

GEOWORLD

STUDENTS' JOURNAL

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DEPARTMENT OF GEOLOGY
TRI-CHANDRA MULTIPLE CAMPUS
TRIBHUVAN UNIVERSITY

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Department of Geology
Tri-Chandra Multiple Campus
Ghantaghar, Kathmandu

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Sincerely,

Editor-in-chief
Shraddha Neupane

Message From the Editor-in-Chief

It is with great pride and excitement that we present the GEOWORLD STUDENTS' Journal. On behalf of the editorial team, I extend a warm welcome to all our readers. We are thrilled to share with you the 12th volume of the Geoworld Students' Journal, the annual publication of the Geology Department at Tri-Chandra Multiple Campus.

This milestone is a testament not only to our dedication to academic excellence but also to the collaborative effort that made this achievement possible. The journey of publishing this journal has been both rewarding and challenging, requiring collective effort in gathering articles, encouraging participation, and refining submissions to create a resource that truly benefits students.

GEOWORLD STUDENTS' Journal continues to be an independent platform designed to support geology students in honing their research and writing skills. The journal provides a forum for sharing insights on a wide range of earth science-related topics. These include but are not limited to environmental concerns, geohazards, hydrogeology, geomorphology, engineering surveys, GIS applications, and much more. Contributions range from overviews and review studies to case studies, interviews, and analytical reports.

Our team has worked tirelessly to improve the quality of submissions, streamline manuscript processing, ensure fair reviews, and enhance the editorial workflow.

The journal reflects a research-oriented approach, bridging the gap between academic inquiry and professional practice in geology. Under the guidance of our esteemed professors, I believe we are on the right path toward achieving this goal. We also encourage more contributions from the broader scientific community and industry experts to ensure the continued growth of the journal. We welcome submissions, feedback, and suggestions to improve the quality of GEOWORLD. Thank you for your support, and we hope you find this issue both informative and engaging.

Shraddha Neupane
Editor-in-Chief
Geoworld Students' Journal
Vol. 12, 2024

Acknowledgement

The Geo-World Volume 12 extends sincere gratitude to all individuals whose support and collaboration have been fundamental to the completion of this journal.

A special thanks goes to Associate Professor Dr. Subodh Dhakal, Head of Department of Geology at Tri-Chandra Multiple Campus. His support and encouragement are greatly appreciated. The immense support provided by the faculty members and department staffs has been detrimental in the completion and publication of this journal. Furthermore, we are deeply indebted to Mr. Basanta Bhandari for his assistance and guidance in the process of article writing. His vast knowledge and expertise in the field of geology have significantly contributed to the quality and depth of our articles.

The volume is indebted to Mr. Aniruddha Poudel, Director of Environment and Social Studies Department of Nepal Electricity Authority, Professor Dr. Deb Jaisi, Professor at Department of Earth Sciences; Plant and Soil Sciences of University of Delaware, Newark and Mr. Dinesh Nepali Deputy Director General of petroleum exploration Nepal and Shova Singh Senior Divisional Geologist of dmng Nepal for graciously accepting out invitation to interview despite their busy schedule. Your insight and experience shared will make a great impact on the readers.

We would like to express our appreciation to the author, 4th year BSc. Geology students from Department of Geology, Tri-Chandra Multiple Campus for their invaluable contribution of time, energy and knowledge for the journal. Their enthusiasm in contributing an article for the journal was exception. We are also grateful to the review committee who shared their suggestions and expertise in enhancing the quality of articles provided. The review committee help in maintaining the standards of the journal is recognized.

The editorial board who has endlessly and tirelessly worked and led the journal to the completion and publication is highly regarded. Their dedication to the success of the journal is invaluable. We would also like to express our gratitude to Ms. Smiriti Mahat for contributing the image used as the cover.

We are also indebted to Mr. Dinesh Nepali, Petroleum head ofDMG Nepal for facilitating the publication of our Journal.

Last but not the least, the journal would like to thank each and every individual who has directly or indirectly been part of our journey.



Tribhuvan University
Tri-Chandra Multiple Campus

Ph. No. 4-244047

(Estd. 1913 A.D.)



Office of the Campus Chief
Saraswati Sadan,
Kathmandu, Nepal.

Ref. No.:-

Date:

September 24, 2024

Message from the Campus Chief

I am pleased to commend the GEOWORLD committee and Department of Geology of Tri-Chandra Multiple Campus for their outstanding work in providing a platform for students and professionals to publish their outstanding work in providing a platform for students and professionals to publish their work and compiling and producing this significant volume 12 of GEOWORLD student journal. Your dedication and efforts in showcasing articles and research in the field of geology is commendable and reflect positively on our institution.

GEOWORLD continues to be an important platform for the exchange of innovative ideas and research findings. I hope Volume 12, with its diverse range of articles, contributes meaningfully to the academic community and reinforces the reputation of our college as a pioneer in fostering scholarly excellence.

I extend my congratulations to all those involved in the journal's publication. Your commitment in advancing academic knowledge and promoting intellectual is truly appreciated.

Prof. Dr. Nilam Shrestha Pradhan
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Date: _____
September 25, 2024

Message from the Department Head

I am pleased to write this message regarding the publication of "GEOWORLD" student journal Volume 12 by the students of B.Sc. 4th Year in Geology (2076 batch) at the Department of Geology, Tri-Chandra Multiple Campus. I take this opportunity to congratulate the editorial team, reviewer team, contributors and all the students of B.Sc. 4th Year in Geology at our department. The publication of this type of journal from the sole endeavors of students is indeed a commendable job and I am happy to be a part of it in the capacity of the head of department. I am confident that the entire process of publishing a student journal provides the ample opportunities to increase the research and other academic capabilities of the students. Department of Geology, Tri-Chandra Multiple Campus has been always motivating the research and other extracurricular activities of students. I assure that the department will continue supporting such activities in future.

I suggest and encourage the students to work further in increasing the quality of the journal by incorporating the research papers of the faculties and other researchers in the related field. We will work on every possibility to make arrangements to write one research papers by each students of B.Sc. 4th year for this GEOWORLD student journal. This will definitely ensure the ownership of this valuable publication by each and every students of that particular batch.

I wish all the very best for the academic and research endeavors of our students in future.

Subodh Dhakal, PhD
Head
Department of Geology, Tri-Chandra Multiple Campus
Tribhuvan University, Nepal



Table of Content

SN	Contributor	Contribution	Page Number
1	Mr. Aniruddha Poudel	Interview with Aniruddha sir regarding NEA and his expertise and experience	1
2	Dr. Deb Jaisi	Interview with Deb Jaisi regarding his experiences as a professor in international university and his expertise	4
3	Mr. Dinesh Nepali	Interview with Dinesh Nepali regarding petroleum geological context in Nepal	12
4	Mrs. Shova Shrestha	Interview with Shova Shrestha regarding her experience as a woman in geo science	14

Students Article

SN	Author Name	Article Name	Page Number
1	Aakriti Aryal	A Comprehensive Review Of River Dynamics And Fluvial Processes In The Kathmandu Basin	16
2	Amit Bhandari	Use Of Bio Engineering Techniques To Control Mass Movement In Nepal	20
3	Ashmita Bhandari	Application Of Remote Sensing And GIS In Earthquake Sensing Landslide	24
4	Ayush Dahal	Paleontological Richness Of Kathmandu Valley: Fossil Records And Climate Evolution	28
5	Ayushma Karki	Bridging The Gap: Assessing The Environmental And Social Costs Of Unsustainable Mining	32
6	Bibek Achhami	Gorkha Earthquake 2015	36
7	Bidisha Dhakal	Seismic Site Effect Of Gorkha Earthquake 2015 In Kathmandu Valley	40
8	Devendra K. Dhungana	Sand And Gravel Mining And Its Impacts On Ratu River	47
9	Durga Bahadur Khadka	Urban Expansion And Its Impact On Land Use Of Kathmandu District	51
10	Himal Bhandari	The Change In Livelihood Of People In Armala After Sinkhole	55
11	Jiya Khatiwada	Assessment of Knowledge on Earthquake Mechanism and Preparedness Measures Among the Secondary Level Students in Kathmandu Valley, Central Nepal.	59
12	Kabita Guragain	Different Scales Used In The Measurement And Categorization Of The Gorkha Earthquake 2015	63
13	Kripa Kattel	Impact Of Climate Change On Himalayan Glaciers	67
14	Krishnakala Paudel	Landslide Inventory And Mapping Of Bhalebas Area	71

15	Kushal Babu Dumre	Seismic Activity On Other Planets: Insights From Mars And The Moon	74
16	Mahotsav Basnet	Effects Of Unplanned Urbanization Of Kathmandu Valley : Hidden Rivers Of Kapan Area	78
17	Nabindra Pandey	River Dynamism In The Himalayas: Impact Of Climate Change And Anthropogenic Activities	82
18	Ojaswi Upadhaya	Microplastic Pollution In The Himalayas	86
19	Prajina Adhikari	Overview Of Direct Rotary Drilling Method In Jawalakhel	90
20	Pramish Subedi	Tracing Earthquake History: Paleoseismic Investigations In The Nepal Himalaya	94
21	Prapti Dhungana	Hindu Kush Himlaya 3rd Pole	98
22	Prashna Dhungel	Neotectonics Of The Nepal Himalaya : An Overview And Its Implications	102
23	Pratik Khatiwada	Rock Slope Assessment Along Chatara-Barahakshetra Road Section Using Kinematic Analysis And Rmr	106
24	Priyanka Dhami	A Case Study On Tube Well Inventory Of Madiphant Area, Palpa, Nepal	110
25	Punam Koirala	Impact Of Climate Change On Kathmandu Valley	114
26	Sabina Adhikari	Causes And Effects Of Earthquake In Nepal	118
27	Sahaj Shrestha	Geological Fieldwork: The Real Way To Learn Geology	122
28	Saurav Mainali	The Fascinating World Beneath Our Feet: Exploring The Role Of Soil Microorganisms In Geology	126
29	Sharad Pandey	Integration Of Urban Geology In Nepal's Urban Planning And Development: A Review Of Its Importance, Trends And Challenges.	129
30	Shraddha Neupane	History Of Groundwater Investigation In Nepal	133
31	Shrijana Ghimire	Understanding Landslides: Causes, Impacts, And Mitigation Strategies	137
32	Smriti Mahat	Factor Influencing Nepal's Groundwater Resources	141
33	Sristhi Shrestha	Potential Geological Hazards In Nepal	145
34	Sujan Bhandari	Rubies and Fancy Color Sapphires of Dhading, Nepal	149
35	Sulav Gautam	Influence Of Geological Hazards On Urbanization Of Ghorahi Sub-Metropolitan City	152
36	Swastika Rimal	Assessing The Impact Of Climate Change On Glacial Lake Outburst Flood In Nepal Himalaya	156
37	Yunisha Rijal	GIS And Remote Sensing : Contemporary Technologies Of Paramount Importance In Hydrogeology	160

Interview with Mr. Aniruddha Poudel

Aniruddha Poudel is a distinguished geologist with over two decades of experience, currently serving as the Director of the Environment and Social Studies Department at the Nepal Electricity Authority (NEA). He holds a Bachelor's degree in Geology from Tri-Chandra Multiple Campus and a Master's degree from the Central Department of Geology. Since joining NEA in 2001, he has become a key figure in the hydropower sector, specializing in tunnel design, dam treatment, and powerhouse foundations. Aniruddha's expertise extends to road alignment fixation and transmission line route surveys, further complemented by his active role in environmental conservation. His involvement in numerous Environmental Impact Assessments (EIA) and Initial Environmental Examinations (IEE) showcases his commitment to sustainable infrastructure. With his recent promotion to Level-11 (Director), Aniruddha continues to lead efforts in balancing development with environmental responsibility.

Can you provide brief introduction to NEA?

The Nepal Electricity Authority (NEA) is a government-owned organization that manages the generation, transmission, and distribution of electricity in Nepal. Formed in 1985 by merging several electricity-related agencies, NEA's main goal is to provide a reliable supply of electricity across the country. It plays a key role in developing Nepal's energy sector, especially in using the country's abundant hydropower resources. NEA is also involved in building and operating power projects and works to



improve the nation's energy infrastructure to meet increasing demand.

Could you share us different work done by environment and social studies department NEA?

The Environment and Social Studies Department (ESSD) of the Nepal Electricity Authority (NEA) handles key environmental and social responsibilities in NEA projects. It conducts Environmental and Social Impact Assessments, monitors compliance with environmental regulations, and manages resettlement and rehabilitation for affected communities. ESSD also ensures public consultation, develops Environmental Management Plans, promotes biodiversity conservation, and integrates climate change considerations. Additionally, it provides training on environmental safeguards and oversees Corporate Social Responsibility (CSR) initiatives, ensuring that NEA's projects are sustainable and socially responsible.

What training program is NEA providing to its geologist?

The Nepal Electricity Authority (NEA) provides various training and professional development opportunities to its geologists to enhance their skills and knowledge. These opportunities are designed to keep them updated with the latest advancements in

geology, particularly in the context of hydropower and infrastructure development. Some of the key training and professional development opportunities include training programs, workshops and seminars, on the job training and international training and conference which are helping to boost the knowledge and expand vision of the employee. Other initiatives are also taken for overall development.

What inspired you to pursue a career in geology and hydropower?

Honestly I didn't have any plan about my future but as I got enrolled in BSc. geology, I found some sort of connection in that subject. After the completion of my study I started following path which destiny was planning for me with honesty and dedication and I was able to establish myself in geology and hydropower.

How do you prioritize task and manage multiple projects simultaneously?

We need immense focus and time management skill for doing multiple job simultaneously. Actually I try to keep myself calm and organized so the burden of task doesn't overtake me. Then I rearrange my task on basis of urgency importance and deadline. Then the task gets completed. Panicking is never the solution.

Can you share your experience in managing large scale hydropower project?

Managing large scale hydropower project is honestly very different than it seems from outside. The job is never easy you need to have discipline, politeness, observation and spontaneous decision. The way you handle the situation and its complexity determines the success of project. So you must shower your mental skills for better result.

What are key factors to consider while designing a foundation in hydropower?

Designing a foundation for a hydropower plant is crucial for ensuring structural stability and efficiency. The key factors to consider includes geological conditions mostly geological features like rock type, fault lines, seismic activity and slope stability. As well hydrological condition should be addressed, load bearing capacity of the foundation should be determined. This involves determining the vertical and lateral load capacities of the soil or rock beneath the foundation. The environmental conditions should be checked properly to identify whether foundation can resist erosion and seasonal flooding or not. And mainly we should be careful for foundation type selection for durability and stability. Other things like drainage and water control and choice of construction material should also be studied for long lasting foundation.

What are the common problems in tunnel treatment and how do you address them?

Common problems in hydropower tunnel treatment include water seepage, rock instability, sediment accumulation, and structural cracks. Water seepage can lead to erosion and weakening of the tunnel lining, while unstable rock masses cause collapses. Sediment buildup in tunnels obstructs flow, reducing efficiency. Cracks in the structure compromise tunnel integrity, leading to potential failure.

To address these, grouting is used to control seepage, while rock bolting and shotcrete stabilize weak rock. Regular maintenance and cleaning help manage sediment, and monitoring systems detect early signs of structural damage for timely repair. Proper drainage systems are also essential to minimize water-related issues.

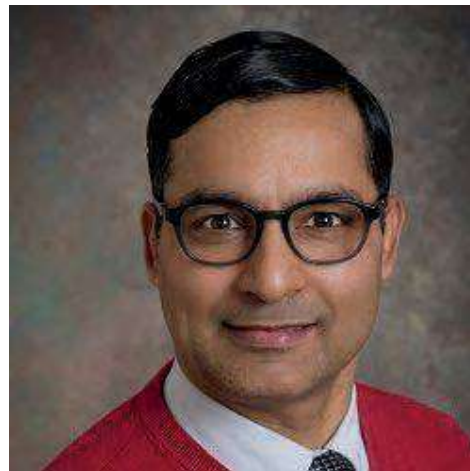
What message will you like to give to reader of this journal?

To all the aspiring geologists, I can tell you honesty and dedication is everything. Since the moment I entered geological field I have been honest and sincere to geology. I am following my passion learning new things each day. So I request you all to be honest, disciplined and dedicated and of course better days are coming.

Interview with Prof. Dr. Deb Jaisi

Dr. Jaisi is a professor at the Department of Plant and Soil Sciences (joint appointment with Earth Science) at the University of Delaware, Newark DE and co-director of Delaware Environmental Isotope System (ES) Center, an instrumentation showcase of the university. He received MS in Geology at Tribhuvan University, MS in Geo-environmental Engineering at the Asian Institute of Technology, Thailand, and PhD in Geological Sciences at Miami University USA.

He was an Interdepartmental Bateman Fellow at Yale University in Geology and Geophysics and Chemical Engineering, National Science (NSF) Fellow at the California Institute of Technology (CalTech), visiting professor at Huazhong A. University, and senior visiting fellow at Xiamen University. He is an associate editor in Clays and Clay Minerals, PLOS One, Soil System, and Pedosphere, and an editorial board member in ACS Earth and Space Chemistry and Soil Methods. His honors and awards include the Gold medal at Tribhuvan University, Gold (Deeswasmongkul) medal at the Asian Institute of Technology, First Geology Doctoral Award at Miami University, and first Interdepartmental Fellow at Yale. He is a Fellow of the International Association of Advanced Materials (IAAM). Other recognitions include NSF CAREER, EPSCOR Fellowship, ACS Early Investigator Award, Jackson Soil Chemistry Award, and ORAU Innovation Award. He serves in various regional, national, and



international professional organizations and advisory boards and councils in the United States and abroad.

1. Could you provide your experience from being a student of geology in Nepal to the faculty of the University of Delaware? For someone who has experienced education system of different nations, including Tribhuvan University, Nepal, Asian Institute of Technology, Thailand and Yale University, United States of America, could you have any suggestions for student regarding what sort of skills they need to develop to stand out?

Academic preparation in geological sciences at Tribhuvan University Nepal is quite rigorous and highly regarded compared to neighboring countries. One of the reasons for this is the learning process which goes hand-in-hand but more importantly high degree of professionalism and the caring nature of professors. In Asian culture, such connections give an opportunity for students to grow scientific curiosity and feel being a part of it. From the beginning, I liked to engage with the faculty, engage in the learning process, and ask questions. When you open up and start a

scientific discourse with faculty, a discussion can continue for hours and sometimes for days. Field trips, short or long, are such rare opportunities for students for in-depth engagement with professors.

The pillar of my curiosity-based or intrigue-based learning initiated in the bachelor's program at Tri-Chandra College. Subsequent degrees like masters, added adornments, provided strengths, and reaffirmed the foundation. That background was key for the next steps I took, the challenges I accepted, and the joy of taking challenging discourse.

If I were to reflect back on my student time in which you all are now, I is a choice". Now you see what it takes to learn! As long as there is a conscious choice for learning, one can take advantage of multiple routes and opportunities. I stumbled upon the value of that trait in the early stage of my student life.

2. So what inspired you to pursue a career in environmental biogeochemistry, and what has been your most significant achievement in this role?

I'm very passionate about scientific research and discovery, and the credit for kickstarting that passion goes to the bachelor's degree field trip to Malekhu, Dhading. It used to be more than a week long field trip for geological reconnaissance and required to write a scientific report. Note that learning and diving into the abyss of knowledge is contagious, but the question is when that contagion imprints in a person's DNA.

I started to ask questions about the observed phenomena but I had more questions than the answers. The scientific

think it was the mindset that was different from most others: the one that is always curious and seeking to learn on every occasion. Hard work comes as an integral part of any proposition. No matter where and when, now or tomorrow, the only pillar of success that will remain universal is hard work. You need to believe in, take on, and carry on. In the current world, there are multiple avenues of learning and gaining knowledge, for a learner who has a sense of curiosity. My mind echoes now what Brian Herbert said, "The capacity to learn is a gift, and the ability to learn is a skill and the willingness to learn

approach of interrogating a question requires testing and validation, for which established methods are needed, which ties to analytical instruments that have the capability to precisely measure certain parameters. I delve into the geochemistry field in which there are robust sets of instruments, well-developed methods, for accurate and quantitative analyses. Perhaps this is the term that should resound in other fields of geological sciences, in which many of the measurements or characterizations are qualitative. Think of a challenge of using a qualitative outcome for devising a regulatory measure or developing a policy.

I am always attracted to intriguing sets of questions that are not just of scientific interest for academic exercise but have public and policy implications. On the path of investigation, one question brings you to one point, and there you open up another set of questions that bring you to the next stage. It is the desire for scientific interrogation, the uncanny hobby of asking

questions, and if you are a research faculty, that hobby becomes your profession.

I was fortunate to work with the kings and queens of geological sciences. You might be reading now Dana's 'A Textbook of Mineralogy', who was a professor at Yale, Gibbs 'Law of Free Energy', or Jay Ague's 'Igneous and Metamorphic Petrology'. It was indeed a 'dream beyond a dream' to touch those names on walls, witness their past offices, or at best talk with them in person. In terms of achievement, scientific discovery and innovation that my team has made so far put us in quite a satisfying stage in the world. Credit always goes to students who work seriously and meticulously. Our mainstream leadership research in phosphate oxygen isotopes has enabled us to interrogate geological and environmental questions such as identifying sources or a particular pathway of cycling of phosphorus in the environment, safe approaches to breaking down herbicides, or developing the next generation of control-release fertilizers. The specificity of the questions we have sought to answer and the discoveries we have made are listed on my research webpage (<https://sites.udel.edu/ebl/>).

3. How does your work in geochemistry and soil science intersect with other field such as hydrology, ecology, or environmental engineering?

My expertise lies in a particular methodology, a tool with translative applications, from agriculture to the environment and deep earth history. It is not a field-specific, per se like ecosystem or sedimentary rocks. My team uses isotope as a major tool, supplemented with Fourier-transformed infrared (FTIR) and Raman

spectroscopies, ultra-high resolution X-ray diffraction (u-XRD), and tandem mass spectrometry (MS/MS) along with high-resolution transmission electron microscopy (HR-TEM) and field emission scanning electron microscopy (FE-SEM) to understand the processes from multiple angles and using independent methods. That process to be sought to understand could be in the water, soil, or geological materials like rock or sediments. The analytical savviness of my team has enabled us to delve into different classical, modern, and emerging fields. It might feel far, but my team was involved in developing a drug for COVID-19 treatment back in 2020. There, we employed isotope tools to identify bioactive compounds and establish the evidence for the drug molecule transport inside a cell.

4. What role do you see soil science playing in addressing global environmental issues, especially to talk about Nepal?

Soil is a matrix that is under-appreciated. Soil is the place where plants grow, and higher trophic level animals live and thrive. In fact, human civilization started and flourished in good soils. Therefore understanding soil is key to our foundation, from buildings, building materials, and to building a family, or the other transect such as growing certain plants, for crops or ornamental values, or a refreshing orchard. One point that connects soil to climate change is that soil stores a whole lot of carbon, about 15 billion tons, second after oceans. If more carbon can be stored in soil or the opposite that soil carbon is protected from oxidation, then it will curb the global emission of greenhouse gases. On the other

hand, the forestation in soil sequesters atmospheric carbon dioxide.

I am not much adept at the science aspect of climate change that is Nepal-specific, if there are any. It, however, is true that the effect of climate change is disproportionately high in Nepal.

5. Your recent publication on tracking phosphorus in the environment. Will you please provide more light on it?

Tracking phosphorus in the environment is our major expertise, which I cast light on before. Most recently, we developed new methods to measure isotopes in selected fragments of a molecule. Perhaps you know the term 'compound specific isotopes' or 'position specific isotopes' in a molecule. We are the first (in the world) to do that in organophosphorus compounds. In the same way, we use conventional methods of measuring isotopes in phosphate minerals. Let me take you one step back. Isotope signatures may be imprinted from particular reactions, particular metabolic pathways, or enzymes involved in those reactions. It means isotope fingerprints allow us to reveal the process or identify particular sources. It means this tool allows us to accurately track phosphorus in the contemporary environment or a distant past in Earth's history. For instance, major discoveries on Earth such as the origin of life or the temperate of the Archean Ocean were made possible by using this isotope. Now you might be curious to know about the biogeochemical process of sedimentary deposits somewhere you visited or let's say, hard-to-miss stromatolites in the Nepal Himalayas. Could they be millions of years old? Or you might of interested know exactly where the phosphorus in these

sediments came from, or what process was undergone in the sedimentary layer exposed on the outcrop now. We address those questions through an integrated approach using isotopes.

5. How have your engagements in the American Geophysical Union and Soil Science Society of America? So how has your role in this organization influenced your research and professional development?

These two are the major professional organizations I'm affiliated with for a long time. I organize workshops and meeting sessions with colleagues with collaborative or complementary expertise and invite leading experts from and outside US for presentations. Many times, such events develop consensus white papers on thematic issues. A series of questions emerged sometimes energizes the team to develop research proposals as well as collaborative projects. My other involvements in these organizations go from mentoring students, giving them career training, and choices and road of opportunities. Many times, I serve on committees on awards, selection of organization positions, and future plans of meetings.

6. Would you please provide light on a research that is very dear to you, and wish all geology aspirants would go through it?

Every research professor is passionate about his/her field of expertise. It is true for dedicated professors that having a good sleep and savory food or taking good care of their health often becomes a subordinate task. The scientific outcomes that I highlighted before are dear to my core heart and are imprinted in DNA.

For all aspiring students, my suggestion is to maintain a strong intrinsic curiosity about the question that matters to you most, bring an innate desire to discover new knowledge and develop a trait of critical thinking. I often see a surge of passion in some students, but that passion becomes short-lived. Being passionate is a great start, but being resilient and adamant to carry on entirely, not leaving the course is something I urge. So do continue, continue to be passionate until your questions are fully answered. Discovery is not known before made. Who knows your discovery help address one of the burgeoning questions for mankind, or you will be bestowed an honor or your legacy will be carved onto scripture, or the building for all future generations to witness.

7. Is there any aspect of geology academic system in Nepal that you wish would improve? What would it be?

Well, I'm not quite sure if I'm the right person to answer that question as it has been away for more than two decades. One thing, I see and is more apparent in the current world, is taking advantage of expertise that has grown overseas. For instance, many of the graduates from the department are now faculty or senior scientists in highly respected institutions in the world. Taking advantage of the alumni network and their expertise to offer remote classes, would be helpful just not for the knowledge but also for inspiring the young generation of students. Perhaps that approach will be additive to what they should be looking at if they wish to choose that path down the road in 10, 20, or 30 years. Perhaps at some point, they might find role models, from within and overseas experts, and create a picture of themselves. I

cannot think of an alumnus who wishes not to be a part of that effort.

9. What advice would you like to give to geology students interested in pursuing research in biogeochemistry and Environmental Sciences?

My best advice is to set a dream now. As I said before and multiple times, it's really important you set a dream and then create a path to chase the dream. For instance, read what motivated Newton on the literally everyday sight of a layman- the falling of an apple. Read what motivated Arnold Schwarzenegger to be the youngest bodybuilder in the world. Motivation speech catalyzes many of us, and more it realigns us to our own dreams and helps us deviate from everyday naysayers, whom you find in each corner. Remember, Eleanor Roosevelt's saying, '*Great minds discuss ideas, average minds discuss events, small minds discuss people*'. Try to promote yourself in the great mind category. Remember, legacy does not come with birth but is earned and built. The world is such a more favorable place, now than before, for realizing your dream. For instance, going to highly respected institutes overseas for study was much more difficult than before. We used to go to the American Center in Kathmandu to search and write a postal mail to the American institutions for admission. Their admission package used to be a thick envelope and often used to get lost. Now everything is at your fingertip. So dream big, be persistent, and never give up to realize your dream.

10. How difficult has it been for you to pursue your career from Nepal to the USA?

I have long removed the word 'difficult' or ' ', from my dictionary. The

longer I sailed in my career, the more I felt this word fits more to the world of excuses. I was always a dreamer and I never thought anything is impossible. Take this from an NBA basketball star, Michael Jordan: *"I've missed more than 9,000 shots in my career and lost almost 300 games. I've failed over and over and over again in my life. And that is why I succeed"*. Remember, every failure takes you one more step closer to success, and you learn more from failure than from success. I never take any failure as discouragement. No question, that there are certain hurdles, there are challenges, but it's the mindset that decides to take on challenges. You will be surprised how much you can achieve.

11. How do you think geology will evolve over time and what branches of geology should students pursue to stay relevant in the future world?

Geological science has evolved over time, so as have other sciences. In each science, there are broad, settled, unsettled, and evolving fields. Long before, perhaps heightened in the Cold War era, and was focused on resource investigations. So finding mines and exploitation for industrial, military, or other development uses took mainstage. This science has evolved since then into more soft fields from hard rock and natural resource-focused sciences. However, in developing countries where a whole lot of infrastructure developments are still to be made, the hard rock geological sciences still prevail and serve as the major pillars of the geological science career. In developed countries, for instance, in the US, hydrogeology and environmental science used to be a small portion of the pie and now have increased substantially. However, geophysics and geochemistry are getting

more and more a portion of the pie in terms of research funding and research infrastructure because these two fields serve both burgeoning questions of academic interests such as on Earth's history, and are equally valuable in hard rock geology for applications. Think of this: every innovation and product development needs natural resources. Now mineral exploration is moved into rare earth metals because of their need for rechargeable battery technology, as the IC (internal combustion) engines are gradually replaced by batteries to power automobiles. The exploration of those metals still requires the classical knowledge of mining, exploration, and metallurgy, but with a little different spin. At a granular level, we can think of getting into a circle, going back to something like 50 some years before. Keeping abreast of the world's trends, country's policies and larger statistics can help connect the dots or create a trend from the dots. One's career is much shorter than how much we can extract from these databases.

12. What advice or support would you give to aspiring geologists in navigating potential career challenges?

Dream. Always dream big, and then always make an earnest effort to achieve it. Dreams are very central to anyone's success, sketching a career. Because of the depth and rigor of knowledge you have, the vocabulary, the idioms, the acronyms, collected give a logical connection and explicit understanding of rather complex subject matter. There is no shortcut to learning, and there is no substitute for hard work as I alluded to before. Now, let me say one philosophically: when you wake up in the morning if the geoscience does not come as the first thing on your mind and the first order of business is not geoscience, then you

can never be an expert in this field. So is true for any other field. You also need to be very accepting of the challenges. Sometimes I see people engulfed themselves in personal ego, where emotion takes over rationalism. This situation draws one into the world of revanchism.

The world is more conducive to collaboration and sharing knowledge. A whole lot of support is out there for someone taking the right path and seeking help righteously. So, challenge yourself for your perseverance, and keep your energy and attitude high up in the positive direction. Start creating a new identity for yourself. Reinvent yourself and start establishing atomic habits in the path of your dream. If I could be helpful anywhere in the spectrum of your thought process and career progress, I am one touch (of an email) away.

13. How do you see the future of geology in the next decade?

The fundamental sciences remain literally the same, but as I mentioned the evolving field in each science changes, so is the size of the pie for each. Most of the time, it is the field itself and its professionals who recast the societal need. Let's take the exploration geophysics and mineral deposits as an example to explain this. Classical metal deposit investigations are now moved into rare earth metals. Who knows geological science will go even further to resource exploration to other planets. There are recent reports that mercury may have 11-mile layer of diamonds. It will be geologists who will be called first if there is a way to go there to get diamonds. We have long thought and made some instrumental progress about going to Mars and inhabiting the planet. Who knows, a whole lot of geologists would be needed for this. While

human needs, whether basic, developmental, or military, may take a turn, but the resource needs are universal. So in terms of the decadal time frame, we do not expect a whole lot of turns and changes. Some might be thinking, well, AI (artificial intelligence) is basically sweeping all across, so will be in geoscience. Partially, to some extent but it cannot undertake research, or create a new field map. It can only iterate what is already there and identify statistically reasonable trends. But that is an infinitesimally small portion of the pie in geoscience. Fundamental science is the elementary block, think of an atom, and everything else is built on it. Iteratively, this means as long as someone is savvy in basic sciences, s/he can morph into the phases a science takes over time.

14. Many universities are closing the Department of Geology. What might be the reason behind it? That is either closing or combining with other scientists and named Earth science in general?

Yes, I have heard about this and talked to a couple of colleagues regarding the closure or merger of a few geoscience departments in the US. I do not know how that number compares to other departments undergoing a similar fate. I mean that without knowing how it fares to other departments, it is unfair to make an interpretation of a stand-alone number. I think we are looking at the wrong side of a pyramid. It is rather how graduates and alumni are keeping their profession's value high in front of society. How seriously members take their responsibility when a particular geoscience field is needed for societal issues, urgent or incremental. How about the quality of recent graduates? Are they creative, problem solvers, and put

energy into addressing some of the burgeoning geoscience questions on hand at the country level or other lower levels? Equally important is the language we speak-it could be opaque or confusing to policymakers or the lay public. Not every analogy works, and there could be a false side of analogical reasoning. Carrying the subtleties and nuances in a field without confusion to the public is a test in itself. We need to work together to recast the image of the profession so that society sees the values and needs and thus supports public funding for continuation.

Interview with Mr Dinesh Nepali

Mr. Dinesh Nepali is the deputy director general at Department of Mines and Geology and is currently working as project chief of Petroleum Project. He received his early education in Tribhuvan University, Nepal and went to Stuttgart University of Applied Sciences to pursue higher education.

1. What inspired you to pursue a career in geoscience and what has been your most significant achievement in this role?

After completing my I. Sc education, I came to know that Geoscience involves a lot of fieldwork, research, and mineral exploration. I enjoy traveling, exploring remote areas, and conducting experiments. This is the main reason why I chose to pursue my career in geoscience.

I am quite satisfied with my decision to serve my country as a professional geologist. Currently, I am working at the Department of Mines and Geology (DMG) in the capacity of Deputy Director General, and I have been recently appointed as a Project Chief of the Petroleum Exploration Project, DMG.

I was a key member of a DMG which has published Engineering and Environmental Geological Maps of different major cities of Nepal. I am thankful to DMG for providing this wonderful opportunity to contribute in a meaningful way. I have completed geological mapping and mineral exploration of different parts of the country under my leadership and supervision, which in my



opm10n has made some significant contribution in the field of geoscientific research and exploration.

2. What are the different techniques that are used in petroleum exploration in Nepal?

Surface geological studies: Petroleum geological mapping, geochemical sampling, and section measurement are the main surface geological investigations carried out during the initial activities of petroleum exploration.

Sub-surface investigation: Geophysical investigations such as seismic survey, gravity survey, aeromagnetic and aerogravity survey and magnetotelluric survey are commonly used geophysical methods in petroleum exploration. Seismic survey is the most important and globally accepted method in the petroleum industries. All the above-mentioned exploration techniques have been applied for petroleum exploration works in Nepal; however, coverage and data density is limited.

3. Are there ongoing projects or partnerships that are particularly exciting?

Currently, DMG is implementing a G to G (Government to Government) project in collaboration with the China Geological Survey with the financial and technical assistance from the Government of China.

The principal aim of this project has been to discover petroleum resources of the country and to prove the commercial viability for production. The main exploration activities under this project have been focused in the Dailekh area, where the exploration well drilling (up to 4000 m) to find oil and gas is in progress. As most of the surface and sub-surface geological conditions are favorable and positive for discovery, this project is very exciting and could be a game changer in the petroleum exploration endeavor of the country.

4. What strategies will your department implement to navigate this changing environment and ensure the long-term viability of our petroleum operation?

Legal frameworks required for the petroleum operation in Nepal are already in place which is the major requirement to operate any petroleum activities.

The Petroleum Regulation, 2041 incorporates the "Model Petroleum Agreement," the most commonly practiced

petroleum agreement around the globe, in the form of Petroleum Sharing Contract (PSC), which is another encouraging condition for international oil and gas companies to invest in Nepal.

5. What are the most common geological and other challenges?

Nepal, located in the Himalayas, faces several geological challenges due to its unique geography and tectonic setting. Here are some of the most common challenges:

- Geological and structural complexity
- Accessibility
- Technical expertise

6. Can you elaborate on your leadership style and how you motivate and empower your team members to achieve their full potential?

- I believe in teamwork, so I would prefer to be a leader rather than a boss.
- I pay more attention toward making a conducive environment for work and progress.
- Frequently, I like to join the working team as an instructor and a learner, and I always try to keep friendly relations with my subordinate staff.

Interview with a Superintendent Geologist Shova Singh

Introduction and Background

Shova Singh is a Superintendent Geologist at the Department of Mines and Geology (DMG) in Nepal, a highly regarded professional with years of experience in the field of geology. She completed her Intermediate of Science (I.Sc) from Padma Kanya College, followed by a Bachelor's degree in Geology from Tri-Chandra Multiple Campus. She later pursued her Master's in Geology from Tribhuvan University (TU), deepening her expertise in the field. She began her government career in 2052 B.S., and since then, she has made significant contributions to Nepal's geoscience sector.

Field of Expertise

Her specialization lies in geology, where she has worked across various projects, both national and international. Over the years, she has demonstrated her skills in geological surveys, project management, and resource exploration. Her role at DMG encompasses handling critical projects .

Inspiration Behind Pursuing Geology

When asked about her inspiration to pursue geology, she fondly recalls her father, who worked in the Department of Forestry. Watching him engage with nature and resource management, she developed a keen interest in the Earth's processes and the



science behind it. "My father's dedication to forestry and the environment had a profound influence on me. It opened my eyes to the importance of conserving and understanding natural resources," she says.

Career Achievements

One of the major milestones in her career was handling a prestigious project in collaboration with Germany, known as the EGP (Energy and Geology Partnership) project. She recalls, "This project was a turning point for me. It was the first major international collaboration after joining the job, and it really tested my ability to manage and execute complex geological operations." The success of this project cemented her reputation as a dedicated and skilled geologist.

Challenges as a Woman in Geoscience

Like many women in science, she has faced her share of challenges, particularly in the field of geoscience, which often involves rigorous fieldwork. Balancing her professional responsibilities with managing her household was one of the most significant challenges. "Fieldwork in remote areas, combined with the expectations of managing a home, created immense pressure," she shares. However, she

persevered through these hurdles, finding a way to strike a balance.

Gender-Related Obstacles and Gender bias,

She admits, gender related biasness exists was another obstacle. "As a woman, you are often given less priority in decision-making or field assignments, and there are more hurdles to overcome than our male counterparts," she explains. However, she never let these barriers hold her back. Her commitment to her work and ability to maintain professionalism has helped her rise above these difficulties.

Successful Projects

Among her many accomplishments, the successful completion of the EGP project stands out. "The discipline, dedication, and hard work that went into this project were immense, but it was worth it," she says proudly. This project has set a benchmark for future initiatives in her department.

Retirement Plan

Though she is nearing retirement, she remains passionate about geology. She shares, "Even after retirement, I want to contribute more to the field of geology. There is still so much to learn and so many ways to give back, and I hope to continue mentoring and participating in geological initiatives." Her dedication to the field shows that her journey in geology will continue long after her formal career ends.

Message to Aspiring Female Geologists

To young women aspiring to enter the field of geoscience, she offers some heartfelt advice. "You need to coordinate more, be your own problem solver, and be disciplined. The challenges are many, but

with hard work and dedication, you can overcome them all." She stresses the importance of resilience, self-motivation, and a passion for the subject

Message to Readers

Finally, she shares a message for all readers: "Geology has a lot of scope, and the field of geoscience is rapidly evolving. Be patient, enthusiastic, and passionate about the subject. Hard work and dedication are the keys to success." Her words are a testament to her years of experience, and she hopes to inspire the next generation of geologists to keep pushing boundaries in the field.

A Comprehensive Review of River Dynamics and Fluvial Processes in the Kathmandu Basin

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Abstract:

The Kathmandu Basin, situated in the central Himalayas, is a region shaped by complex river dynamics and fluvial processes that are integral to its geomorphological development. The rivers, including the Bagmati, Bishnumati, and Manohara, are vital for water resources, sediment transport, and landscape formation. However, rapid urbanization has significantly altered these natural processes. This review synthesizes existing research on river dynamics and fluvial processes in the Kathmandu Basin, focusing on sediment transport, channel morphology, and human impacts. Findings reveal increasing sediment loads, altered river channels, and heightened flood risks linked to urban expansion. Sustainable water management and river restoration strategies are recommended to mitigate these impacts and preserve the basin's ecological balance.

Keywords: River Dynamics, Pluvial Processes, Sediment Transport, Urbanization, Kathmandu Basin.

I.BACKGROUND

1.1 Introduction

The Kathmandu Basin, nestled in the central Himalayas, has been shaped by complex river dynamics over millennia. Rivers like the Bagmati, Bishnumati, and Manohara have significantly influenced the region's geomorphology through sediment transport and landscape formation (Dixit, 2003). However, rapid urbanization in recent decades has disrupted these natural processes. Increasing construction, deforestation, and land-use changes have altered river channels, heightened sediment loads, and raised flood risks (Rimal, 2011). Understanding how these anthropogenic factors impact river dynamics is crucial for sustainable urban planning and water resource management. This review synthesizes current research on fluvial processes in the Kathmandu Basin, focusing on urbanization's effects and strategies for mitigation.

1.2 Aim

This review aims to consolidate existing research on river dynamics and fluvial processes in the Kathmandu Basin, with an emphasis on how human activities have altered these systems.

1.3 Objectives

The review seeks to answer the following key questions:

1. How have sediment transport and deposition patterns evolved in the Kathmandu Basin?
2. What impact has urbanization had on river dynamics and flood risks within the basin?

The specific objectives are to analyze sediment transport and deposition patterns and assess the changes in river channel morphology due to both natural and human factors.

2. MATERIALS AND METHODOLOGY

This review analyzed secondary sources, including scientific journals, reports, and research papers, to examine sediment transport, river dynamics, and the impact of urbanization in the Kathmandu Basin.

3. RESULTS

The review indicates that the Kathmandu Basin's River systems are characterized by complex sediment transport processes, significantly altered by human activities. Historically, rivers transported large volumes of sediment, shaping the basin's alluvial plains (Dixit, 2003). However, increased deforestation, construction activities, and land-use changes have caused higher sediment loads and shifts in river channels (Shrestha et al., 2012). Urban expansion has notably contributed to the narrowing and deepening of river channels, raising the risk of flash floods (Rimal, 2011). For example, the Bagmati River's channel width decreased from 50 meters in 2005 to 35 meters by 2015, exacerbating flood risks (JICA, 1990). Similar trends are observed in other rivers within the basin, such as the Bishnumati and Manohara. This narrowing has made these rivers more prone to channel migration, bank erosion, and increased flood risks, particularly during periods of intense rainfall. Additionally, altered hydrology and sediment transport have led to increased erosion and channel migration (Dixit, 2003). Moreover, the disruption of natural processes has hindered groundwater recharge, impacting the basin's overall water management (Shrestha et al., 2012). The increased sediment loads and altered flow regimes have had downstream impacts, including reduced water quality, changes in aquatic habitats, and altered hydrological cycles. The deposition of fine sediments in riverbeds has also impacted groundwater recharge, further complicating water management efforts in the basin.

Table 1: Comparative analysis of sediment transport rates and channel width changes in the Kathmandu Basin (2005-2015)

S.N.	River	Sediment Transport Rate (tons/year)	Channel width (2005) (meters)	Channel width (2015) (meters)	Change in channel width (meters)
1	Bagmati	250,000	50	35	-15
2	Bishnumati	180,000	30	25	-5
3	Manohara	200,000	40	32	-8
4	Dhobi Khola	150,000	25	18	-7
5	Tukucha	130,000	20	15	-5

4. DISCUSSION

The findings from this review highlight the complex interplay between natural processes and human activities in shaping the river dynamics of the Kathmandu Basin. The increase in

sediment transport rates and changes in channel morphology observed over the past few decades are closely linked to the region's rapid urbanization.

Urbanization has intensified pressure on the basin's river systems. The construction of roads, buildings, and other infrastructure has encroached upon natural floodplains, reducing the rivers' ability to accommodate high flows and increasing the likelihood of flash floods. The narrowing and deepening of river channels, as seen in the Bagmati and Bishnumati rivers, further exacerbate this risk by limiting the rivers' capacity to disperse floodwaters across wider areas.

Increased sediment loads have also contributed to the degradation of aquatic ecosystems. The deposition of fine sediments has smothered riverbeds, reducing habitat quality for aquatic species and disrupting the ecological balance. This sedimentation has also affected the hydraulic conductivity of riverbeds, thereby altering groundwater recharge processes. Consequently, the basin has seen a decline in groundwater levels, which is particularly concerning given the growing demand for water resources due to population growth and urban expansion.

These changes in river dynamics are not unique to the Kathmandu Basin but are part of a broader global trend in urbanizing regions. However, the unique geographical and climatic conditions of the Himalayas make the basin particularly vulnerable to these changes. The steep topography, combined with intense monsoon rains, amplifies the effects of land use changes, making effective water management and urban planning even more critical.

5. CONCLUSION

This review reveals that river dynamics and fluvial processes in the Kathmandu Basin have been significantly influenced by both natural and human factors. Ongoing urbanization and land use changes have disrupted sediment transport patterns, altered river channel morphology, and increased flood risks. The findings highlight the need for integrated water management and sustainable urban planning to mitigate these impacts and ensure the basin's long-term sustainability. Implementing effective water management strategies and adopting environmentally sensitive urban planning practices are critical to countering the negative effects of urbanization on river dynamics and fluvial processes. These measures will help preserve the ecological balance of the Kathmandu Basin. Furthermore, continuous monitoring and further research are necessary to track changes in river dynamics and fluvial processes over time and develop adaptive strategies to address the challenges posed by future urban expansion.

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Use of Bio Engineering techniques to control mass movement in Nepal

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Abstract: Mass movement or mass wasting is understood as " processes of erosion, transport, and accumulation of material that occur on both gentle and steep slopes mainly owing to gravity"(Mass movement, 2007). It generally starts when the critical shear stress of the mass in the slope is reached. This article, present the summarize view on the use of different bio-engineering techniques to control mass movement in Nepal. The use of Napier grass (elephant grass or Uganda grass, *Pennisetum purpureum*) and Utis (*Alnus nepalensis*) to stabilize the road construction done in the Shivapuri watershed as well as the use of Utis (*Alnus nepalensis*), Rhizomes of bamboo and amliso (broom grass, *Thysanolaene maxima*) in Labok to stabilize the reoccurring Landslide is discussed.

Keywords: *Bioengineering, Mass Movement, Slope Stability.*

1. BACKGROUND

Nepal is a landlocked country with hills and mountains making up the majority of the land, about 86% (LRMP, 1986). Altitude ranges from 8848m at its highest point to about 200m at its lowest point. The large change in topography from the highest point in the mountains to the lowest point in the Terai has given rise to steep slopes of varying degrees. Due to various natural and human-made activities, it leads to movement of mass present in the slope down along the gradient. Every year mass movements such as landslides and floods lead to loss of lives and property. And roads and human settlements are among the things that are affected the most. Many efforts have also been provided to overcome such disasters such as different drainage methods, the construction of various types of wall and support structure such as gabion, RCC lining, rock bolting, earth anchoring, etc (Dahal et al., 2006). Modern approach to such effort is, modified bioengineering techniques which uses a combination of natural and artificial methods to mitigate and enhance the stability of a slope. Bioengineering can be described as a technique that makes use of live vegetation to reduce soil erosion, slope stabilization or to enhance the structural integrity of the slope. Bioengineering performs two functions: Mechanical and hydrological. Mechanical Function includes catch function, Armour function, reinforce function, support function, anchor function and drain function. Mechanical functions mainly relate to the properties of vegetation through mechanical parameters such as creation of micro rills, resistance to shear force in soil and support (Clark and Hellin, 1996). In comparison, Hydrological function refers to the ability of vegetation to maintain the stability of the slope. Vegetation shields the soil from direct contact with the water droplets and also increases the permeability of the soil. The stems and roots also increase the overall roughness of the ground and help increase the absorption of water in the soil. The leaves provide more surface area to trap water which evaporates into air. A vegetation also helps to extract water from the soil and release into the air through transpiration. The extensive structure provided by the stem and roots of vegetation helps to temporarily hold the water from precipitation and slow down the runoff rate of the water down the slope.

Aim

This article aims to summarize the use of bioengineering to control mass movement.

2. MATERIALS AND METHODS

This article is prepared by reviewing past literature related bio-engineering techniques applied in the Nepal.

3. RESULTS AND DISCUSSION

Bioengineering technique is most effective and economical for depth up to 500mm in the slope. It has been proved helpful for catching debris, armoring the surface, reinforcing the soil, anchoring the surface, supporting the slope or the draining material (Howell, 1999). In bio-engineering, the different types of vegetation are used which will vary according to the purpose of the slope protection, type of climatic condition and soil. The popular species used in bio-engineering in Nepal are listed below.

Table 1: Popular plant species of Nepal used in soil bioengineering (Dhital et al., 2012).

Species	Local Name	Botanical Name	Characteristics	Best Propagation	Alt. (m)
Grasses	Aruiso	<i>Thysanolaena maxima</i>	Large clumping	Slip cuttings	100-2000
	Babio	<i>Eulaliposis binata</i>	Medium-sized clumping	Slip cuttings/ seeds	100-1500
	Kans	<i>Saccharum pontaneum</i>	Large clumping, spreading	Slip cuttings	100-2000
	Khar	<i>Cymbopogon microtheca</i>	Medium-large clumping	Slip cuttings/ seeds	500-2000
	Narkat	<i>Arundo clonax</i>	Large clumping, spreading	Stem/Slip cuttings	100-1500
Shrubs/ small trees	Bains	<i>Salix tetrasperma</i>	Tree up to 15m high	Hardwood cuttings	100-2700
	Bhujetro	<i>Butea minor</i>	Shrub up to 4m high	Direct seeding	500-1500
Large trees	Dhanyero	<i>Woodfordia fruticosa</i>	Shrub up to 3m high	Seeds/ polypots	100-1500
	Namdi phul	<i>Colquhounia coccinea</i>	Shrub up to 3m high	Hardwood cuttings	1000-2000
	Tilka	<i>Wendlandia puberula</i>	Tree up to 10m high	Seeds/ polypots	100-1500
	Chilaune	<i>Schima wallichii</i>	Large, evergreen	Seeds/ polypots	900-2000
	Khayer	<i>Acacia catechu</i>	Large, thorny	Seeds/ polypots	100-1000
Large trees	Lankuri	<i>Fraxinus jloribunda</i>	Large, deciduous	Seeds/ polypots	1200-2700
	Sisau	<i>Dalbergia sisso</i>	Large, broad-leaved	Seeds/ polypots	100-1400
	Utis	<i>Alnus nepalensis</i>	Large, broad-leaved	Seeds/ polypots	900-2700

3.1 Different Bioengineering techniques used in Nepal (WECS, 2019)

3.1.1 Bush-mattress construction with wood pegs

It is a systematic construction of living branches to form a rectangular mattress. Each mattress has 15 to 30 live branches which consist of plants that grow rapidly (such as *Salix*, *Eleagnus*, *Platanuse*, etc.)

3.1.2 Wattle fences (wicker)

Chestnut pegs (length 1m, diameter 4-5 cm) are driven into the soil (depth 50-70 cm) at one meter interval with shorter pegs driven at 20 cm interval. Live branches are woven around those wooden pegs.

3.1.3 Log Brush Barrier

In this method, log and brush is used to slow surface runoffs, catch sediments and allow infiltration. Trees such as *Cypressus*, *Pinusnigra*, *Quercus*, etc. are used in this method.

3.1.4 Fascines (bush wattles)

This method makes use of living branch of *Salix Vitex* with support from chestnut pegs which are driven into the soil for support.

3.1.5 Vegetated Gabion

In this method, vegetation is introduced alongside the gabion. The vegetation weave between the gaps in the gabion wall and provide extra support to the structure.

3.1.6 Geocells

In this method, geocells made from high density polyethylene of different size is used. The size of cell depend on the type of soil and the slope ratio.

3.2 Case studies of bioengineering in Nepal

The first known use of bio-engineering was in the fifth century AD in ancient China. There is little evidence of bio-engineering in Europe from 500 AD to 1500AD. In Nepal, bio-engineering ideas were introduced only over the last 50 years and the first study related to bio-engineering in Nepal was done by Shrestha (1991) and Clark (1992). Some of the use case of bio-engineering given below.

3.2.1 Planting Napier grass on a road-fill slope In the Shivapuri watershed (Sthapit and Tennyson, 1991)

Shivapuri watershed is located on the northern side of Kathmandu valley. It serves an important role as a catchment area for water supply of Kathmandu city. In 1977, the Government of Nepal constructed a road to get easier access in and around as well as to better manage the area. The difference in elevation of the area was upto 120m, so the road was constructed using cut and fill method for better resource management. In the fill section, the surface was formed from unconsolidated material which was exposed to the environment and was prone to formation of micro rills as well as mass movement. So, to control the movement of mass civil as well as bioengineering methods were applied. In the bio-engineering method use of Napier grass (*Pennisetum purpureum*), also known as elephant grass or Uganda grass, was used along with utis (*Alnus nepalensis*) in some places. Napier grass was planted in a grid pattern with 45 cm spacing with two cuttings per spot. The plantation method for the cutting was such that it rested at an angle to the surface with 2 to 3 nodes buried in the soil and one node exposed to air, and with sound tamping of soil to prevent air pockets (Ness, 1989). All favorable conditions for the plantation were met and the growth was carefully observed until next year after which the grass was harvested for agricultural use. After two year, investigation of rooting depth showed superficial roots at the depth of from 0.3 m to 1.0m (Hansen, 1989). The plantation was done from 1986 to 1989, during this time approximately 20km of road-fill slope was covered. And due to its success at the Shivapuri area, this method was adopted in other bioengineering works in different parts of the country.

3.2.2 Landslide treatment at Labok, Biring watershed, Ilam district (Sthapit and Tennyson, 1991).

The labok landslide which is about three hectares in size located in the Biring River catchment in Illam, has an active landslide mainly due to high rainfall in the area (upto 3000mm annually). The landslide is assumed to have been active even before 1954, when the documented record was made using aerial photography. The site is prone to high infiltration into the soil residuum and the slide area is subjected to toe cutting action. The DSCWM started the work on slope stabilization in 1975. During the first year detailed surveys were conducted and check dams were constructed using bamboo-cum-loose-stone check dams to control the formation of micro rills and reduce the effect of gully erosion. The following year (1976/77), the drainage works were conducted on the site by constructing stone lined diversion work to prevent run-off water from reaching into the slope. Gabion walls were also constructed along with bamboo-cum-loose-stone at the toe to reduce the toe cutting of the slide. In the second phase during the year 1986, seeding of Utis (*Alnus nepalensis*) was planted in grid pattern with 2m spacing. Rhizomes of bamboo and amliso (broom grass, *Thysanolaena maxima*) were also planted in the slide area. About 600 bamboo rhizomes and about 40000 plugs of amliso were planted in rows of (1 x 1 m spacing). It is planted in rows (1 x 1 m spacing) along the contour. Broadcast seeding of amliso (20 kg/ha) and utis (20 kg/ha) was done in the area which were inaccessible.

4. CONCLUSIONS

Failure of a slope occurs mainly due increase in shear stress but combination of various circumstances leads to it. It may be the groundwater condition, type of material in the slope,

presence of fracture and fissures and we can mitigate them using different civil and biological techniques. Civil techniques show immediate results whereas biological techniques such as bio-engineering show results slowly. But bio-engineering shines the most when we observe its benefits over a long period of time. The observation done in the two sites Shivapuri and Labok in successive years from its inception showed significant improvement in soil condition of the area. The vegetation also served as grass fodder to the local population as a feed to their livestock. By applying simple maintenance techniques to the vegetation, we can provide support to the slope for an indefinite period of time.

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Application of Remote Sensing and GIS in Earthquake Triggered Landslides

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Abstract: Landslides triggered by earthquakes are a significant global hazard, causing widespread damage and loss of life. The need for research in this field is evident due to recent earthquakes highlighting the potential for extensive landslides. Geographical Information System (GIS) and remote sensing technologies have played a crucial role in advancing knowledge by enhancing data extraction and analysis. These technologies enable the acquisition of large-scale data, improving documentation and the development of susceptibility, hazard, and risk assessment models. Remote sensing and GIS support information acquisition, analysis, and monitoring, aiding in understanding earthquake-triggered landslides. Additionally, they contribute to identification, mapping, monitoring, and early warning systems, facilitating effective risk evaluation. Nonetheless, there is a research gap regarding the development of automated methods using machine learning and computer vision for landslide detection from satellite imagery. Further research is essential to fully explore the potential of these technologies for landslide assessment and mitigation.

Keywords: *Landslide, Landslide mapping, RemoteSensing, GIS, Earthquake*

1. BACKGROUND

Landslide, a major natural disaster, is one of the most frequent hazards in hilly and mountainous regions worldwide, causing significant loss of life and extensive damage to infrastructure and properties (Renaud et al., 2007). Landslide, as defined by Cruden (2003), refers to the downward mass movement of rock, soil debris, or earth detaching from slopes. Among the primary triggers for landslides, earthquakes play a prominent role across the Earth. Recent years have witnessed notable earthquakes such as, the 2015 Mw7.8 in Gorkha, Nepal, and the 2010 Mw8.8 in Chile (Chen, Zhang and Xu, 2019). These events have demonstrated the ability of earthquakes in mountainous regions to generate several hundred landslides within a short period. The landslides triggered by earthquakes pose a significant threat to society due to their direct and indirect long-term impacts, including infrastructure damage, increased debris flows, and floods resulting from landslide dam failures. Consequently, the research focused on earthquake-triggered landslides has gained substantial attention in recent years due to the potential for loss of life and economic devastation. Geographical Information System (GIS) and remote sensing technologies have greatly facilitated progress in the field of earthquake-triggered landslides by enhancing data extraction efficiency and accuracy. These technologies enable the acquisition of large-scale and extensive data, including satellite imagery and topographic information, leading to improved documentation of earthquake-triggered landslides. Furthermore, they enhance the development of susceptibility, hazard, and risk assessment models, benefiting from advanced processing capabilities for high-precision data (Van Westen, 2002). Remote sensing and GIS technologies play a crucial role in information acquisition and big data analysis, allowing for more comprehensive understanding and monitoring of earthquake-triggered landslides. Additionally, these technologies have advanced the identification, mapping, monitoring, and early warning systems for such landslides, contributing to more effective risk evaluation. However, the development of automated methods using machine learning and computer vision techniques for landslide detection from satellite imagery remains an important research gap. Investigating these techniques can enable

efficient and accurate identification of landslide features, considering the challenges posed by scale and variability across different geographic regions.

Aim

This aim conveys the main focus of the study, which is to explore the application of remote sensing and GIS in the context of automatic method of detection landslides triggered by earthquakes. It also highlights the specific goals of the research, including detection, monitoring, and prediction techniques for a comprehensive understanding of the topic.

Objectives

1. To understand how remote sensing and GIS can be used in mapping and analysis of earthquake triggered landslides.

Research Questions

- 1) In what aspect remote sensing and GIS helps in earthquake triggered landslide?
- 2) How can remote sensing and GIS be used to map and monitor earthquake-triggered landslides in real time?

2. METHODOLOGY

This study is entirely based on secondary sources and desk study. Relevant articles and secondary sources from the internet were reviewed and analyzed as a methodology for this particular term paper. For the literature review, google scholar, science direct and research gate was used. Collected information were then systematically reviewed for logical discussion and draw valuable recommendations.

3. RESULTS

Remote sensing and GIS technologies are used in earthquake-triggered landslide susceptibility and hazard assessments. Here are some ways in which remote sensing and GIS are used in this context:

- a. Information acquisition: Remote sensing and GIS technologies have greatly improved the ability to acquire information and perform big data analysis of earthquake-triggered landslides (Acharya, Yang and Lee, 2016). These technologies enable the collection of various data sources, such as satellite imagery, aerial photography, and topographic maps, which can be integrated and processed to obtain valuable insights into landslide occurrences (Acharya, Yang and Lee, 2016).
- b. Landslide inventory mapping: Researchers can use remote sensing and GIS technologies to prepare earthquake-triggered landslide inventory maps (Gallen et al., 2017). By utilizing high-resolution satellite imagery and aerial photographs, researchers can identify and map landslides that have been triggered by earthquakes. These inventory maps provide a visual representation of the affected areas, helping to assess the extent and distribution of landslides (Guzzetti et al., 2012).
- c. Susceptibility mapping: GIS-based earthquake-triggered landslide susceptibility mapping can be performed using an integrated weighted index model along with remotely sensed data (Acharya, Yang and Lee, 2016). By considering various factors such as slope angle, lithology, landcover, and precipitation, susceptibility maps can be generated to identify areas prone to landslides. Remote sensing data, such as satellite imagery and digital elevation models, can provide essential inputs for the spatial analysis and modeling process (Van Westen, 2002).

- d. Hazard assessment: Remote sensing and GIS technologies can be used to assess the hazard posed by earthquake-triggered landslides, including identifying areas at risk and predicting the likelihood of future landslides (Meena and Tavakkoli Piralilou, 2019). By integrating data on earthquake characteristics, terrain attributes, and historical landslide events, hazard assessment models can be developed. These models aid in understanding the potential impacts of landslides, supporting decision-making processes related to land use planning, infrastructure development, and disaster management (Nyimbili, Erden and Karaman, 2018).
- e. Statical Method: Weights of evidence modeling, information value modeling and logistic regression modelling are statical method used for landslide hazard and susceptibility analysis (Dou et al., 2019). These methods involve the statistical analysis of various factors that contribute to landslides, such as slope steepness, soil type, rainfall intensity, and seismicity. By quantifying the relationships between these factors and landslide occurrences, statistical models can be developed to predict and assess landslide hazards and susceptibilities in different areas (Dou et al., 2019).

In general, remote sensing and GIS technologies are essential for regional earthquake-triggered landslide susceptibility and hazard assessments. They allow researchers to acquire and analyze large amounts of data, prepare inventory maps, and assess the hazard posed by landslides.

4. DISCUSSION

The use of remote sensing and GIS technologies in earthquake-triggered landslide susceptibility and hazard assessments has proven highly valuable. These technologies enable comprehensive data acquisition and analysis, inventory mapping, susceptibility mapping, hazard assessment, and statistical modeling. Findings align with previous research, demonstrating the effectiveness of remote sensing and GIS in assessing landslide hazards and identifying at-risk areas. Integrating diverse data sources allows for comprehensive assessments of landslide occurrences, while high-resolution satellite imagery and aerial photographs aid in the creation of detailed inventory maps. Susceptibility mapping considers multiple contributing factors, and hazard assessment models assist in understanding potential impacts and making informed decisions. Statistical methods further enhance analysis and prediction capabilities. In general, remote sensing and GIS technologies play a crucial role in assessing earthquake-triggered landslide hazards.

5. CONCLUSION

The use of remote sensing and GIS technologies for regional earthquake-triggered landslide susceptibility and hazard assessments has been investigated. The integration of these technologies can be used to acquire and analyze vast amounts of data, create detailed inventory maps, assess landslide susceptibility, and predict future hazards. This enhances our understanding of the complex dynamics of earthquakes and landslides, and supports effective decision-making processes and the implementation of appropriate measures to mitigate the impact of such natural disasters. The study has some limitations, but the findings are likely to be generalizable to other regions. Further research is needed to explore the full potential of these technologies for landslide assessment and mitigation. Recommendations for future research include conducting further studies in different regions, developing new methods for using remote sensing and GIS technologies to assess landslide susceptibility and hazard, and exploring the use of these technologies to develop early warning systems for landslides.

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Paleontological Richness of Kathmandu Valley: Fossil records and Climate Evolution

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Abstract: This article analyses the general prospect of fossils in the Kathmandu Valley, with specific focuses on such species as the Miocene to Pleistocene. It records many a vertebrates, invertebrates and plant fossils and interprets their geological association with the Siwalik Group sediments. For instance, paleontologists have been able to identify species of elephant and variations in climate that have influenced the level and types of species. The study concludes that the fossils record provides insights into ancient ecosystems and tectonic activity, enhancing the Kathmandu Valley's geological and paleoclimatic history. In general, it underscores the significance of the valley primarily as the area of exceptional paleontological value and importance for the issues related to climate change.

Keywords: *MCT (Main Central Thrust), Lacustrine, Paleoenvironment*

1. BACKGROUND

The Kathmandu Valley located at an altitude of 1200 mis one of the large oval shaped basins within the Lesser Himalayan range in Nepal and stretches about 30 km in the east-west direction and 25 km in the north-south direction. The basin is enclosed by mountain ranges such as Shivapuri towards the north, Nagarjun towards the north-west, and Phulchoki towards the south. The basin fill sediments are fluvio-lacustrine or fluvial to fluvio- deltaic in origin and are considered to have resulted from damming in the southern part of the valley (Sakai et al., 2006). The valley sediments have been divided into different stratigraphic units by different researchers on the basis of lithology, facies analysis, radiocarbon dating and palaeomagnetic polarity data (Yoshida and Igarashi 1984, Yoshida and Gautam 1988, Sakai et al., 2001, Goddu et al., 2007 and Sakal et al., 2008). The oldest deposit is the Lukundol Formation (Late Pliocene to Early Pleistocene) which is distributed at the southern part of the basin and overlain by Chapagaon, Boregaon and Pyangaon terrace deposits formed during tilting of the lake towards north due to activation of Main Central Thrust (MCT) in south. The younger Kathmandu Lake covered the large area of the valley and the younger sediments like Kalimati, Dharmasthali, Gokarna, Tokha, Thimi and Patan Formations (Late Pleistocene) were subsequently deposited (Yoshida and Igarashi 1984, Dongal 1985, Yoshida and Gautam 1988, Sakai et al., 2001, Sakai et al., 2008).The collision of the Indian and Euracean continent was an important event as it formed the great Himalayn ranges and EW trending faults all across the Himalayas. So, this study intends to summarize the fossils records from the effect different tectonic units.

Aim

The aim of this study is to find and document the fossil records of the Kathmandu Valley, focusing on the types of fossils found.

Objectives

The objectives of this article are:

1. To identify and classify the types of fossils found in the Kathmandu Valley, including vertebrates, invertebrates, and plant fossils.

2. To access the paleoclimatic conditions of the valley through the study of flora and fauna.

Research questions

1. What types of fossils are found in the Kathmandu Valley, and how can they be classified?
2. How do the fossil records reveal about the paleoenvironment and ecosystems of the Kathmandu Valley?

2. MATERIALS AND METHODS

The materials used for the article were secondary sources like books, articles and websites from where the information is collected.

3. RESULTS

Several genera and species, including ancient relative species of modern elephants (e.g., *Stegodon*), rhinoceros, and various other herbivores and carnivores, multiple species of freshwater fish have been identified, though detailed genera classification is often less documented compared to mammals. These fossils predominantly date to the Miocene (23 to 5.3 million years ago) and Pliocene (5.3 to 2.6 million years ago) epochs. Numerous species and genera of bivalves and gastropods have been recorded, indicating diverse aquatic habitats. While less commonly documented in detail, other invertebrates like crustaceans may also be present. Like the vertebrates, these invertebrates primarily date to the Miocene and Pliocene epochs. Fossilized leaves and wood from various plant species, including both gymnosperms and angiosperms, have been discovered. Specific genera are often linked to the paleoecological studies of ancient forests and vegetation types. Fossil pollen and seeds provide additional insights into the flora of the valley. Plant fossils also date to the Miocene and Pliocene epochs. The valley is known for various vertebrate, invertebrate, and plant fossils from the Lukundol Formation, which dates from late Pliocene to Early Pleistocene, and other formations yielding Late Pleistocene fossils.

Table 1: Some Different species of Fossils (Vertebrates, Invertebrates and Plants) of Kathmandu Valley

Fossils Group	Species Name	Time period	Formation	Published By
Mammals	<i>Elephas maximus</i>	Late Pleistocene	Lukundol Formation	K.N Poudyal (2015)
Mammals	<i>Bos primigenius</i>	Late Pleistocene	Lukundol Formation	K.N Poudyal (2015)
Mammals	<i>Hipopotamus amphibious</i>	Late Pleistocene	Lukundol Formation	K.N Poudyal (2015)
Mollusca	Ammonites	Late Cretaceous		Bhandari et al., (2011)
Brachiopoda	Lingula	Paleozoic		Bhandari et al., (2011)
Bivalve	Pecten	Mesozoic		Bhandari et al. (2011)
Angiosperms	<i>Carpinus</i> sp.	Late Quaternary	Gokarna Formation	Bhandari et al., (2011)
Angiosperms	<i>Pyracantha</i> sp.	Late Quaternary	Gokarna Formation	Bhandari et al., (2011)
Gymnosperms	<i>Tsuga dumosa</i>	Late Quaternary	Gokarna Formation	Bhandari et al., (2011)

4. DISCUSSION

The Pleistocene lacustrine sediments in the Kathmandu Basin yielded vertebrate fossils equivalent to the upper siwalik. Investigation in this direction is still going on in the different part of the country on the evolution of vertebrate fauna as well as climate history of the Nepal Himalays. Plenty of elephant molars were found in the natural forest in south of valley (Poudyal et al., 2011) but the elephant are not being found in this region anymore. Elephants prefer tropical to sub tropical warmer climate. The presence of warm species of angiosperms was in the lower and upper part and cold climate species of gymnosperms in upper part of Gokama Formation was studied to find out the temperate and cold temperate zone respectively. The tectonical upliftment exposes fossil bearing sediments, allowing researchers to analyze plants and animals fossils from Cenozoic era of Kathmandu valley.

5. CONCLUSION

Fossils in Kathmandu Valley have been dated from the Late Miocene to Early Pliocene, approximately 1 to 13 million years ago. Key findings include the Elephant molars from the Lukundol Formation, dated around 9 to 9.5 million years ago. Invertebrate fossils from the Valley, primarily from the Siwalik Group, show significant diversity, including freshwater bivalves and gastropods. The evidence of extinction of Elephant from the Valley suggests that the climate in Late Pliocene to Lower Pliocene in Kathmandu Valley was much warmer than that of today. The dominance of warm climate indicators angiosperms revealed that the lower part was deposited in warm temperature and the cool climate gymnosperms in the upper part of the Gokama Formation provided a good evidence of climate fluctuation. Overall, this article provide insights about fossils, its influencing the biodiversity, paleoclimatic ecosystem, tectonic settings of past environment of the Kathmandu Valley.

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Bridging the Gap: Assessing the Environmental and Social Costs of Unsustainable Mining

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Abstract: This research aims to address the concerns of mining practices highlighting the impacts of unsustainable and improper management of mine wastes along with unscientific reclamation. With increasing number of mines, the need for sustainable and environmental friendly practices is more relevant than ever. Hence, this study discusses the importance of sustainable mining with proper waste management and its contribution to the conservation of nature and safety of human lives. It focuses mainly on the environmental and social impacts of mining.

Keywords: *Environment Degradations, Sustainable Reclamation, Health Risks*

1. BACKGROUND

Mines and mining industry served as a major factor in the economic development of a country. With proper use and utilization of resources, mining can contribute significantly in the national GDP. The comparative importance of mining and contribution to the national GDP shows that Nepal's economic growth is dependent on the mining of potential mineral resources in the country. (Journal of development innovations volume VI 2021)

However, in context of Nepal, the mining sector faces significant challenges that hinder its development and sustainability. Additionally, the lack of sustainable and environmentally responsible mining and waste management practices threaten the natural beauty and ecological balance in the country. The operation of the mines and wastes are not the only factors posing the problems but its proper shutdown is also creating the problems and disturbances to the life of the people. Environmental concerns related to mining are more apparent and usually more intense in case of abundant mines and extractions. Therefore, identifying and prioritizing reclamation sites are crucial. Reclamation practices should concentrate on stabilizing slope, back filling open fields and implementing erosion control to prevent soil degradation and water pollution. (Journal of Engineering and Applied Science, 2024).

Stakeholder involvement can be a crucial part of mine reclamation. Local communities, indigenous groups, government agencies and environmental organizations together can play a vital role in the restorations of abandoned mines.

Aim

The aim of this article is to ensure and assess the current practices of mine waste management in Nepal and the necessary efforts for scientific, systematic and eco-friendly reclamation to address the environmental and social impact of unsustainable practices.

Objectives

1. To expose the current unsustainable practices of mine waste management and reclamation of

mine in Nepal.

2. To identify the consequences of unsystematic and unscientific mine reclamation.

Research Questions

1. What are the major practices of mine waste management and mine reclamation in Nepal?
2. What are the environmental and social impacts of unscientific waste management and proper reclamation of mines?
3. What can be done to ensure scientific mine waste management for mine in operation and effective reclamation of abandoned mining sites?

2. MATERIAL AND METHODS

This article is based mainly on the secondary data extracted and analyzed from books, journals, research articles, police reports, news sources etc. The data has been collected from field observation and interview with local at limestone mine site Chovar, Kathmandu.

3. RESULTS

Unmanaged and unsustainable mine waste management is leading to soil erosion, instability of river bank, environmental pollution, landscape degradation, etc. One of the major problems arising due to this is the loss of natural beauty. On the other hand, the local communities near the mines are facing several challenges due to the unsystematic nature of the mine waste management practices as well as non-reclamation of the mining site.

In Chitwan, limestone quarry has put an entire Chepang indigenous village at risk. The dust from the sites is affecting the health of the people. Improper management of mine wastes not only affects the nearby community but also affects the entire ecosystem. Sand mines at the side of Trishuli River in Dhading District are polluting the river. The river has become muddy and blurry. Along the Prithvi Highway in Dhading district, it's not uncommon to see dozens of sand mines operating near the Trishuli riverside. Several of such sand mines are in operation in Gajuri, Chalise, Siddhalek, Galchhi, Belkhu, Mastar, Malekhu, Charaudi and Bishaltar, among other highway towns. Excessive excavations from streams and riverbeds without proper reclamation have not only raised threats of environmental hazards but also taken the lives of people. Two men from Gajuri, who worked as laborers extracting sand in Dariyal stream, drowned in a sand pit made by the excavators. (The Kathmandu Post, 2019)

Likewise, earlier this summer, a 12-year-old boy died after falling into a 30-foot sandpit in the Banke River, and when protests grew, the police opened fire at the villagers. According to the government's standards, a pit dug for excavating sand and pebbles should not be over three feet deep, but the one at the Banke River was over 30 feet deep, local residents say. (The Kathmandu Post, 2019). Upon the site visit and the interviews with the locals at Chovar area, it was found that no practices of proper reclamation of the limestone mines, which had been used to supply limestone for Himal Cement Factory in Chovar had been introduced even after decades of its closure.

4. DISCUSSION

The article highlights significant environmental consequences arising from unmanaged and unsustainable mine waste practices in Nepal. The major aspects derived for the discussion are:-

Environmental Impact: The issues such as soil erosion, riverbank instability, and landscape degradation are evident. One of the major adverse effects is the loss of natural beauty, which impacts the local tourism industry. Sand mining in riversides has deterred tourists who visit the area for rafting ultimately affecting local businesses and livelihoods. The environmental degradation is not just localized but extends to broader ecosystem disturbances, indicating a pressing need for sustainable waste management practices.

Health and Safety Concerns: The health implications for communities living near mining sites are substantial. Dust from limestone quarries sand mines is affecting the respiratory health of the community. Moreover, the mining sites have become hazardous zones where inadequate safety measures and lack of reclamation have led to fatal accidents. The tragic drowning of laborers in death in a sandpit exemplifies the dire consequences of neglecting mine safety protocols and proper reclamations. These incidents underline the urgent need for regulatory enforcement and community safety measures.

Socio-Economic Impact: The socio-economic impact on local communities due to improper minewaste management is profound. The non-reclamation of mining sites has rendered areas like Chovar, previously used for limestone mining for the Himat Cement Factory, unsafe and detrimental to the local population. The site's adverse impact has persisted for decades, causing accidents and becoming a hotspot for criminal activities. This neglect not only affects the immediate community but also hampers potential socio-economic development. The villagers' protests against unsafe mining practices reflect the growing frustration and demand for safer, sustainable mining operations.

Government and Policy Implications: The government's role in regulating and monitoring mining activities is crucial. The paragraphs suggest a lack of enforcement of existing standards, such as the regulation limiting the depth of sand pits. This negligence has led to unsafe mining practices, resulting in environmental degradation and loss of lives. Effective policies and strict enforcement are essential to ensure that mining activities do not compromise environmental integrity and community safety. The government's proactive involvement in reclamation projects and sustainable mining practices can mitigate these adverse impacts and promote long-term environmental and social well-being.

5. CONCLUSION

Proper and sustainable mine waste management, combined with effective reclamation practices, is essential for mitigating environmental damage and fostering social development. It ensures the protection of natural resources, enhances public health, supports economic stability, and promotes community well-being. Promoting recycling and recovery from mine waste can be crucial to reduce volume of waste sent to landfills and enhance resource efficiency. Community involvement can also be encouraged to help improve compliance with environmental standards and foster community support.

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Abstract: Nepal is considered an earthquake-prone zone due to its location and tectonic relation with the Indian Plate and the Tibetan Plate. This paper mainly emphasizes the study of the Gorkha Earthquake 2015 regarding its effect on the geological aspect and the socio-economic aspect. This paper is mainly prepared by the analysis of secondary data like articles and research papers. It mainly focuses on the cause, role of the locking line, wave amplification, and aftershocks of the Gorkha Earthquake, 2015. The zone of transition from brittle rocks to rocks under creep and stress accumulation to rupture is discussed. The results elaborate on the role of density in wave amplification and shed light on the aftershocks caused by the main shock. This earthquake led to a massive loss in the country's GDP and human life. The use of building codes and proper awareness about these seismic events should be given to minimize the effects. Detailed study about the tectonics and the Himalayas along with the monitoring of seismic activities is required.

Keywords: *Earthquake, Locking line, Seismic waves, Magnitude*

1. BACKGROUND

The Gorkha earthquake, of 2015 is considered one of the most destructive earthquakes that occurred in Nepal in recent years. This earthquake occurred on the 25th of April, 2015 at 11:26 UTC followed by several aftershocks. This earthquake had a magnitude of 7.6 as reported by the National Seismological Center of the Department of Mines and Geology. The epicenter was located roughly 77 km northwest of the Kathmandu Valley in the Barpak Village, Gorkha District. This event occurred because Nepal is a tectonically active region due to the northward convergence of the Indian Plate towards the Tibetan Plate at an annual rate of 18mm/yr (Bilham et al., 2015). Nepal has always been the hub of earthquakes. This largely depends on the presence of 2200km long and 150km wide Himalayas. Over 8 major earthquakes have occurred in Nepal since 1500 A.D with a magnitude over 6.5 leading to the 2015 Gorkha earthquake. Among them, the most talked about is the Great Bihar earthquake, which occurred on January 14, 1934 A.D with a magnitude of 8.1. However, the earthquake that occurred in 1833 A.D with a magnitude of 7.5 overlaps the Gorkha mainshock's rupture area and potentially contributed to stress accumulation and fault interaction (Adhikari, Kato, and Hasegawa, 2015). A large amount of economic and human damage was caused by the Gorkha Earthquake, 2015 with a death toll of 8,856 with 22309 injured as reported by the NDRRIP, 2015. This was largely due to the lack of earthquake-resistant buildings, lack of awareness, and strong safety measures.

Aim

This study's main aim is to discover the cause, mechanism, and effects of the Gorkha earthquake 2015 and its aftershocks.

Objectives

The objectives of this article are:

1. To study the geological settings contributing to the Gorkha Earthquake.
2. To study the stress distribution and rupture of locked segments.
3. To study the role of subsurface lithology in wave amplification.

4. To analyze the aftershocks and their mechanism.

Research Questions

The following are the different research questions:

1. How does the geology of Nepal contribute to the occurrence of high-magnitude earthquakes?
2. What were the patterns of aftershocks and their relation?
3. How can we mitigate the impact of earthquakes in that region and all over Nepal?

2. MATERIALS AND METHODS

The materials used in this research article are mainly books, journals, research papers, newspapers, and news websites. Analysis and interpretation of these resources in a scientific way was done to get the information.

3. RESULTS

3.1 Cause of the Gorkha Earthquake, 2015

The most important factor contributing to this event is the convergence of the Indian plate towards the Eurasian Plate. This factor contributes to stress accumulation and fault rupture which causes high-magnitude earthquakes in Nepal. The same is considered to be the main cause of the Gorkha Earthquake, 2015.

3.2 Aftershocks of the Gorkha Earthquake

According to data provided by the Department of Mines and Geology, 41 aftershocks occurred in 26 hours. Among the aftershocks, two of them were above the magnitude of 6.5. Mitra et al., (2015) adds that the aftershocks were mainly caused due to the balance of residual stress on the lubricated rupture plane. It is also assumed that across the Himalayas about two-thirds of the energy is still to be released. The data about the mainshock and the aftershocks is given in Table 1.

Table 1: Data of Mainshock and Aftershocks of the Gorkha Earthquake, April 25 and April 26, 2015

Event Date	Latitude (°N)	Longitude (°E)	Event Time (NPT)	Moment Magnitude (Mw)	Depth (km)	Slip (m)	Comments
25-04-2015	28.14	84.70	11:56AM	7.8	17±3	1.2	Main shock
25-04-2015	28.193	84.865	12:45 PM	6.6	20		Aftershock
25-04-2015	27.805	84.874	05:42 PM	5.6			Aftershock
25-04-2015	27.794	85.974	05:42 PM	5.6			Aftershock
26-04-2015	27.794	85.974	12:09 PM	6.6	16 ± 3	0.3	Aftershock

Source: (Mitra et al., 2015)

3.3 Role of the Locking Line

The rocks of the crust's upper 15 to 20 km are brittle and remain below at temperatures above 350°C. These rocks remain at aseismic loading or creeping. This transition from brittle rocks to rocks under creeping is coined as the Locking Line. According to Mitra et al., 2015, "As the Indian plate converges with Tibet, elastic strain builds up within the locked zone up-dip of the locking line." The Main Himalaya Thrust's locked segment is where stress accumulation occurs. (Kobayashi, Morishita, and Yarai, 2015). Mitra et al., 2015 suggested that when the strain built up exceeded the limit, the locked segment ruptured and the Himalayas lunched forward over the Indian plate releasing energy and, eventually a high-magnitude seismic

activity. According to Galetzka et al., (2015), "The slip distribution and kinematics of the earthquake indicate significant activity along the locked segment of the MHT."

3.4 Role of subsurface lithology in seismic wave amplification

Subsurface lithology plays a huge role in wave amplification and the degree of damage caused by it. The velocity of seismic waves is higher in denser materials as compared to softer ones (Yeats, 2024). Amplification is the term that states the softer the material the greater the shaking. In the case of Kathmandu Valley, lacustrine deposits are present in a sedimentary basin. Due to the earthquake being at 15 to 20km deep and shallow sedimentary basin attribute of Kathmandu valley, the ground shaking was relatively severe and the damage caused to the infrastructure was also very high.

4. DISCUSSION

The complex geological setting makes Nepal a prime zone for future earthquakes and earthquake-induced natural disasters. Although Nepal is considered one of the most earthquake-prone countries in the world, the safety standards and awareness are still yet to be prominent. Stone-built homes in rural parts of Nepal are still a concern, in case a high-magnitude earthquake hits. However, the construction of earthquake-resistant buildings is being done in big cities of Nepal. Detailed study of the subsurface geology and Disaster risk protocols should be established to prevent economic and human risk. Different organizations like Nepal Risk Reduction Consortium, are widely involved in Disaster risk reduction which is a positive aspect. Forestall of earthquake-induced disasters such as landslides, liquefaction, and avalanches should be studied and mitigated. The Gorkha Earthquake, 2015 is considered a tragic event not only due to loss of human life but also due to its impact on the country's economy. According to NDRRIP, 2015, 8856 people were killed and 22,309 were injured which showed the severe human impact of the earthquake and the lack of safety measures and protocols being implemented. According to Gautam and Bhattarai, (2017), the Post Disaster Need Assessment of the Government of Nepal suggests that about 7 billion dollars of economic impact was caused due to the earthquake which is close to 33% of the GDP. The impact of this earthquake was also seen in the mental health of those affected. It led to issues like loss of homes, displacement, and mental health issues. However, a grant of around 300,000 rupees to those affected by the National Reconstruction Authority. The future goal should be to reduce the impact on the economy, human life, and mental health.

5. CONCLUSION

Based on the results obtained, it is clear that the main factor that resulted in the Gorkha Earthquake, 2015 and different historical and ongoing seismic activities is mainly due to the convergence of the Indian Plate to the Tibetan Plate. The role of the locking line was vital in stress accumulation and release ultimately leading to the Gorkha Earthquake. The zone of transition between the brittle rocks and rocks under aseismic loading in the Main Himalayan Thrust and its rupture is considered the cause of the earthquake. This earthquake had a magnitude of 7.6 according to the Department of Mines and Geology. Several aftershocks were experienced among which two were above the magnitude of 6.5. The subsurface lithology or soil properties also affected the severity of shaking. Different seismic hazards like landslides, subsidence, and ground cracking were also seen in various parts of Nepal. The impact of this event was seen on the economy and human life. Various organizations were actively involved in the rehabilitation of the earthquake-affected. However, the mitigation strategies for a high-magnitude earthquake are still not prominent. Construction of earthquake-resistant buildings, use of building codes, and detailed geotechnical studies should be done to reduce the impact. The study of tectonics and seismic activity along with community awareness is a must with the degree of seismic risk Nepal is in.

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Seismic Site Effect of Gorkha Earthquake 2015 in Kathmandu Valley

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Abstract- Nepal is situated on the converging plate boundary which makes it prone to low- high magnitude earthquake frequently. The last major earthquake occurred was Gorkha earthquake 2015, where many life and property was lost with the major loss being concentrated in Kathmandu Valley. The ground motion data of two locations, one situated on rock and other on soil is taken to understand the nature of the strong ground motion and site response in Kathmandu Valley. Acceleration and velocity time history and acceleration response spectrum is analyzed using seismosignal and from these we can interpret that the soil site composed of thick fluvio- lacustrine deposit experienced long period motion which resonated with taller man-made construction's natural period resulting in their damage. Non-linear effect is observed when the wave travels from rock to soil as seen from the acceleration response spectrum.

KEY WORDS- *Kathmandu Valley, Earthquake, Amplification*

1. BACKGROUND

Nepal covers one third of the Himalaya stretch and is prone to earthquake hazard. In average, Nepal experience hundreds of earthquake annually with occasional significant earthquakes. The Indian plate is continuously moving northeast about 5cm/year into the Eurasian plate (Patriat and Achache, 1984) where the southern flat is locked and causes seismic strain to build up along the plate boundary thrust fault, Main Himalayan Thrust (MHT). The elastic strain so accumulated is released in form of moderate to micro seismic activities originating in shallow depth (10-12km) and forming a seismic arc in the front of Higher Himalaya (Pandey et.al., 1999). Meanwhile, the major or large earthquakes are usually traced to the decollement beneath the Siwalik and Lesser Himalaya (Chamlagain and Gautam, 2015).

Nepal witnessed the major devastating earthquakes in 1344, 1255, 1833, 1934, 1988, and 2015. The aftermath of these frequent earthquakes has been devastating throughout the country but Kathmandu, the capital city of Nepal, shows higher rate of seismic borne damages to both life and property in comparison.

Gorkha Earthquake 2015

On April 25 of 2015, at 11:56 AM a massive earthquake of 7.8 Mw with the epicenter in a village called Barpak of Gorkha district, 76 km northwest of Kathmandu, jolted central Nepal. According to Avouac (2015), the earthquake originated in the MHT; ~15 km below the surface and ruptured a 140 km fault eastward from the initiation point (Avouac et al., 2015; Pagliarolia

et. al., 2018). The main shock was followed by thousands of aftershocks including successive 7.3 Mw and 6.3 Mw shocks on 12th May 2015. The aftershocks propagated eastward from the epicenter encompassing Kathmandu and causing devastating aftermath (Chamlagain et al., 2018).

The disaster resulted in loss of around 9000 lives and infrastructures worth billions including UNESCO World Heritage Sites. The damage was considerably high in Kathmandu Valley due to it being built over fluvio-lacustrine deposit. The loose, unconsolidated nature of the upper strata amplifies ground shaking and contributes to soil liquefaction in certain areas (Chamlagain and Gautam, 2015).

The Gorkha earthquake showcased different intensity in different locations within the valley. It might be caused by the modification of the seismic wave caused as a response to local geology. Strong seismic site effect was observed and in this study it is aimed to analyze the strong ground motion of Gorkha Earthquake in Kathmandu Valley to provide insights on seismic site effects in the Kathmandu Valley.

Objectives

1. To understand the nature of strong ground motion of the Gorkha Earthquake, 2015
2. To understand the seismic site effect of Gorkha Earthquake in Kathmandu Valley.

Research Questions

1. What are the characteristics of strong ground motion of Gorkha Earthquake?
2. What is the nature of effect in the Kathmandu Valley due to Gorkha Earthquake?

2. MATERIAL AND METHODS

In this study, we analyzed the ground motion data of two location; Kirtipur and Patan. The ground motion data is obtained from accelerometric network set up by Hokkaido University, Japan (Takai et al., 2015) in collaboration with the Central Department of Geology (CDG), Tribhuvan University (TU) shown in figure 1, where Kirtipur is situated in rock mass (rock site), whereas Patan is situated in a thick fluvio- alluvial deposit (soil site). The data recorded in accelerometer at KTP (Kirtipur Municipality Office, Kirtipur), PTN (Institute of Engineering, Tribhuvan University, Patan) are taken for data analysis.

A commercial software, Seismosignal, is used to analyze the ground motion

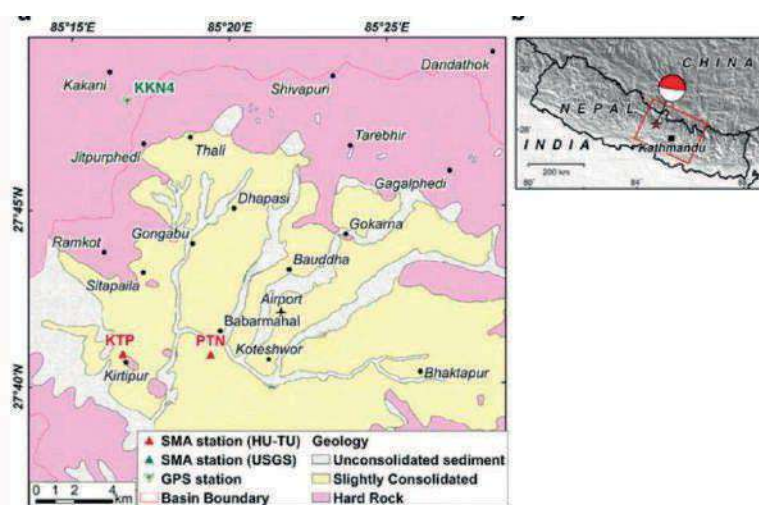


Figure 1, Geological Map of Kathmandu Valley with the locations of accelerometer (adopted from Takai et. al., 2016)

data and acceleration time history velocity time history, displacement time history and acceleration response spectrum are computed. Grapher software is used to represent the data in numerical mode.

3. RESULTS

Here, the acceleration, and velocity time history in the North- South, East-West and vertical component is discussed along with acceleration response spectrum to understand the strong ground motion in Kathmandu Valley..

The Peak Ground Acceleration (PGA) of 0.26g was recorded in the horizontal component in E-W direction at 28.07sec in the accelerometer at Kirtipur. In contrast, the ground motion in Patan region showed less intense acceleration with the N-S component attaining the highest acceleration of 0.15g at 30.1 sec. The maximum acceleration in N-S component of both Patan and Kirtipur shows similar value at 0.15g. The vertical component maximum acceleration at both locations was almost similar. The main contrast in maximum acceleration between the two station is observed in E-W component where the Kirtipur attains the Peak Ground Acceleration of 0.26g meanwhile in Patan the maximum acceleration is 0.13, almost half in comparison to Patan. In figure 1 we can observe that the waves have relatively longer period in Patan than Kirtipur. The mean period in Patan ranged from 1.2 sec to 1.4 sec for horizontal components whereas the vertical component has around half of the value.

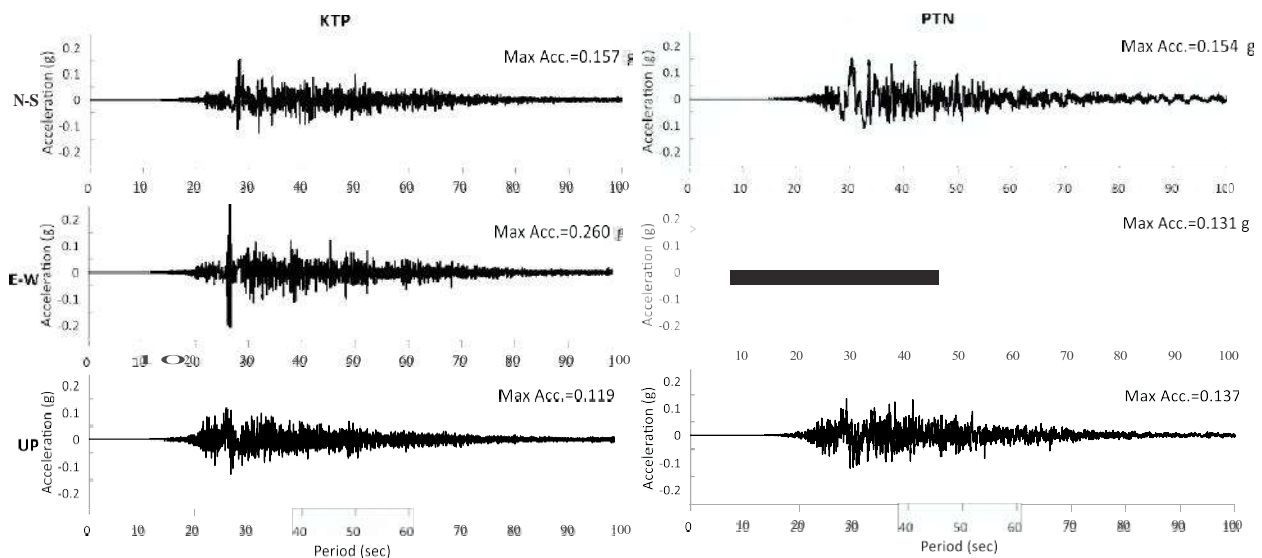


Figure 2 Acceleration Time History

In contrast to acceleration, the maximum velocity in Kirtipur is attained at the vertical component of 40.668cm/sec at 27.73 sec and the Peak Ground Velocity (PGV) is attained in the N-S component of Patan with 67.934 cm/sec at 30.71sec. The maximum velocity for horizontal component and vertical component ranges between 25cm/sec to 40 cm/sec and 50cm/sec to 70 cm/sec respectively in both locations.

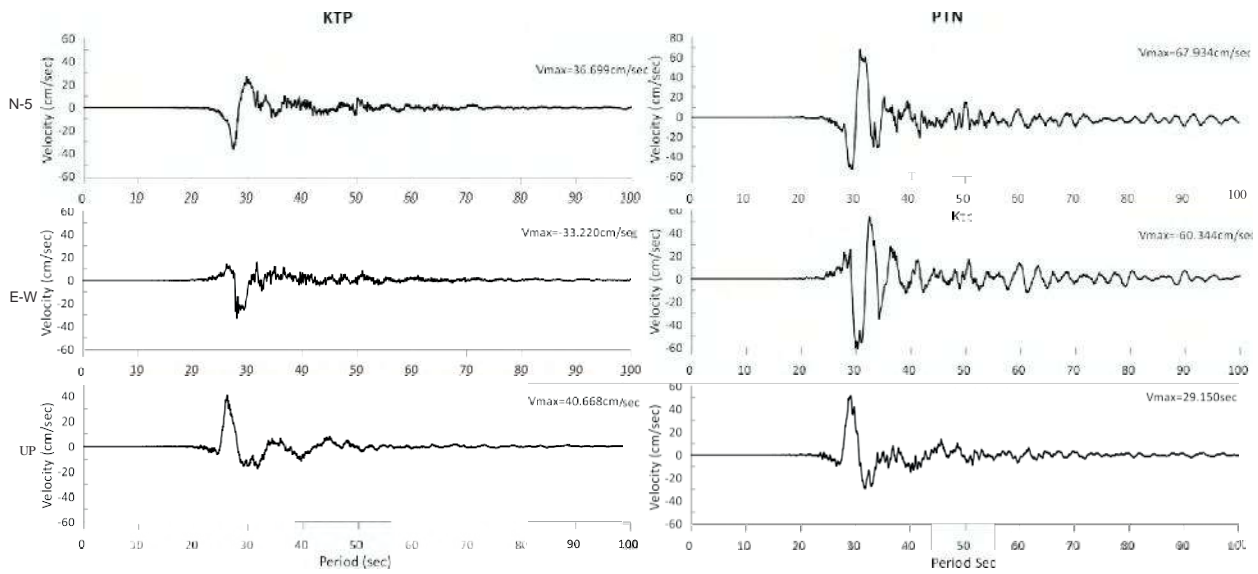


Figure 3 Velocity Time History

From table 1 we know that the maximum displacement was observed in N-S component at 99.97 sec with an extreme value of 163.86cm at Patan. The maximum displacement on E-W and vertical component was attained at around 30 sec from the time of first wave arrival. In case of Kirtipur, maximum displacement of 28.448cm, 67.707cm and 58.166cm at around 28 seconds from waves first arrival in E-W, N-S and Vertical component respectively.

The acceleration response spectrum of E-W components of PTN and KTP at 5% damping is given in figure 4. As observed in the figure, the peak acceleration spectrum of Kirtipur is almost 1 at 0.25 sec with one clear peak value. In contrast, the peak acceleration response at Patan is around 0.35 observed in 1-2 second period. The acceleration response is characterized by smaller peaks in response acceleration spread over a period of 0.2 to 2 second.

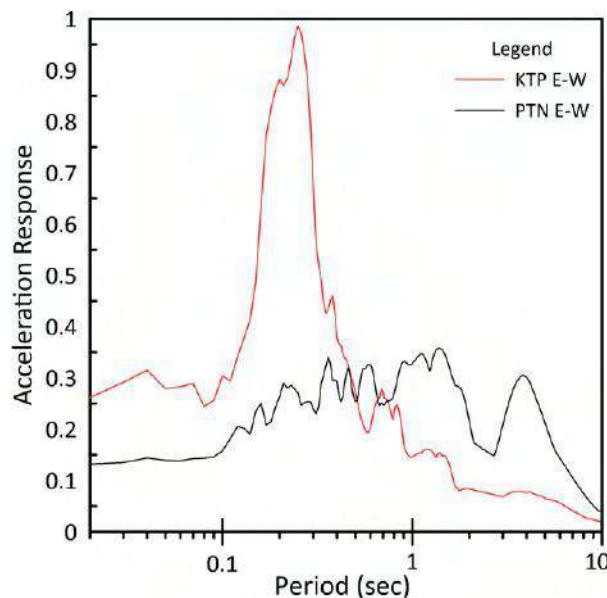


Figure 4 Acceleration Response spectra at 5% damping.

Table 1 Different Ground Motion Parameter Values in Gorkha Earthquake

Parameters	KTP		East-West		North-South		East-West		North-South	
	Maximum Acceleration	0.15	0.18	0.12	0.15	0.10	0.12	0.15	0.18	0.20
Maximum Velocity	1.5	2.0	1.0	1.5	0.8	1.0	1.5	2.0	2.5	3.0
Maximum Displacement	1.5	2.0	1.0	1.5	0.8	1.0	1.5	2.0	2.5	3.0
Arias Intensity	0.1	0.15	0.08	0.1	0.06	0.08	0.1	0.15	0.2	0.25
Mean Period	1.2	1.5	1.0	1.2	0.8	1.0	1.2	1.5	1.8	2.0
Predominant Period (Tp)	1.2	1.5	1.0	1.2	0.8	1.0	1.2	1.5	1.8	2.0

4. DISCUSSION

The ground response of Kathmandu Valley to Gorkha Earthquake differs from place to place as the two locations that we observed reacted differently to the lethal seismic wave. The sediment filled basin showed long period motion with an average mean period of around 1.3 sec in the

horizontal component and 0.6 sec in the vertical component. The soil site however shows deamplification of PGA value with high velocity comparison to the rock site which resulted in long period shaking of the tall buildings and causes them to collapse. The destruction caused by the Gorkha earthquake in Kathmandu valley, where tall historical temples, palaces and buildings collapsed but smaller to mid-sized building remained minimally affected fits the after effect criteria of long period motion.

In the acceleration response spectrum, we observed that acceleration response peaked at 0.3 sec at Kirtipur whereas at Patan it peaked around 3-5 sec which is due to the local site effect of local geology. The rock site has a distinct peak value but in case of the soil site the acceleration spectrum gradually increases before attaining a maximum value at 3 second.

A non-linear effect in the soil site can be observed when the waves travel from rock to soil. This effect was discussed by Rajaure et al.(2016), where the waves were amplified at higher period and deamplified at lower periods.

5. CONCLUSION

The seismic wave travelling through Kathmandu shows long period motion in the sedimentary filled valley with high velocity and low acceleration but the surrounding hills built on the rocks of lesser Himalaya has waves passing promptly with high acceleration and short period motion. The sediment filled valley has higher risk to destruction as it shows high displacement in all three directions and its mean wave period is more than one second which resonated with manmade constructions natural period. Any construction of high rise building should be thoroughly studied in future. An earthquake of similar or higher magnitude near or within the valley will bring devastating results to both life and property as there is chance of strong modification of the seismic waves in the valley.

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Sand and Gravel Mining and Its Impacts on Ratu River in Bardibas-Lalgadh Area

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Abstract: Sand mining is the process of extracting sand, gravel, and other materials from natural environments such as riverbeds, breaches, lagoons and ocean floor which serves as a primary material for constructions and industrial purposes. This journal insight on how sand mining on Ratu river impacted the river flow, water quality, environment and local community. The extraction of sand from the riverbed has led to substantial ecological damage, including riverbank erosion, disruption of aquatic habitats, decline in water quality and increased turbidity. Urbanization grown in Bardibas has increased the demand rate of construction and sand materials. Despite of laws and regulation, illegal and unregulated sand mining are still in existence. Sustainable sand mining and strict regulation must be implemented to mitigate adverse effects and ensure the responsible use of this resource. Research and technological innovations are needed to explore alternative materials and recycling methods to reduce reliance on natural sand.

Keywords: *Sand mining, Riverbeds, Ratu river, Turbidity, Construction material*

1. BACKGROUND:

The Ratu river originates from Mithan in the north at an attitude of 740 above the sea level. The total length of the main channel is 82 km within the territory of Nepal. It flows through relatively wide valleys within the Siwaliks (25km), fan (10km), and alluvial plain (47km) and finally across the Nepal-India border (Bajracharya, S.R 2021). The river is relatively flat with having 200m width. The river has braided river system and the river bed consists of boulders, sand and gravels (Adhikari and Sitoula,2018). Side cutting action of river is very fast and recently due to deforestation and concentrated precipitation, Siwalik is highly degraded; and is susceptible to high grade of weathering and landslide which are source of sediment deposition (Dhakal, 2014). Due to high abundance of construction materials in Ratu river, mining companies are extracting by accelerating the rate for economic benefit without considering its environmental impacts. As per the environmental impact assessment conducted in 2021 A.D, an agreement was reached to extract 121,500 cubic meters of riverbed materials from four sections of the Ratu river: Kisannagar, Pathalaiya, Jure tole and phulbari tole. However, based on the report from the survey sub- committee, the crusher companies has reportedly extracted seven times more materials than what was mentioned in the contract. In 2080 B.S., Supreme Court also issued a short-term interim order to stop the mining immediately, saying that the illegal mining in the Ratu River of Mahottari has adversely affected the environment. After Nepal Government act 1991, banned the riverbed mining, illegal mining has still been in existence in the river site. A team from the district coordination committee during an inspection found most of the crusher industries are operating illegally. Very few papers have been published on sand mining along Ratu river and its environmental impacts, which shows a clear research gap.

Aim

The main aim is to study the haphazard sand mining in Ratu river and its environmental impacts.

Objectives

1. To study the impact of sand mining in Ratu river.
2. To investigate environmental and social impact of sand mining.
3. To suggest some preventive measures.

Research Questions

1. How does sand mining in the Ratu river impact the local ecosystem and socio-economic conditions of nearby communities?
2. What are the long-term effects of sand mining on the hydrology and sediment dynamics of the Ratu river?
3. How effective are current regulations and policies in managing sand mining activities in the Ratu River?

2. MATERIALS AND METHODS

The information of this article was collected through secondary sources such as journals, articles, books, newspaper, reports, website etc.

3. RESULT

The Ratu river faces a depletion of water during the winter season due to haphazard excavation. As a result of unorganized and unscientific river mining practices, the water sources started drying up. This situation has resulted in arable land facing desertification and locals facing severe water and food crises. Removing sand from riverbeds increases the rate of erosion and turbidity in the river. Riverbed excavation of sand has affected bridges, roads and many nearby houses. Tamrakar (2004) and Bajracharya (2006) stated that riverbed mining was one of the major causes of river degradation and accelerated stream bank erosion. Mining disturbs the riverbed, increasing sediment in the water, which can reduce water quality and harm aquatic life. Sand mining, which is shown in figure 1, has changed the riverbed and bank structures altering the flow of river, causing increased flooding and changes in the course of river.

4. DISCUSSION

Since there is a high need for building materials, sand mining poses a serious environmental risks. It causes negative consequences such as contamination of waterways, loss of biodiversity, and changes to river ecosystems. These effects are made worse by unregulated and illegal mining operations, which frequently lead habitat destruction and deteriorated water quality. In order to lessen these negative effects on the environment, research emphasises the urgent need for sustainable laws and regulations. It also emphasises the significance of qualitative and quantitative data for efficient management plans. To reduce the sand mining, the government and local authorities must make strict laws and regulation and should implement it. While sand and gravel mining are necessary for modern development, the negative consequences of unchecked extraction are too significant to ignore. By enforcing stricter regulations, exploring alternative materials, and involving communities in sustainable practices, can mitigate the environmental and socio-economic impacts. It is essential to find a balance that meets the needs of development without compromising the health of ecosystems and communities. This includes evaluating projects for feasibility, communities in decision-making, and rehabilitating mined areas.

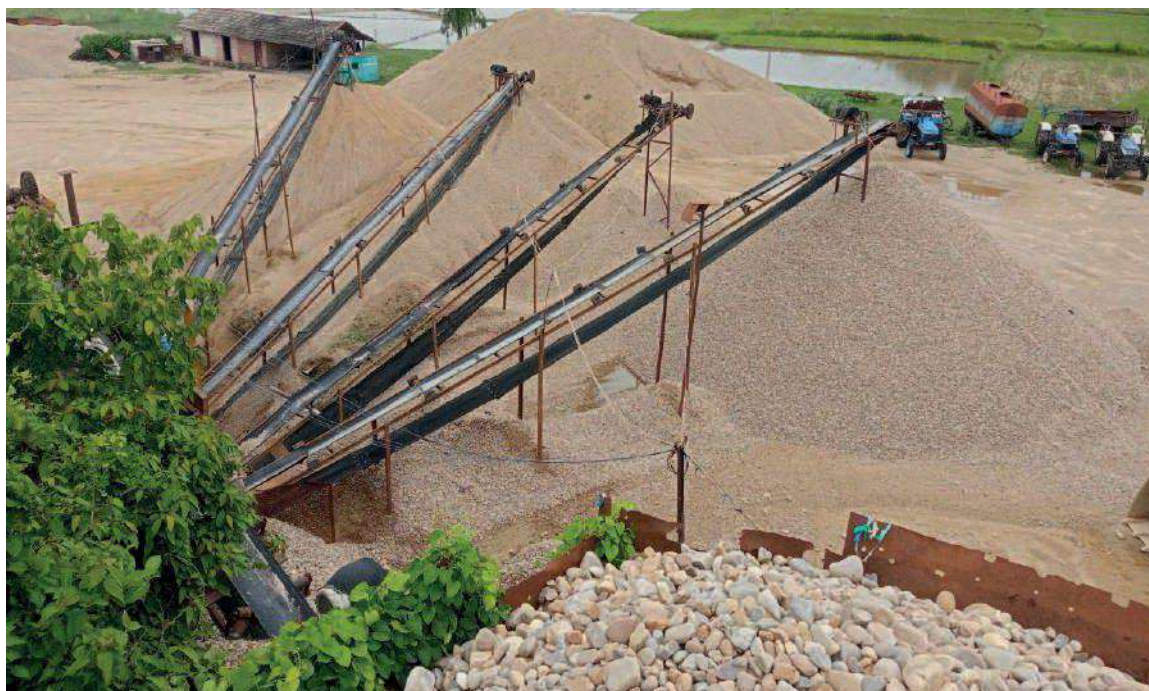


Figure 1: Extraction of Riverbed material from Ratu River

5. CONCLUSION

This research aims to examine the impact of haphazard extraction of riverbed materials in Ratu Khola section and propose effective mitigation measures. The field study was carried out to notice the significant changes on river surrounding due to the haphazard extraction of riverbed material. The findings show that it is against the law to extract materials from riverbed in a haphazard manner according to current laws and regulations. If not, it might result in a number of detrimental effects that would worsen with time, such as soil erosion, river bank cutting, etc. The site's existing extraction methods have detrimental impacts that include notable irrigation loss, damage to the bridge foundation, imbalance in the aquatic ecology and more. The result of this study may help local governments or other relevant authorities create appropriate regulations to prevent the unplanned and uncontrolled removal of materials from riverbed. Ultimately, the goal is to achieve a sustainable balance where the economic benefits of sand mining do not come at the cost of environmental degradation. This requires ongoing collaboration among government agencies, industry players, environmental groups, and local communities. By working together, it is possible to develop and implement strategies that protect the Ratu River's ecological integrity while supporting economic and social development.

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Urban Expansion and Its Impact on Land Use of Kathmandu District

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Abstract: Land cover indicates the surface of the earth such as forest, bare soil whereas land use describes how the land is used such as agricultural land, urban land. Kathmandu is the capital city of Nepal as a result population, migration rate, rate of urbanization and infrastructure development activities are high. These are the major reason that are responsible for land use and land cover change in Kathmandu. The main objective of this article is to analyze the changing pattern of land use and land cover and its impact on the environment in Kathmandu. Relevant published articles, reports, books, newspapers, documents, Landsat images were collected and thoroughly studied. The forest, cropland, settlement, wetland, grassland covered the major portion of land cover in the Kathmandu district. Loss of biodiversity, frequent flooding, declination of water level, waste contamination, water pollution and temperature increases are the major impact of land use and land cover change in Kathmandu. Implementing land-use regulation, governmental policy and planning, green infrastructure, and smart development strategies can help Kathmandu achieve a more balanced approach to growth.

Keywords: *Land Use and Cover, Landsat, Flooding, Urbanization, Governmental Policy*

1. BACKGROUND

Introduction

Land use and land cover is one of the main driving forces of global environmental change. The Land cover indicates the surface of the earth such as forest, bare soil whereas land use describes how the land is used by people such as agricultural land, urban etc. Human activities are major factor responsible for change land use and land cover in city area during the last half-century (Rimal, 2011). Land use change is the process by which human activities transform the natural landscape. It refers to how the land used had transformed economic activities (Rudel, 2009). The global urbanization reached 55% in 2018 and is expected to reach 68% by 2050 (Kookana, et al. 2020). Likewise, land use and land cover change is rapidly increasing in Kathmandu by people as well as policy makers, urban planners and environmental specialists in the name of development, and urbanization. Land use and land cover change in Kathmandu is a significant topic due to the rapid urbanization and environmental challenges the region faces. In general, the forest covers the maximum area of the Kathmandu district. Following the forest, cropland, settlement, grassland, wetland etc covered the surface of Kathmandu. As per UN-HABITAT, the last quarter of the 20th century saw rapid expansion of Kathmandu, reflecting the trend of urban growth dominant in the Himalayan region (UN-HABITAT, 2013).

Aim

The main aim of this study is to identify the change in the variable of land use over a certain period and its impact on the environment.

Objectives

The objective of the study are as follows,

1. To analyze and compare the land use and land cover changing pattern in between 2013 to 2019
2. To study and analyze the impact of land use change on the environment.

Research Question

In this article, the following research questions are included,

1. What is the impact of the land use change on the environment?
2. How can urbanization be managed?

2. MATERIALS AND METHODS

This article was prepared by gathering all the necessary data, information about past status, present status of land use and land cover and its changing pattern from secondary sources such as scientific journals, books, published reports and research papers.

3. RESULT

The study showed that the major portion of the land surface was covered by forest, cropland and settlement in both 2013 and 2019. The largest area is covered by forest. After the forest, Cropland occupies the next largest area, followed by settlement. The remaining areas are covered by grassland, wetland and others land. The land use and land cover change in Kathmandu district between 2013 and 2019 are illustrated in Table 1 and Fig 1.

Table 1: Land Use and Land Cover Change in Kathmandu in between 2013 to 2019

Land cover Class	Area m 2013 (km ²)	Area m 2019 (km ²)	Change in Area (km ²)
Forest	170.987	172.065	1.078
Cropland	132.27	113.449	-18.821
Settlement	77.61	91.209	13.599
Grassland	6.012	5.098	-0.914
Wetland	0.0894	0.152	0.062
Other Land	27.172	32.167	4.995
Total	414.14	414.14	

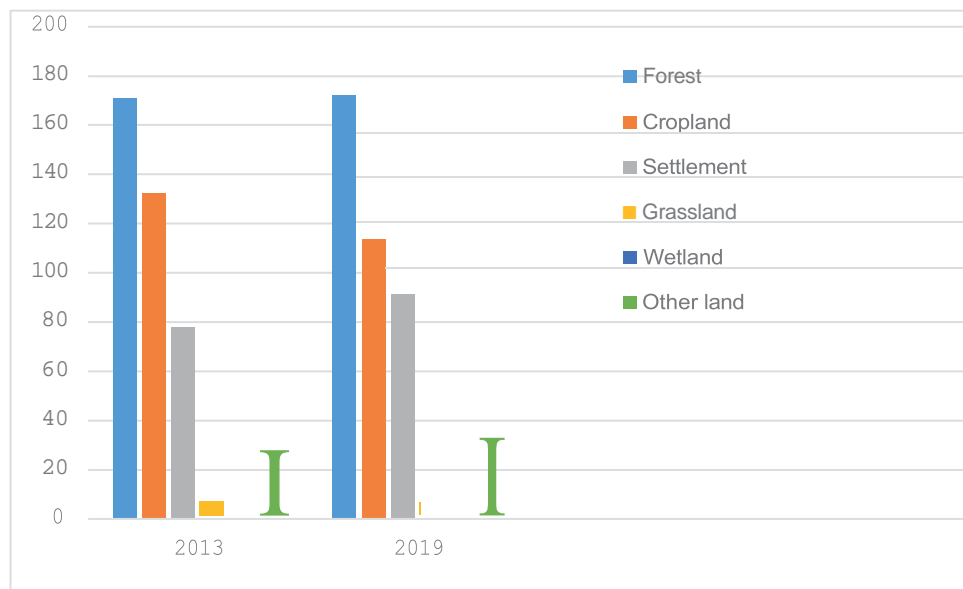


Fig 1: Bar diagram Showing Land use and Land Cover Change between 2013 to 2019

In 2013, the forest covered 170.987 km² area of Kathmandu district. Similarly cropland covered the second most area of Kathmandu district i.e. 132.27 km². Settlement, Grassland, Wetland and Other land covered 77.61 km², 6.012 km², 0.0894 km² and 27.172 km² of the total area respectively. Whereas, in 2019, the forest also covers the major area i.e. 172.065 km² of the total area of the Kathmandu district. The cropland, Settlement, Grassland, Wetland and Other land covered 113.449 km², 91.209 km², 5.098 km², 0.152 km² and 32.167 km² of the total area respectively. Bar diagram showed the land use and land cover change from 2013 to 2019. Area of Forest, Settlement, Wetland and Other land has been increased by 1.078 km², 35.599 km², 0.062 km² and 4.995 km² respectively. Whereas the area of Cropland and Grassland have been decreased by 18.821 km² and 0.914 km² respectively. During 6 years, the rate of urbanization has increased. Loss of greenery, air pollution, surface water as well as subsurface water resources pollution, reduction of soil fertility, frequent flooding, lowering of water table, decrease local food production and health are the major impact of land use and land cover change on environment. The flow of water has been decreased in almost all the water resources. Urban expansions and other engineering activities decrease the green forest, oxygen level, fertility of soil that causes loss of biodiversity while increases harmful gases such as Carbon dioxide, Nitrogen, Carbon monoxide, Sulphur dioxide, heat absorption as a result higher temperature is in urban area than rural area.

4. DISCUSSION

As interpreted from the above results, four major types of land cover are seen i.e. forest, cropland, settlement and other land. It is clear that, the rate of land use change is increased day to day in Kathmandu. Urbanization, engineering development and human activities are the major factors responsible for land use and land cover change in Kathmandu (Rimal, 2011). Area of forest, settlement, wetland and other land are expanding whereas are of cropland and grassland are decreasing in 2019 based on the initial year 2013 as a reference. The rapid land use change in Kathmandu area confirms past reports by United Nations Department of Economic and Social Affairs. FRTC shows that there is no bare soil in Kathmandu district. Due to the rapid land use

change in Kathmandu, various problems are seen. Groundwater recharge potential is declining in Kathmandu day to day which ultimately declines the water level. This result is nearly similar to previous studies (Shrestha et al. 2023). There are many consequences of land use change such as increasing level of carbon dioxide, contamination of water resources, higher temperature, frequent flooding, and lowering of water table have seen in Kathmandu district. Over population, migration, infrastructure development, urbanization, natural disasters, governmental policy and planning are the major reason of land use change in Kathmandu district.

5. CONCLUSION

This paper shows the image of a Kathmandu city struggling with the challenges of rapid land use change. Based on above analysis, forest, cropland, settlement and grassland are the major land use pattern. Cropland has decreased overall while settlement has increased rapidly over the past years. Also the area of forest has increased. These changes have many consequences, including increased strain on water resources, high lightened risk of landslides and floods, and potential biodiversity loss. The urgent need for sustainable urban planning practices is clear. Implementing land-use regulation, green infrastructure, and smart development strategies can help Kathmandu achieve a more balanced approach to growth. Protecting the environment reduce the negative impacts of increase of lands use are crucial for the city's long-term sustainability. Furthermore, observing the lasting effects of the 2015 earthquake on land-use patterns is essential. By understanding these factors, policy makers can implement effective policies that ensure Kathmandu's future development is sustainable. However, further more study is essential for reliable result.

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The Change in Livelihood of People in Armala after Sinkhole

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Abstract: Pokhara valley is formed by the huge debris flow occurred due to the avalanche in Annapurna Mountain carrying the calcareous sediment. A small valley in the Pokhara originated by the Kali Khola River has been experiencing the sinkhole since last 11 years. The area is rich with calcareous clast sediment which easily dissolvable by the river, due to which the karst topography is being seen in that area. The deposit along the Armala Valley is undergoing subsurface erosion due to flow of subsurface water resulting the formation of subsurface caves and ultimate formation of sinkholes. From the direct interaction method with locals and desk study, we found that the illegal river sediment encroachment caused the reactivation of sinkholes as the level of river flow decreased. They also are benefiting from the sinkholes as the land in the areas were wetland throughout the year, now as the water in soaked the land is turned into plot for sale.

Keywords: Sinkhole, Calcareous, Electrical resistivity tomography, mining, compaction, ground injection.

1. BACKGROUND

The study area lies in, Kaski district Pokhara metropolitan city ward no. 16 Armala, jumleti phat situated 10km. north-east from Prithivi chowk, Pokhara. Pokhara valley. The Pokhara valley is predominantly formed of calcareous sediment originated by debris flow carried by the huge avalanche and followed by Seti River. Same like Pokhara valley, the Armala valley is also dominant by elastic calcareous sediment (Yamanaka et al., 1982, and Fort., 1987). Due to the high amount of concentration of calcareous materials in the sediment carried by Kalikhola and deposited sediment in the valley originated from Kali River, it is experiencing the sudden occurrence of sinkhole since 2013. The sediment with high concentration of calcareous clast is highly dissolvable, which is the sole reason of sinkhole occurrence in the area. The main problem associated with sinkholes (already collapsed or not) is that they pose serious threat to properties like buildings, agricultural farmland, roads, etc. An example of Karst-related destruction in Pokhara valley is the collapse of a highway bridge over the Seti River (Dhital and Giri., 1993). The Armala area is essentially formed by silt containing lime, which was deposited by the Seti River flowing through the Annapurna range. Chemically, it generally contains $\text{CaO} = 35\%$ and $\text{MgO} = 2\%$ (Technical Research Report, 2014). As result, the main characteristic of this loose silt is that it easily dissolves in the water. In the damaged area, the surface water seepage ultimately saturated the calcareous silty material, which was dissolved in the water.

Aim

The sole purpose of writing this article is to understand about the sinkhole and the livelihood affected by sinkholes in Armala.

Objectives

1. To know the cause and local's opinion regarding Armala sinkhole.
2. To know the after effects of sinkholes in Armala.

Research Questions:

1. How frequently is sinkhole observed in the area?

2. What might be the causes of sinkhole?
3. What changes have been in the livelihood of the people in Armala?

2. MATERIALS AND METHODS

The major methodology for the article is individual field visit in the affected area. Few locals in the area were questioned. For further information regarding sinkhole in Armala secondary data was gathered from various articles, books, and websites.

3. RESULTS

The sediment in armala area is silty calcareous in nature. They easily get dissolved and the vacant area is created. The water starts to flow in subsurface and seeps into the land. The subsurface flowing of water causes the erosion inside the surface. The upper part is covered with sediments while the hollow zone is created inside the land which is known as Sinkhole. (Bhandari et al., 2019). As per the locals the nearby Kali Khola River used to flow in more upper part than where it is flowing. Due to illegal sand mining in the river the flowing level significantly decreased. Only after the sand mining they started experiencing sinkholes. Since the stoppage of sand mining the continuous sinkhole are not seen in area. The locals suggested that before the sinkhole the whole area was wetland. The land was neither possible for cultivation nor for residential purpose but now after sinkhole the wetland has turned into plot which they are labelling for sale. Although various geological team who has studied the area has suggested not suitable for human residence or major development activities the people are still engaged in that matter for short term profit. The team of geophysicists from Nepal and Germany conducted the ERT (Electrical resistivity tomography) and more than six sinkholes were identified and covered by sediments. The geophysicists suggested in the article that the house taller than one storey shall not be constructed in the area for safety measures. (Himalkhabar.com/2013)



Figure 1: Calcareous sediment in Armala



Figure 2: Kali Khola iver



Figure 3: Settlement in a Sinkhole Area

4. DISCUSSION

Pokhara valley as a whole is a risk zone for sinkhole. Famous caves like Mahendra cave, Chamere Cave, Gupteshwar Mahadev cave are the result of the sinkhole. Even in present time Parsyang, Nadipur which are in river bank area are experiencing the sinkhole. Armala faced the new sinkhole in 2024 January in the farmland but the local backfilled it and make the area like as if nothing happened. The geological society has conducted various surveys, research and published many articles mentioning the risk and mitigating measures for the betterment of the people residing in the area. According to Geologist, Srikamal Dwivedi, people were suggested not to use irrigation for cultivation of land and change the system of agriculture or stop the paddy cultivation. But the locals neglected the notice by governing bodies and they had to suffer again. The sinkholes can obstruct the means of transportation and communication which may cause havoc among the locals. To avoid that mitigating measures shall be implemented for their own safety.

5. CONCLUSION

The main aim of the article is to understand the livelihood of people of armala after the sinkhole in the area. Armala area used to be the famous place for the paddy species locally called as Jetho Budo. Since the various geological committee and governing bodies suggested them to stop the cultivation and manage the proper drainage system the land has turned barren. Agriculture being the major economic activity in the area affected their livelihood. Since there was no use of land in agriculture local make the land available for sale for their economic stability. The main reason for sinkhole in that area is the decreasing level of Kali Khola River due illegal mining and seepage of water in the subsurface. For that illegal mining must be stopped. Locals have been doing the backfilling of sinkhole as a temporary solution but not the adequate solution. It can get reactivated in rainy season. For the mitigation measure following points can be implemented:

- i. Preventing water withdrawal and controlling irrigation,
- ii. Prevent the fluctuation of water table;
- iii. Using effective drainage system and diverting surface runoff.
- iv. Improving the ground by compaction or ground injection to increase the strength and bearing capacity of the soils. (Pokhrel et al., 2015).

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Assessment of Knowledge on Earthquake Mechanism and Preparedness Measures among the Secondary Level Students in Kathmandu Valley, Central Nepal

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Abstract: Nepal's vulnerability to earthquakes requires a well-informed population, particularly among students. This study assessed the knowledge and preparedness of secondary-level students in Kathmandu Valley regarding earthquake mechanisms and safety measures. A questionnaire was administered to 223 students from various private schools, revealing that while 97.3% understood what an earthquake is, only 70% identified tectonic plate movement as a cause. Preparedness levels were concerning, with only 58.3% aware of the "Drop, Cover, and Hold On" technique. More than half of the participants (62.3%) reported receiving earthquake preparedness training. However, it was primarily theoretical, leaving them inadequately prepared without practical experience such as mock drills. Although the majority (76.2%) had learned about earthquakes in school, a significant portion (74.9%) felt that their schools were not sufficiently equipped for earthquake preparedness. The findings highlight critical gaps in practical preparedness despite adequate theoretical knowledge, emphasizing the need for improved educational strategies in Nepal.

Keywords: *Earthquake, Preparedness, Knowledge, Secondary Level Students*

1. INTRODUCTION

Nepal lies in a high earthquake risk zone due to geological settings and active tectonics. Fragile geology, poor socio-economic conditions, unplanned urbanization, and inadequate preparedness are major factors increasing earthquake risk in Nepal (MoHA, 2016). On April 25, 2015, a devastating 7.6 Ml earthquake occurred in the Gorkha district of Nepal resulting 8970 deaths including 1380 children aged 6-16, and 22,302 injuries. The education sector was highly affected, with 5,003 schools destroyed, 24,840 classrooms and other facilities heavily damaged, and another 36,190 partially impacted (MoHA, 2016). This tragic event known as the Gorkha earthquake highlighted the critical need for better earthquake preparedness, especially among students, who are among the most vulnerable in disasters like earthquakes. Educating students on earthquake mechanisms and preparedness is crucial to reduce future risk. This research focuses on assessing how well-prepared secondary-level students are in Kathmandu by evaluating their knowledge of earthquake mechanisms and preparedness, aiming to determine if students are prepared for future earthquakes and to identify areas where improvements are still needed.

Aim

This study aims to evaluate the knowledge and preparedness of secondary-level school students in Kathmandu, Nepal, concerning earthquake mechanisms and safety measures.

Objectives

The objective of this study is to assess the current level of knowledge about earthquake mechanisms and preparedness among secondary-level students in Kathmandu.

Research Questions:

To explore the knowledge and preparedness of secondary-level students in Kathmandu concerning earthquakes, this study will explore the following key questions:

- 1) How well do secondary students in Kathmandu understand the geological processes of earthquakes?

2) What is their awareness of effective earthquake safety measures and preparedness strategies?

2. MATERIALS AND METHODS:

The study population consisted of 223 secondary-level students (Grade 9 and 10) from various schools in Kathmandu. A questionnaire was prepared with 17 questions in it and data were collected from private schools located in Kathmandu Metropolitan City, Budhanilkantha Municipality, Tokha Municipality, and Gokameshwor Municipality.

2.1 Questionnaire Preparation

A questionnaire was developed to assess the knowledge and preparedness of secondary-level students regarding earthquakes. The questionnaire consisted of 17 structured questions designed to gather student's understanding of earthquake mechanisms, their awareness of safety, and overall preparedness for such events. The questionnaire was structured into different sections: the first part focused on demographic information, the second part focused on their knowledge about earthquake mechanism, and the third part focused on their overall preparedness. Additionally, two open-ended questions were included to gather student's opinions on what the government and schools can do to reduce the earthquake risk.

2.2 Data Collection

Data were collected from five different schools in Kathmandu. The purpose of study was explained to students and their participation was voluntary. Informed consent was obtained from both the school administration and the students.

2.3 Data Analysis

The collected data were analyzed using the descriptive analysis method.

3. RESULTS

3.1 Demographic Information

The study involved 223 secondary-level students from private schools in Kathmandu. As shown in Figure 1, the participant's age ranged from 13 to 17 years old while most participants were 14 to 15 years old. Figure 2 indicates that 115 students were from grade 9 and 108 from grade 10. Additionally, there were 126 male and 97 female participants.

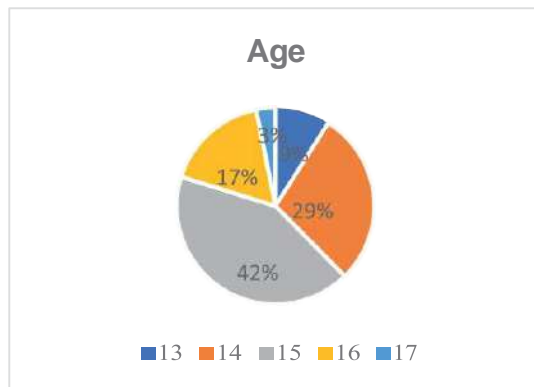


Figure 1: Age of participants

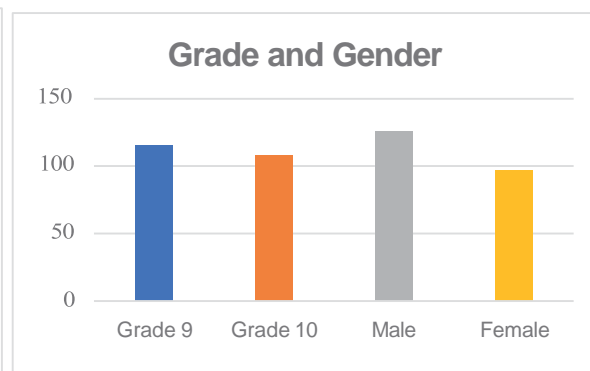


Figure 2: Grade and gender of participants

3.2 Knowledge of earthquake mechanism

Table 1 presents the student's responses to questions assessing their knowledge of earthquake mechanisms. The majority of students (97.3%) correctly identified what earthquake is while only 80.3% think that Nepal lies in an earthquake risk zone. Regarding the causes of the earthquakes in Nepal, 70% of students correctly answered movement of tectonic plates while 30% mentioned other incorrect causes such as mining and volcanic eruptions. In terms of measuring earthquakes, 76.2% of students identified seismograph as the correct instrument while 23.8% gave incorrect responses.

Table 1: Responses on Knowledge on Earthquake Mechanism

S.N.	Questions	Response	Percentage
	What is Earthquake	Shaking of the ground	97.3%
2	Does Nepal lie in earthquake risk zone?	Yes	80.3%
3	Cause of Earthquake in Nepal?	Movement of tectonic plates	70%
		Other causes (Volcanic Eruptions, Mining)	30%
4	Instrument to measure the size of an earthquake?	Seismograph	76.2%
		Other Instruments	23.8%

3.3 Preparedness for Earthquake

Table 2 outlines the student's responses regarding their preparedness for earthquakes. When asked about immediate response during earthquake while inside the building, 58.3% responded with "Drop, Cover and Hold on" technique, and 35.9% responded with running to safe places immediately. For actions when outside a building during an earthquake, 79.4% correctly indicated moving to an open area away from trees, poles, and buildings while 11.7% incorrectly suggested running inside to hide under a table. Regarding earthquake preparedness training, 62.3% of students reported having received training on what to do before, during, and after earthquake whereas 37.7% they haven't received any sort of training. Additionally, 76.2% of students mentioned that they learned about earthquakes in school. In terms of concern about earthquakes, 47.5% of students expressed high concern while 52.5% were less concerned. The majority of students (74.9%) believed their school was not well-prepared for earthquakes while only 25.1% of students felt their school was well-prepared.

Table 2: Responses on Earthquake Preparedness

S.N.	Questions	Response	Percentage
1	Immediate Actions during Earthquake if inside a building	Know "Drop, Cover, and Hold On"	58.3%
		Run to safe places immediately	35.9%
2	Immediate Actions during earthquake if outside a building	Move to an open area away from buildings, trees or poles	79.4%
		Run inside immediately to hide under table	11.7%
2	Received training on what to do before, during and after earthquake	Yes	62.3%
		No	37.7%
3	Learned about earthquakes from?	School	76.2%
4	Concerned about earthquakes	Very concerned(4-5)	47.5%
		Less concerned(1-3)	52.5%
5	School well-prepared for earthquake	Yes	25.1%
		No	74.9%

3.4 Recommendations from Students

When asked about what the government should do to reduce the risks caused by earthquakes, most participants suggested that the government enforce strict regulations for earthquake-resistant buildings, establish an alert system, create designated safe areas for evacuation, and conduct more awareness programs on earthquake preparedness. For schools, they recommended practical education on earthquakes with emergency drills, a well-prepared emergency plan, first aid training, and safe gathering areas in school during an earthquake.

4. DISCUSSION

The findings of this study reveals educational gaps and preparedness levels in a region highly susceptible to seismic activity. While 58.3% of students answered "drop, cover, hold on"

technique for actions when inside a building during an earthquake, 11.3% of students responded with "Run inside to hide under table" when asked about actions when outside during an earthquake. This highlights a gap in their practical knowledge and effective safety measures particularly in relation to the infrastructure they are living in. The findings indicate that while students possess a basic understanding of what an earthquake is, there are significant gaps in their knowledge regarding the causes of earthquakes and the appropriate safety measures to take during such events. Comparing with research done by Lage et al., 2023 in grade 9 and 10 of government schools in Bhaktapur, about 50 percent of total students have adequate knowledge of earthquake preparedness while they have limited practice. The research conducted in Savar, Dhaka concluded that, high school students are vulnerable to earthquake due to the lack of a seismic education program. (Rahman, M. L, 2019). Findings of a research done by Tuladhar et al., 2013, indicated that existing disaster education initiatives in Nepal are insufficient. A significant challenge for disaster risk reduction (DRR) within school communities is the effective implementation of educational methods at the individual level. To address these challenges and prepare school students for future seismic events, it is vital to incorporate disaster risk reduction programs and practical education on earthquake safety measures into school curriculum.

5. CONCLUSION

This study examined the knowledge and preparedness of secondary-level students in private schools in Kathmandu regarding earthquakes. While students showed a basic understanding of earthquake mechanisms, their practical preparedness remains insufficient. These findings highlight the need for targeted disaster risk reduction and educational programs that integrate both theoretical knowledge and hands-on training. This approach will ensure that students not only understand the concepts but also acquire practical skills and preparedness for real-life situations. Moreover, government involvement in enforcing stricter building codes and promoting school-based awareness programs can enhance community readiness, ensuring that students are more prepared to respond effectively to future seismic events.

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Different Scales Used in the Measurement and Categorization of the Gorkha Earthquake, 2015

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Abstract: This article addresses the different reported magnitudes (7.8 and 8.1) during Gorkha earthquake 2015, highlighting the differences between the two scales. The Richter Scale measures seismic wave amplitude, while the Moment Magnitude Scale assesses the total energy released, offering a more accurate measure for large earthquakes. The Gorkha earthquake, classified as "great" with a magnitude of 8.1 on the Moment Magnitude Scale and this emphasizes the better public education on seismic measurements and the importance of robust disaster preparedness and response strategies ensuring the public safety.

Keywords: *Earthquake, Richter scale, Moment magnitude scale, seismic measurement, seismic waves, disaster preparedness.*

1. BACKGROUND

Nepal, situated in a seismically active region, has faced significant challenges due to earthquakes. The most notable recent earthquake occurred on 12th Baisakh 2072, also known as the Gorkha earthquake, with its epicenter east of Gorkha District at Barpak. This devastating event caused widespread destruction of property and loss of life, leaving long-term psychological and psychosocial impacts. The magnitude of the earthquake was reported differently by various sources: some news channels reported it as 7.8 while others reported it as 8.1 which created confusion among the people regarding the different magnitudes. This was developed due to lack of knowledge about the different scales.

The differences in reported magnitudes can be attributed to the use of different magnitude scales. The Richter Scale (ML) measures the amplitude of seismic waves and is often used for small to medium-sized earthquakes which was developed by Charles F. Richter in 1935. The Moment Magnitude Scale (Mw), on the other hand, measures the total energy released by an earthquake, providing a more accurate assessment for large-scale seismic events. There are other various magnitude scales also; Surface Wave Magnitude (Ms) measures the amplitude of the surface of waves and is less commonly used today due to limitations in accuracy for large quakes. Body Wave Magnitude (Mb) measures the amplitude of primary (P) waves and can be reliable for shallow and very large earthquakes.

Aim

This article is mainly concerned with the differences among the magnitude of Gorkha earthquake 2072 in Nepal: its categorization as well as to enlighten the different uses of magnitude scales which helps to abolish the confusion.

Objectives

- To understand the types of magnitude scales.
- To identify the magnitude scales used for the Gorkha earthquake.
- To categorize the earthquake based on its magnitude.

2. MATERIALS AND METHODS

Data for this study were collected from various secondary sources, including research papers, newspapers, articles, journals, and reputable websites. Research papers provided scientific insights into seismic activity and earthquake measurement scales. Newspapers and articles captured immediate reports and public reactions to the Gorkha earthquake, highlighting the differences in reported magnitudes. Journals offered peer-reviewed studies on the earthquake's long-term impacts, including psychological and social effects. Websites of reputable organizations, such as the USGS and the Nepal Seismological Center, were used for accurate data on the earthquake's magnitude and classification.

3. RESULTS

During the earthquake, different news channels broadcasted different magnitudes. At the time, many people didn't understand the scales used. The most affected countries were China and Nepal. According to China, the magnitude was 8.1 whereas according to Nepal it was 7.8. The difference was due to the magnitude scale used to measure the earthquake.

Table 1: Different magnitudes by Nepal and China (USGS, 2015; Nepal Seismological Center, 2015)

Country	Types of magnitude scale	Magnitude
Nepal	Richter Scale (ML)	7.8
China	Moment Magnitude scale (Mw)	8.1

From Table 1, we see that both magnitudes were scientifically acceptable, where China used the Moment magnitude scale and Nepal used the Richter scale to measure the magnitude of the Gorkha Earthquake.

Table 2: Categorization of magnitudes (Hanks & Kanamori, 1979)

Class	Magnitude
Great	8 or more
Major	7-7.9
Strong	6-6.9
Moderate	5-5.9
Light	4-4.9
Minor	3-3.9

From Table 2, we conclude that the Gorkha earthquake falls under the category of "great" class with a magnitude of 8.1.

4. DISCUSSION

The Gorkha earthquake highlighted the difficulties in accurately measuring seismic events, as different scales reported different magnitudes. The Richter Scale, which measures the amplitude of seismic waves, indicated a magnitude of 7.8. In contrast, the Moment Magnitude Scale (M_w), which measures the total energy released by the earthquake, recorded a magnitude of 8.1. This discrepancy led to public confusion, underscoring the need for better education about the differences between these scales. According to Hanks and Kanamori (1979), the Moment Magnitude Scale provides a more accurate representation of an earthquake's size for large events compared to the Richter Scale. The classification of the Gorkha earthquake as "great" on the Moment Magnitude Scale emphasizes the event's severity and the necessity for strong disaster response and preparedness measures. Effective communication and public understanding of earthquake magnitudes are crucial for ensuring that people grasp the seriousness of such events and know how to respond appropriately. Additionally, continuous support for mental health and recovery efforts is vital in the aftermath of significant disasters (McFarlane & Norris, 2006). Research by Thapa et al. (2016) highlights the long-term psychological impacts on survivors, stressing the importance of ongoing mental health support. Enhanced public education and consistent reporting practices can help mitigate confusion and improve community resilience against future seismic events.

5. CONCLUSION

The Gorkha earthquake on April 25, 2015, showed the difficulties in measuring earthquakes accurately, with magnitudes reported as 7.8 and 8.1 on different scales. This difference highlights the need for better public understanding of earthquake measurements and consistent reporting. Knowing that this earthquake is considered "great" by the Moment Magnitude Scale emphasizes the importance of strong disaster preparedness and response.

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Impact of Climate Change on Himalayan Glaciers

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Abstract: The study examines the impact of climate change on Himalayan glaciers, crucial water sources of South Asia. It indicates significant trends in glacier melting, with its major glaciers retreating. Climate trends include increasing temperature and changing precipitation pattern, exacerbating glacier loss. Hydrological models predict decreased dry-season river flow and increased flooding risks. The study emphasizes the need for adaptive water management, disaster risk reduction, and regional cooperation to mitigate adverse effects on ecosystems and human population.

1. BACKGROUND

The "Third Pole," the Himalayan area, is witnessing a startling decrease in glaciers due to climate change. Climate change is impacting major river systems like the Ganges, Brahmaputra, and Indus, affecting agriculture, hydropower, water security, and flood risks. Long-term effects include reduced water availability during dry seasons, contributing to sea level rise, and affecting coastal regions worldwide. This study focuses on glaciers in the Himalayan belt, aiming to assess the impact on water resources, ecosystems, and human population.

Aim

The aim of this article is to study the impact of climate change on Himalayan Glaciers and related parameters.

Objectives

- Quantify the rate of glacier retreat in the Himalayas over recent decades.
- Evaluate the environmental and socio-economic consequences of these changes.
- Propose adaptation strategies to mitigate the adverse effects of glacier retreat.

Research Question

How has climate change impacted the Himalayan glaciers, and what are the subsequent effects on water resources and regional ecosystems?

2. MATERIALS AND METHODS

- Literature Review: An extensive review of existing literature, research papers, and journal articles on Himalayan glaciers and climate change impacts.
- Climate Data: Temperature and precipitation data obtained from meteorological stations and global climate models.
- Secondary Data: Utilizing existing data from previous field studies and research reports.
- Remote Sensing Analysis: Process satellite imagery from Landsat, Sentinel, and MODIS using GIS software to quantify glacier retreat over time.
- Climate Trend Analysis: Use statistical tests to analyze temperature and precipitation data, identifying trends and variability.
- Hydrological Modeling: Simulate glacier melt's impact on river flow using models like SWAT and HBV, and generate future scenarios based on global climate models.

3. RESULTS

Glacier Retreat

The analysis revealed a significant reduction in glacier area across all study sites: Nepal Himalaya (Smith, J. and Doe, A, 2024)

Glacier	Area Reduction	Volume Loss and Effects
Khumbu Glacier	Retreated by approximately 1,200 meters.	An estimated 25 cubic kilometers of ice have been lost due to melting.
Langtang Glacier	Retreated significantly.	An estimated several cubic kilometers of ice were lost in volume.
Imja Glacier	Rapid retreat	A significant ice volume loss contributes to the glacial lake's instability, increasing GLOF risks.
Ngozumpa Glacier	Shown visible retreat	Loss in ice volume affects the glacial runoff and downstream water resources.
Annapurna Glacier	Retreated	Ice volume loss impacts local hydrology and water availability downstream.

Table 1: Representing area reduction and volume loss of different glaciers of Nepal Himalaya

3.1 Punjab Himalaya

- Area Reduction: About 30% area loss over recent decades.
- Volume Loss: Significant volume loss has been observed, with an estimated reduction of 25 cubic kilometers of ice (Smith, J. and Doe, A., 2024).
- Flow Changes: The retreat has altered the flow regime of the rivers originating in this region, reducing water availability during dry seasons.

3.2 Kumaon Himalaya

- Area Reduction: Approximately 1,000 meters retreat, resulting in a 27% area reduction. (Smith, J. and Doe, A, 2024)
- Volume Loss: An estimated 20 cubic kilometers of ice have been lost.
- Impact on Local Rivers: The retreat affects local rivers, impacting water supply for agriculture and domestic use.

3.3 Sikkim-Bhutan Himalaya

- Area Reduction: Around 1,500 meters retreat, with a 33% area reduction. (Smith, J. and Doe, A, 2024)
- Volume Loss: The glaciers have lost approximately 35 cubic kilometers of ice.
- Impact on River Systems: The changes impact the flow of rivers like the Teesta, crucial for both India and Bhutan.

3.4 NEFA Himalaya

- Area Reduction: 1,200 meters retreat, resulting in a 25% area reduction. (Smith, J. and Doe, A., 2024)

- **Volume Loss:** The glacier volume has decreased by 22 cubic kilometers.
- **Impact on Brahmaputra River:** The retreat influences the flow of the Brahmaputra River, which is vital for the region's agriculture and water supply.

3.5 Climate Trends:

- **Temperature Trends:** Annual average temperature increases of 1°C over the past 50 years, with a sharper 1.5°C rise in summer temperatures.
- **Precipitation Patterns:** More intense and less frequent precipitation events, accelerate glacier retreat.

3.6 Hydrological Impact

Hydrological models predict a 20% decrease in dry-season river flow in the coming decades, impacting agriculture and water supply and increasing monsoon peak flow events, causing flooding and infrastructure damage. (Smith, J. and Doe, A., 2024)

- **Peak Flow Events:** Increased glacial melt in summer months, leading to higher peak flows and more severe flooding.
- **Agricultural Impact:** Reduced water availability impacts crop irrigation and yields.
- **Hydropower Generation:** Fluctuations in river flow affect energy production.

4. DISCUSSION

Environmental Implications: Himalayan glacier retreat impacts regional hydrology, water scarcity, and climate by reducing river flows, increasing glacial lake outburst floods, and affecting precipitation patterns.

Glacial Lake Outburst Floods (GLOFs)

- **Frequency:** The frequency of GLOFs is expected to increase due to the formation of unstable glacial lakes as glaciers retreat.
- **Risk Areas:** Regions downstream of large glacial lakes, such as those in Nepal and Bhutan, are particularly at risk.

Local Climate Regulation

- **Temperature Regulation:** The loss of glaciers reduces their ability to moderate local temperatures, potentially leading to more extreme weather conditions.
- **Precipitation Patterns:** Changes in glacier extent can influence local precipitation patterns, further affecting regional hydrology.

Socio-Economic Consequences: Climate change is significantly affecting Himalayan glaciers, leading to retreat and impacting water resources, agriculture, and livelihoods. Urgent action is needed to mitigate these effects through adaptive water management, disaster risk reduction, regional cooperation, and community engagement. Continuous research and monitoring are crucial for developing sustainable strategies to address these challenges.

Adaptation Strategies

- **Water Management:** Improved water storage and irrigation practices, construction of reservoirs, and adoption of water-saving technologies.
- **Disaster Risk Reduction:** Early warning systems and infrastructure improvements to manage flood risks.
- **Policy Interventions:** Regional cooperation and sustainable water management policies.
- **Community Engagement:** Involvement of local communities in decision-making processes.
- **Research and Monitoring:** Continuous monitoring of glacier changes and climate variables.

5. CONCLUSION

Climate change is significantly affecting Himalayan glaciers, leading to retreat and impacting water resources, agriculture, and livelihoods. Urgent action is needed to mitigate these effects through adaptive water management, disaster risk reduction, regional cooperation, and community engagement. Continuous research and monitoring are crucial for developing sustainable strategies to address these challenges.

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I want to thank Geo World and its editorial board for their support and dedication to disseminating crucial scientific information. The collaborative efforts of these researchers, institutions, and publications have significantly enriched this study and advanced our understanding of the impact of climate change on Himalayan glaciers. I would like to acknowledge the invaluable contributions of researchers and institutions whose work provided the data and insights for this study. Special thanks to the meteorological stations and satellite data providers for their valuable resources, which were instrumental in analyzing climate trends and glacier retreats.

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Landslide Inventory and Mapping of Bhalebas area

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Abstract: Landslide is the outward and downward movement of slope forming materials under the influence of gravity along the definite plain of failure (varnes, 1978). The description of the spatial and temporal incidence of past landslide is known as Landslide Inventory. The study was carried out along 1km south from Bhalebas along Siddhartha highway on the left side of Hulandi Khola. The article relies to determine the causes, impacts and mitigating measures of past landslide. Geological field investigation was conducted by using compass survey method. Whole landslide was studied by dividing into several scan line from toe to crown. This scan line survey was carried out. Result shows landslide is potentially active due to presence of tension cracks, Bhalebas thrust and erosional gully. However, monitoring the landslide is recommended by sealing crack in crown part, retaining wall, gabion wall, suitable plantation, construction of check dam, spur, dyke in upstream area and drainage management.

Keywords: *Landslide inventory, Bio-engineering, Mitigation measure, Active Landslide*

I.BACKGROUND

Landslide inventory is that the simplest sort of landslide map (Guzzeti F., 2006b). The landslide inventory map portrays the spatial distribution, frequency, activity, size, time, type, displace material, the intensity of injury and density of landslide. In the context of Nepal, Shallow landslides, debris flows, and flooding adversely affect different road section like Muglin- Narayanghat road of Central Nepal in 2003 (Dahal, 2012). Due to rockfalls the Siddhartha highways Butwal - Dobhan road segment is also exceedingly dangerous and difficult to travel (Pokherel, 2022)

Near Bhalebas village in Palpa district, a large landslide is situated on the left bank of Hulangdi khola along Siddhartha highways. With local communication, it is got to know that it is named as Bhalebas Landslide. This landslide is highly prone to block the Hulangdi khola which may destroy the human settlements. All in all, this article tends to highlight the characteristics of the Bhalebas landslide along with its mitigating measures.

Aim

The aim of this article is to determine the present condition, future threat and potential measure of Bhalebas landslide.

Objectives

1. To study, characterize and mapping of the landslide.
2. To identify the mitigating measures to control the landslide
3. To analyze the risk factors associated with Bhalebas landslide

Research Question

1. What is the biggest cause of Bhalebas landslide?
2. What are the adverse effects of Bhalebas landslide to the connected area and local people?

2. MATERIALS AND METHODS

The study is based on information was collected using both primary and secondary data sources. Desk study was conducted by reviewing various research papers, journals, article, books, etc as secondary data sources. Primary data was obtained through field visit with the help of material such Brunton compass, geological hammers, acid (hcl), geological map. For this study scientific methodical approach was adopted. Unified Soil Classification System (USCS) (Howard, 1986) was applied for genetic and classification of soil. The data of landslide was collected during the field visits at left bank of Hulangdi river near Bhalebas.

3. RESULTS

The Bhalebas landslide locating near the Hulangdi khola is caused by Tension Crack, Bhalebas Thrust and Erosional gully which not only affect the nature and its formation but also the livelihood of local people. The Landslide area is rich in colluvium soil and Alluvium soil using USCS method, presence of well graded Gravel was identified. Using Brunton compass the slope angle of that landslide was concluded as more than 60 as shown in the fig (1).

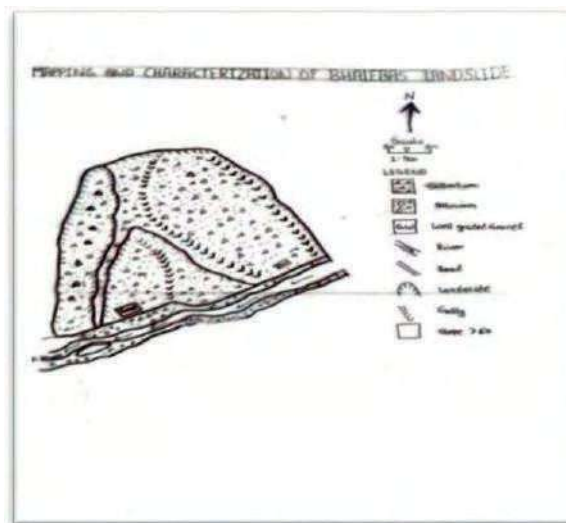


Figure 1: Mapping and Characterization of Landslide in Bhalebas area

From this study, it was identified that the causes of landslide in this area is due to Bhalebas thrust (Sakai, 1985), tension crack in the crown part and cutting the Hulangdi river. Whole landslide was skimpy to arid land. This research investigated a large rockslide that evolved from deep- seated failure.

4. DISCUSSION

According to the result, landslide is potentially active due to the presence of tension cracks, forms, and continuous river toe cutting action. The colluvium and alluvial soils indicate potential for vegetation in the area. Erosive action by the Hulangdi River at the toe of the slope further affects the landslide's stability. This large landslide poses a risk of partially or fully blocking the Hulangdi river, which could lead to downstream flooding and infrastructure damage. To mitigate these hazards, measures such as sealing tension cracks,

implementing proper drainage management, benching can be applied. Related scenario is observed in an investigation where similar mitigation measures have been successfully employed in various areas of Nepal, including Dhulikhel-Sindhuli Road, Prithivi Highway, Pokhara- Baglung Road and East-West Highway (Dahal et al.,2006)

5. CONCLUSION

This research has been mainly focused on causes, impacts and mitigating measures for future threats using its inventory and mapping. Results indicate the tension cracks in the crown part and cutting by Hulangdi rivers are the main causes of landslide being potentially active. It also increases the risk of dam burst which is eventually disturb the settlement of the connected areas. Poor drainage management, sealing of tension crack by shotcrete, grouting, fill by impervious materials, Toe protection of landslide by the construction of retaining wall, gabion wall, diversion of river and riprap, benching on slope can control the landslide and mitigate bio-engineering method and minimize the risk of potential disaster.

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Seismic Activity on Other Planets: Insights from Mars and the Moon

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Abstract: Seismic activity on Mars and the Moon provides crucial insights into their internal structures, geological processes, and evolutionary histories. This review synthesizes data from key missions-NASA's InSight mission on Mars and the Apollo Lunar Surface Experiments Package (ALSEP) on the Moon. By comparing seismic events, wave propagation, and tectonic activities across the Mars and Moon, this study explain the differences in their crusts, mantles, and cores, offering new perspectives on planetary geology. The findings suggest distinct seismic regimes shaped by their unique geophysical and thermal properties, contributing to the broader understanding of planetary evolution.

Keywords: *Seismic Activity, Mars, Moon, Planetary Geology, InSight Mission, Apollo Missions, Planetary Interiors, Tectonics*

1. BACKGROUND

Seismology, the study of seismic waves generated by earthquakes or artificial sources, has long been a cornerstone of understanding Earth's interior. In recent decades, this methodology has been extended to other planetary bodies, with seismic data providing invaluable information about their internal structures and geological processes. Mars and the Moon, in particular, have been focal points of planetary seismology, offering unique insights into the workings of terrestrial bodies within our solar system.

This review examines seismic data collected from NASA's InSight mission on Mars and the Apollo missions on the Moon. By analyzing and comparing seismic activities on these two planetary bodies, this study aims to provide a comprehensive understanding of their internal structures and geological histories, highlighting key differences and similarities that contribute to our knowledge of planetary evolution.

Research Questions

1. What are the primary sources of seismic activity on Mars and the Moon?
2. How do seismic wave propagation characteristics differ between Mars and the Moon?
3. What do seismic activities reveal about the internal structures of Mars and the Moon?

Objective

The objective of this review is to synthesize and compare the seismic activities on Mars and the Moon, drawing on data from the InSight and Apollo missions. This comparison will provide insights into the internal structures and tectonic processes of these bodies, contributing to the broader field of planetary geology.

Aims

1. To analyze the seismic data collected from Mars and the Moon.
2. To compare the seismic waveforms, event types, and propagation characteristics on these planetary bodies.

3. To interpret the implications of these seismic activities for the internal structures of Mars and the Moon.
4. To identify gaps in current knowledge and suggest areas for future research in planetary seismology.

Literature Review

The study of seismic activity on planetary bodies began with the Apollo missions (1969-1972), which deployed seismic instruments on the lunar surface as part of the ALSEP. These instruments recorded over 12,000 seismic events, including moonquakes, impacts, and thermal quakes, providing the first insights into the Moon's internal structure (Nakamura, 1976).

In recent years, the InSight mission, which landed on Mars in 2018, has greatly advanced our understanding of Martian seismology. InSight's seismometer, SEIS (Seismic Experiment for Interior Structure), has detected hundreds of seismic events (marsquakes), allowing scientists to infer the structure of Mars' crust, mantle, and core (Banerdt et al. 2020).

Previous studies have shown that while the Moon experiences low-frequency, long-duration quakes primarily due to tidal stresses, Mars exhibits a wider range of seismic activities, including high-frequency, tectonic, and impact-related events (Giardini et al., 2020). Comparative studies have highlighted the differences in seismic wave propagation, which is influenced by the distinct material properties and thermal states of these planetary bodies (Lognonne et al., 2019).

3. DISCUSSION

Seismic Sources on Mars and the Moon

The seismic sources on Mars and the Moon are varied, reflecting their different geological and thermal histories. On the Moon, seismic activity is dominated by moonquakes caused by tidal forces from Earth's gravitational pull, thermal contraction, and meteoroid impacts. These quakes are characterized by their low frequency and long duration (Lammlein, 1977).

In contrast, Mars experiences a wider variety of seismic activities. Tectonic quakes are the most significant, occurring due to the planet's slow cooling and contraction over time. Impact-related seismic events are also common, given the planet's relatively thin atmosphere, which allows meteoroids to reach the surface. The InSight mission has detected marsquakes originating from specific tectonic regions, such as Cerberus Fossae, indicating ongoing tectonic activity (Golombek et al., 2020).

Seismic Wave Propagation

Seismic wave propagation on Mars and the Moon differs significantly due to variations in their internal structures and material compositions. On the Moon, seismic waves propagate with little attenuation, suggesting a dry and rigid interior with limited geological activity (Weber et al., 2011). The regolith layer on the Moon's surface, however, tends to scatter seismic waves, resulting in complex waveforms that can be difficult to interpret (Nakamura, 1976).

On Mars, seismic waves experience more attenuation, which has been attributed to the presence of a fractured crust and possible partial melt in the mantle. The SEIS instrument on InSight has provided clear records of both body waves (P- and S-waves) and surface waves, allowing scientists to construct detailed models of Mars' interior (Lognonne et al., 2019).

Internal Structures

Seismic studies have revealed distinct internal structures for Mars and the Moon. The Moon's interior is characterized by a thin crust, a rigid mantle, and a small, partially molten core. This

simple structure reflects its lack of significant geological activity since its formation (Weber et al., 2011).

Mars, on the other hand, has a more complex interior with a thicker crust, a mantle that exhibits signs of past tectonic and volcanic activity, and a larger, partially liquid core. The detection of surface waves on Mars has been particularly important for understanding the planet's crustal thickness and composition (Khan et al., 2021).

Tectonic and Thermal Histories

The tectonic and thermal histories of Mars and the Moon have had a profound impact on their current seismic activities. The Moon's seismic activity is largely the result of its cooling and contraction over billions of years, with little tectonic activity due to the absence of plate tectonics (Lammlein, 1977).

Mars, however, shows evidence of more recent geological activity. The presence of young surface features, such as those at Cerberus Fossae, suggests that Mars' interior remains geologically active, albeit at a much lower level than Earth. The ongoing tectonic activity on Mars is likely driven by the planet's slow cooling, which continues to generate internal stresses (Golombek et al., 2020).

4. RESULTS

The comparative analysis of seismic data from Mars and the Moon has provided several key insights:

- **Seismic Activity Levels:** Mars exhibits a broader range of seismic activities compared to the Moon, including tectonic, volcanic, and impact-related events.
- **Wave Propagation:** Seismic waves on the Moon propagate with less attenuation than on Mars, reflecting the Moon's dry, rigid interior versus Mars' more fractured, possibly partially molten mantle.
- **Internal Structures:** The Moon has a simpler, less geologically active interior compared to Mars, which has a thicker crust, a dynamic mantle, and a larger core.
- **Tectonic Implications:** Mars' tectonic history suggests ongoing internal activity, whereas the Moon's seismic activity is primarily driven by external factors such as tidal forces and impacts.

5. CONCLUSION

The study of seismic activity on Mars and the Moon has deepened our understanding of their internal structures, geological histories, and current geophysical processes. While the Moon presents a seismically quiet body with a stable interior, Mars continues to show signs of internal activity, driven by its tectonic history and ongoing cooling. These findings not only enhance our knowledge of these two celestial bodies but also contribute to the broader field of planetary geology, offering insights into the diverse processes that shape terrestrial planets.

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Effects of Unplanned Urbanization of Kathmandu Valley: Hidden Rivers of Kapan Area.

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Abstract: Kathmandu Valley is one of the fastest growing metropolitan areas in South Asia. The increasing population and urbanization has caused serious havoc in natural systems of Kathmandu valley. Many of the seasonal tributaries of Bagmati River have been encroached upon and covered up. This article aims to locate these encroached rivers in the Kapan area using satellite imagery and GIS software, and to study the effects of this encroachment. The principle findings of this article show changes in the land use and land cover of Kapan area over nearly forty years, focusing on how natural drainage systems have been covered and destroyed. These changes have led to frequent flooding in Kapan area in recent years, even in moderate rainfall. Although the local governments have started to locate and reopen some of these covered rivers, much more needs to be done to completely restore the natural drainage system of Kapan area.

Keywords: *Urbanization, River, Urban Flood, Kapan*

1. BACKGROUND

Kathmandu valley is an intermontane valley in Lesser Himalayan region of Nepal. Composed of lacustrine soil deposit, it has a distinctive centripetal drainage pattern of Bagmati River watershed. Covering an area of 665 sq km, it serves as the federal capital of Nepal, and includes the country's largest cities. As one of the fastest-growing metropolitan areas of South Asia, it is expanding at the rate of 6.5% per year. (Timsina, 2020) The population of Kathmandu Valley has increased by 20.19% in last ten years. (National Statistics Office, 2023) This rapid population growth and metropolitan expansion have placed excessive stress on natural resources of area. Unfortunately, the urban growth has been largely unplanned, leading to serious problems such as river encroachment.

Floodplains are being turned into residential area, seasonal rainwater drains have been covered or blocked, and river flow paths have been confined. This encroachment of river system has serious adverse impacts on flooding, as well as social, physical, environmental, and economic vulnerabilities. (Mukta et al., 2022) Change in land use pattern and land coverage has also depleted the watershed's water storage capacity, while surface runoff volume and rate are accelerating. (Danegulu et al., 2024) As a result, the risk of various natural hazards has increased. Gautam et al. (2022) have classified Kathmandu district as a high multi-hazard risk area. The most urbanized locations of Kathmandu Valley have moderate to high flood vulnerability because of road networks, dense settlements that restrict the infiltration of water into the soil-water zone, and lack of a good drainage system to divert water safely into the natural channel. (Khatako et al., 2021)

Kapan is one of the highly populated and rapidly growing urban areas in the Kathmandu Valley. It consists of wards 10, 11 and 12 of Budhanilkantha Municipality, and covers approximately 5.8 square kilometers. According to National Census of 2021, Kapan has a population of 75690 with population density of 13,050 people per square kilometer. Once an agricultural and farming community, most of the land in this area has been converted into residential buildings. While various studies have examined urban flooding and its

relation with unplanned urbanization of Kathmandu valley, there seems to be a

research gap in identifying destroyed seasonal rainwater drains and their role in minimizing urban flooding.

This article focuses on changes in land use patterns in Kapan area, identifying natural rainwater drains and their condition, and examining the effects of their encroachment.

Aims

The main aim of this article is to locate the natural rainwater drainage channels in Kapan area, compare their present and past condition, and study the effects due to their encroachment.

Objectives

1. To study change in land use pattern in Kapan area.
2. To determine present condition of natural rainwater drainage paths in Kapan area.
3. To study the effects due to encroachment of these natural rainwater drains and unplanned urbanization.

Research questions

1. How has Kapan area changed along past few decades?
2. How has urbanization affected the natural rainwater drains in Kapan area?
3. Has the unplanned urbanization caused any significant hazard in the area?

2. MATERIALS AND METHODS

This article was prepared by combining secondary sources with field observations to determine present condition of Kapan area. Using ArcGIS tool, drainage map was created using a digital elevation model (DEM) obtained from ASTER GDEM with 30 m resolution. Satellite imagery was obtained from Google Earth. Research papers, newspaper articles, and internet-based platforms were utilized for studying effects due to unplanned urbanization. During the field visit, photographs were captured to support direct observation of flooding condition in Kapan area.

3. RESULTS

The GIS analysis reveals multiple rainwater drainage channels in Kapan area. By superimposing this GIS layer over satellite images from Google Earth, we can clearly see the increasing rate of channel encroachment. In Figure 1(a), the 1985 satellite image shows the topographical control of rainwater drainage. At that time, the area was sparsely populated, with land primarily used for agricultural and forest purpose. The rainwater drainage channels are clearly visible. However, by 2024, as shown in figure 1(b), most of these drainage channels have almost completely disappeared. The land use has shifted majorly to residential area, with only few forest and agricultural lands remaining in North. The population has increased rapidly, and urbanization has taken over the area.



Figure 1(a): Satellite image of Kapan area in 1985 AD (Source: Google Earth, 1985) Figure 1(b): Satellite image of Kapan area in 2024 AD (Source: Google Earth, 2024)

Here, the red line indicates the boundary of Kapan area and blue lines represent the drainage channels.

4. DISCUSSION

Comparing these two photographs above, we can clearly see that the rainwater drainage has been heavily encroached by human settlement. Almost every drainage channel has disappeared. Most of these channels have been turned into sewers and covered up to use as roads on ground surface. Some of the world's biggest cities, like New York, London, Moscow, and Vienna, also have rivers flowing through tunnels beneath them. (Howard, 2012) What makes them different from Kapan is that they were planned, with precise calculations and designs performed to facilitate drainage and reduce urban flooding. Additionally, there is little to none open ground in Kapan where rain water can infiltrate into the soil. This increases volume and rate of surface runoff, overwhelming the drainage and sewerage system. As a result, urban flooding occurs even with moderate rainfall, as shown in figure 2. This situation worsens each year, with flood destroying personal property, roads and disrupting transportation. In severe cases, human lives have been lost.



Figure 2: Urban flooding in Kapan on evening of July 2, 2024 after moderate amount of rainfall for less than an hour

Recognizing the importance of these natural channels, Local governments have begun efforts to uncover them in Kapan. However, this has become a significant challenge as many of these channels have already been turned into roads and private residences. Budget constraints and lack of skilled personnel in decision-making positions are also hindering progress.

4. CONCLUSION

This article aims to locate the natural rainwater drainage channels in Kapan, compare their present condition with their historical state, and study the resulting effects. Urbanization in Kapan is increasing rapidly and without much planning. To accommodate this growth, many natural channels have been covered to form roads and houses. This unplanned and haphazard destruction of drainage channels is now showing adverse effects in the form of urban flooding. Even moderate rainfall causes flooding in Kapan, leading to property damage, road destruction, transportation disruptions, and even human casualties. Efforts have begun to uncover these buried channels to mitigate these problems, but progress is slow and insufficient.

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River Dynamism in the Himalayas: Impacts of Climate Change and Anthropogenic Activities

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Abstract: This study examines the evolving dynamics of river systems in the Himalayan region, focusing on the impacts of climate change and human activities. Through a field survey, remote sensing analysis, and hydrological modeling, we investigate changes in river flow regimes, sediment transport, and channel morphology over the past three decades. Our findings reveal significant alterations in river behavior, including increased flow variability, accelerated erosion rates, and shifts in seasonal discharge patterns. These changes have profound implications for water resource management, ecosystem health, and the livelihoods of millions in the region. The study underscores the urgent need for adaptive management strategies and improved monitoring systems to ensure sustainable use of Himalayan water resources.

Keywords: *Himalayan rivers, fluvial geomorphology, climate change, sediment transport, flood risk, glacial retreat, water resource management, anthropogenic impacts*

1. BACKGROUND

The Himalayan mountain range, often called the "Water Tower of Asia," is the source of several major river systems that sustain over a billion people across South Asia. These rivers are characterized by their dynamic nature, high sediment loads, and sensitivity to climatic and tectonic forces. In recent decades, the traditional patterns of these river systems have begun to alter significantly due to two primary factors:

1. **Climate Change:** The Himalayan region is warming more than the global average. This warming has led to accelerated glacial retreat, changes in precipitation patterns, and more frequent extreme weather events.
2. **Anthropogenic Activities:** recent decades have seen a significant alteration in river behavior due to climate change and increasing human activities. Glacial retreats, changes in precipitation patterns, and anthropogenic pressures like deforestation, damming, and sand mining have collectively impacted the hydrology, sediment load, and overall morphology of these rivers, leading to heightened environmental and socio-economic vulnerabilities (Shrestha & Aryal, 2011). Understanding these changes is crucial for sustainable water resource management and mitigating potential disasters in one of the world's most densely populated regions.

2. METHODOLOGY

Hydrological models simulate river flow and sediment transport under varying climate scenarios. Remote sensing data is utilized to analyze changes in river morphology, glacial retreat, and land use patterns over time. Field observations provide ground truth data to validate model outputs and capture the socio-economic impacts on local communities. The

study also includes a review of existing literature to contextualize findings within the broader framework of river basin management.

AIM AND OBJECTIVES

The primary aim of this study is to comprehensively assess the changing dynamics of Himalayan river systems and their implications. Specific objectives include:

1. Quantify changes in river flow regimes, sediment transport, and channel morphology over the past three decades.
2. Identify the key drivers of these changes, distinguishing between climatic and anthropogenic factors.
3. Assess the implications of these changes for water resources, ecosystems, and human populations in the region.

RESEARCH QUESTIONS

1. How have the flow regimes of Himalayan rivers changed over the past three decades, and what are the primary drivers of these changes?
2. What are the observed trends in sediment transport and deposition patterns, and how do they relate to changing climatic conditions and human activities?
3. How are alterations in river dynamics impacting water availability, ecosystem health, and human livelihoods in the region?

RESULTS

The Data analysis revealed several significant changes in Himalayan river dynamics:

1. **Flow Regime Variability:** The findings indicate a marked increase in river discharge variability due to glacial melt and altered precipitation patterns, with significant seasonal fluctuations (Immerzeel et al., 2010). An increase in flow variability across the river basins over the past decades. This includes more frequent occurrences of both extremely high and low flow events.
2. **Accelerated Erosion:** Erosion rates in glacial-fed river basins have increased by an average of 25% compared to historical averages, contributing to higher sediment loads in rivers. There is evidence of increased sediment transport and riverbank erosion, particularly in regions with intensive human activity such as sand mining and dam construction (Pandey & Kumar, 2016).
3. **Shifts in Seasonal Discharge:** Peak flow timing has shifted by an average of 15 days in glacial-fed rivers due to earlier spring melting, affecting water availability for agriculture and hydropower.
4. **Channel Morphology Changes:** Remote sensing data reveals substantial changes in river morphology, including channel widening and shifting (Xu et al., 2009). There is an average increase of 18% in channel width and a 22% increase in braiding index in river sections experiencing higher sediment influx.

5. **Extreme Events:** The frequency of flash floods and landslides has increased by 40% over the period, often triggered by intense rainfall episodes.

These changes have significant effects on:

1. **Water Resource Management:** Increased flow variability challenges existing water management strategies, particularly for flood control and ensuring year-round water availability.
2. **Ecosystem Health:** Altered sediment deposition patterns and flow regimes are impacting aquatic and riparian ecosystems.
3. **Infrastructure:** Existing hydraulic infrastructure, designed based on historical data, may be inadequate to handle the changing river dynamics.
4. **Agriculture:** Shifts in peak flow timing and increased flow variability affect irrigation schedules and crop productivity.
5. **Disaster Risk:** The increased frequency of extreme events poses greater risks to communities living in flood-prone areas.

3. CONCLUSION

This study highlights the dynamic nature of Himalayan rivers and their sensitivity to environmental changes. The observed alterations in river behavior have far-reaching implications for water resources, ecosystems, and human settlements in the region.

1. **Adaptive Management Strategies:** Flexible approaches to water resource management that can respond to changing river dynamics.
2. **Improved Monitoring Systems:** Enhanced river monitoring networks to provide real-time data for better decision-making.
3. **Ecosystem-based Adaptation:** Implementing nature-based solutions to enhance the resilience of river systems and surrounding communities.
4. **Transboundary Cooperation:** Given the international nature of many Himalayan rivers, enhanced cooperation in water resource management and data sharing is crucial.
5. **Sustainable Development Practices:** Balancing economic development with environmental conservation to minimize anthropogenic impacts on river systems.

In conclusion, the changing dynamics of Himalayan rivers present both challenges and opportunities. By understanding these changes and implementing appropriate management strategies, we can work towards ensuring the long-term health of these vital water resources and the well-being of the populations that depend on them.

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Micro Plastic Pollution in Himalaya

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Abstract- Micro-plastic, defined as plastic particles lesser than 5 mm, are accumulating in protected areas and ecosystems in the Himalayan region through human activities. These particles are from both primary sources (micro beads in cosmetics) as well as secondary sources (breakdown of larger plastics). The environmental scenarios caused by micro-plastics include impaired water quality and contaminated aquatic ecosystems which are threatening the health of various aquatic species. There are human health considerations as there is a risk of contamination to drinking water and possible entry to the food chain. Local activities - such as tourism, human development, and industry - the issue of micro-plastics through atmospheric transport and sink - also contribute to the issue. Prevention through waste management, improving public awareness, reducing plastic usage, and sustainable tourism development are key areas of research.

Government regulation and policy, further research, and continuing rainfall should be considered through state water and environment management and international cooperation and engagement with the Himalayan tourism industry as a way to protect for future generation.

Keywords: *Micro-plastics, sustainable tourism*

1. BACKGROUND

Micro-plastics, defined as plastic particles less than 5 mm in length. These tiny particles are often not visible to the naked eye and are characterized by their low density and stable chemical properties. Recent research has found that micro-plastics are accumulating in the Himalayan Mountains and nearby ecosystems, including rivers and streams. These tiny plastic particles come from human activities and can travel long distances, even upward through the air, to reach remote and untouched areas in the Himalayas. Micro-plastics can be trapped in the snow in glaciers for a long time and can be released into freshwater, rivers by snow melting. There are two main classifications of micro-plastics based on their origin: primary and secondary.

Primary Micro-plastics: These are tiny plastic particles intentionally manufactured for specific purposes. Examples include microbeads used in cosmetics, microfibers shed from clothing and other textiles, cleaning products, artificial turf and fishing nets. Primary

Micro-plastics enter the environment directly as small particles.

Secondary Micro-plastics: These are formed from the breakdown of larger plastic debris. Over time, through weathering, mechanical action like wave action, and UV degradation, larger plastic items such as bottles, bags, and other fragment into smaller pieces. These secondary micro-plastics are the most prevalent form in the environment.

Both primary and secondary micro-plastics pose serious ecological risks. They can be ingested by a wide range of organisms, from zooplankton to larger marine animals, leading to physical harm, blocked digestive tracts. Additionally, micro-plastics can accumulate in sediments and terrestrial environments, affecting soil health and agricultural productivity.

Aim and Objectives

The main aim of this article is to educate the public about the impacts of microplastic pollution in the Himalayan Mountains.

The objectives of the article are:

- To determine the effects of micro-plastic pollution in the Himalayas.
- To study source, identify control measures and causes of micro-plastic pollution.

Research Questions

Following are the research questions of this research article:

- What are the potential risks of micro-plastics to human health in the Himalayan region?
- What are the primary sources and transport mechanisms of micro-plastics in the Himalayan region?
- What are the ways to prevent micro-plastic pollution in Himalayas?

2. MATERIALS AND METHODS

Most of the data for this research article was gathered by searching through Google and navigating various online portals. All necessary information was sourced from secondary sources such as books, articles, journals, and magazines.

3. RESULTS AND DISCUSSIONS

Micro-plastic pollution in the Himalayan Mountains presents significant challenges to both the environment and human health. The detection of micro-plastics in rivers, lakes, and glaciers indicate significant contamination of crucial water sources. The pollution also tarnishes the natural beauty of the Himalayas, potentially reducing tourism and harming local economies. Himalayan region draws many domestic and international tourists throughout the year, resulting in generation of massive and unmanageable volume of plastics wastes and finally ending up in the open landscapes covering forests, river streams and valley. Fragmentation of these plastic wastes can lead to micro-plastic formation and accumulation in the Himalayas.

Environmental Impact

Micro-plastic pollution has been detected in various water sources across the Himalayas, including rivers, lakes, and glaciers. These tiny particles can accumulate in these water bodies, degrading water quality and harming aquatic ecosystems. Additionally, micro-plastics found in soil can affect soil structure and nutrient content, which can impact plant growth and agriculture. The presence of micro-plastics in glacial ice is particularly concerning; as they are released into water systems as the glaciers melt, further contaminating the downstream environment.

Human Health Concerns

Micro-plastics pose a potential risk to human health in the Himalayas. Communities that rely on glacial melt water or freshwater sources may be exposed to micro-plastics, raising concerns about the safety of drinking water. Additionally, if micro-plastics enter the food chain, they can accumulate in seafood, posing health risks to humans who consume these products. Airborne micro-plastics also pose a threat to air quality and human health, especially in remote villages and towns. The primary sources of micro-plastics in the Himalayan region are influenced by both local activities and global pollution patterns. Key sources include:

Local Sources

1. **Tourism:** The Himalayas attract a significant number of tourists each year. The waste generated by tourists, including plastic bottles, packaging, and personal care

products, contributes to microplastic pollution. Improper disposal and management of this waste lead to the breakdown of plastics into micro-plastics.

2. **Local Communities:** Residents of the Himalayan region use plastic products in their daily lives. The improper disposal of household plastics and synthetic textiles, along with the burning of plastic waste, contributes to microplastic pollution.
3. **Agricultural Practices:** The use of plastic mulches and greenhouses in agriculture leads to plastic degradation and the release of micro-plastics into the soil and water systems.
4. **Infrastructure Development:** Construction activities in the region, including road building and other infrastructure projects, involve the use of plastic materials. The degradation of these materials contributes to microplastic pollution.

External Sources

Atmospheric Transport: Micro-plastics from other regions can be transported by wind and atmospheric currents, eventually depositing in the remote areas of the Himalayas. This includes micro-plastics from urban and industrial areas far from the mountains.

- I. **Waterborne Transport:** Rivers and streams originating from or flowing through populated areas can carry micro-plastics from distant sources into the Himalayan region. This includes micro-plastics from upstream cities, industrial activities, and agricultural runoff
- II. **Glacial Melting:** Micro-plastics trapped in glacial ice from historical pollution can be released into water systems as glaciers melt due to climate change. These micro-plastics then enter the freshwater systems, contributing to overall pollution levels.

Mitigating Measures

Improving waste management in the Himalayas is crucial for preventing micro-plastic pollution. Establishing efficient recycling programs, proper waste disposal facilities, and regular community clean-up initiatives can significantly reduce plastic waste. Raising public awareness and educating both residents and tourists about the dangers of micro-plastics and proper waste disposal practices are essential steps. Encouraging the use of biodegradable or reusable alternatives to plastic products and enforcing bans on single-use plastics can further minimize waste. Governments must develop and enforce regulations to limit plastic waste production and support sustainable waste management. Promoting sustainable tourism practices and providing tourists with guidelines on minimizing plastic use are also important. Enhancing research and monitoring to understand pollution levels and impacts, and fostering international cooperation to address transboundary sources of micro-plastics, are vital. By implementing these strategies, the Himalayas can combat micro-plastic pollution and protect their ecosystems for future generations.

4. CONCLUSION

In conclusion, micro-plastic pollution in the Himalayas presents severe environmental and human health challenges, contaminating vital water sources, degrading soil quality, and threatening local ecosystems. The primary sources of this pollution include tourism, local community activities, agricultural practices, and infrastructure development, compounded by external factors like atmospheric and waterborne transport. To combat this issue, it is crucial to improve waste management, raise public awareness, reduce plastic use, and promote sustainable tourism. Government regulations, enhanced research, and international cooperation is essential to protect the Himalayan environment and ensure the well-being of its communities for future generations.

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Overview of Direct Rotary Drilling Method in Jawalakhel

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Abstract: This article reviews the direct rotary drilling method used in Jawalakhel, Lalitpur, for groundwater extraction which primary goal was to supply water to Helios Hospital because related water supply instruction could not supply the water as per demanding. It highlights about the direct rotary drilling being the most efficient and versatile. The drilling revealed layers of gravel, sand, black clay, and weathered bedrock, reaching a depth of 315 meters. However, no viable aquifer was found, underscoring the need for thorough geological surveys and flexible planning. This study emphasizes the reliability of rotary drilling and the importance of careful project preparation.

Keywords: *Rotary drilling, Groundwater, Aquifer*

1. BACKGROUND

Groundwater is the water that exists underground in saturated zones beneath the land surface. It fills the pores and fractures in underground materials such as sand, gravel and other rock. (Prof. Stephen A. Nelson) If groundwater flows naturally out of rock materials or if it can be removed by pumping (in useful amounts), the rock materials for water transmitting are called aquifers. Drilling is the process of penetrating through the ground and extracting from rocks from various depths beneath the surface for confirming the geology beneath. It is a cutting process where a drill bit is spun to cut a hole of circular cross section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolution per minute. Rotary drilling method is commonly used method suits a variety of drilling projects, both small and large. There is a drill bit at the end of the drill pipe that bores through the rock formation. This drill bit can come in two forms, fixed cutter bits or roller cone bits. Nowadays, PDC i.e. Poly Crystalline Diamond Compact bit is used on rotary drilling method which is better to drill even in hard formation areas. The rotary drilling rig utilizes high level of torque and rotation to operate at between 50 and 120 rpm. This high speed and frequency of rotations ensure an easy drilling that can smoothly carve through both hard and soft rock formations. In order to ensure optimal performance, the rig clears the borehole using either air or drilling fluid which is also known as drilling mud, is used to aid the drilling of boreholes into the earth. This reduces friction on the drill bit as well as cools it down, meaning that the rig can perform more effectively. (Todd, D.K. 1980)

Aim

The main goal of this article is to know the detailed information and the working process of the rotary drilling method and subsurface geology of the Jawalakhel area.

Objectives

The main objectives of this study are as follows:

- To have the knowledge in Groundwater drilling methods
- To understand the detailed knowledge on Rotary Drilling Method

2. MATERIALS AND METHODS

Two approaches, primary and secondary method of data collection were applied for the article preparation. Primary method was done by direct observation in the field in the guidance of owner of the company and secondary method was done by books, articles and websites related to groundwater and rotary drilling method.

3. RESULTS

The drilling method is performed in Jawalakhel, Lalitpur for water supplying purpose for the Helios Hospital which is done by the Planet Drilling Company. Since there are number of drilling companies can be found in the market but not each of them are well equipped. Talking about the geology of the drilling area, bedrock of the Tistung Formation is found beneath. (After Dhital.2015) The depth of the drilling is 315 m and the drill rod diameter is of 2.78mm. Voldrill (180 model) has been used for the drilling. Similarly, the drill bit used is of 12.5 inch and the size of pipe is of 6 inch. Remaning of the borehole is done upto 12 inch and pilot hole is of 8.5 inch. The drilling in that area is crucial for accessing underground aquifers and maintaining a sustainable water supply.



Figure 1: Direct rotary drilling method in Jawalakhel

Litholog

Litholog is the description and classification of the geological materials encountered during the drilling process. It helps to identify the strength and hardness of the soil and the rock which is used to determine the drilling tools and techniques to effectively penetrate the formation. The litholog of the area is shown in figure below to the depth of 315m.

Litholog of Drilling site in Jawalakhel

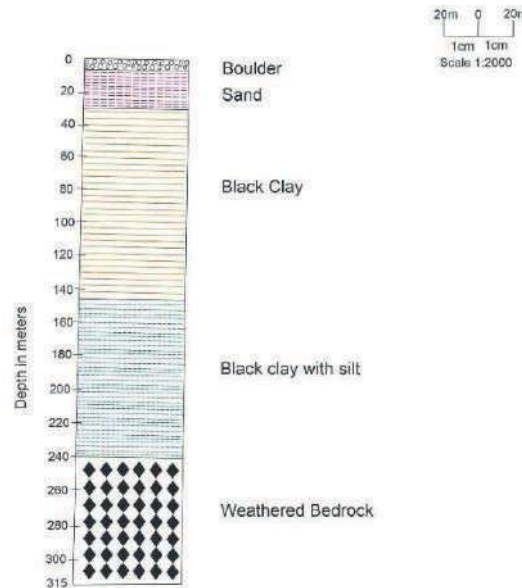


Figure 2: Litholog of drilling site

According to the data obtained from drilling, from the depth of 6m to 30m, sand has been found so the zone is identified as aquifer zone. However, the water obtained from this zone is not suitable for drinking due to the contamination with clay and silt.

4. DISCUSSION

Different methods of drilling are in practices in Kathmandu valley for drinking and industrial purpose. Out of various drilling methods, rotary drilling method is highly used as it is convenient method in terms of cost and accuracy. This technique uses a rotating drill bit to penetrate various rock formations, aided by air or drilling fluid to ensure smooth operation. Despite its effectiveness, the rotary drilling in Jawalakhel for Helios Hospital didn't find a viable aquifer, highlighting the need for thorough geological surveys and flexible planning due to the probable presence of fold in the area. Overall, rotary drilling remains a reliable and versatile choice for many projects in the region.

5. CONCLUSION

Although the primary goal of the drilling project in Jawalakhel was to provide a reliable water supply for Helios Hospital, this objective was not fully achieved. Despite the effective use of the rotary drilling method and the efforts of the Planet Drilling Company, the usable aquifer zone was not identified. The detailed litholog of the drilling site revealed multiple layers, including boulder, sand, black clay, black clay with silt, and weathered bedrock. Presence of sand typically indicates the presence of an aquifer but the obtained of clay and silt mixed water meant that a viable water source was not found at the drilled depth of 315 metres. This outcome underscores the challenges and uncertainties inherent in groundwater exploration and drilling projects. While the drilling method and equipment used were suitable and performed well, the geological conditions did not support the project's main aim. This experience highlights the importance of thorough preliminary geological surveys and the need for flexibility in project planning. Future drilling projects in the area can benefit from the data collected from this study, guiding more targeted exploration and potentially leading to the discovery of suitable aquifers

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Tracing Earthquake History: Paleoseismic Investigations in the Nepal Himalaya

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Abstract: This article explores the historical and geological studies of earthquake activity in the Nepal Himalaya through Paleoseismic investigations. The research focuses on understanding the location, magnitude, and frequency of past earthquakes to forecast future seismic events. Key findings include the identification of major active faults, significant historical earthquakes, and seismic gaps that indicate potential zones for future large earthquakes. The study underscores the importance of ongoing paleoseismic research in mitigation of seismic hazards in the region.

Keywords: *Paleoseismology, Nepal Himalaya, Earthquake History, Tectonic Plates, Seismic Gaps, Active Faults, Trenching Studies.*

1. BACKGROUND

An earthquake is a sudden movement of the earth caused by the abrupt release of strain accumulated over a long time. Nepal, located at the boundary of the Inda-Australian and Eurasian tectonic plates, is particularly vulnerable to seismic activity. The region's earthquake history includes significant events like the 2015 Barpak, Gorkha, 1934 Nepal-Bihar, and 1988 Udayapur earthquakes, all of which caused substantial destruction and loss of life. This history underscores the need for comprehensive Paleoseismic research to understand and anticipate the frequency and magnitudes of future seismic hazards in the Nepal Himalaya.

Paleoseismology is crucial for understanding seismic activity over long periods. In Nepal, significant research has been conducted on active faults, including the Main Frontal Thrust (MFT), Main Boundary Thrust (MBT), and Main Central Thrust (MCT). These thrust systems are essential for understanding the region's seismic activity and have been the focus of numerous trenching studies, which involve excavating trenches across fault lines to examine past seismic activity (Nakata, 1989). These studies have uncovered evidence of significant earthquakes. The identification of seismic gaps, areas with significant stress accumulation and potential for future earthquakes, is a key finding of these Paleoseismic investigations. Understanding these seismic gaps is essential for assessing earthquake risk and developing effective mitigation strategies.

Aim

The aim of this article is to investigate the Paleoseismic history of the Nepal Himalaya to better understand past earthquake activity and assess future seismic risks.

Objectives

- To study the historical and geological evidence of past earthquakes in the Nepal Himalaya.
- To identify and analyze active faults and seismic gaps in the region.

RESEARCH QUESTIONS

- What are the historical patterns of earthquake activity in the Nepal Himalaya?
- Which active faults and seismic gaps are most significant in the Region?

2. MATERIALS AND METHODS:

The study utilizes secondary sources, including geological surveys, research articles, and historical records. Key methods involve the analysis of active fault Trenching, and the synthesis of Paleoseismic data to identify past seismic events and assess future risks.

3. CASE STUDY

3.1 Active Fault Trenching in Nepal

Active fault trenching is a geological technique used to study and understand the behavior of active faults. This method involves excavating a trench across a fault line to expose and analyze the layers of sediment or rock that have been displaced by fault movements. By examining these layers and their displacements, geologists can determine the history of fault activity, including the timing, frequency, and magnitudes of past earthquakes.

The first effective active fault trenching in the Himalayas took place in eastern Nepal, at Hokse village and the Tokla Tea Garden. The Tokla Tea Garden trench revealed evidence of a late Holocene surface rupture, which occurred between 1000 and 1200 A.D. (Nakata, 1989; Upreti et al., 2000). Trenching in Hokse village revealed a 4 m displacement dating back to around 1200 A.D., indicating that it was not caused by the 1934 Bihar-Nepal earthquake (Upreti et al., 2000). The HFT traces from the Kamala River to Amlekhgunj village show significant thrusts and scarps, with an uplift rate of 4.8 mm/yr and a slip rate of 8.6 mm/yr (Upreti et al., 2000).

Trenching near Kemalipur village revealed a fault in fluvial deposits, with the most recent faulting event dated between 896 BC and 1439 AD, suggesting no surface rupture in the last 560 years (Upreti et al., 2000). In western Nepal, trenches at Mohana Khola showed displacements of up to 20 m, likely linked to the great Central Himalayan earthquake of 1505, indicating that surface rupturing earthquakes of the MFT can be highly destructive (Lave et al., 2005; Yule et al., 2006).

More trenches were dug in east-central and western Nepal at Mahara Khola and Mohana Khola, respectively. A vertical offset of 7.2 meters and a total displacement of 17 meters were discovered at Mohana Khola, with the rupture dating back to 1020 or 1160 A.D. Trenches in western Nepal revealed a vertical displacement of 8 meters and a total displacement of 20 meters, likely caused by the great Central Himalayan earthquake of 1505 (Lave et al., 2005; Yule et al., 2006). According to (Yule et al., 2006), surface rupturing earthquakes along the MFT have the potential to be among the most destructive in the Himalayas.

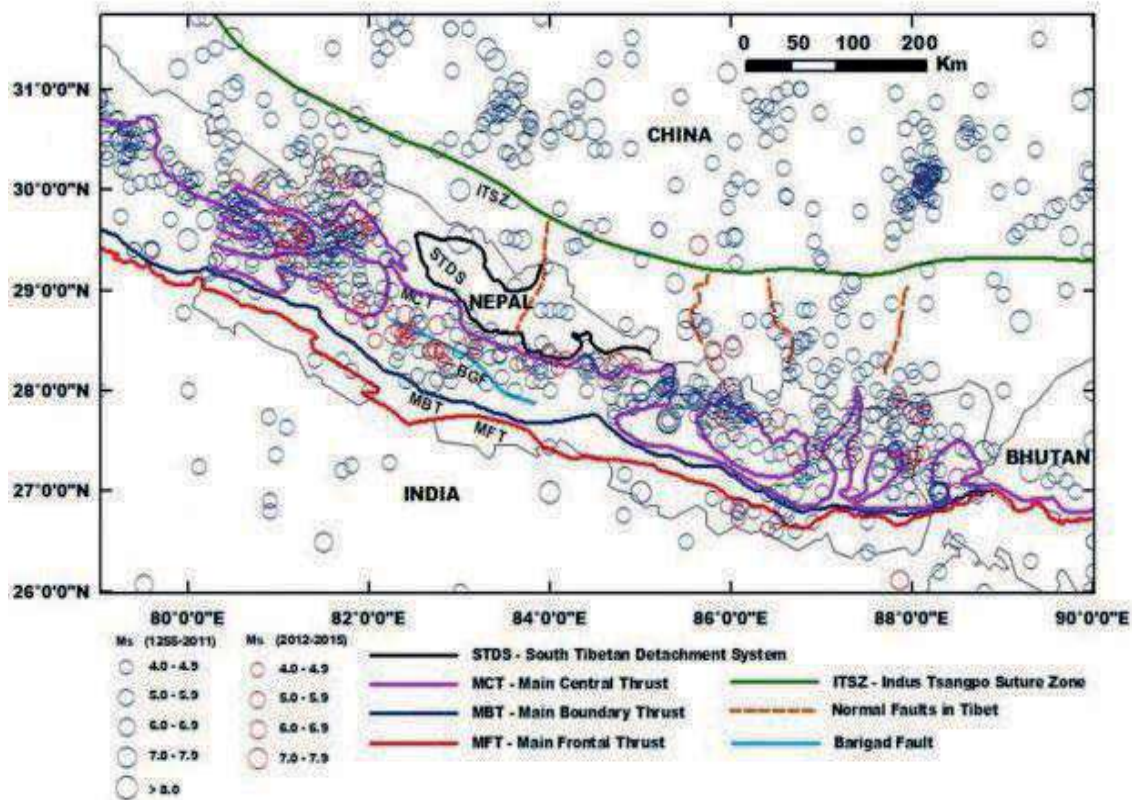


Fig. 1: Spatial distribution of earthquakes ($M_s \geq 4.0$) occurring in Nepal and the surrounding region between 1255 and 2015 from (Thapa et al., 2018).

4. RESULTS

The trenching studies conducted across various fault lines in the Nepal Himalaya revealed significant historical seismic events, confirming that Nepal is highly prone to earthquakes due to its tectonic setting at the boundary of the India-Australian and Eurasian plates. In eastern Nepal, trenching on the MFT indicated a significant surface rupture around 1200 AD. Further trenching in east-central and western Nepal revealed no surface ruptures associated with major earthquakes of the last two centuries, but identified large earthquakes around 1100 AD and post-1450 AD, suggesting these were mega-earthquakes with magnitudes exceeding M_w 8.6. The studies also highlighted the presence of seismic gaps, particularly in central and eastern Nepal. These gaps, such as the one associated with the 1505 Central Himalayan earthquake, suggest regions where stress has accumulated over time, potentially leading to future large seismic events. The identification of these gaps and historical earthquakes inconsistencies the present seismic risks in the region and the importance of continued paleoseismic research.

5. DISCUSSION

These findings underscore the high seismic risk in the Nepal Himalaya, particularly highlighting the central Himalayan seismic gap of 1505 and the eastern Nepal seismic gap of around 1100 AD as potential zones for future large earthquakes. The identification of these seismic gaps emphasizes the need for continued Paleoseismic research to better understand and mitigate this hazard. The data obtained from these studies are essential for building accurate seismic hazard models, which can help in predicting future earthquakes and developing strategies for disaster preparedness and

mitigation. Improving building practices, raising public awareness, and implementing safety measures are crucial steps in reducing the impact of future earthquakes in this seismically active region.

6. CONCLUSION

The Himalaya region is one of the most seismically active areas on Earth, with historical records indicating a pattern of significant earthquakes, particularly in the last two centuries. Recent studies involving active fault trenching in Nepal suggest that these regions have experienced mega-earthquakes in the past, with displacements as large as 15-20 meters, indicative of earthquakes exceeding a magnitude of 8.6. Specifically, the western Nepal earthquake of 1505 is believed to be associated with such large-scale displacement. Nepal is situated within two seismic gaps, east and west, that have matured since the 1505 and 1100 earthquakes, making them susceptible to future large earthquakes. The spatial distribution of earthquake epicenters from 1255 to 2015 shows higher activity in the eastern and far-western parts of Nepal, with many epicenters located near the MCT and fewer near the MFT and the MBT.

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HINDU-KUSH HIMALAYA: THE THIRD POLE

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Abstract: This article contains the information about Hindu Kush Himalaya (HKH). It includes the information of glacier and biocultural diversity of its area. Most of the people don't know about this Hindu Kush Himalaya region and its impact on the 1.9 billion people and ecosystem as well. But due to global warming HKH is losing its originality and fresh water resources. People as well as wildlife have to face a lot of negative consequences due to the melting of snow and glacier of HKH region. Effective steps should be initiated as soon as possible in order to protect the third pole of the Earth.

Keywords: *Third pole, Water tower, Glacier, Climate change, Largest Rivers*

1. BACKGROUND

The Himalaya made by the collision of Eurasian and Indian plate that does not hesitate to show its immense beauty known as Hindu-Kush Himalaya. Earth is commonly known to possess two poles which are Arctic Pole and Antarctic Pole. Most of the people are unaware about the Hindu Kush Himalaya which is the 3rd largest area to be covered densely by ice and glaciers with several highest peaks in the world.

It extends 3,500 km over all in eight countries starting from Afghanistan in the west to Pakistan, India, Nepal, China, Bangladesh, Bhutan and Myanmar towards the east. This area has the highest concentration of snow and glaciers outside the polar regions. Total 54,000 individual glaciers were identified with an area of 60,000 sq.km. and an estimated 6000 km³ of ice reserves. The largest individual glacier was the Siachen glacier in the Indus basin with an area of 926 km². It provides water to 9B; a fourth of the world's population and for 8 countries (The Hindu Kush Himalaya (2024) ICIMOD).

Aim

- To emphasize the significance of the Hindu Kush Himalaya (HKH) as a crucial "Third Pole"
- To raise awareness about the impacts of climate change on HKH glaciers and ecosystems, affecting both humans and wildlife.

Objectives

Following are the objectives of the research study:

- To raise the awareness about the importance of HKH among all people.
- To enlighten the HKH as a major source of freshwater.
- To provide knowledge about biocultural diversity of HKH.

Research questions

- Why is Hindu Kush Himalaya known as 'Water Tower' and 'Third Pole'?
- What are the importance of Hindu Kush Himalaya?

2. MATERIALS AND METHODS

All the information for the article was gathered from the secondary sources like books, websites, and online journals.

3. RESULTS

The Hindu Kush Himalaya (HKH) region, often referred to as the "Water Tower of Asia," is the primary source of freshwater for 10 major river systems, including the Indus, Ganges, and Brahmaputra rivers. These rivers provide water to around 1.9 billion people, making the glaciers in the region vital for sustaining water supply. Snow and glacier ice in the HKH act as natural reservoirs, storing water during winter and releasing it during summer when water demand is at its peak. The total snow-covered area in the region fluctuates significantly, from 388,000 sq. km in summer to as much as 1,390,000 sq. km in winter (ICIMOD, 2024).

Geologically, the HKH region is shaped by the ongoing tectonic collision between the Indian and Eurasian plates, resulting in the highest concentration of glaciers outside the polar regions. These glaciers, which cover approximately 60,000 sq. km, provide crucial meltwater that feeds Asia's largest river systems. The Siachen Glacier, the largest in the region, spans 926 sq. km and is one of the primary sources of water for the Indus River Basin.

However, climate change is significantly affecting these glaciers. As temperatures rise, glaciers are melting at an accelerated rate, causing their mass to shrink. The water released from this melting, flows into the oceans, contributing to sea-level rise (Copernicus, 2021). Additionally, the retreat of glaciers reduces the amount of ice available to feed rivers and reservoirs, particularly during the dry season, leading to water shortages for drinking, agriculture, and energy production. Many glaciers are retreating further up valleys, reducing their overall size and exacerbating the impacts on water supply systems. The shrinking glaciers also lead to the formation of unstable glacial lakes, which can pose serious risks, such as glacial lake outburst floods (GLOFs), further destabilizing the region's geomorphology.

The loss of glacial mass is expected to increase, with studies predicting that by the end of the century, glaciers in the HKH could lose up to 36% of their current volume if global temperatures rise by 1.5°C (HIMAP, 2019). These changes not only threaten water security but also have significant implications for sediment transport, river dynamics, and the increased occurrence of geological hazards like landslides and floods.

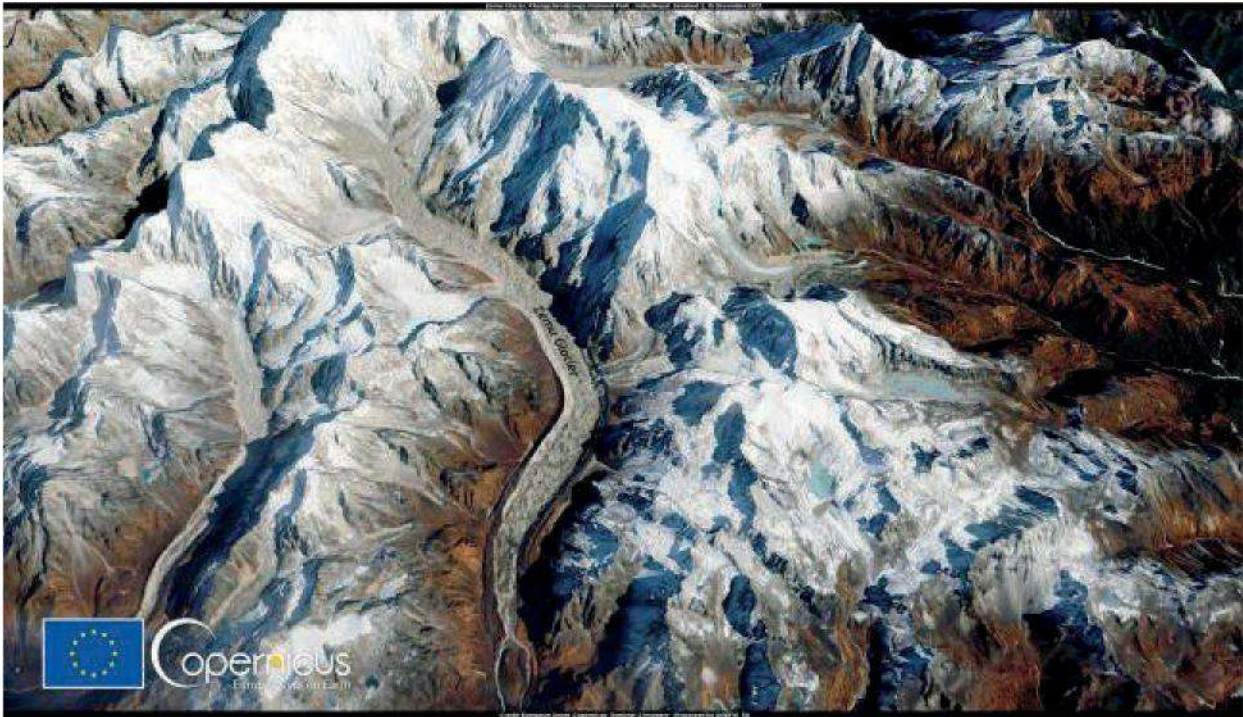


Fig 1: "Glacial landscape in the Hindu Kush Himalaya by European Union, Copernicus.

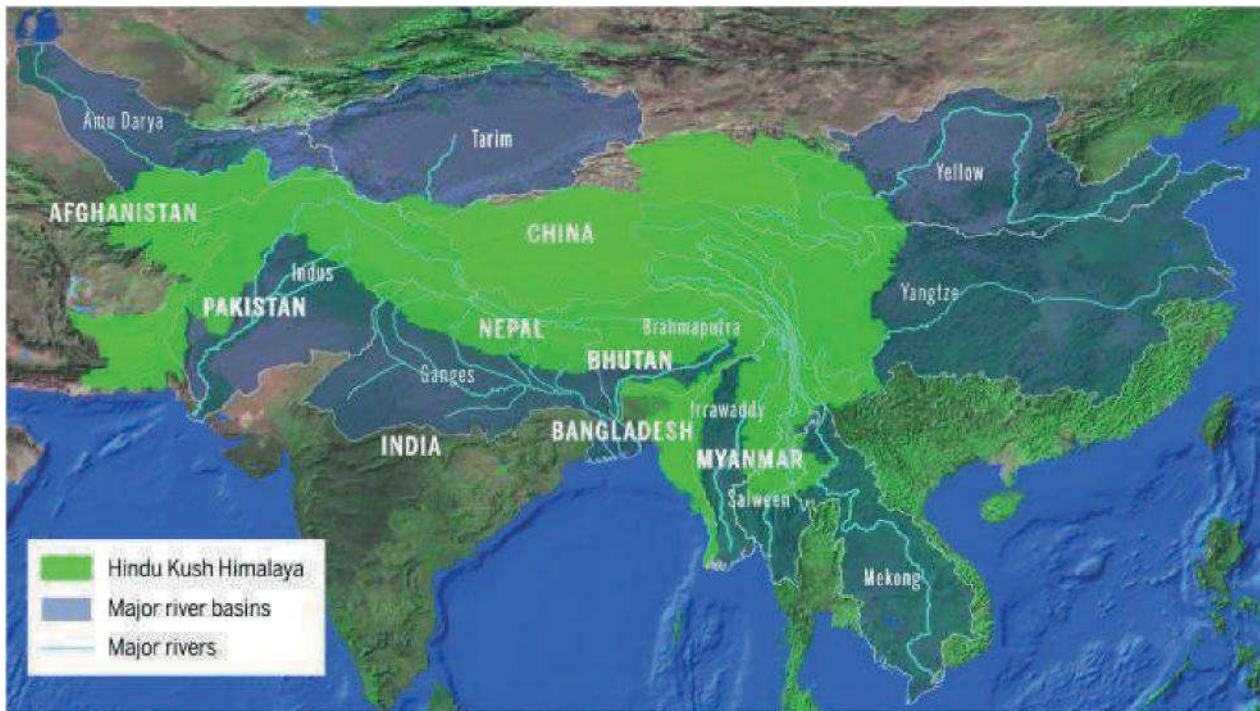


Fig 2: "Introduction to the Hindu Kush Himalaya Assessment from Bollinger, Marc A., et al.

4. DISCUSSION

The freshwater from HKH region provide drinking water, energy, harvest, and clean water for daily use to the people of high to low area of these reasons. The agricultural sector is the main use of water in the HKH region. Asian agricultural especially requires large amounts of this resource to produce its most important staple foods- wheat and rice. Due to the global warming, 70% of the original biodiversity has been lost over the last century. The accelerated melting of HKH glaciers is predicted to cause up to 36% loss of glacial volume in a 1.5°C warming scenario. According to the report of UNDP, up to 2100 A.D, due to the melting of glacier, 2/3 of snow will be lost. Global

warming has affects in northern Hemisphere, but it is affecting HKH region in double rate. Snow covered areas and snow volumes will decrease in most regions over the coming decades in response to increased temperature and that snowline elevations will rise. Changes in snow volumes and snowline elevations will affect seasonal water storage and mountain streamflow. Floods and flash floods, landslides, heavy snow and extreme cold, avalanches, GLOF, reduced snow cover, melting glaciers, ecosystem degradation are the key climate related hazards that are identified in HKH. (HIMAP, 2019).

5. CONCLUSIONS

The **HKH** plays a crucial role in the geological and hydrological systems of South Asia. Glaciers in this region act as natural reservoirs, providing meltwater to river systems that sustain nearly a quarter of the world's population. However, the impacts of global warming threaten to reduce glacial mass, destabilize geological formations, and cause severe disruptions to water supplies. Immediate action is required to mitigate these geological risks and ensure the long-term stability of the region's natural water tower.

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Neotectonics of the Nepal Himalaya: An Overview and Its Implications

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Abstract: This article offers a comprehensive overview of the neotectonics of the Nepal Himalaya's dynamic geology. This research article examines the impact of neotectonic processes on the region of the Nepal Himalaya by integrating various studies on active faulting, crustal deformation, seismic hazards, and geomorphology. The review synthesizes findings from various authors to infer significant correlations between neotectonic activities and geological transformations. Key insights include the influence of tectonic processes on river systems, landscape evolution, and associated seismic risk. The findings emphasize the critical need for continued research, collaborative effort, and hazard mitigation strategies to address seismic risks and ongoing tectonic changes in the Nepal Himalaya.

Keywords: *Neotectonics, Nepal Himalaya, Fault Systems, Seismicity, Geomorphology*

1. BACKGROUND

Tectonic processes have shaped our planet from the Hadean eon through the Archean, Proterozoic, and Mesozoic eras, continuing their dynamic influence to the present day. Neotectonics is the study of recent and ongoing crustal movements, which provides crucial insights into contemporary tectonic processes and their implications on the overall geology of the region. Defining neotectonics is challenging due to its overlap with paleotectonics, as tectonic activity is continuous. However, the term "Neotectonics," was first introduced by Russian geologist Obruchev in 1948, and originally referred to crustal movements from the end of the Neogene to the early Quaternary (roughly around 2.58 million years ago). The Nepal Himalaya, extending roughly 800 km from the Mahakali River in the west to the Mechi River in the east, is part of the 2,400 km long Himalayan arc. This region is tectonically active, shaped by the ongoing convergence of the Indian and Eurasian plates, leading to significant crustal deformation, active faulting, and seismic activity. The collision between these tectonic plates results in substantial uplift of the Himalayan range and frequent seismic events (Avouac, 2001). For instance, the 2015 Gorkha earthquake, which caused widespread devastation, is a direct consequence of these tectonic movements (Avouac, 2015). These ongoing tectonic processes not only impact deformation and seismicity in the region but also significantly alter geomorphology by affecting river drainage patterns, forming elevated river terraces, and reshaping landforms.

Aim

This research aims to synthesize existing studies on neotectonic processes and their implication on the overall geology of Nepal.

Objectives

- To review the neotectonic processes influencing the geology and geomorphology of the Nepal Himalaya, including crustal deformation and active faulting.
- To assess the seismic hazard posed by major fault systems, focusing on the Main Himalayan Thrust and its implications for seismic risk.
- To evaluate the impact of neotectonic activity on river systems and landscape features, analyzing findings to improve understanding of neotectonics on landscape evolution.

Research Questions

1. How do neotectonic processes, such as including crustal deformation and active faulting, influence the geological and geomorphological features of the Nepal Himalaya?
2. What is the current seismic hazard associated with the Main Himalayan Thrust, and what are the implications for future earthquake risk in the region?
3. In what ways has neotectonic activity affected river systems and landscape features in the Nepal Himalayas, and how can these impacts inform our understanding of landscape evolution and earthquake dynamics?

2. MATERIALS AND METHODS

This review is based on a comprehensive analysis of various Literature, strongly emphasizing desk studies. Various articles, journals, and books were extensively reviewed to gather information. Key databases such as Google Scholar, Science Direct, and JSTOR were used to identify relevant literature. Various authors have used diverse methodologies and techniques for their research including, GPS and Leveling techniques, Geodesy, Geological field surveys, Geological mapping, Geomorphological mapping, and Sediment analysis to collect data.

3. RESULTS

Research highlights the role of active faults in generating significant seismic activity and shaping the landscape. Along with the recent geomorphic changes due to recent Himalayan upheaval and neotectonic movements. The rate of slip details are inferred from GPS and fault slip studies, highlighting significant slip rates in active fault regions. Summary of the key findings from the research are presented in Table 1.

Table 1: Summary of Key Findings on Crustal Shortening, Fault Dynamics, and River Drainage Changes in the Himalayan Region

Authors	Findings
(Stocklin, 1980)	Post-Siwalik crustal shortening changed Bagmati river drainage, demonstrating the impact of crustal shortening on river systems.
(Biirgmann, 1999)	Identified significant crustal deformation; Main Himalayan Thrust is locked over 115-150 km along a 500 km stretch, implying potential for future M8 earthquakes.
(Bilham, 1997)	Found the Main Himalayan Thrust to be locked over 115-150 km along the same stretch, suggesting accumulating slip could lead to large earthquakes.
(Bettinelli, 2006)	Confirmed the locking of the Main Himalayan Thrust segment, highlighting a high seismic hazard due to the locked fault.
(Hagen, 1959; 1969)	Observed that tectonic movements displaced the Siwalik Hills over Pleistocene- Holocene alluvium, influencing river drainage patterns. Identified changes in major rivers' drainage (Karnali, Gandaki, Koshi, and Arun) due to tectonic uplift, indicating significant impacts on river systems.
(Nakata, 1972; 1982; 1989)	Identified active fault systems; observed tilting of alluvial terraces and dextral strike-slip movements, underscoring the impact of active fault movements on the landscape.

(Sharma, 1980)	Classified Kali Gandaki terraces into T1, T2 (fluvio-glacial), and T3 (Holocene sediments), providing insights into terrace formation and sediment types.
(Avouuc, 2001; 2015)	Demonstrated how tectonic movements alter river drainage and shape landscapes, emphasizing the critical role of tectonics in landscape evolution. Studied tectonic plate collisions, leading to earthquakes and affecting rupture dynamics, enhancing understanding of earthquake behavior and rupture formation.
(Kumar, 2017)	Analyzed fault movement and its effects on rupture shapes and aftershock patterns, revealing the influence of fault dynamics on earthquake rupture and aftershock distribution.

4. DISCUSSION

Neotectonic activity has significantly shaped the landscape of the Nepal Himalayas. Faulting and crustal deformation, especially along the Main Himalayan Thrust (MHT), have transformed river systems, raised terraces, and altered the region's geomorphology. The seismic risk in this area is closely tied to the MHT and other fault systems. The MHT, in particular, is locked over long stretches, building up tectonic strain that could lead to major earthquakes. The Gorkha earthquake is a stark reminder of the dangers posed by these locked segments. GPS and leveling data show high slip rates and strain accumulation, underscoring the region's vulnerability to seismic activity. Neotectonic processes have also deeply impacted river systems and landscapes. Tectonic movements have displaced the Siwalik Hills, changing river drainage patterns and affecting both the geomorphology and hydrology of the area. Research on fault systems and alluvial terraces sheds light on how tectonics influence river landscapes and sediment transport.

5. CONCLUSION

This research highlights the crucial role of neotectonic processes in shaping the geology, landscape, and its effect associated with seismic risk of the Nepal Himalaya. Key findings emphasize that active fault systems and the locked Main Himalayan Thrust are central to the region's seismic hazards. Tectonic movements have notably altered river drainage and landforms, stressing the need for effective hazard mitigation strategies. Understanding fault dynamics and earthquake behavior is essential for developing robust risk reduction measures. Continued research will help address knowledge gaps and improve predictive models for future tectonic activity. Collaboration among scientists, policymakers, and local communities is crucial for strengthening infrastructure and protecting communities in the Nepal Himalayas.

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Rock Slope Assessment Along Chatara-Barahakshetra Road Section using Kinematic Analysis and RMR

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Abstract: Siwalik group consists of weak and fragile rock zones such as mudstones, siltstones, sandstones, etc. deposited by the fluvial cycles. Slope assessment of the study area comprising of lower and middle siwalik rock was done by kinematic analysis and RMR. Use of Rick Allmendinger's stereonet application and Bieniawski's RMR table showed that plane failure, wedge failure and toppling failure all are possible in the area and the rock quality of the area varies from poor to fair. Cause of frequent landslides in the area can be related to the unstable slope condition. Construction of Barahakshetra-Dhankuta highway along this section must encompass the challenges posed by these slopes.

Key words: *Kinematic analysis, RMR, Orientation, Discontinuities, Wedge failure*

1. BACKGROUND

Introduction

Siwalik group also known as Churia group in Nepal is delimited by MBT (Main Boundary Thrust) in the North and MFT (Main Frontal Thrust) in the South, which consist of vast pile of Neogene molasse deposited on the southern flank of Himalaya that is made up of fluvial cycles of mudstone, sandstone and conglomerate (Ulak, 2004). Lithologically, the study area consists of two members of siwalik group i.e. Lower Siwalik that consists of variegated mudstone, siltstone, fine grained sandstone and Middle Siwalik that consists salt-and-pepper sandstone and pebbly sandstone around-Brahmananda Khola (Adhikari et.al., 2018). The rock of siwalik zones are very weak and fragile with shallow and deep landslides very common during heavy and continuous rainfall, and the landslide in the busy road and agglomerate settlements are destroying the life and properties every year in rainy season (D Thapa, BP Bhandari, 2019). Such landslide prone area can be seen along the study area of this research. Since, the Barahakshetra-Dhankuta highway is proposed and under construction along this area, no slope stability research is carried out in this area. In order to fulfill this gap and to point out the potential slope failure along the road section, this research is conducted.

Aim

The aim of this research paper is to understand the slope stability condition and the quality of rock found in the area.

Objective

The main objectives of this research are as:

- a. To identify the orientation of planes of weakness.
- b. To understand the modes of failure.
- c. To know the quality of rock using RMR scale
- d. To identify the potential consequences such as landslides.

Research Questions

Four important research questions are assigned to this study, which are as:

- 1) What are the orientation of planes of weakness?
- 2) What are the major modes of failure?
- 3) What is the quality of rock found in the area?
- 4) What is the significance of the study in the specific area?

2. MATERIALS AND METHODS

The investigation used both primary and secondary data, including research papers, articles, journals, and books. Fieldwork over two days along the Chatara-Barahakshetra road involved studying exposed outcrops and slopes, measuring discontinuities with a Brunton compass, geological hammer, and other tools. Eight locations were analyzed, with dip amounts and directions measured, and an internal friction angle of 38° applied (Sujit, M., 2015). Kinematic analysis was conducted using methods from (Goodman, R.E., 1991) "Introduction to Rock Mechanics," and stereonet plots were digitized using Rick Allmendinger's application.

3. RESULT

Based on the field observations, the data obtained are tabulated as:

Table 1: Orientation of discontinuities and slope with respect to location along with potential failure modes determined through Kinematic analysis.

Location	Latitude	Longitude	Rock type	Bedding plane	Hill slope	J1	J2	Potential Failure
L1	26.839935	87.151214	Fine grained sandstone	$32^\circ/146^\circ$	$66^\circ/285^\circ$	$48^\circ/329^\circ$	$17^\circ/108^\circ$	No
L2	26.850700	87.152267	Fine grained sandstone	$43^\circ/62^\circ$	$50^\circ/226^\circ$	$50^\circ/261^\circ$	$82^\circ/150^\circ$	Wedge failure
L3	26.856770	87.152857	Salt and pepper sandstone	$27^\circ/10^\circ$	$72^\circ/319^\circ$	$74^\circ/278^\circ$	$63^\circ/167^\circ$	No
L4	26.861230	87.152980	Thick bedded medium grained sandstone	$28^\circ/40^\circ$	$54^\circ/237^\circ$	$48^\circ/111^\circ$	$37^\circ/228^\circ$	No
LS	26.869475	87.153864	Salt and pepper sandstone	$80^\circ/25^\circ$	$78^\circ/290^\circ$	$34^\circ/68^\circ$	$81^\circ/276^\circ$	Toppling failure along bedding, slope and J2
L6	26.870398	87.155147	Salt and pepper sandstone	$13^\circ/53^\circ$	$166^\circ/248^\circ$	$85^\circ/178^\circ$	$168^\circ/265^\circ$	No
L7	26.871683	87.160268	Salt and pepper sandstone	$15^\circ/117^\circ$	$74^\circ/30^\circ$	$70^\circ/28^\circ$	$66^\circ/284^\circ$	Plane failure along J1
LS	26.871897	87.161871	Pebbly sandstone	$128^\circ/105^\circ$	$181^\circ/320^\circ$	$163^\circ/20^\circ$	$158^\circ/248^\circ$	No

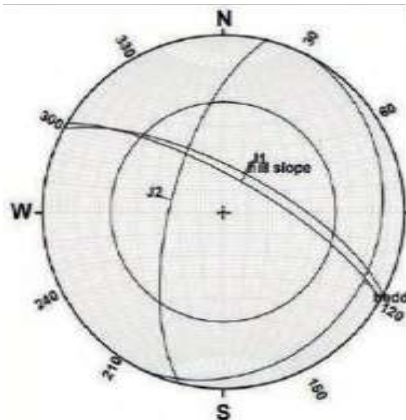


Figure 1: Kinematic analysis showing plane failure along J1 and hill slope

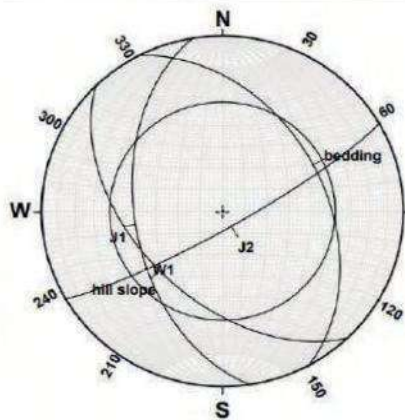


Figure 2: Kinematic analysis showing wedge failure along W1

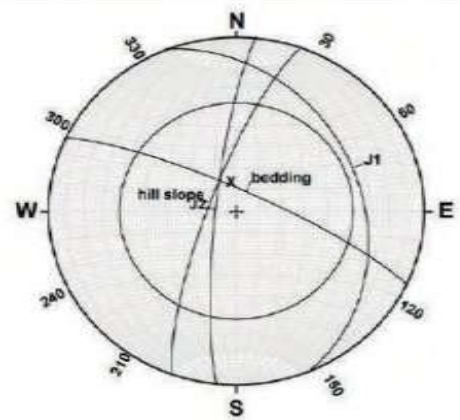


Figure 3: Kinematic analysis showing toppling failure along X

After kinematic analysis of three main sets of discontinuities i.e. (bedding plane, J1 and J2) and slope, we observed that all three modes of failure are possible in the area. Among the locations, L2 is potential for wedge failure, L7 is potential for plane failure and L8 is potential for toppling failure.

Similarly, Table 2 shows the rock mass rating and also the quality of rocks found in the studied area. Among the locations, under worst case scenario, 6 of them has fair rock quality while L1 has good rock quality and L9 has poor rock quality. The data obtained from rock mass rating (RMR) of the slopes are tabulated as:

Table 2: Value of RMR of each parameter obtained using Bieniawski's RMR table

Locations	Spacing	Aperture	Persistence	Roughness	Weathering	Infilling	Groundwater	RQD (115-3.3JV)	Intact rock strength	Total RMR	Rock quality
L1(J1/J2)	10/10	5/4	6/4	3/3	5/5	6/6	10/10	17	12	74/67	Good rock
L2(J1/J2)	10/8	5/5	2/2	3/3	5/5	2/2	10/10	13	12	62/60	Fair rock
L3(J1/J2)	8/8	5/4	6/1	3/3	3/3	2/2	10/10	8	12	57/51	Fair rock
L4(J1/J2)	8/8	5/5	4/2	5/5	5/3	2/2	10/10	13	12	64/58	Fair rock
L5(J1/J2)	10/8	6/5	4/6	3/3	3/3	2/2	10/10	5	7	50/49	Fair rock
L6(J1/J2)	8/8	1/2	4/4	3/3	1/3	0/2	4/7	5	7	33/41	Poor rock
L7(J1/J2)	10/8	5/5	6/4	3/5	5/3	2/2	7/7	5	12	55/51	Fair rock
L8(J1/J2)	15/15	5/4	2/2	1/1	1/1	2/2	10/10	13	7	56/55	Fair rock

4. DISCUSSION

From the above result, three major modes of failure i.e. plane failure, wedge failure and toppling failure are possible in the area. Frequent landslides and slope failure around the study area also points towards the presence of unstable ground condition. Moreover, the cause of those landslides can be improper drainage, river incision and mainly the slope stability condition, also discussed by (Gyawali, P. and Tamrakar, N.K., 2018) in similar

lithology (siwalik) which validates the above mentioned findings. Apart from joint set orientations, the rock mass rating also shows the dominance of fair quality rock in the area in which the external force can act easily which can trigger the failure.

5. CONCLUSION

The study aims to assess the stability of rock slopes and quality of rocks found in the slopes. After the observation it can be concluded as, L2 of study area has potential for wedge failure, L5 has potential for toppling failure and L7 has potential for plane failure. Similarly, out of 8 locations observed, in worst case scenario, 6 locations have fair rock quality, 1 location have good rock quality and a location has poor rock quality. The data obtained supports the environmental conditions around the study area as there are numerous slope failure and landslides in the area. It is important to emphasize that these findings are section specific and shouldn't be considered as the finding of whole Siwalik group. This article serves as an aid for the authority that is responsible for construction of highway along the studied road section. The article further urges for thorough examination of geological characteristics during construction.

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A Case Study on Tube Well Inventory of Madiphant Area, Palpa, Nepal

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Abstract: Madiphant is located in Palpa district, with a great potential for groundwater. The groundwater is accessible through shallow tube wells, which has resulted in the fulfillment of irrigational needs, household requirements of locals, eventually uplifting standards of living in the area. This review paper is a case study of the area, resembling the inventory of the shallow tube wells in the residents as well as estimating the recharge and discharge of the study area.

Keywords: Tube well, Shallow Tube well, Static water level

1. BACKGROUND

Madiphant is a small intermontane valley located in mid-hills of Palpa district with an elevation ranging from 2245 to 2260 feet amsl (DOI, 2073). Madiphant is a tectonic valley as it was formed due to the tectonic processes of Mahabharat range. Madiphant is accessible through Siddhartha Highway (Butwal-Pokhara). The valley is composed of thick layers of alluvium, which consist of sand-gravel and clay. The feasibility of shallow tube wells is limited to alluvial deposits that are sufficiently thick and permeable to support groundwater flow. These deposits are capable of providing sufficient yield through tube wells, with discharge rates as low as five liters per second making the study area abundant in groundwater potential. The water level in the region is found to be at a level that is suitable for using surface mounted pumps. A few of the wells even have water flowing freely because the water level is higher than the ground surface. The formation of the area is the result of accumulation from Tinau River and its tributaries. The irrigation area is relatively flat with slight undulations and becomes increasingly level toward the riverbed.

The Study area belongs to the Heklang Formation of Lesser Himalaya of West Central Nepal, comprising of highly weathered Phyllite, pale yellow in color. The Himalayan range is considered as one of the most recently formed mountain ranges globally, primarily composed of elevated sedimentary and metamorphic rocks.

Aim

This paper aims to provide a compiled study of tube wells in Madiphant area, their inventory, present condition, and their impact on the socio-economic status of people.

Objective

The objective of this study is to outline the groundwater potential of Madiphant area through shallow tube wells installed in the area and its benefits to local lives.

Research Questions

The three potential research questions of the research paper can be as follows;

- 1) What is the main purpose to install shallow tube wells in the area?
- 2) Why are shallow tube wells preferred over other Tube well in this region?
- 3) How has the utilization of shallow tube wells impacted on agricultural aspect of the region?

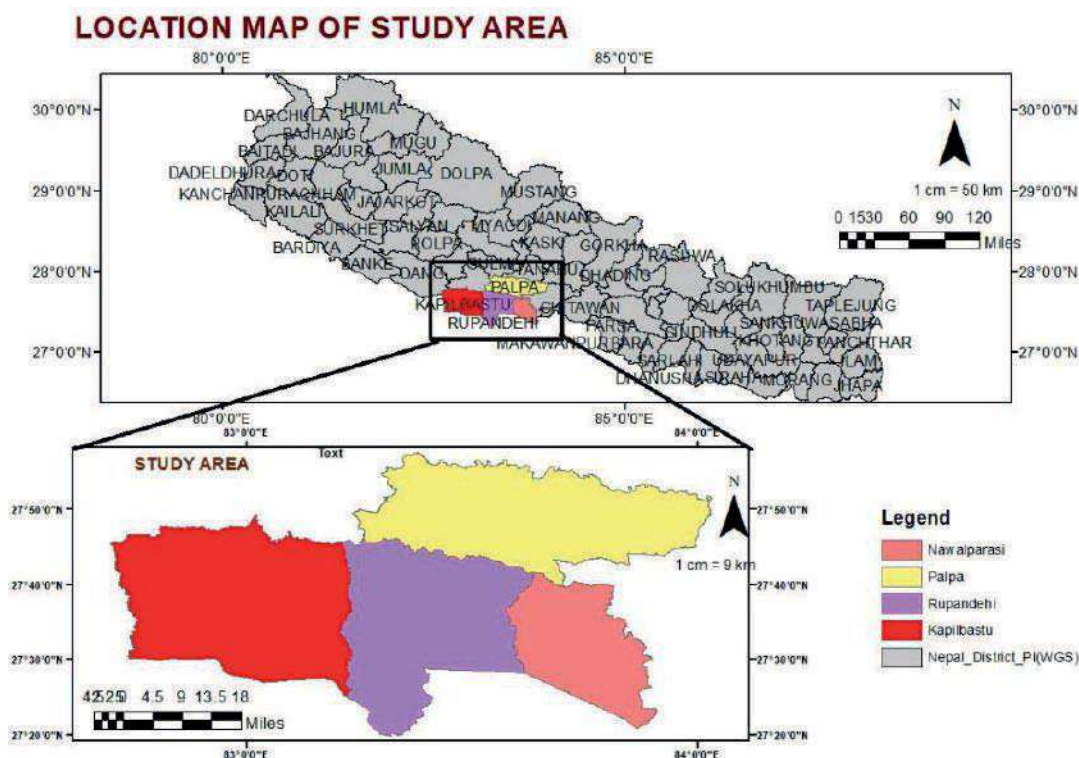


Figure 1: Location map of study area

2. MATERIALS AND METHODS

This study was carried out in two phases; Desk Study and Field survey. The desk study was carried out utilizing journals, reports, articles, research papers, geological, hydrogeological map, topographical map, google map. Both primary and secondary data was incorporated for the study. The primary data was obtained through the field work to Palpa during one day individual field work of hydrogeology i.e. investigation of tube well inventory in Madiphant area. Meanwhile, the secondary data was obtained by the help of impact study of shallow tube well irrigation project conducted by Department of Irrigation.

The methodology applied in individual field work of hydrogeology to Madiphant on tube well inventory was; Questionnaire survey, filling standard Inventory form, Water sample survey, estimation of discharge measurement, static water level, pumping water level and discussion with the local people.

3. RESULTS

Based on the field survey and after (DOI,2073) following data has been obtained.

Tube well inventory data

The discharge estimation is calculated as follows;

Average Discharge of tube well= 4L/sec

Number tube wells in the area= 20, Pumping days=275 days, pumping hours=5 hr/day

Table 1: Tube Well Inventory Data

S.N.	Location	Village	Land owners Name	Depth (ft)	Screen length (ft)	Coordinate		SWL (m)	Discharge (1/sec)
						Latitude	Longitude		
1	Tintiyaan	Madanpokhara-6	Sita Giri	64ft	7	30.79172	45.7344	Free flowing	6
2	Tintiyaan	Madanpokhara-7	Rupa Thapa	73	7	27.82979	83.56606	4.2	3-4
3	Tintiyaan	Madanpokhara-7	Mohan Sapkota	43	7	27.8291	83.5702	1.37	2-4
4	Tintiyaan	Durgamandir	Krishna Kumari Pandey	73	7	27.82785	83.57339	2.44	3-5
5	Tintiyaan	Durgamandir	Lekh Nath Bhandari	73	3	27.83003	83.57691	0.45	2-3
6	Tintiyaan	Durgamandir	Top Lal Bhattarai	73	7	27.83129	83.56559		
7	Tintiyaan	Namunabasti	Tej Kumari Bashyal	38	7	27.82937	83.57845	1.19	3-5
8	Tintiyaan	Namunabasti	Lok Nath Ghimire	33	4	27.82932	83.57921	1.7	2-4
9	Gharital	Namunabasti	Kamal Pathak	57	5	27.82357	83.58061	1.57	3-4
10	Gharital	Namunabasti	Karna Bahadur Nepali	45	3	27.82473	83.5819	1.65	2-4
11	Gharital	Namunabasti	Ghan Prasad Ghimire	53	7	27.82675	83.5817	1.95	2-4
12	Gharital	Namunabasti	Ishara Khanal	53	3	27.82955	83.5741	1.4	3-5
13	Gharital	Namunabasti	Shyam Bashyal	50	6	27.82216	83.57745	1.5	
14	Gharital	Namunabasti	Parbati Gaire	53	3	27.82429	83.57658	1.5	2-4
15	Gharital	Namunabasti	Khada Nanda Basyal	53	8	27.82548	83.57671	1.17	3-5
16	Gharital	Namunabasti	Hema Kanauje	43	3	27.82658	83.5758	1.3	
17	Gharital	Namunabasti	Tej Bahadur Thapa	100	5	27.83047	83.57597	0.6	4-6
18	Gharital	Namunabasti	UmaRana	89	3	27.82605	83.57877	0.6	1-2
19	Gharital	Namunabasti	Nim Bahadur Shrestha	53	4	27.8254	83.57797	2.12	4-6
20	Gharital	Namunabasti	Pushpa Shrestha	53	4	27.81939	83.57739	2.5	3-5

The discharge estimation is calculated as follows;

Average Discharge of tube well= 4L/sec

Number tube wells in the area= 20, Pumping days=275 days, pumping hours=5 hr./day

On assumption that the tube well runs every 5 hrs. per day, in whole year annual discharge is calculated as;

Discharge per day= $4 \times 20 \times 5 \times 275$

= 110000 x 60 x 60 l/day

= 396000000 liters/day

= 396000 MCM

So, the discharge per year= 396000×365

= 134685000 m³/ year

The estimated discharge per year is 134685000 m³/ year

The recharge estimation in the Madiphant area is calculated as follows;

Area=15160000m²

Infiltration rate=18.8%

Average Rainfall=1.6mm per year

$$\begin{aligned} \text{Estimation of Recharge in the area} &= \text{Area} \times \text{infiltration \%} \times \text{Average Rainfall} \\ &= 15160000 \times 0.188 \times 1.6 \\ &= 4560128 \text{ m}^3 \text{ per year} \end{aligned}$$

4. DISCUSSION

As mentioned above the data collected from the study area has been discussed by DOI (2073) in Impact study of Shallow tube wells of Madiphant are by Ministry of Irrigation. The discharge of the shallow tube wells in the area majorly ranges from 3 to 5 l/sec which is also mentioned in the final report of DOI (2073). The recharge discharge relation in the study area from the above calculation shows that discharge is more in the area than recharge. Madiphant is found to be favorable for groundwater due to its geology and lithological significance. The static water level ranges from freely flowing to 2.5 on an average making the study area abundant in groundwater resource and within suction limit of centrifugal pump.

5. CONCLUSION

The shallow tube wells implanted have aided in the socio-economic aspect of people in the area. Most of the locals have been self-sufficient in irrigation and agricultural practices. Few of the shallow tube wells in the area are facing issues of well interference, multiple interference and iron contamination which has resulted in the loss of sum and efforts of some families. The cause for these problems is probably the lack of skilled manpower, professional techniques and knowledge regarding geology/water resources, while installing of Tube wells. Overall, the agricultural and farming practices flourished in the area through these shallow tube wells have created a fruitful opportunity for self-employment and generation of income among locals.

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IMPACT OF CLIMATE CHANGE ON KATHMANDU VALLEY

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Abstract: The article discusses the impact of climate change on the weather pattern in Kathmandu Valley. The impact of climate change on the valley is multifaceted, leading to changes in temperature, rainfall patterns, and geological activity. These changes, in turn, result in various natural disasters such as landslides, floods, soil erosion, and drought.

The research relies on secondary data to understand the impact of climate change. The findings highlight the importance of understanding more frequent and severe extreme weather events. Humans play a vital role in climate change, and it is essential to recognize the consequences of their actions.

The increased change in climate patterns has resulted in significant reductions in agricultural production, leading to food insecurity and strained water resources. Additionally, the loss of forests and biodiversity, as well as damaged infrastructure, is also major concerns. Overall, the article concludes that climate change has a profound impact on the environment and human societies, emphasizing the need to mitigate its effects.

Keywords: *Weather pattern, geological activity, climate change*

I.BACKGROUND

Climate change refers to the shifting of the mean meteorological indices of rainfall and temperature across a longer time span (Sharma, et al., 2022). Climate change will have some serious impact on biodiversity as well as ecosystem, but the impact will be far greater on the already overstretched natural habitat of Nepal. The rapidly retreating glaciers, rapid rise in temperature, erratic rainfalls and increase in frequency of extreme events such as floods and drought like situation are some of the effect Nepal is facing during last few years (Karki et al.,2010).

Kathmandu valley is settled at an elevation of about 1400 meter and encircled by four major mountains: Shivapuri, Phulchoki, Nagarjun, Chandragiri. Climate change deeply impacts the environment and the ecosystems sustaining them, bringing many challenges such as floods, droughts, and landslides which can destruct roads, homes, and other infrastructure. Some of the most vital challenges comprise changes in temperature and increases in rainfall. The phenomena associated with the climate change like unpredictable and irregular precipitations as well as increase in global temperature have enhanced the risk of geological hazards (Dhakal, 2013). According to Kathmandu Post, the most affected area is squatter area like Dhobikhola bank by flooding due to extreme rainfall and unmanaged system.(Pokharel, (August 15, 2014) 'Sleepless in Kathmandu's slums' Kathmandu Post). This research gap necessitates further exploration and investigation to obtain a comprehensive understanding of the climate change and its impact.

Aim

The main aim of the research paper is to understand the climate change in Kathmandu valley and its causes, impact along with their control measures.

Objectives

The specific objectives of article are:

1. To Identify the cause and factor contributing to the climate change.
2. To identify the impact of climate change

Research questions

1. What is the geological factor contributing to the climate change?
2. What is the impact of climate change?

2. MATERIALS AND METHODS

The information for the article was collected mostly using secondary sources such as textbooks, scientific journals, past articles, published and unpublished reports, and available literature on websites.

3. RESULTS

The given graph (figure 1 & figure 2) shows the difference on the temperature and rainfall on the Kathmandu valley over time. Figure 1 shows the increasing temperature every year which exert influence on people's daily activities and agriculture too. The whole ecosystem can be harmed by the extreme temperature rise. Extreme precipitation can also cause landslides, and floods which can cause waterborne diseases as well as damage infrastructures, roads etc. On current situation, Kathmandu is experiencing severe rainfall, resulting in significant flooding. Loss of property and loss of human lives as well as stray animals are the major effect of flood due to heavy rainfall. In context of climate change it is important to highlight the easy-going measures. Which includes managed drainage system, afforestation as well as early warning system. Executing modifications to infrastructure and enhancing emergency readiness to mitigate these effects and guarantee the safety of the impacted regions.



Figure 1: Monthly variation of mean temperature during 2011-2017(A. Thapa et al.2021)

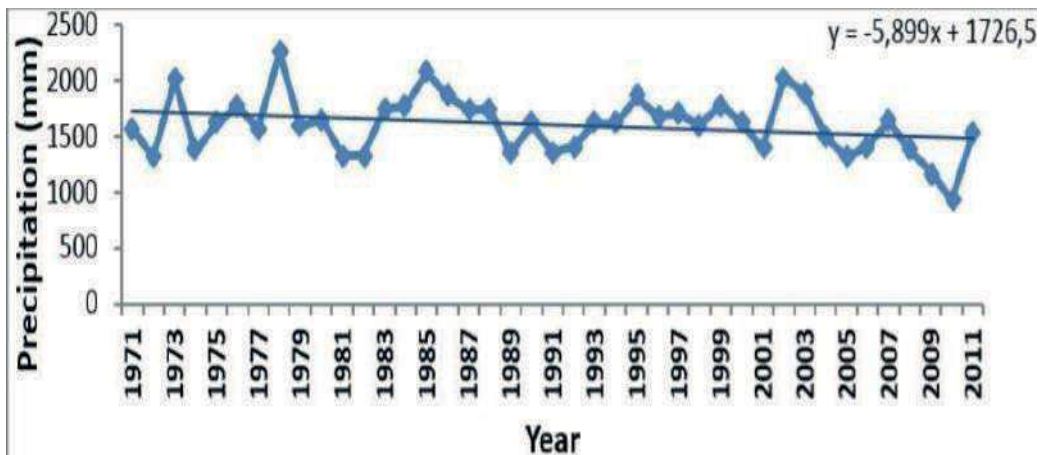


Figure 2: Trend in rainfall in the Kathmandu valley during 1971-2011 (Journal of Natural resources and Development 2017).

4. DISCUSSION

Analysing the impact of climate change on geological hazards like landslides, erosion, floods, and temperature is essential for understanding and addressing these challenges. The findings of our study are consistent with previous research, which suggests that the Kathmandu Valley is experiencing a rapid increase in temperature, with an average rise of 0.06°C per year (Khanal, 2017). This trend is likely to continue, with projections indicating that the valley will warm by 1.5°C to 2°C by 2050 (Shrestha et al., 2012). Implementing measures such as land-use planning, slope stabilization, erosion control, and flood management can help mitigate the risks associated with these geological hazards. The above two figure shows the different pattern of temperature and rainfall figure 1 and figure 2 respectively. Temperature rise can cause the melting of glacier which invite the other natural calamities. On the other hand, the change in rainfall pattern can cause flooding, landslides and soil erosion as well. The flooding has made the many human settlement to red alert area and interrupted the transportation as well as communication. Finally, to prevent such disasters from reoccurring in the future, those measures must be taken as a matter of great importance. Some of the prevention strategies which should involve right land use planning, vegetation planting including community awareness and education.

5. CONCLUSION

The research focuses on understanding the impact of climate change on livelihood and ecosystem and developing the effective measures. This research finds out the impact of climate change which is clearly seen on the bank of Dhobikhola. Improper drainage management in that area resulted in residents experiencing flooding within their homes during the rainy season. To mitigate the occurrence and impact of climate change several strategies are highly recommended.

Mitigation measures such as:-

- building the flood defenses,
- early warning system to reduce the loss due to flooding,
- planning for heat waves,
- install better draining pavement to deal with flood.

To reduce the risks posed by climate change this article suggests that more research and monitoring efforts are needed by concerned authorities and government.

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Cause and Effects of Earthquake in Nepal

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Abstract: This article reviews the historical records of earthquakes in Nepal, primarily through desk study. The article explores how plate tectonics and the presence of fault lines cause earthquakes in Nepal. Situated in a seismically active zone where the Indian and Eurasian tectonic plates converge, Nepal has a long history of earthquakes. This tectonic collision generates significant pressure and strain, leading to periodic energy releases as earthquakes. The country's challenging terrain and numerous major fault lines further contribute to its seismic activity. Earthquakes have profoundly affected Nepal, impacting its infrastructure, economy, and most importantly, its people. This article chronologically examines the immediate and long-term effects of these significant earthquakes, their causes, and their overall societal effects, drawing on historical records, geological evidence, and scientific research. This study provides a comprehensive overview of the earthquake's impact and offers recommendations for improving resilience and preparedness in the face of future seismic events.

Keywords: *Earthquake, Indian and Eurasian plates, Fault lines*

1. BACKGROUND

An earthquake is a natural phenomenon characterized by the sudden and rapid shaking of the Earth's surface, resulting from the release of energy stored in the Earth's crust. This energy release is often due to the movement and interaction of tectonic plates, which are large segments of the Earth's lithosphere, volcanic eruptions, or man-made explosions. When these plates move, they become stuck at their edges due to friction. Over time, stress builds up in the rocks until the strain exceeds the frictional force, causing the plates to suddenly shift and release energy in the form of seismic waves. These seismic waves propagate outward from the hypocenter, which is the point within the Earth where the earthquake originates. Nepal is vulnerable to quakes due to its location as Nepal is located at the boundary of two massive tectonic plates the Indo-Australian and the Asian Plates. It is the collision of these plates that has produced the Himalaya Mountains, with them earthquakes (Sharma, 2022). Earthquakes in Nepal have wide-ranging and severe impacts on the environment and human society, including structural damage, human casualties, landslides, avalanches, economic impact, destruction of cultural heritage, and physiological and mental health effects (Earle, 2022). Despite prior studies, there are research gaps in understanding the specific causes and nuanced effects of seismic events. This article aims to address these gaps by providing a detailed analysis of geological mechanisms driving earthquakes in Nepal and examining their multifaceted impact on society and the environment.

Aim

This article aims to investigate the underlying causes of frequent earthquakes in Nepal, assess their impact on the environment and communities, and evaluate the resulting effects on the country's economy

Objectives

1. To investigate how the movement of Earth's plates triggers shaking and its resulting consequences.
2. To analyze geological causes, environmental impact, and socio-economic effects.

Research Questions

The article tends to address the following research questions:

1. What are the primary geological and tectonic factors contributing to the frequency and intensity of earthquakes in Nepal?
2. How do earthquakes impact the socioeconomic landscape and psychological effects on the people of Nepal?

2. MATERIALS AND METHODS

Every piece of information and data required for this article was gathered from secondary sources, such as journals, articles, and web pages about earthquakes in Nepal.

3. RESULTS

Nepal is one of the most earthquake-prone countries in the world, ranking 11th out of 200 countries. According to historical records, there have been 18 major earthquakes in Nepal between 1310 BS and 2072 BS (762 years). The earthquake that occurred on Baisakh 12¹\ 2072 B.S. is one of the most devastating natural disasters in the history of Nepal. According to historical records, the earthquake that occurred in 1310 B.S. (1255 A.D) caused significant damage in Kathmandu Valley. This earthquake resulted in the loss of around one-third of the population of Kathmandu Valley and the king of Bhaktapur district Abhaya Malla also died . Aftershocks were felt for 15 days, and the severity of the quake left fresh wounds that lingered for months. In 1934 AD between 10700 and 12000 people were killed and caused massive destruction similarly, in 2015 A.D around 8,000 people were killed and widespread destruction occurred in the surrounding areas (Sharma, 2022).

Causes of Earthquakes in Nepal

Nepal is situated in one of the world's most seismically active regions due to its location at the boundary between the Indian Plate and the Eurasian Plate. The primary cause of earthquakes is the intense tectonic activity resulting from the ongoing collision and convergence of these two massive plates. As the Indian Plate pushes northward into the Eurasian Plate, it causes significant stress to build up along fault lines, particularly the Main Himalayan Thrust (MHT), where the Indian Plate is subducting beneath the Eurasian Plate. This immense pressure is eventually released in the form of earthquakes. Additionally, the complex network of fault lines, including the Himalayan Frontal Thrust (HFT) and Secondary Himalayan Thrust (SHT), further contributes to seismic activity by accommodating the stress in Earth's crust. The region's dramatic topography, characterized by towering mountain ranges and deep valleys, exacerbates the seismic risks. While human activities such as construction and land use do impact ground stability, they play a relatively minor role compared to the natural tectonic processes driving the frequent and powerful earthquakes experienced in Nepal. Understanding these cases is crucial for improving earthquake preparedness and mitigating the risks associated with seismic events in this vulnerable region. The major earthquakes and their effects that occurred in Nepal are described in Table 1.

Table 1: The major earthquakes and its effects that occurred in Nepal

S	Year	Richter Scale	Effects of Earthquake
1	1255 AD	7.8	It was a multifaceted disaster with extensive financial, environmental, and mental health impacts. The financial strain from rebuilding and loss of livelihoods would have been immense, compounded by environmental damage that disrupted agriculture and water systems. Meanwhile, the mental health impact, though not understood in modern terms, would have manifested in widespread trauma, grief, and anxiety, affecting the social fabric of the Kathmandu valley for generation.
2	1934 AD	8.4	It is also known as Bihar- Nepal Earthquake caused widespread economic devastation in Nepal. The agricultural sector was also severely affected as farmlands were damaged and many livestock perished. The ecologic balance was disrupted and environmental damage also had long term effect on agricultural as fertile land lost or degraded, impacting food production in the years following the disaster. The lack of mental health services at the time meant that people had to cope with their trauma is isolation, which may have led to long- lasting mental health issues, including post- traumatic stress disorder.
3	2015 AD	7.8	The impacts of earthquakes on Nepal is profound and widespread. Human casualties are often the most heart wrenching outcomes, as seen in 2015 Gorkha earthquake, which claimed nearly 8000 lives and dealt a financial blow of at least \$6 billion to the country's economy (Sharma, 2022). The destruction of infrastructure further compounds the tragedy, with homes, schools, and hospitals reduced to rubble. This is not only causes immediate suffering but also disrupts economics activities, leading to a long-term financial burden on the nation. Additionally, environmental consequences, such as landslides and changes in river courses, can have lasting effects on agriculture and habitation. Approximately 89% of survivors had their homes either damaged or destroyed, and 69% experienced injury or the loss of close relatives in the 2015 earthquake. The psychological tool for survivors, who must cope with the trauma of loss and the fear of aftershocks, cannot be overlooked.

4. DISCUSSION

Nepal is highly susceptible to earthquakes primarily due to its geographical location and geological characteristics. The country's topography, characterized by rugged terrain, steep slopes, and fragile geological formations, exacerbates its vulnerability, often amplifying the effects of earthquakes and leading to greater damage and casualties. The rapid urbanization in Nepal, often without the implementation of earthquake-resistant building techniques, further

increases this vulnerability. Coupled with this are limited disaster awareness and education, and a weak disaster response capacity (Morland, 2015). To mitigate earthquake impacts, Nepal has undertaken plans to implement as follows:

- A. Strengthening building codes and construction practices
- B. Public awareness and education
- C. Improving early warning system
- D. Disaster risk reduction and management plans
- E. International collaboration and support
- F. Urban planning and land use management
- G. Emergency preparedness and response planning
- H. International aid and rehabilitation programs etc.

5. CONCLUSION

This research aims to analyze Nepal's vulnerability to earthquakes stems from a combination of its geographic location, topographical features, and rapid urbanization without adequate consideration for earthquake-resistant construction. The rugged terrain and fragile geological formations intensify the impact of seismic events, resulting in significant damage and loss of life. The situation is further aggravated by insufficient disaster awareness, outdated response frameworks, and inadequate health emergency preparedness. However, Nepal is making strides toward mitigating these risks through initiatives aimed at improving infrastructure, adopting earthquake-resistant building practices, and enhancing disaster response capabilities. Continued efforts in education, policy updates, and community engagement are essential for building resilience against future earthquakes, ultimately reducing their devastating effects on the nation.

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Geological Fieldwork: The Real Way To Learn Geology

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Abstract: This article presents the necessity of the geological field in geology. Fieldwork, in geology plays a role in enhancing our understanding of Earth's systems. Geological fieldwork is a cornerstone of geology, yet its significance can be overshadowed by classroom learning. This article delves into the significance of hands-on fieldwork in education and research emphasizing how direct observation in environments deepens our grasp of geological processes and argues that venturing into the field is not just about data collection; it's a transformative learning experience. By outlining the aims, approaches and results of fieldwork this study underscores its contribution to the field of earth sciences. Through life examples and case studies, we demonstrate how fieldwork effectively bridges the gap between theory and practical knowledge presenting it as the pathway, to mastering geology. Fieldwork fosters a deeper understanding of geological concepts, hones essential skills like critical thinking and problem-solving, and ignites a passion for unraveling Earth's history. This article highlights the documented benefits of fieldwork through existing research and emphasizes its enduring value in shaping future generations of geologists.

Keywords: *Academic journal, Geological fieldwork, Problem-solving, Critical thinking.*

1. BACKGROUND

Introduction:

Geology is a fascinating subject. It is best learned at fieldwork in addition to studying books and journals. Geological fieldwork forms the backbone of Geology, providing crucial insights and offering a direct hands-on approach to understanding the Earth's structure, history, and processes. Fieldwork will normally be carried out once or twice per year during graduate degrees for geology from a single day to over weeks at a time. Fieldwork involves direct observation and collection of geological samples from natural environments, enabling geologists to analyze rock formations, soil composition, and mineral deposits. By examining these rocks, minerals, fossils and landscape in their natural environments, geologists piece together the puzzles of earth's history deciphering ancient climates, tectonic movements, and evolutionary patterns. From the rugged terrains of mountain ranges to the vast expanses of desert landscapes, fieldwork enables geologists to observe geological features and interpret geological history, deposition environment and phenomena directly. Field sites are ideal for observing different types of landforms, minerals, rocks and geological structures like faults, folds, joints and unconformities. Unlike laboratory-based research, fieldwork involves observing and collecting data from natural settings such as from river beds, rock beds, etc. This practice extends beyond mere observation; it involves rigorous mapping, sampling, and analysis to interpret the physical, chemical, and biological processes that have shaped the Earth over millions of years.

Geological fieldwork's presents several scientific and practical applications. For example, Fieldwork studies helps in the sustainable exploration and extraction of natural resources such as minerals, oil, and gas from earth's crust which are essential for economic development and determining earthquake hazards and influencing construction norms m

seismically active places need an understanding of fault zones and rock formations. Field studies moreover play a vital role in environmental conservation and management. By geological mapping soil and rock, geologists help to predict and mitigate the impacts of natural hazards like landslides and floods which are very essential in the context of our country. Additionally, field observations are essential for reconstructing past climatic conditions, contributing to our understanding of climate change and its effects on the planet.

The main points of this article are to emphasize geological fieldwork in geology as the backbone of learning geology & demonstrate the importance of geological fieldwork beyond academics.

The objectives of the article outline the specific aspects that need to be covered to achieve the overall aim, which can be pointed out as;

- Highlight the Significance of Fieldwork
- Demonstrate Benefits of Fieldwork

2. MATERIALS AND METHODS

This article explores the significance of geological fieldwork as a fundamental learning tool in geology. Here's a breakdown of the materials and methods used in writing it:

- Scientific Literature: Research papers on the effectiveness of fieldwork in geoscience education. Examples include "Geological Fieldwork: A study carried out with Portuguese secondary school students".
- Online Resources: Websites of geological organizations or educational institutions that promote the value of fieldwork such as Geological Society of America.

By combining these materials and methods, the article can effectively illustrate how geological fieldwork is the "real way to learn geology." It can showcase how fieldwork transforms theoretical knowledge into a tangible and engaging learning experience.

3. RESULTS

This article argued that geological fieldwork is the foundation of a true way to learn geology and as a fundamental learning tool in the field acting bridging the gap between theory and practical. Aspiring geologists learn more about the features and processes of the Earth by going outside the classroom and into the natural world. Here's a summary of the key takeaways:

Theory and Practice Collide: The theoretical ideas found in textbooks and their real-world implementations are connected through fieldwork. Fieldwork bridges the gap between theoretical concepts learned in textbooks and their practical application in the real world. Students can observe the rock formations, fossils, and structures they have only seen in books, photographs and figures.

Developing knowledge and Skills: Fieldwork helps geologists to develop essential skills for critical thinking, problem-solving, data gathering, and observational abilities of the real world. Students actively participate in the learning process, taking measurements, collecting samples, and creating maps, which solidify their understanding.

Hands-on Learning: The interactive nature of fieldwork fosters a deeper engagement with the subject matter. By taking measurements, gathering samples, and making maps, students actively engage in the learning process and strengthen their comprehension.

Career Preparation: The fieldwork concerns the practical outcome of preparing students to progress further in geology, either to graduate education or to geology careers.

Enhanced Comprehension of Geological Concepts: The results of this study, aligned with the standards and findings of the Geological Society of America (GSA), underscore the critical importance of geological fieldwork in enhancing educational outcomes and practical skills.

Table 1 demonstrates the significant improvement in students' understanding of key geological concepts before and after participating in fieldwork activities, consistent with the GSA's emphasis on experiential learning.

Concept	Pre-Fieldwork	Post-Fieldwork
Rock Identification	62	90
Geological mapping	68	89
Structural Geology	65	87
Mineral Identification	70	88

Visualizing the Impact: A Photographic look



Figure 1 A group of students are examining a rock outcrop in the field. Some students are kneeling and closely inspecting the rock, while others are taking notes and discussing their observations.

This photograph depicts a group of students actively engaged in geological fieldwork. By directly interacting with the rock outcrop, they are likely:

- Observing features like rock textures, mineral composition, and layering.
- Collecting data such as measurements, sketches, and photographs.
- Formulating hypotheses about the rock's origin and formation processes.

Overall, geological fieldwork is not just a learning method; it's an immersive experience that brings geology to life. It fosters a sense of discovery and ignites a passion for understanding the Earth's story. This hands-on experience allows them to connect classroom knowledge with real-world observations, fostering a deeper understanding of geological concepts.

4. DISCUSSION

The results of this study emphasize that the essence of geological fieldwork in both educational and practical contexts, aligning with the standards and findings of the Geological Society of America (GSA). Here, we discuss the implications of these results and their broader significance. Our findings resonate with existing research on the topic.

Several studies have documented the positive impact of fieldwork on student learning. For instance, (Esteves et al., 2020) highlights how fieldwork enhances students' understanding of geological concepts and improves their ability to analyze and interpret data. Similarly, Genge in 2020 emphasizes the role of fieldwork in developing critical thinking and problem-solving skills in geoscience education. While our work aligns with these existing findings, it doesn't

present quantitative data on student learning outcomes. Future Several studies emerging from our qualitative analysis are consistent with those identified from previous research into the value of field education (Pyle, 2009; Stokes and Boyle, 2009;) indicating, why field education is valuable, study participants valued undergraduate geology fieldwork for its perceived effectiveness in developing knowledge and skills (cognitive and practical) through direct engagement with geologic phenomena. Our emphasis on the "real-world" aspect of fieldwork aligns with the growing recognition of the importance of experiential learning in education. Fieldwork provides a unique opportunity for students to connect classroom theory with the complexities of the natural world, fostering a deeper engagement with the subject matter. This article doesn't claim to explore novel territory; rather, it aims to emphasize the enduring value of fieldwork in clear and concise manner. By highlighting the documented benefits of fieldwork through existing research and relatable examples, this article can serve as a valuable resource for educators and students alike.

5. CONCLUSION

In conclusion, the findings of this study reinforce the importance of geological fieldwork as a cornerstone of geological education and practice. Fieldwork enhances comprehension, develops practical skills, validates theoretical knowledge, integrates advanced technologies, and contributes to resource management and environmental protection. Our findings demonstrate that fieldwork is not just a data collection exercise; it's an immersive learning experience that bridges the gap between theory and practice. Geological fieldwork isn't just about acquiring data; it's a transformative learning experience. By venturing into the field, students bridge the gap between theory and practice, develop essential skills, and gain a profound appreciation for the Earth's dynamic history. Through firsthand observation and hands-on activities, students gain a deeper understanding of geological concepts, develop essential skills, and cultivate a passion for Earth science. Our discussion highlighted the alignment of these findings with existing research on the positive impact of fieldwork in geology. The emphasis on the "real-world" aspect of fieldwork underscores its value in fostering experiential learning, a crucial aspect of effective education. While future research could delve deeper into quantitative data on student learning outcomes, this article serves as a clear and concise reminder of the enduring importance of geological fieldwork in shaping future generations of geologists.

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The Fascinating world beneath our feet: Exploring the role of soil microorganisms in Geology

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Abstract: This article examines the vital role of soil microorganisms, including bacteria, fungi, archaea, and protozoa, in geological processes. Categorized into autochthonous and allochthonous groups, these microorganisms are crucial for soil formation, nutrient cycling, and mineral weathering. They facilitate biogeochemical cycles, making essential elements available to plants. Their functions are key to soil health, agriculture, and climate change mitigation. The review covers case studies on mycorrhizal fungi's impact on crop yields, bacterial bioremediation of contaminated soils, and microorganisms' role in carbon sequestration, highlighting the need for further research to improve environmental management.

Keywords: *Soil microorganisms, nutrient cycling, mineral weathering, biogeochemical cycles, carbon sequestration*

1. BACKGROUND

The ground beneath our feet swarms with life, housing a complex network of microorganisms that play vital role in shaping our world. Soil microorganisms are divided according to the nature of their presence in the soil into two groups by the Russian scientist Winogradsky, which are: Autochthonous and Allochthonous microorganisms (Jassim et al. 2023). Soil microorganisms like bacteria, fungi, archaea, and protozoa are some of them which are essential to the earth's ecosystem. They play key roles in geological processes, such as soil formation, nutrient cycling, and mineral weathering. These microorganisms are vital for breaking down rocks into soil. Beyond their role in soil formation, microorganisms are central to various biogeochemical cycle. They drive the cycling of key elements such as nitrogen, carbon, phosphorus, and sulfur, transforming these elements into forms that can be utilized by plants and other organisms. They produce acids and enzymes that dissolve minerals, releasing important nutrients. Studying these microorganisms helps us understand how they maintain soil health, support plant growth, and affect global nutrient cycles. Understanding the functions of soil microorganisms is critical for addressing numerous environmental challenges. Their activities influence soil health, agricultural productivity, and the global climate. As soil microorganisms are involved in the sequestration of carbon, which can help mitigate the impacts of climate change. Additionally, they play a role in the bioremediation of contaminated soils, breaking down pollutants and restoring soil health. The study of soil microorganisms in geology not only enhances our understanding of these fundamental processes but also provides insights into suitable land management practices. By harnessing the power of these microorganisms, the soil fertility, crop yields boost, and developing strategies to combat environmental issues can be improved. Research question "How do soil microorganisms influence soil formation, nutrient cycling, and carbon sequestration, and what implications do these processes have?"

Aim: The aim of this article is to summarize the role of soil microorganisms in geology.

Objectives

To investigate and summarize the role of soil microorganisms, including bacteria, fungi, archaea, and protozoa, in geological processes such as soil formation, nutrient cycling, and carbon sequestration.

2. MATERIALS AND METHODS

This review is based on an extensive survey of scientific literature, including peer-reviewed journals, books, and authoritative online resources. Database such as PubMed, Google Scholar, and JSTOR were utilized to gather relevant studies on soil microorganisms and their geological roles. The collected data were analyzed to identify common themes, significant findings, and gaps in the existing research.

3. RESULTS

- **Soil Formation and Mineral Weathering:** Soil microorganisms contribute to soil formation through biological weathering. Fungi and bacteria produce organic acids that dissolve minerals, aiding in the breakdown of rocks into smaller particles. Microorganisms such as iron-oxidizing bacteria and sulfate-reducing bacteria facilitate mineral transformation by precipitating minerals like iron oxides, gypsum, and pyrite.
- **Biogeochemical Cycles:** Soil microorganisms play a crucial role in facilitating biogeochemical cycles, such as the nitrogen, carbon, phosphorus, and sulfur cycles. They produce acids and enzymes that transform essential elements into bioavailable forms, supporting plant growth and maintaining ecosystem health.
- **Impact on Agriculture:** Case studies reveal that microorganisms like mycorrhizal fungi significantly improve agricultural productivity by enhancing nutrient uptake and soil structure. Research by Smith et al. (2020) highlights the potential of utilizing these fungi to sustainably boost crop yields.
- **Microbial Remediation:** Microorganisms also play a vital role in bioremediation. Johnson and Lee (2019) demonstrated that certain bacteria can immobilize heavy metals in contaminated soils, reducing their toxicity and offering a promising method for restoring polluted environments.
- **Carbon Sequestration:** Research shows that microorganisms can enhance carbon storage in soils, mitigating climate change. Jones et al. (2021) found that promoting microbial activity could significantly increase carbon sequestration in soils.

4. DISCUSSION

- **Soil Microorganisms as Environmental Engineers:** The results emphasize the indispensable role of microorganisms in geological and environmental processes. Their ability to break down rocks into soil and drive nutrient cycling processes demonstrates their foundational importance in supporting terrestrial ecosystems. These microbial activities are critical for maintaining soil health and, consequently, for sustaining plant and animal life.
- **Agriculture and Environmental Management:** The positive impact of microorganisms on agricultural productivity and soil health underscores the potential of these organisms in sustainable farming practices. Harnessing the symbiotic relationships between fungi and

plant roots, for instance, could offer more environmentally friendly alternatives to chemical fertilizers.

- **Future Research and Climate Change Mitigation:** The role of microorganisms in carbon sequestration presents an exciting avenue for future research. Given their potential to capture and store atmospheric carbon, managing soil microbial communities could be a crucial strategy for combating climate change. However, more research is needed to fully understand these processes and how they can be effectively utilized for large-scale environmental management.
- **Microbial Bioremediation:** The application of microorganisms in cleaning up contaminated soils shows promise as a sustainable remediation technique. The ability of bacteria to immobilize toxic heavy metals could lead to more eco-friendly solutions for managing industrial pollution. Further studies are necessary to scale these methods for broader environmental applications.

5. CONCLUSION

Soil microorganisms are indispensable to the Earth's geological and ecological processes. Their roles in soil formation, nutrient cycling, and mineral transformation highlight their importance in maintaining soil health and supporting sustainable agriculture. Future research should focus on understanding the complex interactions between microorganisms and geological processes to harness their potential for environmental management and climate change mitigation.

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Integration of Urban Geology in Nepal's Urban Planning & Development: A review of its Importance, Trends & Challenges.

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Abstract: The integration of urban geology into urban planning is crucial for addressing the challenges posed by rapid urbanization in Nepal. Importance, current trends & challenges ineffective integration & application of urban geology in Nepal's urban planning framework are examined in this review. The findings highlight the need for policy developments, comprehensive geological assessments & researches, & interdisciplinary collaborations to enhance resilient & sustainable urban growth.

Keywords: *Urban geology, urban planning, natural hazards, sustainability, interdisciplinary collaboration, Nepal.*

1. INTRODUCTION

Urbanization in Nepal has accelerated dramatically in recent decades, particularly in the Kathmandu valley & other urban clusters around the country. As cities expand, understanding the geological situation of their locations becomes crucial for planning & sustainable development. Urban Geology focuses on the geological factors that influence urban environments & it plays a vital role in executing informed planning processes & mitigating risks associated with natural hazards.

Aim

This review aims to explore & examine the significance of urban geology, current trends in its application & identify the challenges associated in its integration in Nepal's urban planning & development process.

Objectives

- To evaluate the importance of urban geology & its applications in urban planning & development in Nepal.
- To analyze the trends in the integration of urban geology into Nepal's urban planning.
- To identify the challenges in the effective application of urban geology in Nepal

Research Questions

- What is the significance of urban geology in Nepal's context?
- How is urban geology integrated into Nepal's urban planning & development?

- What are the challenges in the effective application of geosciences in Nepal's urban development practices ?

2. MATERIALS & METHODS

This review is based on comprehensive literature analyses of academic articles, books, reports published by governmental bodies as well as non-governmental organizations, & policy documents related to urban planning & development in Nepal. Sources include studies on geological hazards, urban growth patterns, & policy frameworks related to integration of geosciences into urban planning.

3. RESULTS

3.1 Importance of Urban Geology:

- **Natural Hazard Mitigation:** Nepal is prone to natural hazards including earthquakes, landslides & floods which posing significant risks to urban areas. The effective integration of geoscientific data into urban planning can reduce disaster vulnerability by identifying vulnerable zones & informed land use planning. For instance, the Kathmandu valley is in a seismically active zone & requires effective planning to mitigate earthquake risks. Geoscientific assessments can guide planners in selecting safe locations for infrastructure & housing, ultimately reducing the vulnerability of urban populations (Rimal et al., 2020).
- **Groundwater Exploration:** Proper water supply has been a challenge in modern urban centers of Nepal. Geological studies are necessary for groundwater exploration & management, which is vital for urban water supply systems (Joshi, 2019).
- **Sustainable Land Use:** Unplanned urban growth in Nepal's cities has led to challenges such as environmental degradation, loss of agricultural land & green spaces. Geosciences provides data on soil types, land capabilities & environmental challenges, which allows planners to make well informed decisions about land allocation & zoning, ensuring that urban expansion doesn't compromise agricultural productivity or ecological integrity (National Urban Development Strategy, 2017).
- **Infrastructure Development:** Geological studies such as assessments of suitability of sites for roads & structures is vital in the construction of urban infrastructure. In areas like the Kathmandu valley, it is particularly important as the geological landscape can pose significant challenges to the construction processes (Haack et al., 2002).

3.2 Trends in Nepal

- **Increased Urbanization:** Nepal's urban population grew from 3.6% in 1991 to 6.5% in 2001, reflecting a major shift towards urbanization (National Urban Development Strategy, 2017).

This rapid growth has necessitated effective integration of geoscientific data into planning process.

- **Research & Policy Development:** There has been a growing trend of research focused on the relationship between geosciences & urban development. Importance of disaster risk reduction & environmental management in urban areas have been increasingly recognized & reflected in the recent policies. The National Urban Development Strategy (NUDS) emphasizes the need for incorporating geoscientific & environmental insights to address urban challenges effectively & sustainably (National Urban Development Strategy, 2017).
- **Technological Advancements:** Remote sensing & Geographical Information Systems (GIS), & other geo technologies are being increasingly used to analyze urban expansion, geology & environment. Studies have documented urban growth patterns & their implications for land use & resource management utilizing satellite imagery (Rimal et al., 2020).
- **Focus on Sustainable Development:** Urban planning strategies have begun to include principle of sustainability, focusing on the need for integrated planning that considers geological & environmental factors. The NUDS emphasizes sustainable approach to urban development, balancing it with environmental conservation (Rimal et al., 2020).

3.3 Challenges in Integration

- **Lack of Comprehensive Geological Data:** Lack of detailed geological surveys & comprehensive geological data is one of the major challenges in the integration of urban geology into urban planning & development. inhibits the planners to assess risks associated with natural hazards & make effective decisions (Timsina et al., 2020).
- **Unplanned Urban Growth:** Nepal's rapid & often unplanned urban growth complicates the integration of geological insights into planning of the urban centers. Urbanization in Kathmandu valley is a prime example; unplanned land use, shrinking open spaces, encroachments, etc. have led to the environmental degradation & increased vulnerability to disasters among the urban population (Timsina et al., 2020).
- **Public Awareness & Engagement:** Engaging communities & raising awareness about geological hazards & sustainable practices is vital for fostering support for geoscience-informed urban planning initiatives (Joshi, 2019). There is a general lack of awareness among people regarding the importance of urban geology.
- **Challenges in Interdisciplinary Collaboration:** Collaboration among stakeholders including geologists, urban planners, engineers, architects, policymakers & governments is vital for effective integration for geosciences into urban planning. However, differing priorities, communication barriers, lack of a common framework & such other challenges can impede progress (Yildiz, 2024).

4. DISCUSSION

Lack of comprehensive geological data, unplanned urban growth, lack of public awareness about urban geology's importance & lack of interdisciplinary collaboration among stakeholders are the

key challenges in the effective integration of geoscientific insights into Nepal's urban planning & development.

To address these challenges significant works still need to be done on the policy level. These challenges point towards the need for the development of a common framework where all the stakeholders, governmental entities, local governments & organizations can pose as a single united front to carry out comprehensive researches & planning regarding urban expansion & development. This can facilitate comprehensive surveys, data collection & resource sharing. The data can then be used by the planners & engineers to develop sustainably planned cities across the country.

4. CONCLUSION:

While there have been positive trends in recognizing the importance of geological insights, significant challenges are yet to be overcome. As Nepal continues towards urbanization, addressing the challenges & leveraging geoscientific insights into the planning process will be vital for transforming unplanned urban clusters into planned, beautiful, vibrant & sustainable cities across the country.

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HISTORY OF GROUNDWATER INVESTIGATION IN NEPAL

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Abstract: There is however a major inequality in the distribution of groundwater in Nepal: the Terai plain has a large amount of it while the Kathmandu valley and the mountains have very limited access to it. Large flat plain of Terai developed from river deposit is much suitable for water storage with more than 150000 numbers of shallow tube wells for irrigation. The Kathmandu valley in comparison has severe issues of groundwater mining and pollution because of its inertia towards urbanization-industrialization process which makes it unfit for consumption in its original form. The other areas that face difficulty in accessing water also include hilly regions and the Himalayas whereby water; availability is also restricted due to its nature and small holding capacity due to the kind of terrain. Other methods such as GIS, MCDA and GWP mapping are being applied in order to determine GW potential areas. But, shortage of funds for carrying on the exploration work concerning the availability and extent of groundwater resources does pose constraints. This study highlights the need for sustainable management of the limited groundwater resource and lack of new ideas for recharging the existing resource in order to achieve efficiency in the resource distribution for the future of Nepal.

Keywords: groundwater, Irrigation, Investigation

1. BACKGROUND

Nepal, a landlocked country situated in the heart of the Himalayas, is a region of immense geological complexity and diverse hydrogeological characteristics. The geology of Nepal is dominated by the collision of the Indian and Eurasian tectonic plates, resulting in the formation of the Himalayan Mountain range, which has profoundly influenced the distribution and nature of groundwater resources in the country (Upreti & Dhital, 1996) (Sah & Paudyal, 2019). Groundwater usage in Nepal has a long history. People traditionally used dug wells and manual techniques to extract water. Modern pumps and drilling methods were introduced after World War II. Systematic exploration for groundwater began in the late 1960s. Groundwater Investigation Section was also established in 1973 under the Department of Irrigation, Hydrology and Meteorology and some permanent posts created for the first time so that the groundwater development activities could be institutionalized in the regular HMG/N functions. This Groundwater investigation section was later upgraded to the present Groundwater Irrigation Division under the Department of Irrigation in 1993 when the department underwent major reorganization, leading to the establishment of the Groundwater Resources Development Board (GWRDB) in 1974. GWRDB's activities, now implemented through the Groundwater Resources Development Project and certain area-specific projects, include installation of investigation and production wells, development of tube well irrigation facilities including distribution systems(one of the supporting structure for groundwater irrigation which is generally open or buried) , basic data generation, monitoring of overall ground water development and associated utilization, and operation and management of large production wells. This agency is now responsible for investigating, developing, and managing groundwater resources in Nepal, with a focus on irrigation in the Terai region. According to the report of Department of Irrigation, the developed infrastructure of the groundwater irrigation is about 500,000 hectare out of total developed infrastructure in 1221000 hectare. In the groundwater infrastructure, about 1450 DTWs and 111,517 STW are constructed. However, 395 DTWs are seen older than 15 years which covers about 20,248 ha (42%) irrigated land. Similarly, the

31,825 STWs are seen older than 15 Years and its coverage land is about 108,649 ha (32%). All together about 128,933 ha (33%) land which showing irrigated through the groundwater irrigation.

Aims

The review article aims to illuminate the ground water resources of Nepal, exploring how the investigation of water resources has been carried out in Nepal.

Objectives

- To study the investigation of water of Terai region in Nepal.
- To study the investigation of water of Kathmandu valley of Nepal
- To study the investigation of water of hilly region of Nepal

Research question

1. What is the history of investigation of groundwater in Nepal?
2. How is investigation going on in various region of Nepal and their present status.?

2. MATERIAL AND METHODS

The review is based completely on careful evaluation and interpretation of secondary sources like books, previously published articles, journals, papers, international and national reports, and so on. The sources that were relevant to the research were chosen, meta-analysis and a systematic review were done and the results were presented systematically and scientifically.

3.RESULT

Nepal's groundwater resources are distributed unevenly. The Terai, bordering India, holds the richest reserves. Here, annual recharge reaches 8800 million cubic meters (MCM) to 11598 MCM (as calculated by UNDP/ GWRDP), and the water quality is generally good for drinking (except Shallow levels) and irrigation. The Terai's layered sediments, deposited by rivers, create ideal conditions for storing groundwater. In contrast, the middle hills and Kathmandu Valley face limitations. While aquifers exist, they're less extensive. Kathmandu Valley specifically struggles with overexploitation, where water withdrawal outpaces natural recharge. High Himalayan regions have limited groundwater potential due to the rock formations being less suitable for water storage. (Rajaram And Prajapati et.al)

The Terai region:

Nepal has undertaken significant efforts to explore and develop groundwater resources, particularly in the Terai region. The Groundwater Resources Development Board (GWRDB) and other agencies have been instrumental in constructing deep tube wells (DTWs) and shallow tube wells (STWs) throughout the Terai. Over 700 DTWs have been installed, focusing on specific projects in various districts. Additionally, estimates suggest over 50,000 STWs have been established through programs funded by the Agricultural Development Bank of Nepal (ADBN) and other donors. ADBN has played a leading role in promoting STW development and providing credit to farmers for irrigation purposes. "Furthermore, projects like the GWRDB/UNDP Shallow Aquifer Investigation Project have improved understanding of the Terai's shallow aquifers. These initiatives highlight Nepal's commitment to utilizing groundwater resources for agricultural development and community needs." (YL VAIDYA)

The Kathmandu valley

In Kathmandu intermountain basin the major exploration program ran from 1969-1974 with report from USAID. Studies by JICA (Japan International Cooperation Agency) in 1990 helped define the hydrogeological districts within the valley. The total number of tube well around the valley under different study program is 91. Various project functional in Kathmandu valley for ground water extraction is presented in the table (extracted from Comprehensive study of groundwater resources in Kathmandu valley). Moreover, the perception of groundwater in the Kathmandu Valley has shifted from an open-access resource to an overexploited, degraded, and state-controlled one (Pandey & Kazama, 2013). The increasing extraction of groundwater in the

valley due to population growth, urbanization, and industrialization has further exacerbated the situation (Ganesh et al., 2018). Studies have also pointed out the poor quality of groundwater in the region, highlighting chemical and microbial contamination issues that make it unsuitable for direct consumption (Shrestha et al., 2019; Maharjan et al., 2020).

SN	Organization	Project	Year	No.ofDTWs.
	Indian co-operation mission (ICM)	study of sub-surface Geology	1960 & 1966	12
2	US Aid	Department of irrigation	1960-1963	17
3	WHO	Binnie & Partners	1971-1974	-25
4	JICA	Ground water Management project in Kath-valley	1990	4
5	Department of mines and geology	Gas project	1993 and 2014	1
6.	Melamchi water Investigation Development project	Water level monitoring	2001	14
7	Melamchi water Investigation Development project	Artificial Recharge pilot project	2001	3
8	Initiated by Sakai.Hv	Paleo:kathmandu lake Sediment	2001	3

The hilly region:

Groundwater is a critical resource for the hilly regions of Nepal, providing essential water for drinking, domestic use, and irrigation. However, the complex topography and varying climatic conditions pose significant challenges for groundwater exploration and management. Groundwater potential zones in the mid-hill region of Nepal can be effectively mapped using various thematic layers such as elevation, slope, land use, drainage density, geomorphology, lineament density, rock and soil distribution, and precipitation. High groundwater potential areas are often found along river courses, while low potential areas are typically in the western parts. Deep neural networks and GIS-based Multi-Criteria Decision Analysis (MCDA) techniques have been successfully applied to capture and map groundwater potential zones. These methods have shown high accuracy in predicting groundwater potential, with lineament density and hydro-geomorphology being the most influential factor. (A. Pradhan et al)

DISCUSSION

Nepal's groundwater distribution is uneven, with the Terai holding abundant, well-managed reserves while the hilly and Himalayan regions face challenges due to geology and potential overexploitation. While the Terai's success with DTWs and STWs shows promise, Kathmandu Valley's struggles highlight the need for sustainable management practices, particularly in drought-prone areas. Employing innovative mapping techniques and prioritizing recharge projects can ensure this vital resource benefits all of Nepal. There is no provision for estimation of budget like in developed country for the investigation of ground water in Nepal which is hampering in the proper investigation of the water resources.

CONCLUSION

Despite abundant groundwater reserves in the Terai, managed through deep and shallow tube wells, Nepal faces challenges in the hilly and Himalayan regions due to complex geology and potential overuse in Kathmandu Valley. While the Terai's success story provides a model, Kathmandu Valley's struggles highlight the need for sustainable practices like innovative mapping techniques for locating potential zones and recharge projects to combat

overexploitation and ensure this vital resource benefits all of Nepal, with increased budget allocation being essential for a more comprehensive understanding of the country's groundwater potential.

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Understanding Landslides: Causes, Impacts, and Mitigation Strategies

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Abstract

Nepal, a country renowned for its breathtaking landscapes, faces persistent challenges from landslides due to its complex geography, monsoonal rainfall, and climatic conditions. Geologically, the area is characterized by steep slopes composed of unstable rock formations and weathered soils, prone to mass movements triggered by intense rainfall and seismic activity. Structural weaknesses, such as faults or joint systems, play crucial roles in landslide initiation, while topographic features influence the direction and extent of debris flow. This article explores the proactive measures being implemented to understand, mitigate, and adapt to landslide risks in Nepal, aiming to build resilience and protect lives and livelihoods.

Key Words: *Landslide in Nepal; Causes of Landslide; Impacts of Landslide; Mitigation Strategies*

1. BACKGROUND

Introduction

A landslide is the downslope movement of soil, rock, and organic materials under the effect force of gravity through a definite plane of failure (slip surface). They can happen suddenly or more slowly over long periods of time. When the force of gravity acting on a slope exceeds the resisting forces of a slope, the slope will fail and a landslide will occur. Landslide is defined as "the downward and outward movement of slope-forming materials under the influence of gravity" (Varnes 1978). According to the Oxford Learner Dictionary (2024) "landslide is a mass of earth, rock, etc. That falls down the slope of a mountain or a cliff". Landslides may be triggered by natural or anthropogenic factors.

Nepal is characterized by rugged and mountainous terrain with steep slopes. This topography increases the gravitational forces acting on slopes, making them more susceptible to landslides, especially during periods of heavy rainfall or seismic activity (Dahal, 2012). Nepal is located in a seismically active region, prone to earthquakes which can induce landslides by shaking and destabilizing slopes, especially in areas already weakened by other factors (United States Geological Survey). Nepal's geological formations include weak and easily weathered rocks which also contribute to erosion and instability of slopes. The presence of faults and joints also weakens rock structures, making slopes more susceptible to failure. Poorly planned roads and highways without adequate slope stabilization also lead to destabilize the slopes and increase landslide risks. Rapid urbanization and improper land-use practices in hilly and mountainous areas alter natural drainage patterns and increase surface runoff, further contributing to landslide hazards.

Aim

This research aims to explore the causes, impacts, and mitigation strategies associated with landslides in Nepal.

Objective

The main objectives and scope of the study are:

- To understand about causes of landslide
- To assess the impacts of landslide
- To learn the landslide mitigation strategies

Research Questions

- What are the factors that initiate the landslide every year?
- How landslide impacts the lives and livelihoods?
- What are the probable mitigation strategies for landslides?

2. MATERIALS AND METHODS

The research began by reviewing existing literature and studies on landslides to understand current knowledge, methodologies, and gaps in research. Desk Study was done. The field study done during the excursion also helped a lot in this research paper's preparation. Data were collected through secondary sources such as books, articles, project reports, websites, etc.

3. RESULTS

Causes of landslide

Natural factors

Natural factors that can lead to landslides are mentioned below;

- Tectonic Activity like Earthquakes resulting from ongoing collisions can trigger landslides by destabilizing slopes and triggering ground shaking.
- Weak or fractured rocks, such as shale and schist, are particularly susceptible to landslides when exposed to weathering and erosion processes (Bhandary, 2008).
- Nepal's rugged terrain with steep slopes, high mountains, and deeply incised valleys increases the susceptibility to landslides. Slope angles, combined with factors like soil depth and vegetation cover, play a crucial role in landslide initiation (Deepak Chamlagain, 2010).
- Heavy monsoon rainfall is a significant triggering factor for landslides in Nepal. Prolonged rainfall saturates the soil, reducing its shear strength and increasing pore water pressure, which can lead to slope instability and failure (Dahal, 2012)
- Glacier retreat and permafrost degradation in the Himalayan region can destabilize slopes and contribute to landslide hazards. The melting of glaciers and seasonal snow can also increase sediment supply to slopes, making them more susceptible to failure.

Anthropogenic factors

Anthropogenic factors include:

- Clearing forests and vegetation destabilizes slopes by reducing root cohesion and increasing surface runoff, leading to soil erosion and slope instability.
- Excavation, grading, and construction activities change natural slope gradients and drainage patterns, potentially weakening slopes and triggering landslides.
- Extraction activities can weaken rock and soil structures, disturb groundwater levels, and create artificial slopes that are prone to failure.
- Roads, highways, and infrastructure projects can alter natural drainage systems, increase surface runoff, and create new slope failure planes.

- Poorly managed irrigation practices can lead to waterlogging and saturation of slopes, increasing landslide risks.
- Improper disposal of waste and landfill activities can affect slope stability and introduce additional weight and pressure on the underlying soil layers.
- Large-scale dams and reservoirs can also disturb natural river flows and sediment transport, potentially inducing landslides in downstream areas.

Effects of landslide:

- Landslides can cause fatalities and injuries, particularly in communities living in vulnerable areas where sudden slope failures occur.
- People living in landslide-prone areas may be forced to evacuate, leading to displacement. Homes, infrastructure, and agricultural land can also be damaged or destroyed.
- Landslides often block roads and trails, disrupting transportation networks crucial for access to services, markets, and emergency response.
- Agricultural land can be buried or rendered unusable by landslides, affecting livelihoods dependent on farming and livestock.
- Landslides can result in the loss of biodiversity, habitat destruction, and altered hydrological patterns, impacting ecosystems and water quality.
- Communities affected by landslides may experience social disruption, loss of community cohesion, and psychological stress due to trauma and uncertainty.

4. DISCUSSION

Prevention and Mitigation Measures of Landslides

Prevention and mitigation strategies for landslides are mentioned below:

- Conduct detailed geological surveys and site investigations to identify potential landslide-prone areas. This includes studying the type of rocks, soil composition, slope characteristics, and groundwater conditions.
- Implement monitoring systems such as inclinometers, piezometers, and satellite-based remote sensing to detect ground movement, slope instability, and changes in groundwater levels. Early warning systems can alert authorities and residents to evacuate or take preventive measures.
- Maintain and restore natural vegetation cover on slopes, as roots help bind soil together and reduce erosion. Proper land use planning that avoids construction on steep slopes or requires appropriate engineering controls is crucial.
- Poor drainage can lead to increased water infiltration, saturation of slopes, and ultimately, landslides. Implement surface drainage systems like channels, terraces, and retaining walls to manage water runoff and prevent saturation of slopes.
- Depending on the geological conditions, stabilize the slope using engineering techniques such as Retaining walls, Rock bolts and mesh, Soil nailing, and Grouting.
- Construct buildings and infrastructure using earthquake-resistant and landslide-resistant designs. This includes ensuring foundations are stable, using appropriate building materials, and designing structures to withstand lateral forces.
- Educate communities living in landslide-prone areas about the risks and signs of landslides. Promote preparedness and evacuation plans to minimize casualties and property damage during landslide events.

5. CONCLUSION

In Nepal, landslides are quite a common natural hazard deeply connected with the country's geological diversity and environmental factors (Deepak Chamlagain, 2010). The steep terrain, geological composition, seismic activity, and intense monsoon rains converge to create conditions that drive landslides. Geological studies have shown that rock type, slope angle, soil characteristics, and groundwater levels significantly influence landslide susceptibility. To effectively mitigate landslide risks in Nepal, it is essential to prioritize comprehensive geological assessments and monitoring systems. These efforts can enhance early warning capabilities, allowing for timely evacuation and minimizing casualties. Implementing sustainable land use practices, such as afforestation and erosion control measures, can help stabilize slopes and reduce landslide occurrences. Moreover, engineering solutions like retaining walls, drainage systems, and slope stabilization techniques tailored to local geological conditions are essential. Community awareness and preparedness initiatives must complement these efforts to ensure swift response and resilience in landslide-prone areas.

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Factors Influencing Nepal's Groundwater Resources

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Abstract: Nepal is rich in groundwater resources due to differences in its geography, geomorphology and physiography. Within the intra-mountain valleys such as Kathmandu, Dang and comparative other valleys, groundwater is confined to well-defined and sometime isolated basins, while groundwater within flat plains of south of the Himalayan mountain ranges, the Terai, forms a portion of the bigger framework working within the large Indo-Gangetic plain. Nearly one half of the country's population is living within the Terai and they depend solely on groundwater for their residential water needs. In spite of the fact that the accessible groundwater asset within the Terai encompasses a potential to play a crucial part in water system to guarantee the country's nourishment security and financial development. A differentiating situation exists in Kathmandu valley, where the asset likely is as of now being over-exploited.

Keywords: *Factors, Groundwater, Factors, Urbanization, Extraction*

I . BACKGROUND

Introduction

Nepal is a landlocked country which is very fortunate to have plentiful groundwater and fresh water resources. The groundwater resource supplied water for millions of people and supports farming throughout the country. In Terai region of Nepal the annual availability of groundwater recharge is about 8800MCM (Million Cubic Meter) in which 22% dynamic groundwater recharge is used for the irrigation and drinking and farming purpose (Shrestha et al.,2018).

The groundwater present in every part of the country is being exploited. Due to increase in population there is also increase in water demand. This led to the over-extraction of groundwater. Rapid urbanization is also impact on recharge, discharge and monitoring of the groundwater. Exploitation of groundwater system, changes in the water cycle, irregular rainfall, exploitation of river and riverbed material, climate change and increased destruction of the Chure region have led to decrease in groundwater and water crisis. Groundwater pollution and contamination is also another arising problem. Many groundwater in terai region are highly contaminated with arsenic which poses a significant risk to public health of the people. From the clinical observation of patients in arsenic affected districted showed that half a million people living in these area are believed to have been exposed to arsenic level greater than 50 μ g/L in their drinking water whereas, 3.5 million people (31%) in those region are estimated to have been exposed to arensenci level between 10 μ g/L-50 μ g/L (Pokhrel et al.,2009).

The level of groundwater is declining due to increased extraction, and now it needs to dig deeper to access groundwater. A 2010 study conducted by Bishnu Prasad Pandey shows that demand for water increased as population increased. Between 1980 and 2000, the report states that groundwater levels declined by 1.3 to 3 metres, annually in 9.6m cubic meters of land areas. Similarly, groundwater level declined by 1.38 to 7.5 meters between 2000 and 2008. According to

the Underground Water Resource Management Policy, 2069, the groundwater level in the valley is decreasing at an average rate of 1m per year where it is 2.5m per year in some places.

Aim

The main aim of this article is to understand the current problems of the groundwater resources and find out suitable solutions.

Objectives

The main objectives are as follows

1. To understand the different factors influencing Nepal's groundwater resources.
2. To find out suitable solution of the problems arising from those factors.

Research Questions

1. What are the factors influencing the groundwater resources in Nepal?
2. What are the suitable solutions of the problems arising from those factors?

2.MATERIALS AND METHODS

The article utilized secondary data from different journals and articles and analysis of those data. The materials needed for this study includes books, journal, and published newspaper articles.

3.RESULTS

The major factor in decline of groundwater in Nepal are population and unplanned urbanization. Rapid growth in population leads to increase in water demand which ultimately lead to use of more water resources. Unplanned and rapid urbanization lead to disturbance in groundwater system and hinder in water cycle. The another major factor influencing the groundwater in Nepal is water quality. Being an agricultural country, water quality is a necessary factor. Higher concentration of arsenic in groundwater is reported in several districts of terai region. The water containing arsenic is toxic and can't be used for drinking and other purposes. There is increasing demand of the agricultural products in the market of Nepal, which is also another element. So, to fulfill the demand of the product, farmers rely on any water resources including groundwater resources to carry out irrigation and other agricultural function. Farmers of the terai region totally depend on groundwater. The construction of roads, dams and other infrastructures are seen to be underlying component for the groundwater. For eg: a good paved road doesn't allow water to be absorbed by soil which is an essential factor of water cycle and groundwater system. Climate change is also a major factor affecting the groundwater resources in our country. Due to increase in climate change, decline in groundwater level are being observed. Increase in industry and various economic activities contribute in groundwater pollution and contamination. The contaminated water that flow from in the surface seep into the soil and pollute the groundwater.

It is important to solve all the issues arising from the factors that are influencing groundwater resources. Some solution are listed below:

1. Regular monitoring of groundwater
11. Protection of recharge areas
111. Proper groundwater management quality management system
- 1v. Proper utilization of water from the resources
- v. Strictly implementing the policy of groundwater preservation

- v1. Carrying out awareness program
- vn. Encouraging rainwater harvesting and other artificial recharge techniques
- v111. Arsenic monitoring and mitigation program should be carried out throughout the country.
- 1x. Keep the surface water resources clean.

4. DISSCUSSION

There are various factors affecting the groundwater resources of the Nepal. It is important to monitor those factors regularly to protect our groundwater resources. The groundwater resources in Nepal depends on sustainable practices and proper management. The factors like population growth, urbanization, agricultural demand and climate change should be faced with a proper approach. The policies regulated by the government for the protection of the groundwater needed to be strictly implemented. The groundwater must be preserved for future generation use.

5. CONCLUSION

Sustainable groundwater resource management would be jeopardized in Nepal by the current factors influencing the groundwater development. Right now, it is very necessary to detect those factors and analyze them to conserve our groundwater resources. People should be aware about the factors such as overpopulation, climate change etc influencing the groundwater. The stricter regulation on groundwater extraction and preservation need to be carried out. The rainwater should be harvested along with various artificial recharge techniques are also used in today modern world for the water preservation. Public awareness about proper use of water and preservation of groundwater should be carried. For the future of Nepal and its groundwater resource immediate actions need to be carried out. All community, society and government need to work together for the conservation of groundwater for the future generation. Million livelihood of people as well as water and food security would be assured only by protecting groundwater resources.

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Potential geological hazards in Nepal

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Abstract: Nepal, a landlocked country having a quite dynamic Geology is known for its stunning landscapes and towering Mountains. However, its unique geography also makes it highly susceptible to various Geological hazards. Different zones of Nepal go through different Geological Hazards every year but the amount of risk of all these hazards isn't the same throughout Nepal. The Nepal Himalayas are prone to harmful disasters from natural hazards such as floods, landslides, earthquakes, sinkholes, River blockage, and also other weather-related events and their combination. The increase in the rural road Network has caused multiple hazards leading to accelerated soil erosion rates and cultivated land losses. This chapter provides a deep insight into the possible geological hazards in different areas of Nepal. Shallow landslide, debris flows, and flooding consequently pose serious issues as evidenced by the natural disaster that struck South and South-east Kathmandu in 1993 and the Muglin-Narayanghat Road of Central Nepal in 2003 (Dahal, 2012).

Keywords: *Geological hazards, flood, landslide, earthquake, Avalanche*

1. BACKGROUND

Nepal is yearly exposed to multiple hazards that have different causes. In geology, Hazard refer to natural events or processes that have the potential to cause damage or harm to humans, property, and the environment.

A landslide is defined as "the movement of a mass of a rock debris or earth down a slope" (Cruden, 1991). Landslides are either caused naturally or by excessive anthropogenic interferences such as unplanned urbanization, unsuitable cultivation practices, and deforestation (Sonyok, 2009). An earthquake is a natural disaster that comes to different parts of the earth every year. Most of them are very weak and unnoticeable but some are too severe which leads to great loss of lives and destruction of properties. On the other hand, Flood is also one of the most devastating Geological hazards in Nepal, which is a sudden outflow of a high volume of water beyond the river channel for a short time caused by Heavy rainfall. (Leopold et.al., 1995). Additionally, avalanches, which involve the rapid flow of snow down a slope, present significant risks in mountainous regions (Daffern, Rocky Mountain Books, 1999).

Aim

The main aim of this research is to uncover the condition of Geological hazards like landslides, floods, earthquakes, avalanches, etc. occurring time and again in different regions of Nepal.

Objectives

1. To know the pattern of different Geological hazards in Nepal
2. To study the geological causes of those hazards

Research questions

1. What are Nepal's potential geological hazards?

2. What geological factors drive the rise in hazards like landslides, floods, earthquakes, and avalanches?

2. MATERIALS AND METHOD

The study is based on secondary sources such as articles, journals, and websites to collect data and thorough study of relevant books on the subject of study.

3. RESULTS

3.1 Landslide

Nepal's landslide density rose sharply from 0.85 events per 1000 km² in 2011 to 3.34 in 2020, averaging a 0.25 event increase annually (Petle, 2024). This rise, particularly after the 2015 Gorkha Earthquake, remains high in the 14 worst-affected districts. In 2022, 327 landslides resulted in 99 deaths, 88 injuries, and affected 992 families, with economic losses of around NPR 88 million (Maden, 2023). Landslide factors include steep slopes, fragile geology, high rainfall, deforestation, and unplanned settlements. Recently, a landslide in Chitwan metropolitan-29, Simaltal, swept away two buses, leaving 65 passengers missing. Seventeen bodies have been found, with the status of the remaining passengers unknown (Rastriya Samachar Samiti, 2024).

3.2 Earthquake

Nepal frequently experiences earthquakes due to its location at the intersection of the Indian and Tibetan tectonic plates. The country lies in seismic zone V, indicating a high risk of earthquakes. Seismic activity is clustered into three regions: western, central, and eastern Nepal. The most vulnerable areas are the Siwalik, the Lesser Himalayas, and the frontal parts of the Higher Himalayas. Major earthquakes in the 20th century include the 1934 Bihar-Nepal earthquake, the 1980 Bajhang earthquake, and the 1988 Udayapur earthquake. According to the Global Report on Disaster Risk, Nepal ranks 11th in earthquake risk. The 2015 Gorkha earthquake, with a magnitude of 7.8, struck on April 25 at 11:56 NST, centered 77 km northwest of Kathmandu at a depth of 10-15 km (Wyss & Chamlagain, 2019). This earthquake caused widespread destruction, triggered landslides, and blocked roads, complicating rescue efforts. Poorly built stone or brick masonry structures suffered significant damage, while most reinforced concrete (RC) buildings remained intact. This disaster underscored the need for better earthquake-resistant designs, especially for high-rise buildings in Kathmandu. In the context of Nepal, the seismic hazard distribution pattern is illustrated in Figure 1 above.



Figure 1: Seismic Hazard Map of Nepal (Pande, 2013)

northwest of Kathmandu at a depth of 10-15 km (Wyss & Chamlagain, 2019). This earthquake caused widespread destruction, triggered landslides, and blocked roads, complicating rescue efforts. Poorly built stone or brick masonry structures suffered significant damage, while most reinforced concrete (RC) buildings remained intact. This disaster underscored the need for better earthquake-resistant designs, especially for high-rise buildings in Kathmandu. In the context of Nepal, the seismic hazard distribution pattern is illustrated in Figure 1 above.

3.3 Flood

It is estimated that more than 6,000 rivers and rivulets are in Nepal flowing from north to south. Among these, snow-fed rivers, such as the Koshi, Narayani, Karnali, and Mahakali, are perennial rivers. They originate from the Himalayas and snowcapped mountains and pass through the hills to the Terai plains. During the monsoon (June-September), these rivers swell and cause damage to the villages, crops lands, and people and livestock remaining within the river basins. Historical data has shown that Nepal witnessed major floods in the Tinao Basin (1978), Koshi River (1980), Tadi River Basin (1985), Sunkoshi Basin (1987), and a devastating

cloud burst in the Kulekhani area (1993) which alone claimed the lives of 1336 people (econeal, 2024).

3.4 Avalanche

Avalanches can be extremely destructive, especially in high mountainous regions (Figure 2) with rugged, steep terrain. Nepal has reported several destructive avalanches, including the unexpected Seti River flood on May 5, 2012, in the Kaski district, which exemplifies this type of hazard (Poudel & Hama, Assessment of Natural Hazard in the Himalayas: A Case). A massive avalanche occurred in the iconic Manaslu Mountain in Samagaun of Chumanubri Rural Municipality-I in north Gorkha this morning, triggering urgent warnings for nearby residents (RSS, 2024).

4. DISCUSSION

Hazards in Nepal, such as landslides, floods, earthquakes, and avalanches, vary annually but stem from continuous triggering activities. Landslides result from heavy monsoon rainfall, earthquakes, deforestation, and unmanaged road construction, which destabilize rock and soil. Floods are caused by steep mountainous terrain, poor drainage systems, glacial lake outburst

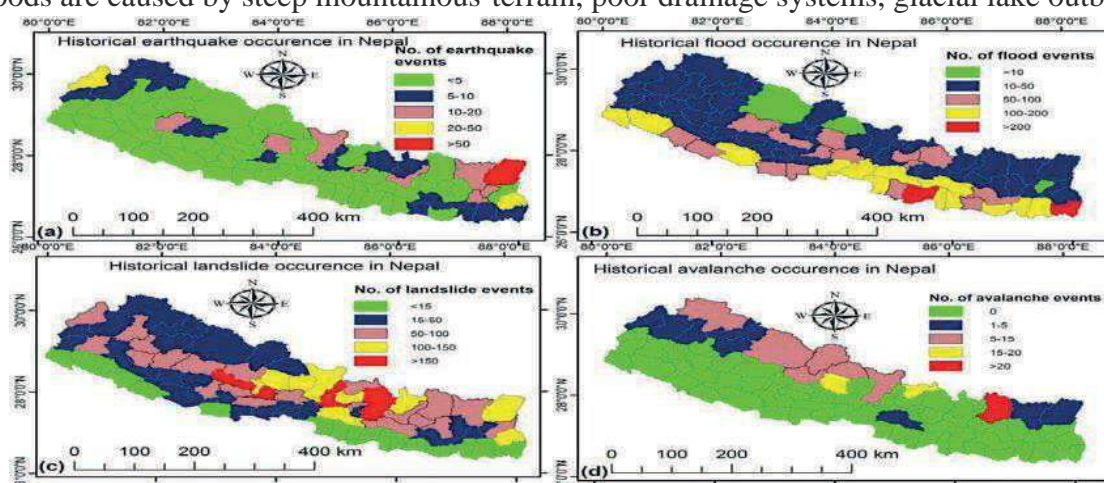


Figure 2: District level zonation of Geological Hazard (1971-2018): (a) earthquake, (b) flood, (c) landslide, (d) avalanche (Gautam, Thapa, Pokhrel, & Lamichhane, 2021)

floods, and monsoon rains. Earthquakes occur due to tectonic plate collisions, fault lines, subduction zones, and crust deformation. Avalanches in the Himalayas are triggered by heavy snowfall, temperature changes, rapid winds, snowpack instability, earthquakes, mountaineering, skiing, and glacial movement.

5. CONCLUSION

This title examines the significant geological hazards in Nepal, which severely impact the daily lives of its citizens. The primary challenges hindering the country's development include landslides, floods, earthquakes, and avalanches. However, data and historical analysis indicate that landslides and floods are the most persistent threats, frequently resulting in loss of life, property, and infrastructure damage. The high reliance on road transportation in Nepal exacerbates these impacts. Key factors contributing to these geological hazards are continuous heavy rainfall, unmanaged road construction, poor drainage systems, and slope instability.

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Rubies and Fancy-Color Sapphires of Dhading, Nepal

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Abstract: This study examines the geological characteristics of ruby and sapphire deposits in the Dhading District of Nepal, with a focus on the Chumar and Ruyil mines. The Himalayan Mountains, formed by the collision of the Indian and Asian plates, provide a unique geological setting for the formation of these precious stones. The research reveals that the corundum deposits in the region are characterized by a diverse range of inclusions, including rutile needles, orange to black crystals, and apatite. The study identifies three new inclusions in rubies, including uvite tourmaline, anorthite feldspar, and diaspore, which are distinct from those found in other marble-like sources. The gemological qualities, chemical composition, and inclusions of the samples from Chumar and Ruyil are comparable, with the presence of graphite in Ruyil's corundum suggesting a possible ruby signature. The study highlights the potential for further discoveries of ruby and sapphire reserves in Nepal, despite the challenges posed by remoteness, high altitudes, and severe weather. The findings of this research have implications for the development of more advanced mining techniques and equipment to fully utilize these valuable minerals.

1. BACKGROUND

The geology of Nepal is dominated by the Himalayan Mountains, formed by a collision between the Indian and Asian plates around 30 to 50 million years ago. The Indian plate continued in a northward drift, pushing beneath the Asian plate, causing a major structural breakage known as the Main Central Thrust (MCT). This major structural breakage extends east-west, forming the Himalayan Mountains. The Ganesh Himal corundum occurs near the top of the lower-grade metasediments of the Nawakot Series, below the MCT. The dolomite marble layer has been torn into a dozen isolated bodies, each with a slightly different suite of minerals. The Ruyil deposit is a notable variation, with abundant graphite formed due to a local abundance of marine organic material in the original interlayer. The westernmost four dolomite bodies, Pola, Chumar, Shongla, and Shelghar, have produced corundum, while Ruyil and Sublay are corundum-bearing bodies. This study focuses primarily on the Chumar and Ruyil deposit.

The Chumar deposit is located approximately 550 meters east to west and has a central thickness of about 150 meters. It was first studied by the AMB in 1984. At the west end of the dolomitic mass, a fault that dips sharply to the northeast and trends N60°W encircles it. There is no fault line along the boundary, and the east end of the body tapers to a tail. The curved north west. The enormous, eroded domes that make up the rest of the body are created by different beds. The seams are located about 8 m apart and average around 20 cm in thickness; however, they vary substantially in thickness. They descend 32°. They are occasionally folded on a tiny scales of dolomite body where it strikes east-west, give it a sigmoidal shape.

The first studies on the Ruyil deposit were conducted by AMB in 1985. The dolomite body's western portion seems to stop abruptly in a curving contour of broken dolomite with no discernible bedding, although there isn't a visible fault line. This deposit has a typical thickness of 60 meters and stretches roughly 128 meters east-west. There has been no discovery of corundum in the continuous outcrops of bedded dolomite on the eastern side.

Aim

The paper aims of research is to know the deposition and identification of rubies and sapphires around Dhading district.

Objectives

- To determine the quality of the minerals.
- To evaluate the characteristics of minerals and correlate it.

Research Questions

- What are the gemological characteristics of the rubies and fancy-color sapphires?
- What is status of Rubies and Sapphires?

2. MATERIALS AND METHODS

Secondary data were used in this investigation. A careful selection of credible sources, including books, scholarly articles, journals, and trustworthy websites, was made in order to collect the data and information needed for the study.

3. RESULTS

The sample of Rubies and fancy color sapphires showed a diverse range of inclusion, including rutile needles, bright orange to black crystals, stringer type inclusion patterns, apatite, mica margarite, and light brown phlogopite mica. Transparent colorless crystals of calcite and dolomite were rare, while black uvite tourmaline and transparent anorthite feldspar were identified. A wide range of fingerprint like inclusion were observed. Distinct color zoning was present in most of the sample rubies and sapphires from Nepal. Kiefert and Schmetzer (1986, 1987) identified growth planes consisting of the second-order hexagonal prism a (1120) and hexagonal dipyrmaid v (4481). Nepali rubies' blue color zones and banding have a few unique features. These include the large red and dark violetish blue zones (i.e., bicolored stones); the successions of straight and angular, thin-to-thick bands parallel to the dipyrmaid z (2241) planes; the "wedge-shaped" color zones; and the wispy to smoke-like textures seen in the color bands and "halos" of nonblue zoning surrounding mineral inclusion.

The color zones of sample corundums exhibited varying responses to UV light, with red to pink zones fluorescing red in short-wave and long-wave UV radiation, and dark violetish blue zones having little effect. The gemological qualities, FTIR, UV-Vis-NIR, and crystal morphology, chemical composition, and inclusions of the samples from Chumar and Ruyil did not consistently differ from one another. But the presence of graphite in Ruyil's corundum could point to a ruby.

4. DISCUSSION

Tamang people use shovels, picks, and crowbars for gemstone mining, with blasting occasionally. Hammering is more common after blasting at the Chumar deposit than Ruyil. No secondary deposits have been reported, with corundum being the primary indication. Three new inclusions in rubies have been identified by this study, which examines the gemological literature on corundum from Nepal: uvite tourmaline, anorthite feldspar, and diaspore as well as several distinctive inclusion and color joining patterns but was not observed as described by Kiefert and Schmetzer (1996). The findings offer comprehensive geographical information and corroborate past study. Nepal's fancy-colored sapphires and rubies are comparable to corundum found in other marble-like sources such as Tanzania, Afghanistan, Pakistan, Vietnam, and Myanmar. The inclusions, which contain dense clusters of extremely thin, short rutile needles, are the most characteristics of Nepalese corundum. Dense concentration of very fine short rutile needles contrast sharply with the long, highly iridescent rutilite needles present in most rubies

from deposits of the marble type. Additionally, the study discovered rod-shaped minerals, which have never been reported in fancy-colored sapphires or rubies from any other source.

5. CONCLUSION

Recently, reserves of rubies and sapphires have been found in Nepal, a major supply of corundum. In the northern Dhading District, the Chumar and Ruyil mines are the main sources of these stones. Research indicates that greater reserves may yet to be found despite their low production, which is attributed to remoteness, high altitudes, and severe weather. To fully utilize these minerals, more advanced mining techniques and equipment are required.

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Influence of Geological Hazards on Urbanization of Ghorahi Sub-Metropolitan city

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Abstract: The article offers an overview of impacts of geological hazards on urban development of Ghorahi Sub-Metropolitan City, Dang. The aim of the article is to identify the major geological hazards that affect urbanization of the city, focusing particularly on the impacts of floods and seismic activity on region's infrastructure and population. Additionally, the research indicates the need for proper urban planning strategies that assess the geological risk to ensure sustainable and safe development. The research concludes with recommendations for mitigating the impact of these hazards through proper risk management and land use planning.

Keywords- Geological hazards, Urbanization, Proper risk management

1. BACKGROUND

The urban population of the world has reached 3.9 billion. Today, 54 per cent of the world's population lives in urban areas, a proportion that is expected to increase to 66 per cent by 2050 (UN, 2014). Rate of urbanization from 2014- 2050 is projected at an annual rate of 1.9% (UN, 2015). This shows that the world, along with escalating population, is heading towards rapid urbanization and issues regarding urbanization should not be left out. Ghorahi is an Inner-Terai Valley situated in Dang district. Recently, in 2017 it was converted into Sub-Metropolitan City. This city is the hub of education and commerce for the people from Rukum, Rolpa, Pyuthan and Salyan. The population growth in this city is triggered by the in-migration from these areas. The total population of Ghorahi is 200,530 and the land area is 522 sq. km (MoFALD, 2017).



Figure 1: Map of study area (Source: Google Earth Pro)

Yet, Ghorahi lacks proper planning and implementation of the planning approaches. The city is characterized by its diverse topography, and is prone to specific geological hazards such as floods and seismic activity. Urban planning in Ghorahi City presents unique challenges due to complex interaction between natural geological processes and human development. Effective

urban planning in the city requires deep understanding of geological features to ensure sustainable and safe development.

Aim

The aim of this paper is to assess key geological hazards, and identifying impact of these hazards on the urban development of Ghorahi Sub-Metropolitan City.

Objectives

The major objective of this research includes:

- To assess the geological hazards commonly found in Ghorahi Sub-Metropolitan City.
- To analyze the impact of geological threats on urban development.

Research Questions

- What are the major geological hazards in Ghorahi Sub-Metropolitan City?
- How do these hazards influence the urbanization of Ghorahi Sub-Metropolitan City?
- What steps can be taken to reduce the impact of these hazards for human development?

2. MATERIALS AND METHODS

The paper is heavily based on the analysis and interpretation of secondary data. The materials collected for this research includes books, journals, published reports, google maps and satellite images. Key methods used in the research include:

2.1 Seismic Hazard Analysis: This analysis evaluates the seismic risk in the city by reviewing different papers. Furthermore, assess the vulnerability of earthquakes for the human settlement.

2.2 Hydrogeological Analysis: This analysis evaluates potential floods in the city by reviewing different papers and journals.

3. RESULTS

3.1 Geological Hazards: The city is characterized by significant risk of flood particularly in the areas where most of the population is concentrated, especially during monsoon season. Heavy rainfall, deforestation in surrounding hills and unmanaged drainage system significantly contributes to risk of flooding. Another major hazard includes seismic activities occurring near the city area. As Ghorahi Sub-Metropolitan City, making the area vulnerable to seismic activities lies in Dang valley which is in the proximity of Main Frontal Thrust (MFT).

3.2 Impact on Urban Development: Haphazard and unmanaged urbanization in Ghorahi SubMetropolitan City is growing rapidly which makes the human settlement vulnerable to geological hazards. These geological hazards can damage buildings, roads and other infrastructure as well as also disrupts essential services such as communication, water supply, electricity and transportation (shown in fig.2).

3.3 Mitigation of Geological Hazards: To mitigate flood risk, the city needs effective urban planning. Planning needs to identify safe zones for development of the settlement and also implement mitigation measures such as flood barriers and managed drainage systems. Furthermore, without the proper risk management strategies the city gets exposed to seismic hazards. However, the city can grow towards healthy urbanization through land use zoning, developing early alarm system, and constructing earthquake-resistant infrastructure.



Figure 2: Flood disrupting transportation in Lamahi-Ghorahi road section (source: myrepublica newsportal)

4. DISCUSSION

Nepal is rapidly urbanizing. Until 2014, only 20% of the total population lived in urban areas, but in 2015, over 65% of people were classified as urban dwellers (Bhattarai, K., Conway, D. 2021). Thus, the importance of planning the city and mitigating geological hazards increases significantly. Vast difference can be observed between planned and unplanned areas within Ghorahi Sub-Metropolitan City, as people in unplanned areas are developing settlements even in flood prone areas (shown in Figure 3). People in unplanned urban areas are also informed about geological hazards. However, people tend to neglect the vulnerability in order make settlements more cost effective, which ultimately force changes in land use planning.



Figure 3: Contrast between planned and unplanned urbanization within Ghorahi Metropolitan city

Moreover, flood has resulted in the death of 71 peoples within Ghorahi Sub-metropolitan city in Last 5 years (source: The Himalayan Times). Thus it is important to expand our understanding regarding causes and consequences of flooding events to inform urban planning. (Acharya, P., Shukla, A. 2022.). Since 2023, Ghorahi has had 20 earthquakes of magnitudes above 2 and up to 5.7 within up to 100 km (63 mi) distance (source: allquakes.com). Proper understanding of seismic vulnerability of critical infrastructure is therefore essential for disaster risk reduction (Gautam .D, Rupakhety, R, 2021).

5. CONCLUSION

The geological hazards in Ghorahi Sub-Metropolitan City, including flooding and seismic activity have a significant risk to city's population and infrastructure hampering the urbanization of city. Ghorahi Sub-Metropolitan City requires proper risk management such

that integrating detailed study of the geological hazards into urban planning and development. Proper mitigating strategies need to be implemented in the city such as reforestation particularly on the outside hills, construction of flood barriers and implementation of earthquake resistant building practices. Overall, the research demonstrates the influence of geological hazards for developing safe and sustainable urban areas.

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Assessing the impact of climate change on Glacial Lake Outburst Flood in Nepal Himalaya

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ABSTRACT Glacial Lake Outburst Flood (GLOFs) represents a significant natural hazard in Nepal Himalaya, where climate change is accelerating the melting of glaciers and increasing the likelihood of catastrophic drainage events. GLOFs can endanger thousands of people, hundreds of villages, and critical infrastructure such as trails, bridges, and hydropower plants. A comprehensive study was conducted to assess the status of glacial lakes and GLOF risk in Nepal. The evaluation framework was applied to 24 potentially dangerous glacial lakes, with Tsho Rolpa Lake identified as having the highest national exposure and impact. The assessment provides valuable information for GLOF risk management in Nepal and describes a detailed methodology that can be applied throughout the Himalayan region. However, region-wide cooperation is needed to develop a more coordinated approach and establish a glacial lake outburst risk reduction policy.

Keywords: Climate change. Glacial Lake Outburst Flood (GLOF), Risk assessing, Adaptive Strategies

1. BACKGROUND

Glacial Lake Outburst Flood (GLOFs) are the type of catastrophic flood that occurs when the dam containing a glacial lake fails, releasing the water stored within. These events can be extremely destructive causing significant damage downstream. Climate change is the major driver of increased GLOF risk, as it leads to glacier retreat and the formation and expansion of glacial lakes. The increase in air temperature and changes in precipitation amount, frequency, and pattern are prominent signals of climate change—directly or indirectly responsible for majority of the environmental changes. The high mountain regions of Asia are highly sensitive to climate change and are prioritized as one of the vulnerable regions as the accelerated glacier shrinkage would affect millions of people in future (Kraaijenbrink et al. 2017; Hock et al. 2019). Nepal has a history of devastating GLOFs. The Dig Tsho GLOF in 1985 serves as a stark reminder of the destructive potential of these events. Studying past occurrences helps scientists understand the mechanisms of GLOF formation and develop better prediction and mitigation strategies. ICIMOD (2003) provides a detailed analysis of climate change impacts on glaciers and glacial lakes in the Nepal Himalayas, emphasizing the increasing risk of GLOFs due to rising temperatures and altered precipitation patterns.

The GLOF threat in Nepal is not just a local issue. The downstream impacts can affect millions across the region. Additionally, the disruption of water resources due to GLOFs can have cascading consequences for agriculture, hydropower generation, and overall ecosystem health.

2. AIM AND OBJECTIVE

This study aims to assess the impact caused by climate change in glacial lake outburst flood in Nepal. The objectives of this study are:

- To analyze the past records of GLOF to assess the impact and future consequences caused by retreat of glacier.

- To analyze the impact of climate of climate change in increasing glacial lake outburst flood.

Research Question: This article intends to answer the following questions:

1. What is the impact of climate change on Glacial Lake Outburst Flood in Nepal Himalaya?
2. What are the possible mitigation measures and how to minimize their impact?

3. MATERIALS AND METHODS

The article primarily relies on the analysis and interpretation of secondary data strongly emphasize on desk studies. The materials used for the study include books, journals, newspaper, published reports and articles from national and international agencies.

4. RESULTS

There has been a notable increase in the frequency and intensity of GLOFs in Nepal Himalaya over the past few decades. Historical data shows the rising trends of GLOF events with increase glacier melt and formation of new glacier lakes. There is clear upward trend in average temperatures in the Nepal Himalaya, accompanied by changes in precipitation patterns. Climate records indicates rise in temperature by 0.2° to 0.6° per decades, including increased heavy rainfalls. Kraaijenbrink et al. (2017) explore the impact of a 1.5° C global temperature rise on Asia's glaciers, noting significant implications for glacier melt and glacial lake stability.

The areas of Tsho Rolpa, Thulgai and Imja Glacier are most vulnerable areas for GLOFs events occurring in near future. Watanabe, Kameyama, and Sato (1995) examine the melt rates and changes in the Imja Glacier, discussing the potential dangers of lake drainage and the need for continuous monitoring. Extreme events such as heavy snowfall or high temperature could destabilize the lakes. Earthquakes could also affect moraine and lake stability, however assessment of the potential danger of glacial lake outburst as induced by earthquake tremor is likely beyond current competence. All three lakes need to be monitored for seepage which can cause moraine dam failure by piping or undermining.

GLOFs have significant impacts on downstream communities causing loss of life, property damage and disruption of livelihoods. A case study from past GLOFs events, such as Dig Tsho and Tama Pokhari floods, highlights the devastating effects on infrastructure, agriculture and human settlements.

Table 1.1: **GLOF events recorded in Nepal** (after Moo! et al. 1995, 2001a: Yamada 1998a : Bajracharya et al. 2008; Ives et al. 2010)

S.N	Glacial Outburst Flood events in History of Nepal	Date	Causes	Impacts
1.	Seti Khola {Macchapuchhre Lake}	450 years ago,	Moraine Collapse	Pokhara Valley covered by 50-60m deep sediments.
2.	Dudh Koshi {Nare Lake}	3 Sep 1977	Moraine Collapse	Human lives, bridges and others
3.	Tamar {Nagma Pokhari}	23 Jun 1980	Moraine Collapse	Villages Destroyed 71km from source.
4.	Dudh Koshi {Dig Tsho}	4 Aug 1985	Ice Avalanche	Human lives, hydropower station,

				14 bridges.
5.	Tama Koshi (Chubung Lake)	12 Jul 1991	Moraine Collapse	Houses, farmlands
6.	Dudh Koshi (Tama Pokhari)	3 Sep 1998	Moraine Collapse	Human lives and more than Nrs. 156 million
7.	Madi River (Kabache Lake)	15 Aug 2003	Moraine Collapse	Not known
8.	Madi River (Kabache Lake)	Unknown	Moraine Collapse	Not known
9.	Arun River (Barun Khola)	Unknown	Moraine Collapse	Not known
10.	Arun River (Barun Khola)	Unknown	Moraine Collapse	Not known
11.	Dudh Koshi (Chokarma Cho)	Unknown	Moraine Collapse	Not known
12.	Kali Gandaki (Mustang)	Unknown	Moraine Collapse	Not known
13.	Kali Gandaki (Mustang)	Unknown	Moraine Collapse	Not known
14.	Mugu Karnali (Unnamed)	Unknown	Moraine Collapse	Not known
	Flood events originated from China region			
15.	Sun Koshi (Tara_Cho lake)	Aug 1935	Piping	66,770sq. km of wheat fields, livestock etc.
16.	Trishuli (Longda)	25 Aug 1964	Not Known	Not known
17.	Arun River (Gelhaipuco)	21 Sep 1964	Glacier surge	Highway and 12 trucks
18.	Sun Koshi (Zhangza ngbo)	1964	Piping	No remarkable damage
19.	Arun (Ayaco)	1968	Not known	Roads, bridges etc.
20.	Arun (Ayaco)	1969	Not known	Not known
21.	Arun (Ayaco)	1970	Not known	Not known
22.	Sun Koshi (Zhangza ngbo)	11 July 1981	Ice Avalanche	Hydropower station
23.	Arun River (Jinco Lake)	27 Aug 1982	Glacier surge	Livestock, farmland
24.	Trishuli (Zanaco)	6 Jun 1995	Not known	Not known

5. DISCUSSION

Augmenting temperatures in the Himalaya accelerate the melting of glaciers leading to expansion and formation of glacial lakes. Changes in precipitation patterns including

increased frequency and intensity of monsoon and unseasonal rain, can destabilize glacial lakes. Heavy rainfall adds to the water volume in lakes, while also potentially triggering landslides and avalanches that can cause outburst. The accumulation of meltwater increases hydrostatic pressure against natural dams which can cause fail under pressure, releasing vast quantities of water downstream. The 1985 Dig Tsho GLOF in Nepal which causes significant damage was a result of such a pressure build up. The destruction caused by GLOFs results in substantial economic losses, disrupting livelihoods, especially in regions dependent on agriculture and tourism. Displacement of communities and long-term rehabilitation pose significant social challenges. The psychological impact on the affected populations is profound. Key feature including hydrometeorological conditions such as lake water level, excessive drainage, or extreme climatic conditions and dam conditions such as subsidence or collapse of lateral or terminal moraines and moraine dam crest height and width should be monitored. Construction of controlled drainage systems, reinforcing natural dams, building artificial barriers can mitigate the risk of sudden outbursts. By combining scientific research, technological innovations and community engagement, it is possible to mitigate the impacts GLOFs and protect vulnerable populations and ecosystems.

6. CONCLUSION

The impact of climate change on glacial lake outburst floods in the Nepal Himalaya is profound, with significant increases in the frequency and intensity of GLOFs. The expansion and formation of glacial lakes, driven by rising temperatures and changing precipitation patterns are the most contributing factors that heightened the risk. To protect vulnerable downstream communities, it is essential to continue monitoring climatic and hydrological changes, implement early warning systems and develop comprehensive adaptation. UNDP (2015) highlights the importance of community-based approaches to reduce GLOF risks, stressing the need for local involvement in mitigation strategies.

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GIS and Remote Sensing: Contemporary Technologies of Paramount Importance in Hydrogeology

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Abstract: This Article attempts to enlighten the gist definition of Geographic Information System (GIS) and Remote Sensing (RS), illustrating their contributions in Hydrogeological Investigations. The use of GIS allows for the efficient management and spatial analysis of large datasets, enabling the visualization of complex hydrogeological phenomena. Remote Sensing, through Satellite imagery and aerial photography, provides critical information on Hydrogeological patterns over time. This paper reviews the applications of GIS and RS in hydrogeology, highlighting their utility in identifying groundwater potential zones, mapping surface and subsurface water features, and assessment of groundwater recharge and contamination. The use of GIS and RS has improved the accuracy and efficiency of groundwater resource management, revolutionizing the way hydrogeologists collect, analyze and interpret the relevant data. The Article concludes by discussing future trends and the potential for these technologies to further advance hydrogeological research and practice.

Keywords: *Geographic Information System (GIS), Remote Sensing (RS), Hydrogeology, Groundwater.*

I.BACKGROUND

We are slowly getting more and more integrated towards the digital world. Digital Technologies are ushering in a new era of development. Likewise, GIS is one of the emerging technologies that has contributed in making the individuals and organizations better understand spatial patterns and relationships. Geographic Information systems combine interactive mapping with a database and analytical tools that are optimized for exploring geographic relationships (Daniel C. Edelson 2014). Remote Sensing has been defined as the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a sensor that is not in direct contact with the target of investigation (RITCHIE, J. C., and RANGO, A. 1996).

The potential of remote sensing for hydrological applications began to be recognized in the 1960s with the advent of orbital space flights. By the 1970s and 1980s, the development of improved sensors, including multispectral and thermal scanners, expanded the capabilities of remote sensing. The integration of Geographic Information Systems with remote sensing data became prominent in the late 1980s and early 1990s (Hoffmann and sander 2006). This combination allowed for the spatial analysis of hydrological data, enhancing the ability to model groundwater systems and assess water resource management strategies. However, The Remote sensing and GIS technologies are being practiced for water resources development and management since the first Landsat satellite was launched in 23 July 1972 by NASA (Tiwari, G., and Shukla, J.P. 2015). In present scenario, GIS and remote sensing are used extensively in hydrogeology for various applications, including groundwater modeling, flood risk assessment, and monitoring changes in land use and climate impacts on water resources.

Aim

This article is mainly concerned to explore how GIS and Remote Sensing technologies can be integrated to enhance the assessment and management of groundwater resources, particularly in areas lacking detailed geological data.

Objectives

1. To present various case studies that illustrate the successful application of GIS and remote sensing in hydrogeology.
2. To assess the challenges and limitations associated with the use of remote sensing and GIS in hydrogeology.
3. To identify future research directions and technological advancements in GIS and remote sensing that could further enhance their application in hydrogeology.

Research Questions

1. How can GIS and remote sensing techniques be integrated to identify and map groundwater potential zones?
2. How can GIS be used to combine spatial data from various sources to provide meaningful recharge estimates for large areas?
3. How can the integration of remote sensing and GIS be improved to provide more reliable and accurate information for groundwater resource assessment and management?

2. MATERIALS AND METHODS

This article was prepared by gathering all the necessary information about GIS and Remote sensing, its history, applications in hydrogeology, recent trends and future directions from secondary materials such as scientific Journals, Research Papers and extensive review of existing literatures from various reputed websites (link.springer.com, researchgate.net, mdpi.com etc.)

3. RESULTS

Remote sensing techniques enable the identification of aquifer recharge areas by analyzing vegetation patterns, soil moisture, and surface temperature changes. GIS allows for the extraction and analysis of lineaments and drainage networks from remote sensing data and integrates various thematic layers, such as land use, lithology, and geomorphology, to create groundwater potential maps (Figure 1). Successful utilization of multispectral satellite imagery and geospatial modeling techniques help to assess various water quality parameters such as turbidity, chlorophyll concentration and total suspended solids. Integration of these parameters with field monitoring helps in the identification of contamination zones and high-resolution mapping of contamination zones will further help in allocating remediation efforts to the critically affected areas. GIS and remote sensing data, including Digital Elevation Models (DEMs) and satellite imagery, can be used to map flood-prone areas, model flood dynamics, and assess flood risks which is crucial for water resource management and disaster preparedness. GIS provides a platform for modeling and visualizing surface water features, such as rivers, lakes, and wetlands, using datasets like the national hydrography dataset (NHD) and Watershed Boundary Dataset (WBD). By integrating satellite derived rainfall data with GIS, Thematic maps can be generated to identify areas with high runoff potential, which aids in water resource planning and management.

Despite being indispensable tools in modern world, many developing countries are still unfamiliar about GIS and Remote Sensing. For Instance, Nepal as a developing country is long way back in acquainting these technologies in diverse sectors. One of the major reasons behind

this is lack of awareness about the capabilities and benefits of GIS and Remote Sensing technologies among potential users and even if they are aware, the hindering factor can be Inadequate Finances. Developing countries often face budget constraints for acquiring the necessary hardware, software, and infrastructure to support GIS and remote sensing technologies. They also lack comprehensive, high-quality spatial and demographic data required for GIS and remote sensing applications. There is also shortage of skilled personnel with the necessary expertise to effectively implement and utilize GIS and remote sensing. However, overcoming these hurdles is not an impossible task. Hence, evolvement of these technologies in developing countries in near future can be expected.

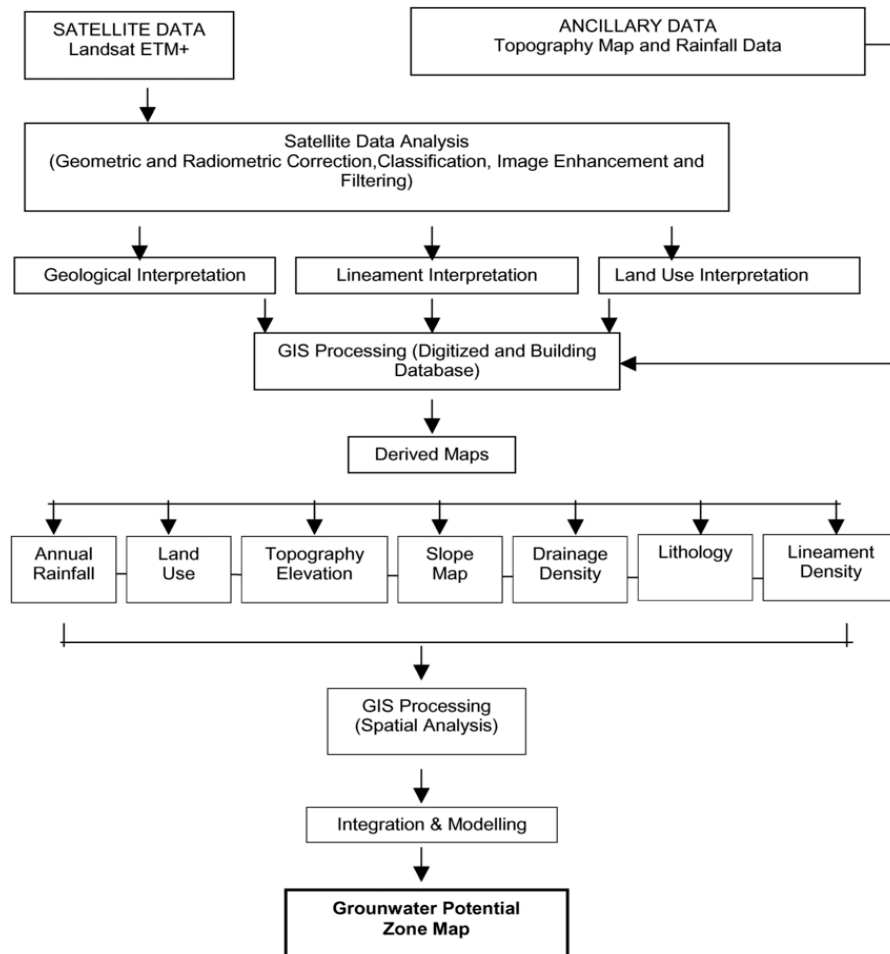


Figure 1: Methodology Flowchart for Groundwater Exploration (source: Researchgate.net Sener,E., Davraz, A. and Ozcelik, M. (2005).

4. DISCUSSION

As per the Result, the integration of GIS and remote sensing provides a robust framework for mapping groundwater potential zones, Water Quality Monitoring, Flood Risk Assessment, Artificial Recharge site investigation, Groundwater Recharge Assessment and hydrological Modeling. Remote sensing and GIS technologies are without doubt the backbone of hydrogeological reconnaissance in areas of the world where the coverage of detailed geological maps and field data is insufficient (Hoffmann and sander 2006). While remote sensing and GIS offer powerful tools for hydrogeological assessments, their effectiveness is often constrained by data quality, integration

challenges, the need for ground validation, and resource limitations. Addressing these challenges in developing countries is crucial for future advancements. Capacity-building initiatives that focus on training local professionals and improving data infrastructure can enhance the ability to utilize these technologies effectively in groundwater studies.

5. CONCLUSION

The Article demonstrates how the integration of Geographic Information Systems (GIS) and Remote Sensing technologies has revolutionized the field of hydrogeology, providing powerful tools for the assessment and management of water resources. These technologies enable the collection, analysis, and visualization of spatial data, facilitating a comprehensive understanding of complex hydrogeological systems. However, it is essential to acknowledge the limitations with these technologies. Future advancements in sensor technologies, machine learning, and real-time monitoring systems hold great promise for overcoming these challenges and further improving the effectiveness of GIS and remote sensing in hydrogeology. As the demand for freshwater resources continues to grow amid climate change and increasing population pressures, the role of GIS and Remote Sensing will become even more critical.

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In Loving Memory



Prakash Das Ulak

2020/ 01/04 - 2081/ 07/ 14

We are deeply saddened to hear loss of our esteemed Ass.Prof Prakash Das Ulak. Please know that you have our heartfelt condolences. In this time of grief, may you find strength and solace in the embrace of family and friends who care deeply for you.