Temperatures are rising, rainfall patterns are changing, and the timing and intensity of precipitation are becoming less predictable in many places. Changes in snow and glacier dynamics can also influence downstream water availability. For springs, however, the important question is what happens to water after it falls as rain or melts from snow. Some of that water runs over the land surface, while some infiltrates into the soil and moves downward to replenish groundwater. If rainfall becomes concentrated into short and intense events, more water may run off quickly rather than infiltrating into the ground. Longer dry periods can also reduce the amount of water available for recharge. This does not mean that every spring will respond to climate change in the same way. Local geology and groundwater pathways matter greatly. But changes in rainfall and temperature can alter the balance between recharge and discharge that keeps a spring flowing.

• Changes in land and vegetation

The landscape above a spring is just as important as the spring outlet itself. Changes in land use, agricultural practices, vegetation, settlements, and forest cover can influence how rainwater moves across and through the landscape. Roads and other infrastructure can interrupt

natural drainage pathways, compact soil, or redirect runoff. Consider a road constructed across a mountain slope. The road may provide an important connection for people and goods, but excavation and drainage structures can also change the way water moves through the slope. In some cases, subsurface water may be intercepted or diverted. Such changes may not immediately cause a visible problem at the spring. Groundwater systems can respond slowly. A spring may continue to flow while changes are gradually taking place within its recharge area.

- **Increasing water demand**

Water demand is also changing in many mountain areas. Population growth, expanding settlements, tourism, changing livelihoods, and agricultural needs can increase pressure on available water resources. Where groundwater abstraction becomes greater than natural replenishment, spring systems may eventually be affected. This can create a difficult cycle. As traditional springs become less reliable, people may look for alternative groundwater sources. At the same time, increasing demand can place further pressure on the groundwater system.

- **Roads, construction, and other infrastructure development**

Mountain development is necessary. Roads, buildings, water-supply infrastructure, hydropower projects, and other facilities can improve access and livelihoods. But development that does not consider groundwater can unintentionally affect springs. Excavation for roads, tunnels, buildings, and other structures may intercept underground water pathways or alter drainage patterns. In areas where communities depend heavily on springs, these impacts can be significant. A spring should therefore not be considered only as a point where water comes out of the ground. It is the visible end of a much larger and mostly invisible groundwater system.

- **Geology and seismic activity**

Geology plays a fundamental role in determining where springs occur and how they behave. In the hills and mountains, groundwater may move through fractures, along geological contacts, or through permeable layers before emerging at the surface. Geological contacts and lithological contrasts, where rocks with different

permeability occur together, can create pathways for groundwater flow and influence where springs emerge. Similarly, fractures and faults can act as conduits or barriers to groundwater movement, concentrating flow and controlling spring location and discharge. Changes in these subsurface pathways can alter spring discharge or shift the location where water emerges. The Himalayan region is also a tectonically active region. Earthquakes and other geological disturbances can modify fractures and subsurface pathways. In some situations, this may cause a spring to weaken, disappear, or emerge at a different location. These geological controls remind us that not every spring problem can be solved simply by increasing recharge at the surface. The behaviour of each spring depends on its own hydrogeological setting.

When a spring dries, what is lost?

When a spring stops flowing, the loss is rarely limited to water. For a household, less water can mean more time spent collecting it. In many mountain communities, women and girls continue to carry much of the responsibility for household water collection. A longer journey for water can therefore mean less time for education, paid work, farming, or other activities. Agriculture can also suffer. Reduced spring flow may limit irrigation, reduce crop production, or influence which crops farmers can grow. Livestock require water too, and households may have to spend additional money or labour to meet their needs. Over time, these pressures can affect household income and food security. There are also ecological consequences. Springs can support vegetation, wetlands, small streams, and other freshwater-dependent ecosystems. When spring discharge declines, the effects can extend beyond the immediate water collection point. And there is another loss that is harder to measure: the loss of confidence in a water source that people once considered dependable.

The hidden social and economic costs

Spring drying is often described as a water-security problem. It is also an economic and social issue. A community facing water shortages may need to construct new pipelines, storage tanks, pumping systems, or alternative water-supply schemes. These interventions require investment and ongoing maintenance. At the

household level, people may pay to transport water or spend additional hours collecting it. Farmers may lose production because irrigation water is no longer available when crops need it most. These costs are not shared equally. A household with financial resources may be able to install a private water connection or find an alternative source. A poorer household may have fewer options. Older people, people with disabilities, women, and other groups facing social or physical barriers may experience greater difficulties in accessing alternative sources.

This is why spring decline should not be understood only in terms of litres of water lost. We also need to ask: Who is affected? How much does it cost? Who has the ability to adapt?

Can a drying spring be restored?

This is one of the first questions communities often ask when a spring begins to decline. Sometimes, interventions that improve groundwater recharge can help. Protecting recharge areas, reducing runoff, restoring degraded land, and creating suitable infiltration measures may increase the amount of water entering the groundwater system. But there is no universal recipe for reviving a spring.

A measure that works in one location may have little effect in another because the geology, slope, soil, recharge characteristics, and groundwater pathways are different. Before implementing recharge measures, it is therefore important to understand where the water comes from and how it moves underground. The area that contributes water to a spring is known as the springshed (Figure 1).

This is where springshed management becomes important. Instead of looking only at the spring outlet, springshed management looks at the wider area that contributes water to the spring. Understanding springshed helps identify where protection, recharge,

land-management, and monitoring efforts are likely to have the greatest benefit. In simple terms, the aim is to manage the landscape that feeds the spring, not just the place where the water emerges.

From spring protection to springshed management

Building resilience does not necessarily require complicated solutions. It begins with understanding the spring. Regular monitoring can tell us whether discharge is changing and how that change relates to rainfall and seasonal conditions. Regular monitoring of spring discharge, rainfall, and, where possible, groundwater levels can help identify changes in spring behaviour over time and assess how these changes relate to climate variability and local conditions. Long-term monitoring is particularly important for distinguishing climate-related changes from impacts associated with geology, land-use change, infrastructure development, and groundwater abstraction. Such evidence can strengthen understanding of the spring system and support more appropriate springshed management decisions. Local observations can be particularly valuable. People who have used a spring for decades often know when its flow changed, which seasons are most difficult, and how the surrounding landscape has changed. scientific assessment and local knowledge can complement each other. This combination of scientific assessment, local knowledge, and systematic field investigation is central to the six-step protocol for spring revival developed by International Centre for Integrated Mountain Development (ICIMOD) and the Advanced Center for Water Resources Development and Management (ACWADAM), which provides a practical framework for understanding springs and planning appropriate springshed management interventions (Shrestha et al., 2018).

What is a springshed?

A springshed is a set of watersheds and aquifers that integrate into a system that supplies water to a group of springs.

1. Rainfall
2. Spring recharge zone
3. Top soil
4. Groundwater flow
5. Spring (groundwater discharge)
6. Stream
7. Runoff
8. Aquifers
9. Pond
10. Bedrock

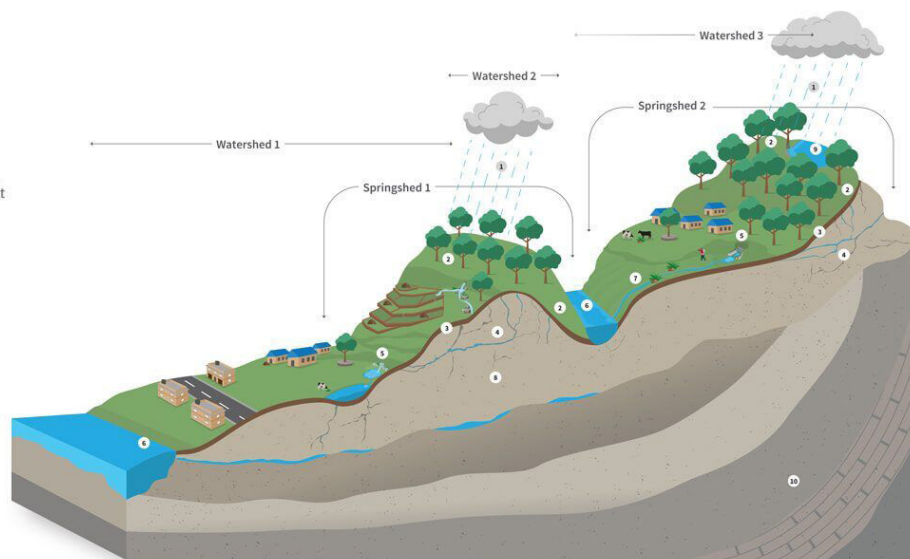


Fig. 1: Cross section of a springshed (Source: ICIMOD)

Once the recharge area and groundwater pathways are better understood, appropriate measures can be considered. Depending on local conditions, these may include infiltration trenches, recharge ponds, restoration of degraded land, vegetation management, protection of drainage pathways, or other recharge and conservation measures. The important point is that interventions should be based on the hydrogeological characteristics of the site rather than applying the same approach everywhere.

Community participation is equally important. Springs are local resources, and their management affects local lives. Communities should therefore have a meaningful role in deciding what needs to be protected, where interventions should take place, and how the results should be monitored. Spring management also needs to relate to wider development planning. Roads, agriculture, forests, settlements, water-supply systems, and disaster-risk reduction are not separate from groundwater. Decisions in one sector can affect water availability in another.

Way forward

The future of springs in Nepal Himalaya will be shaped by both global changes and local decisions. Climate change will continue to create uncertainty for

mountain water systems. At the same time, the way land is managed, roads are constructed, water is used, and recharge areas are protected can influence how much water remains available underground.

Not every spring can be restored. Not every recharge intervention will work. And some changes may already be difficult to reverse. But waiting until a spring has completely dried is not the only option. There is much that can be done before that point—mapping springs, monitoring discharge, identifying recharge areas, protecting sensitive landscapes, documenting local knowledge, and including springs in local development planning.

Most importantly, springs need to be recognised as part of larger groundwater systems. They are not simply taps on a mountainside. For the people who depend on them, springs represent water security, agricultural productivity, livelihoods, ecosystems, and a connection with the landscape around them. Protecting them is therefore not only about keeping water flowing. It is about strengthening the resilience of mountain communities in a changing climate. The real challenge, then, is not to revive springs after they have disappeared. It is to understand and protect them while there is still time.

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काठमाण्डौ उपत्यकाको भूमिगत जल व्यवस्थापनमा काठमाडौं उपत्यका खानेपानी व्यवस्थापन बोर्डको भूमिका

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काठमाडौं उपत्यका खानेपानी व्यवस्थापन बोर्ड उपत्यका भित्रका नगरपालिका क्षेत्रको खानेपानी सेवा तथा सरसफाई सेवा हेर्ने निकायको रूपमा खानेपानी व्यवस्थापन बोर्ड ऐन, २०६३ अनुसार स्थापना भएको सरकारी संस्था हो जसले उपत्यकाभित्रको भूमिगत जलस्रोतको पानी उपयोगकर्तालाई विभिन्न ५ प्रयोजनार्थ परिमाणमात्मक बन्देज सहित अनुमतिपत्र प्रदान गर्दै भूमिगत जलस्रोत सम्बन्धी अनुसन्धान गर्दै व्यवस्थित र वैज्ञानिक तवरबाट भूमिगत जलस्रोत व्यवस्थापन सम्बन्धी नीति नियमहरू बनाउँदै र कार्यान्वयन गराउँदै आईरहेको छ। स्थापना कालको दशकपछि बोर्डले निरन्तर विभिन्न विषयमा भूमिगत जलस्रोत सम्बन्धी अध्ययन अनुसन्धान गर्दै भूमिगत जलभण्डारको नक्साङ्कन, प्राचिन कालदेखि पानीको लागि प्रयोग हुँदै आईरहेको राजकुलो, ढुङ्गे धारा तथा पोखरीहरूको इन्भेन्ट्री तयार गर्ने, क्षेत्रगत वाटर सेक्युरिटी इण्डेक्स म्याप तयार गर्ने, ग्राउण्ड वाटर मनिटरिङ द्युब वेल निर्माण गरी भूमिगत जल सतहको नियमित मापन गर्ने जस्ता कार्यहरू सम्पन्न गरिसकेको छ। साथै भविष्यमा पनि आवश्यक अध्ययन अनुसन्धान गर्दै वैज्ञानिक र समय सापेक्षित नीति नियम बनाउन लागि परेको छ।

परिचय

काठमाडौं उपत्यका खानेपानी व्यवस्थापन बोर्ड काठमाडौं उपत्यका भित्रका नगरपालिका क्षेत्रको खानेपानी सेवा तथा सरसफाई सेवालाई नियमित, व्यवस्थित र प्रभावकारी संचालन गर्न गराउनका लागि वि.सं. २०६३ सालमा नेपाल सरकारले प्रतिनिधि सभामा घोषणा गरी जारी भएको “खानेपानी व्यवस्थापन बोर्ड ऐन, २०६३” अन्तर्गत स्थापना भएको अबिच्छिन्न उत्तराधिकारीवाला स्वशासित सरकारी संगठित संस्था हो। यस बोर्डको विभिन्न प्रमुख काम र कर्तव्यहरू मध्य उपत्यका भित्र भूमिगत श्रोतबाट पानी निकाल्ने र उपयोग गर्ने कार्यलाई तोके बमोजिम नियमित, नियन्त्रण र निषेध गर्ने, आवश्यकता अनुसार त्यस्तो पानी निकाल्न वा उपयोग गर्न तोकिए बमोजिम अनुमतिपत्र प्रदान गर्ने कार्य तथा भूमिगत श्रोतको पानीको उपयोग सम्बन्धि आवश्यक नीति तर्जुमा गरी नेपाल सरकारको स्वीकृतिको लागि मन्त्रालय समक्ष पेश गर्ने जस्ता भूमिगत जलश्रोत तर्फको प्रमुख काम/कर्तव्य हो। सोहि कर्तव्य पुरा गर्न यस बोर्डले २०६८/०६९ सालमा अस्थाई भूमिगत श्रोतको पानी निकाल्ने तथा उपयोग गर्ने गर्ने अनुमतिपत्र जारी गर्ने निर्देशिका जारी गरी उपत्यका भित्र डिप द्युबवेलहरू मार्फत भूमिगत श्रोतको पानी प्रयोग गर्ने संघ/संस्थाहरूलाई भूमिगत श्रोतको पानी उपयोग गर्ने अनुमतिपत्र प्रदान गर्न सुरु गरेको थियो। पछि २०७१ सालमा “भूमिगत श्रोतको पानी निकाल्ने तथा उपयोग गर्ने अनुमतिपत्र जारी गर्ने निर्देशिका २०७१” जारी गरी सोहि अनुसार अनुमतिपत्र प्रदान

गर्दै आईरहेको छ। सो निर्देशिका अनुसार बोर्डले चार(४) विभिन्न प्रयोजनार्थ अनुमतिपत्र जारी गर्दै आईरहेको छ। ती प्रयोजनहरू यस प्रकार रहेका छन् :

- क) व्यक्तिगत प्रयोजन
- ख) औद्योगिक प्रयोजन
- ग) व्यवसायिक प्रयोजन
- घ) सार्वजनिक प्रयोजन
- ङ) अन्य प्रयोजन

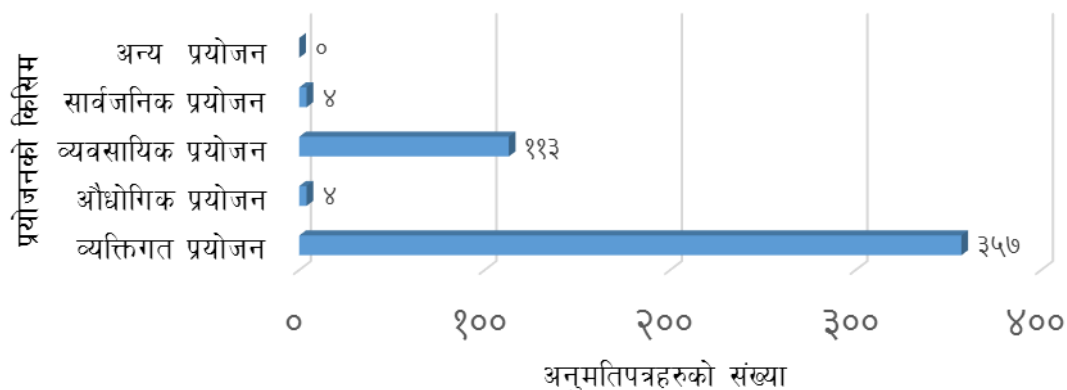
सो निर्देशिका अनुसार कुनै पनि व्यक्ति/संस्था वा उद्योगले उपत्यका भित्र डिप द्युबवेल मार्फत भूमिगत श्रोतको पानी उपयोग गर्ने अनुमतिपत्र प्राप्त गर्नको लागि दुई चरणमा बोर्डबाट अनुमति लिनुपर्ने व्यवस्था छ। पहिलो चरणमा डिप द्युबवेल खन्नको लागि निवेदकले निवेदन सहित बोर्डले तोकेका सम्पूर्ण कागजातहरू पेश गर्नु पर्नेछ। पेश भएका कागजातहरू चेकजाँच गरी विद्यमान नियम अनुसार डिप द्युबवेल खन्न स्वीकृती दिन सकिने अवस्थामा निवेदकलाई ६ महिना भित्र निर्माण सम्पन्न गर्नेगरी डिप द्युबवेल निर्माणको स्वीकृति प्रदान गरिन्छ। निवेदक संस्थाले निर्माण सम्पन्न पश्चात ड्रिलिङ रिपोर्ट सहित बोर्ड समक्ष भूमिगत श्रोतको पानी निकाल्ने तथा उपयोग गर्ने अनुमतिपत्र पाउँ भनेर निवेदन पेश गर्नु पर्नेछ। निवेदकले पेश गरेको ड्रिलिङ रिपोर्टमा

हाइड्रोजियोलोजिष्टले सहिछाप गरेको हुनपर्ने नीतिगत व्यवस्था रहेको छ । पेश भएको ड्रिलिङ रिपोर्ट र भएका निति, नियम अनुसार ती संस्थाहरूलाई भूमिगत श्रोतको पानी निकाल्ने तथा उपयोग गर्ने अधिकतम परीमाण तोकिएको विभिन्न शर्तहरू सहित अनुमतिपत्र प्रदान गर्दै आएको छ । Rain Water Harvesting र पुर्नभरणको व्यवस्था गर्ने, वल्क मिटर जडान गरी नविकरणको समयमा वल्क समटर रिडिङको

कम्तिमा मासिक डाटा र चौमासिक भूमिगत जल गुणस्तर तथ्याङ्क पेश गर्नुपर्ने जस्ता विभिन्न शर्तहरू तोक्ने गरीएको छ । हाल सम्म वोर्डले ५०० वटा विभिन्न संघ संस्थाहरूलाई र के.यू.के.एल. को २४६ वटा डिप ट्युबवेलहरूलाई अनुमतिपत्र प्रदान गरीसकेको छ । सो को विवरण र प्रयोजन अनुसार अनुमति पत्रको संख्या तल प्रस्तुत गरीएको छ ।

क्र सं	अनुमतिपत्र लिने संस्थाको किसिम	अनुमति पत्रको संख्या
१	हाउजिङ/ अपार्टमेन्ट	११२
२	व्यवसायिक भवन	४२
३	दूतावास	५
४	बैंक तथा वित्तीय संस्था	२०
५	अस्पताल	३६
६	होटल	७९
७	शैक्षिक संस्था	१८
८	उपभोक्ता समिति	७
९	पानीको जार तथा बोटलिङ सेवा सञ्चालन गर्ने संस्थाहरू	१८२
१०	के यु क एल	२४४

आ व २०८१-८२ सम्म भूमिगत श्रोतको पानी निकाली उपयोग गर्ने अनुमतिपत्रहरूको प्रयोजनको किसिम अनुसारको संख्या



साथै बोर्डले उपत्यका भित्र ड्रिलिङ कार्य गर्ने ड्रिलिङ कम्पनीहरूलाई पनि नियमन गर्नको निम्ति निर्देशिका तयार गर्दै छ र निकट भविष्यमा नै अनुमतिपत्र लिने व्यवस्था गर्दैछ ।

विभिन्न समयमा विभिन्न अनुसन्धान कर्ताहरूले काठमाडौं उपत्यकाको भूमिगत जलस्रोत सम्बन्धी अध्ययन अनुसन्धान गरेको देखिन्छ । जस्तै GSI (१९६६) WHO (१९७३), बिनी एण्ड पार्टनर (१९८८), JICA (१९९०), गौतम र कृष्ण राव (१९९१) आदि । उपलब्ध तथ्याङ्कहरू अनुसार उपत्यकाको जलभण्डार (Aquifer) प्रणाली ताल जन्य र नदीजन्य डिपोजिटले बनेका छन् । मध्यभागमा पश्चिमदेखि पूर्वसम्म फैलिएका तालजन्य डिपोजिटमा करिब २०० मिटर भन्दा बढी गहिराई सम्म सिल्टी माटो (silty Clay) वा कालीमाटीयुक्त सिल्ट (Clayey Silt)/ कालीमाटी तहको देखिन्छ । कालीमाटीको तह माथि पातलो बालुवाको तह र मुनि पनि बालुवा / गिट्टी को तह रहेका छन् भने उत्तरी क्षेत्रतिर बालुवा, गिट्टी तथा ढुंगाका साना टुक्राहरूको तह रहेका छन् । उपत्यकालाई घेरेका पहाडी क्षेत्रहरू भूमिगत जलका प्रमुख पुनर्भरण क्षेत्र हुन् भने उपत्यकाभित्र रहेका बालुवा तथा गिट्टीका Sedimentary Layers र कडा चट्टान (Bed Rocks) का Fractures and Fissures हरू नै काठमाडौं उपत्यकाका प्रमुख जलभण्डार (Aquifer) हुन् ।

स्थापनाको दशक पछि बोर्डले उपत्यका भित्रको भूमिगत जलस्रोत सम्बन्धि विभिन्न अध्ययन अनुसन्धानहरू गर्दै आईरहेको छ । हाल सम्म बोर्डले सम्पन्न गरेका अध्ययन अनुसन्धानहरू यस प्रकार छन् ।

१) Comprehensive Study of Ground Water Resources of Kathmandu Valley, 2017

यस अध्ययन अनुसन्धानका क्रममा उपत्यका भित्र निर्माण भइसकेका विभिन्न डिप ट्युबवेल तथा स्यालो ट्युबवेलहरूको इन्भेन्ट्री (Inventory) तयार गरी ति डिप ट्युबवेलहरूको लिथोलग (Litholog)को आधारमा Auifer Type Map, Ground Water Recharge Potential Map, Auifer Thickness Map र North -South, East-West Lithological Cross Section तयार गरिएको थियो । यस अध्ययन अनुसन्धानको विषय वस्तुहरू समेटी बोर्डले Ground Water In Kathmandu Valley Status, Challenges and Oppurtunity शिर्षकको पुस्तक प्रकाशन गरेको छ । यो पुस्तक बोर्डको आधिकारिक वेबसाइट बाट डाउनलोड गर्न सकिनेछ ।

२) Stone Spouts and ponds of Kathmandu Valley, 2019

काठमाडौं उपत्यका भित्रको पुराना बस्तिहरूमा मल्लकाल देखि नै हिटी र राजकुलो प्रणालिहरूको विकास भई भूमिगत जलस्रोतको र सतहगत स्रोतको प्रयोग हुँदै आईरहेको छ । यस्ता पोखरी हिटी र

राजकुलाहरूको अवस्था र संख्याको बारेमा बुझ्नको लागि बोर्डले यो अध्ययन गरेको हो । यस अध्ययन अनुसार उपत्यका भित्र जम्मा ८३५ वटा ढुङ्गेधाराहरू रहेकोमा ११९ वटा हराइसकेको र ७१६ वटा सुरक्षित रहेका छन् । ती ७१६ मध्य ३०१ वटा बाट अध्ययनको समय सम्म पानी आइरहेको थियो । जसको समग्र डिसचार्ज (Discharge) ४०,२६,३४८ लि. प्रतिदिन रहेको पाईएको थियो । साथै उपत्यका भित्र २८० वटा पोखरीहरू रहेको र ती मध्य हाल २३५ वटा पोखरीहरू सुरक्षित रहेको देखिन्छ । यस्ता ढुङ्गेधारा र पोखरीहरूको सामाजिक, ऐतिहासिक, परम्परागत र धार्मिक विशेषता रहेको छ । अभै पनि यी ढुङ्गेधाराहरूले हजारौं व्यक्तिहरूको व्यक्तिगत साथसाथै धार्मिक आवश्यकताहरू पुरा गरीरहेकाले हरेक हिसाबबाट यीनको संरक्षण गर्न सरकार देखि व्यक्तिसम्म तत्पर देखिन्छन् ।

३) Water Security Study of Kathmandu Valley, 2023

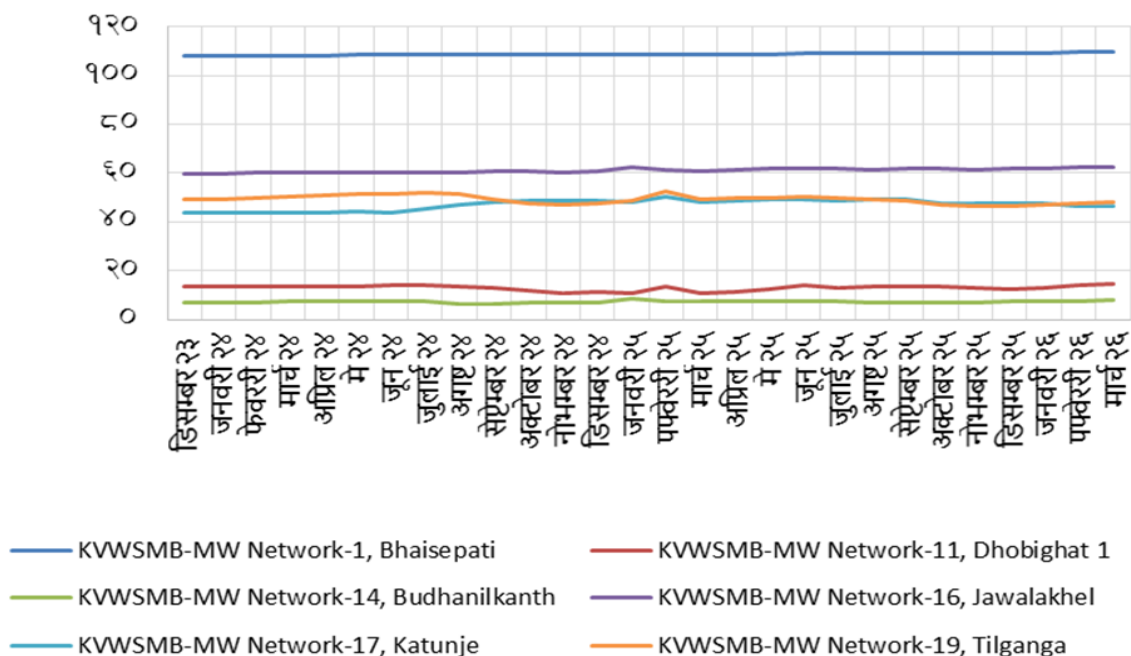
यस अध्ययन अनुसन्धानका क्रममा उपत्यका भित्रको वडा स्तरमा रहेको पानीका स्रोतहरूको अवस्था, भूमिगत जलको अवस्था र संभाव्यता, पानीको माग र आपूर्तिको अवस्था र जनसंख्याको २०५० साल सम्मको प्रोजेक्सन अध्ययन गरी Water Security index map तयार गरिएको थियो । जसले निम्न विषयगत क्षेत्रहरू भित्र विस्तृत कार्ययोजनाको परिकल्पना गरी जलस्रोत मूल्याङ्कन (सतह र भूमिगत), पानीको गुणस्तर मूल्याङ्कन (सतह र भूमिगत), पानीको माग मूल्याङ्कन (वर्तमान र भविष्य), जनसंख्या प्रक्षेपण र प्रत्येक नगरपालिकाका लागि वैकल्पिक स्रोतहरू मूल्याङ्कन गरी प्रयोगकर्ता-मैत्री वेब-आधारित व्यवस्थापन सूचना प्रणाली (MIS) को विकास गरिएको थियो । यसरी तयार गरिएको Water Security Index Map लाई ० देखि १ को मापनमा indexed गरिएको छ, जसमा ० सबैभन्दा कम सूचकांक र १ सबैभन्दा बढी सूचकांक हो । प्राप्त Water Security Map अनुसार उपत्यका भित्रका कुनै पनि वडाहरूको Water Security index ०.८ भन्दा बढी देखिदैन ।

४) Ground Water Exploration, Monitoring and Specific Aquifer Mapping of Kathmandu Valley, 2025

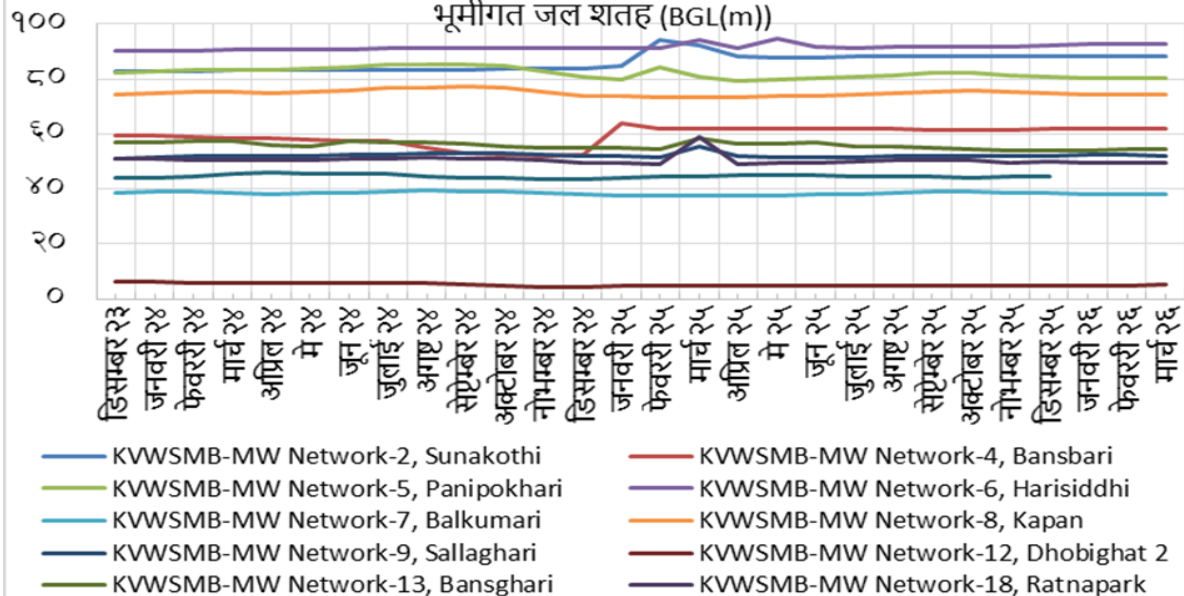
यस अध्ययन अनुसन्धानका क्रममा उपत्यका भित्रको समग्र भूमिगत जलसतहको अवस्था बुझ्नको लागि Ground Water Monitoring Network तयार गरिएको थियो । सो नेटवर्क तयार गर्दा विभिन्न १३ वटा विषयवस्तु समेटी त्यसमा AHP Method लगाइएको थियो । त्यसरी तयार गरेको वैज्ञानिक Monitoring Network अनुसार उपत्यका भित्र ६० स्थानहरूमा मोनिटरिङ ट्युबवेलहरू निर्माण गर्न आवश्यक देखिन्छ । हाल बोर्डले विभिन्न २० ठाउँमा २१ वटा Ground Water Monitoring Well हरू निर्माण गरी त्यसमा Pressure Level Sensor जडान गरी Real Time मा Ground Water Level र Water temperature मापन गरी रहेको छ । ती वेलहरूमा २०२४ को सुरुवात देखि हाल सम्मको Ground Water Level को hydrograph हेर्ने हो भने मिश्रित अवस्थाको देखिन्छ ।

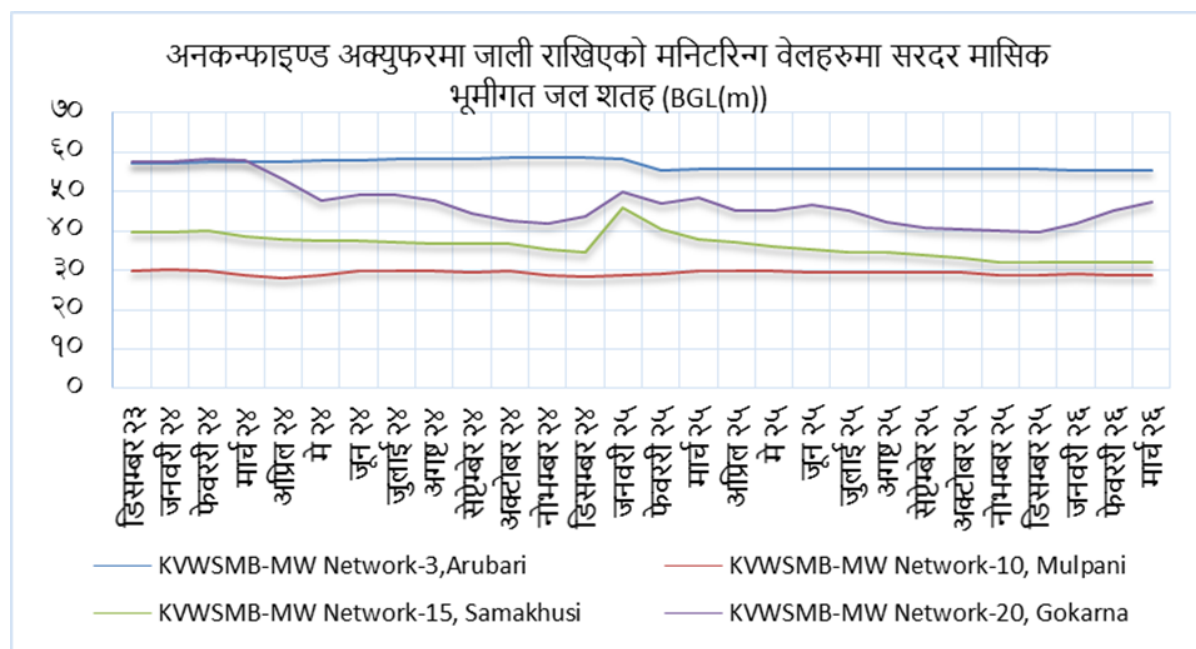
तिनको Water Level data अनुसार पत्रपत्रिकामा आए जस्तो उपत्यकाको प्रत्येक ठाउँहरूमा भूमिगत जल सतह घटेको देखिंदैन । उपत्यकाको उत्तरी क्षेत्रको अधिकांश ठाउँमा भूमिगत जल सतह बढेको देखिन्छ, मध्य क्षेत्रहरूमा करीव यथास्थितिमा रहेको देखिन्छ भने दक्षिण क्षेत्रहरूमा निरन्तर घटेको देखिन्छ ।

बेडरक अक्युफरमा जाली राखिएको मनिटरिग वेलहरूमा सरदर मासिक भूमिगत जल शतह (BGL(m))



कन्फाइण्ड अक्युफरमा जाली राखिएको मनिटरिग वेलहरूमा सरदर मासिक भूमिगत जल शतह (BGL(m))





यी मुख्य अध्ययन अनुसन्धान बाहेक यस बोर्डले साना तिना अनुसन्धानहरू निरन्तर गर्दै आईरहेको छ। साथै भविष्यमा पनि अध्ययन अनुसन्धानको कार्यलाई अघि बढाउँदै बोर्डले उपत्यका भित्रको जलभण्डारको विस्तृत अध्ययन गरी तिनको क्षमता मापन गर्ने, भूमिगत जलस्रोतको पुनर्भरणको लागि MAR को सम्भाव्यता अध्ययन गर्ने र लागु गर्ने, रेन वाटर हार्भेस्टिङ तथा पुनर्भरणको गाइडलाइन तयार गरी व्यवस्थित र वैज्ञानिक तरिकाले लागू गर्ने जस्ता कार्यहरू गर्न आवश्यक देखिन्छ। यसरी बोर्डले आफ्नो कार्यक्षेत्र भित्र भूमिगत जलको नियन्त्रण तथा नियमन कार्यलाई थप प्रभावकारी बनाउनको लागि विभिन्न अध्ययन अनुसन्धान गरी डाटा तयार गर्दै बैज्ञानिक र अवस्था अनुसारको समय सापेक्षित नीति नियम बनाउन लागि परेको छ।

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