The Himalayan Geographers
A Peer-Reviewed Journal
Print ISSN 2362-1532
Email: geography@pncampus.edu.np
Journal Site: http://ejournals.pncampus.edu.np/thg
DOI: https://doi.org/10.3126/thg.v15i1.81399

Published by
Department of Geography
Prithvi Narayan Campus
Tribhuvan University
Pokhara, Nepal

Special Issue - **SILVER JUBILEE:** 15 May, 2025

"Bhimdhunga" and its Driving Force: Analysis with Reflection of the Pokhara Valley Formation, Nepal

Ramjee Prasad Pokharel
Department of Geography, Tribhuvan University, Prithvi Narayan Campus, Pokhara
Corresponding E-mail: ramjee.pokharel@prnc.tu.edu.np

Received: 15 March, 2025, Accepted: 5 April, 2025, Published 15 May, 2025

Abstract

The Pokhara Valley, located in the southern foothills of the Himalayas, has a complex geological history shaped by tectonic movements, glacial activity, and catastrophic natural events. Among its significant geological features Bhimdhunga (giant boulder), a massive rock weighing 1,439.37 tons, which raises important questions about its transportation from the Annapurna region to its present location. This study investigates the forces responsible for moving force such a giant boulder in present position. This study analysis that, the normal river flow, such as the Seti River, lacks the kinetic energy required to transport Bhimdhunga. Instead, a powerful natural event—such as a glacial outburst flood, an earthquake-triggered landslide, or a massive debris flow—was likely responsible. The force required to move the boulder was calculated to be around 756 million Newtons, far exceeding what a typical river current could generate. This suggests that glacial movement during the Ice Age transported Bhimdhunga, along with other large boulders like Chipledhunga in plain area. The study highlights that Bhimdhunga serves as an important geological marker, reflecting the fluvio glacial forces that shaped Pokhara Valley. The findings of this research reinforce the importance of shaping the Himalayan landscape and provide new insights into the tectonic and climatic history of Pokhara Valley. The study underscores the need to preserve such natural landmarks, as they offer valuable evidence of past geological transformations and help expand researchers understanding of tectonic and glacial dynamics in the region.

Keywords: *Bhimdhunga, Pokhara valley, Kinetic force, Seti River, formation, debris, driving force.*

Introduction

Geographically, the isolated rock known as Bhimdhunga (giant boulder) could represent a significant milestone in researching the historical formation of the Pokhara Valley and its current geography. There are substantial foundations suggesting a relationship between the materials accumulated in the Pokhara Valley and Bhimdhunga. This study discusses its location, postulating the driving factors that might have transported it from the Himalayan range.

A assumption is that sediment transportation and deposition processes might be directly related to the formation of the Pokhara valley floor. In relation to the diverse geographical settings of Nepal, Pokhara is situated at the lap of the Annapurna mountain range, surrounded by green hills and seven lakes, along the bank of the Seti River. Natural features like Bhimdhunga epitomize the complex and enigmatic reality of Pokhara. The deep gorge created by the Seti River, the expansive landscape of Bhimkali Patan to the north of Pokhara Metropolitan City (PMC), and the positioning of Bhimdhunga at the present Prithivi Narayan campus premises could be interconnected.. If this rock was situated on the terrace of the Seti River, it would likely not be a significant concern for researchers. According to local folklore, Bhim, the son of Bayu and brother of Yudhisthira, thrown this stone by him and also some fables associated with created a dam called Bhim Dam near Bhimad Bazar, approximately 30 km southeast of Pokhara. It is said he placed this stone there, which is why it is called Bhimdhunga. However, this is not supported by geographical history. Some Newars from Bhaktapur migrated to Pokhara in the eighteenth century, viewing Bhim as a deity and worshiping him. They constructed structures around this rock and worship Bhim as their family deity. In connection with this rock, ward no. 1 of Pokhara Metropolitan City has been named Bhimkali Patan.

Observations and studies of the plain area around Prithivi Narayan Campus and the river terrace alone are insufficient to understand Bhimdhunga comprehensively. It necessitates a detailed study of the rock and the entire valley, including the surrounding area. Bhimdhunga may be connected not only to the structure of the valley but also to the overall structure of the Himalayan range. However, this study attempts to justify the formation process of the Pokhara valley and the sediment transportation forces with the help of Bhimdhunga's position. This study focuses on analyzing its weight and the factors influencing its current situation in the mountainous region. Therefore, this study aims to analyze the tentative weight and triggering forces of Bhimdhunga and predict the depositional agents in the Pokhara Valley, the situation of Bhimdhunga, and the forces that may have shifted it to its present location.

Review of related literature on Pokhra formation

The presence of massive boulders, including Bhimdhunga, suggests a dynamic geological history involving catastrophic seismic and glacial events. Numerous studies have explored the formation processes of Pokhara Valley, analyzing the role of mega-earthquakes, debris flows, and fluvial aggradation. This literature review synthesizes the existing research and contextualizes the geological significance of Bhimdhunga within the broader framework of Pokhara Valley's evolution. Alomg the Seti Gandaki River and Pokhara Valley there are several river trace whcih are classified by Hormann (1974)

Hagen (1969), Gurung (1970), and Sharma (1975) conducted the first detailed studies on the Pokhara Valley's geological evolution. They identified Quaternary river terraces in the valley (Sharma et.al, 1980) and suggested that the deposits resulted from large-scale sedimentation events. Yamanaka (1982) provided a significant breakthrough by applying radiocarbon dating techniques to the Pokhara formation, concluding that its gravels were deposited in catastrophic events between 500 to 1000 years ago. Bernhardt et al. (2014), who re-evaluated the valley's catastrophic infill and attributed it to massive debris flows, later supported this interpretation. Stolle et al. (2017) further confirmed that at least three episodes of catastrophic sedimentation occurred between 700 and 1700 AD, coinciding with three major earthquakes (1100, 1255, and 1344 AD). These seismic events resulted in over 5 km³ of debris deposition, significantly altering the valley's landscape. The sediments filling the Pokhara Valley were not sourced locally but were transported over 70 km downstream from the Higher Himalaya, where they blocked tributaries and led to the formation of floodplain lakes (Stolle, 2018).

Fort & Freytet (1983) highlighted the glacio-fluvial deposits in the Pokhara Valley with climatic cooling and high-energy transport mechanisms. Recent studies (Fort, 2022) reinforce the idea that massive debris flows rapidly filled the Pokhara Valley, damming adjacent river valleys and leading to large-scale flooding events. The remaining lakes in the region, such as Phewa, Rupa, and Begnas, are likely remnants of this process (Poudel & Shrestha, 2025). Schwanghart et al. (2014, 2015) provided further insights into the Pokhara Formation, revealing that it consists of poorly sorted, gravelly fluvial materials interbedded with debris flows and mudflows. These findings suggest highly energetic transport conditions, likely triggered by at least three medieval mega-earthquakes (M>8).

Bhimdhunga's position, near the deep Seti River gorge and Bhimkali Patan**,** suggests that its placement is connected to Pokhara Valley's history of earthquakes, landslides, and fluvialglacio movements**.** This boulder serves as an important geological marker**,** helping researchers understand how natural forces including seismic have shaped the landscape over time**.**

While scientific research supports a geological explanation for Bhimdhunga's presence, according to the local folklore attributes from Mahabharata it was believed to be brought by Bhim.

Limitation of the study

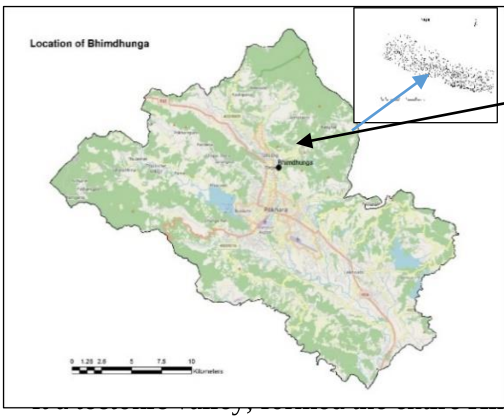
In reality, Bhimdhunga stands as a significant geological monument in the Pokhara Valley, representing the physical structures of this region. Several factors may be associated with the fascinating history of this rock. Limited evidences about the movement of Bhimdhunga is presented without the radiometric dating prevents precise chronological mapping of its movement However, this study focuses on the driving forces that speculated for its transportation to its current location and the processes associated with the formation of the present-day Pokhara Valley floor.

Situation of Pokhara and Bhimdhunga

Geographically, the Pokhara Valley is situated in the southern lap of the Annapurna Range of the Himalayas. Specifically, it extends from 27˚55' north to 28˚33' north latitude and from 83˚48' east to 84˚11' east longitude. Within Kaski District, its reach extends from Ghachowk in Pokhara to Khairani Tar

Figure 1

Location map of study area



Originally, there was a deep lake in this area, which transformed into the present plain due to the ongoing accumulation of various sediments. The geographical position of Bhimdhunga is at 28˚ 14' 22" north latitude and 83˚ 59' 31" east longitude (Figure 1). This rock is positioned at an elevation of 915 meters (as measured by GPS) above sea level. It is evident that the massive rock, Bhimdhunga, represents both the ancient and current relationship between the rock and the materials forming the Pokhara Valley.

Methods and materials

This study is based on both exploratory and analytical in nature. Bhimdhunga serves as the object of study, with its physical characteristics such as circumference, height, assumed depth, and volume being calculated using a sample piece of the huge stone. Previous logical conclusions about Bhimdhunga are referenced based on the researcher's personal observations of the rock's situation, the flow of the Seti River, and the river terraces along the Seti. In addition, secondary documents related to the formation of the Pokhara Valley were consulted. Beyond the researcher's personal experiences, rounds of discussions with seismologists and geographers were also conducted. The circumference of Bhimdhunga is an average of 32 meters, assuming that 3 meters of its part is buried underground. Its height is 11 meters and it is nearly round. A sample rock weighing approximately 500 grams, with a length of 7 cm, a breadth of 6.96 cm, and a height of 3.15 cm, has been used to calculate the volume, density, and weight of Bhimdhunga. After these calculations, the study focuses on predicting the forces that might have driven or triggered from the upper regions to its current location. The calculations are detailed as:

The method used to calculate the volume, density, mass, and weight of Bhimdhunga, based on sample pieces. The average circumference of Bhimdhunga is taken as 30 meters. For the sample pieces, the dimensions are as follows: length (l) = 7 cm, width (b) = 6.96 cm, height (h) = 3.15 cm, and the weight of each sample is 500 grams. The volume of the sample pieces is calculated by multiplying the length, width, and height, yielding a sample volume of 153.46 cm^3 ($7 \times 6.96 \times 3.15$). To calculate the density, the mass (weight) is divided by the volume. We know density of a substance is given by;

$$Density\ (d) = \frac{Mass}{Volume}$$

The method used to calculate the volume, density, mass, and weight of Bhimdhunga, based on sample pieces. The average circumference (C) of Bhimdhunga is taken as 30 meters.

The dimensions of the samples are as follows:

Length (l) = 7 cm, Width (b) = 6.96 cm, Height (h) = 3.15 cm and the weight of each sample is 500 grams. So that volume (V) of the sample is,

$$V = l \times b \times h = 7 \times 6.96 \times 3.15 = 153.46\ cm^3$$

And density (d) of the sample is,

$$d = \frac{mass}{volume} = \frac{500\ g}{153.46\ cm^3} = 3.26\ gcm^{-3} = 3260\ kgm^{-3}$$

The volume of total size of Bhimdhunga (taking as a spherical object),

$V = \frac{4\pi}{3} r^3$ and $r = \frac{circumference(C)}{2\pi} = \frac{30\ m}{2\pi} = 4.78\ m$

So that, $V = \frac{4\pi}{3}(4.78)^3 = 457.48\ m^3$

Hence total mass, $M = d \times V = 3260 \times 457.48 = 1491384.8\ kg$

Therefore, the total mass of the Bhimdhunga = 1491.38 tons.

This study aims to investigate the origins of Bhimdhunga and the forces responsible for its transportation. It is hypothesized that flash flood, glacio-fluvial activity, debris flow, or other geological processes played a role in displacing the rock from its original location.

Seti Gandaki River profile: from Annapurna Range to Prithvi Narayan Campus, Pokhara.

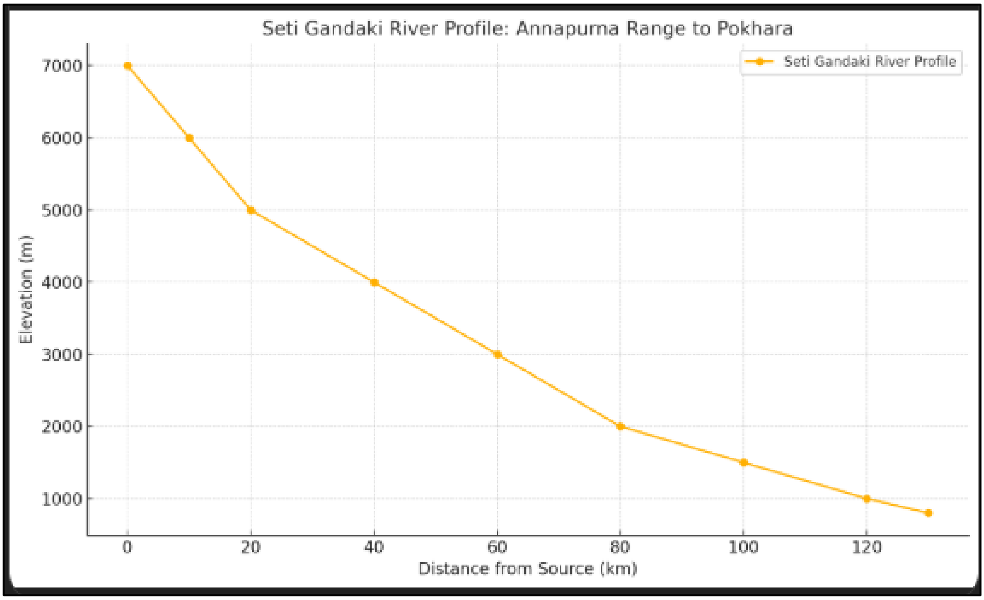
The Seti Gandaki (White River) is one of Pokhara's iconic rivers, originating from the snowfields and glaciers of the Annapurna range. This river flows through a deep gorge in Pokhara, contributing to its scenic beauty, biodiversity, and hydrological significance. The Seti River has carved through sedimentary and metamorphic rocks, creating steep-sided gorges. Limestone and shale dominate the region, making the area prone to erosion and cave formation. The riverbed is mostly rocky with sediment deposits of gravel and sand, The river is fed by snow melt from the Annapurna range, making its flow seasonal and highly dependent on monsoon rainfall, too. The Seti River is joined by several smaller streams originating from the surrounding hills and glaciers. The Seti Gandaki River is not just a natural marvel but also a vital ecological and cultural asset for Pokhara (Khatri et al., 2025). The river creates deep gorges within sedimentary rocks near Pokhara, with some sections over

50 meters deep. Seasonal variations are prominent, with monsoon-fed torrents and lower flows in the dry season.

The channel longitudinal profile of the Seti Gandaki River reflects its role as a powerful erosive agent, shaping the landscape and supporting diverse ecosystems (Figure 2)

Figure: 2

Seti Gandaki river Profile Annapurna to Pokhara, (Bhimdhunga)



The figure 2 illustrates the course of the Seti Gandaki River, originating from the Annapurna Mountain Range (approximately 7,000 meters) and descending to the Pokhara Valley (at around 900 meters). The river follows a steep and dramatic path, carving deep gorges and valleys through the Himalayan terrain. Starting from the glacial regions of Annapurna, the river flows southward, with a dynamic course that includes sharp elevation drops, narrow channels, and widening sections near Pokhara. Key landmarks, including the river's glacial source and the urban hub of Pokhara, a crucial point in the river's journey, mark the path. This visualization highlights the river's vital role in shaping the landscape, supporting biodiversity, and providing resources to the communities in the region. The steep gradient and rugged terrain underscore the river's erosive power and its importance in the hydrological and ecological systems of the area.

Required force to move

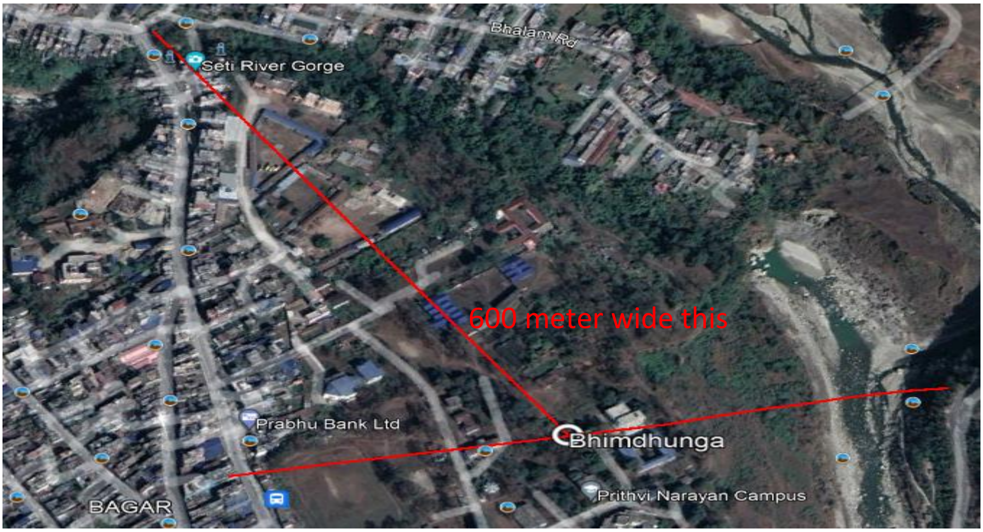
To transport a 1,491.38-ton boulder from the Pokhara Valley plains up to its current location which is approximately 20 km away at an elevation of 1,400 meters so the Seti River would require around 7,060 megajoules (MJ) of energy. This estimate focuses especially on the final 900-meter stretch, where the river's steep gradient would be critical for moving such a massive floating load (Fischer et al., 2006; Fossen, 2016). A megajoule (MJ) is a unit of energy equal to one million joules (1,000,000 J). It is part of the International System of Units (SI) and is commonly used to measure large amounts of energy, such as in physics, engineering, and energy consumption calculations of energy.

This energy comes from the force of flowing water and gravity. As the boulder moves downhill, it loses height, which provides potential energy. If all this energy were perfectly converted into movement, the river could carry the boulder. However, in reality, the river faces resistance from the ground friction and obstacles, meaning much more energy would be needed.

Only powerful natural events, like fluvio-glacial flashfloods or massive river flows, could have transported such a heavy rock. This supports the idea that Bhimdhunga was likely moved by a glacier or an extreme flood event in the past. But considering its elevation of 940 meters above the mean sea level, not possible existing glaciers due to its warm temperature and even no study reported this evidence.

Figure: 3

Bhimdhunga locates terrace width



Thus, a strong flashflood with the mixture of glacio-fluvial forces likely transported Bhimdhunga. The shape of Bhimdhunga is rounded which means it was settled after its long rotational slide. That is possible only in fluvial action. If it was resulted with the glacial action the shape should be flat and also no more enough materials to cover it from the top. Therefore, the geomorphological evedences clearly marked its fluvial action. Due to climate change, ice melted slowly into water, which could not transport such a heavy rock any further by normal volumes of water. The flood that followed the end of the Ice Age transformed multi-leveled Pokhara into a plain; however, it could not bury Bhimdhunga beneath the land surface. Rocks in the lowlands could be completely or partially buried. The slipping stone at Mahendra Bridge on the bank of the Seti River has been almost covered by the land mass. All these facts support the indication that the plain Pokhara Valley was formed by the flow of rivers, and Bhimdhunga was brought to its current location from the lap of the Annapurna range

Bhimdhunga is situated 50 meters above the Seti River and 100 meters from its bank. Despite the presence of many similar rocks along the banks, the Seti River lacks the kinetic energy required to transport a rock of Bhimdhunga's size; therefore, a flashflood flow must be responsible.

If the rock were transported by the river, it would have required a force of approximately 1,275,300 Newtons. Given the landscape, the Seti River would need to span about 600 meters in width from the gate of Prithvi Narayan Campus to the north side of Manipal Hospital. Another factor is that a rock of 11-meter height would require more than deep flowing water to roll. From K.I. Singh Pool (Bridge) to Bhimdhunga, there is a distance of about 620 meters with a height variance of 5 meters (Figure 3). Due to the lack of a steep slope, normal fluvial action cannot roll or move the rock from an upward to a downward side. If we assume that it emerged due to internal movement, there should be more rocks like Bhimdhunga on the surface. Based on the depositional materials of Pokhara, the Seti Gandaki river channel, and the potential huge flood impact index, etc., are insufficient to prove its driving forces.

Conclusion

Pokhara, located at the center of Nepal, is a tectonic valley shaped by fluvio-glaciall processes over thousands of years. The Seti River and its tributaries have carried and deposited various sediments, gradually filling deeper areas and forming the present-day flat valley floor. Among the many geological features in Pokhara, Bhimdhunga (giant boulder) stands as a significant natural landmark that provides key evidence of the valley's geological history.

It is widely believed that a flashflood with heavy sediment carried by fluvio glacial forces (a combination of running water and glacier movement) played a major role in shaping Pokhara rather than fluvial (river) deposition alone. If the Seti River alone had transported Bhimdhunga, it would have required far more kinetic energy than what is realistically possible under normal river flow conditions. Additionally, the massive weight of Bhimdhunga (~1491.38 tons) suggests that it could not have been carried solely by the river's force. Instead, flashflood with glacial activity, influenced by past climate changes, likely transported the boulder from the upper Pokhara region or the southern face of the Annapurna range.

There is no evidence of such conclusion. NO evidence of other parts of the Himalayas reported for glaciers existence in 940 m elevation. There was a history of Ice Age in 10,000 years ago and little Ice Age around 4000-3000 years ago, even those days glaciers advance in the Himalaya was reported only upto 2900 m above the sea level. The next evidence is the rounded shaped bounders which are only the evidence of fluvial down surge of mountainous topography (Baumler)

The Bhimdhunga stands as a symbol of Pokhara's geological evolution and a reminder of the ancient forces that shaped the valley. It is crucial for the scientific community, environmentalists, and local citizens to preserve and promote this natural moraine to safeguard the geological heritage of Pokhara for future generations. However, Bhimdhunga serves as a geological marker that reflects the dynamic history of Pokhara Valley's formation in Nepal.

References

Baumler, R., Kemp-Oberhettinger, M., Zech, W., Heuberger, H., Siebert, A., Madhikarmi, D. P., & Poudel, K. P. (1996). Soil weathering on glacial and glaciofluvial deposits in the Langtang Valley (Central Nepal) and its relation to the glacial history. *Zeitschrift für Geomorphologie, Supplementband, (103),* 373–387

Bernhardt, A., Stolle, A., Adhikari, B. R., & Korup, O. (2014). Reassessing catastrophic infill of the Pokhara Valley, Nepal Himalaya. *Conference Paper,* https://www.researchgate.net/publication/341313825.

Fischer, L., Kaab, A., Huggel, C., & Noetzli, J. (2006). *Geology and Energy of Glacial Landslides: Case Studies from the European Alps.* Engineering Geology, 83(1-3), 43-56.

Fishcer, M., Brettin, J., Roessner, S., Walz, A., Fort, M., & Korup, O. (2022). Rare flood scenarios for a rapidly growing high-mountain city: Pokhara, Nepal.

Natural Hazards and Earth System Sciences, 22(9), 3105–3123. https://nhess.copernicus.org/articles/22/3105/2022/.

Fort, M. (2022). The Pokhara Valley: A product of a natural catastrophe, in: Geomorphological Landscapes of the World, edited by: Migon, P., Springer Science + Business Media B. V., 265–274, https://doi.org/10.1007/978-90-481-3055-9_27, 2010.

Fort, M. and Freytet, P. (1983). The Quaternary sedimentary evolution of the in tramontane basin of Pokhara in relation to the Himalaya Midlands and their Hinterland (west central Nepal). In: Sinha, A. K. (Ed.), *Contemporary Geoscientific Researches in the Himalaya*, 2, 91-96

Fossen, H. (2016). *Structural Geology*. Cambridge University Press.

Gurung, H. (1970). Geomorphology of Pokhara Valley, *Himalayan Review*, II-III. 37-49.

Hagen, T., (1969). *Report on the geological survey of Nepal. Volume* 1: Preliminary econnaissance. Denkschiiften der SchweizerischenNaturforschendenGesellschaft, Band LXXXVI/, 1-185.

Hormann, K., (1974*). Die Terrassen an der Seti Khola – Ein Beitrag zur Quartären Morphogenese in Zentralnepal*. Erdkunde, v. 28, pp. 161–176. DOI:https://doi.org/10.3112/erdkunde.1974.03.01

Khatri, S. K., Hamal, R., Poudel, K. R., Poudel, K. P., & Paudel, N. (2025). Rainfall patterns and hazard susceptibility analysis of Pokhara City, Nepal : implication of climate change. Theoretical and Applied Climatology, 156:146. https://doi.org/10.1007/s00704-025-05384-4

Lamsal S., Sapkota N., Bhandari A., Gyanwali I., PaudyalK.R. and Paudel L. 2017). Geological investigation of river terraces along the Modi Khola valley, Parbat district, western Nepal Lesser Himalaya. *Nepal Geological Society*, 53, 31-37.

Poudel, K. R., & Shrestha, S. (2025). Urban Spatial Growth and Geo-Environmental Risk in Pokhara Metropolitan City : A Geospatial Analysis. *Nepal Journal of Environmental Science*, 13(1), 15–28. https://doi.org/10.3126/njes.v13i1.71842

Schwanghart, W., Bernhardt, A., Stolle, A., Adhikari, B. R., and Korup, O. (2014). Reassessing catastrophic infill of the Pokhara Valley, *Nepal Himalaya. Geophysical Research*, 16, EGU2014-15787, 2014 EGU General Assembly.

Selbi, M. J. (1985). *Earth's Changing Surface*, Clarend Press, Oxford.

Sharma, K. (1975). Geological survey and terrace identification in the Pokhara Valley.

Sharma, T., (1980). Origin of Quaternary deposits of Nepal and their neo-tectonic significance. *The Himalayan Review*, 12, 31-43.

Sharma, T., Upreti B. N., and Vashi, N. M., 1980, Kali Gandaki gravel deposits of central west Nepal-their neotectonic significance. *Tectonophysics*, v. 62, pp. 127–139.

Shresth, B. & Chhetri, D. B. (2008). *Pokhara Valley and Geological Prospective,* Ganga Shrestha & ParbatiChhetri, Pokhara

Singh, S. (1990) *Geomorphology*, Basundhara, Gorkhapur.

Stolle A (2018) Catastrophic Sediment Pulses in the Pokhara Valley, Nepal Katastrophale

Sediment Ablagerungen im Pokhara Tal, Nepal [Universitat Potsdam]. https://publishup.uni-potsdam.de/opus4-ubp/,frontdoor/index/index/year/2018/docId/41334

Stolle, A., Bernhardt, A., Schwanghart, W., Hoelzmann, P., Adhikari, B. R., Fort, M., & Korup, O. (2017). Catastrophic valley fills record large Himalayan earthquakes, Pokhara, Nepal. *Quaternary Science Reviews*, 177, 88-103. https://doi.org/10.1016/j.quascirev.2017.10.005.

UNDP. (2009). *Earthquake risk reduction and recovery preparedness programme for Nepal* cited .25/04/2009.

Yamanaka, H. (1982). Radiocarbon ages of upper Quaternary deposit in central Nepal and their geomorphological significance. The science reports of Tohoku University, *7th Series (Geography)*, (32) 1, 46-60.

***