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Short Communication

Physiographical and Geological Division of Nepal

Ramji Kshetri*

Department of Hydrogeology, Technische University Bergakademie, Freiberg, Germany

ABSTRACT

Nepal is a landlocked country located in South Asia, bordered by China to the north and India to the south, east, and west. The country's physiography and geology are diverse and complex, with various landforms and geological features formed by the convergence nature of the Indian and Eurasian tectonic plates. This study aims to provide an overview of Nepal's physiographical and geological division, including the prominent landforms and geological features that characterize the country's diverse landscape.

Keywords: Geology; Physiography; Tibetan-Tethys zone

ABOUT THE STUDY

Nepal is a small country with an area of 147,516 km^2 and is located between the Ganga plains and the Himalayan peaks in South Asia. The country is characterized by a diverse, rugged, undulating, and rough topography, a hot-cold climate, and is dominated by mountains and hills. Around 83% of the total area is occupied by mountains and hills, and the remaining part is plain land. From the elevation of 59 m south to 8848 m north within an average distance of 200 km [1], Nepal has different geography such as a high range of mountains in the north, a high hilly area in the middle, and flat land in the south. The geology is relatively young and tectonically active, and the mountain range is distinguished by high mountains cut by deep river valleys that undergo constant landscape evolution [2]. Being active and fragile in nature, earthquake is a common type of geological hazard also rugged topography, soft soil cover, and high intensity of rainfall during the monsoon season cause different mass wasting process such as landslide, debris flow, and soil erosion and deposition.

Methodology

Several scientific research papers, books, and the author's knowledge are used to write this article. The figures were developed in the ArcGIS software and geo-referenced through the WGS 1984 45 N geographic coordinate system by using different references which are given below each figure.

Physiography of Nepal

The Himalayas are the most active and fragile mountain in the world. It is characterized as a live mountain with active tectonics. The collision activities are still active, and this process, together with associated phenomena, resulted in the rise of the Himalayas.

The northward movement of the Indian plate into the more stable Tibetan plate contributed the geological hazard such as earthquakes. Furthermore, weak geological structures and triggering factors such as rainfall and earthquakes make the mountains highly vulnerable to landslides and other mass-wasting processes [3]. The combination of these processes makes each physiographic zone unique in terms of altitude, topography, climate, and vegetation.

In 1969 [4], Swiss geologist Toni Hagen successively divided Nepal into eight well-defined physiographic units from south to north [5], which is the most acceptable classification and represents all aspects of the physiographic zone in Nepal. The different physiographic units are, Terai (plain land), Dune Valley (valley formed by Siwalik hills), Siwalik (unconsolidated materials with small hills), Mahabharat (rugged terrain, sharp crests, and steep slopes), Midland (gentle topography, wide river valleys, and mild temperature climate), Fore Himalaya (more rugged and steeper slope, high altitude, snowfall in winter, and warm summer), Higher Himalaya (extremely rugged terrain, very steep slope, deeply cut valleys, and permanent snow cover), and Trans Himalaya (rain shadow zone and dry throughout the year) from south to north. The physiographic division of Nepal is shown in Figure 1, and each geomorphic unit is described below (Table 1).

Correspondence to: Ramji Kshetri, Department of Hydrogeology, Technische University Bergakademie, Freiberg, Germany, Tel: +49-17673508647; E-mail: ramkshnpl@gmail.com

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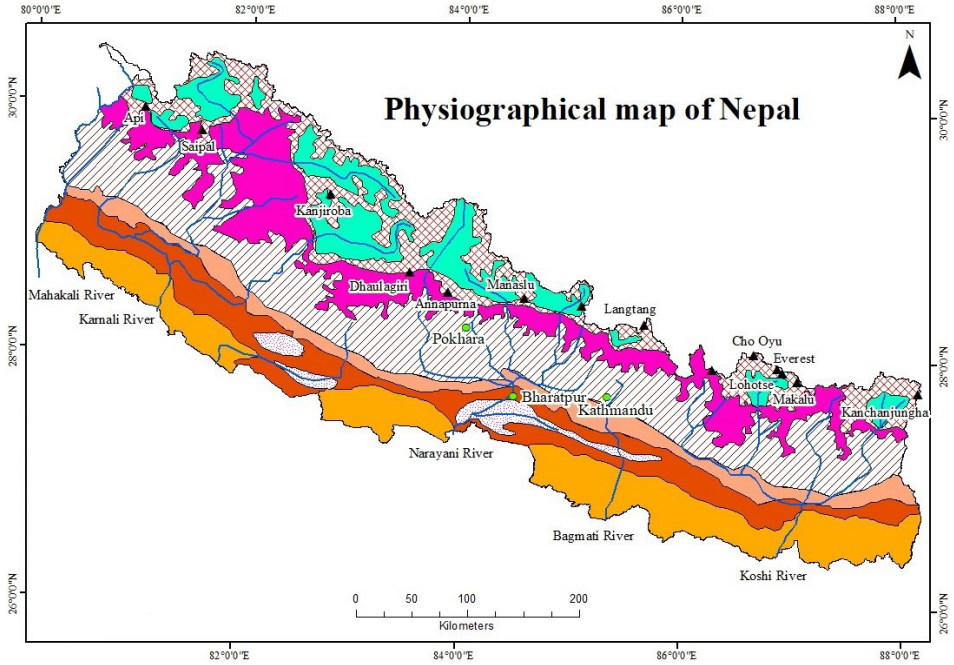

Figure 1: Physiographic division of Nepal. **Note:** Digitized after Upreti, [3], Dahal [5], and Dhital [6]. **Note:** (▲) Peak, (●) Place, (——) River, (▭) No data, (▭) Trans Himalaya, (▭) Higher Himalaya, (▭) Fore Himalaya, (▭) Midlands, (▭) Mahabharat range, (▭) Dun valleys, (▭) Siwalik range, (▭) Terai.

Table 1: Physiographical division of Nepal, Source-Upreti, [3], Dahal [5].

S. No.	Geomorphic unit	Width (km)	Altitude range (masl)	Main rock types	Age	Main process for landform development
1	Terai (Northern edge of Indo-Gangetic plain)	10-50	100-200	Alluvium: Coarse gravel in the north near the foot of the mountains, gradually becoming finer southward.	Recent	River deposition, erosion, and tectonic upliftment
2	Siwalik (Churia) range	10-50	200-1300	Sandstone, mudstone, shale, conglomerate	Mid-Miocene to Pleistocene	Tectonic upliftment, erosion and slope failure
3	Dun valleys	5-30	200-300	Valley within the Churia hills filled up by coarse to fine alluvial sediments	Recent	River deposition, erosion and tectonic upliftment
4	Mahabharat range	10-35	1000-3000	Schist, phyllite, gneiss, quartzite, granite, and limestone belonging to the lesser Himalaya zone	Precambrian, Paleozoic	Tectonic upliftment, weathering, erosion and slope failure
5	Midlands	40-60	200-2000	Schist, phyllite, gneiss, quartzite, granite, and limestone belonging to the lesser Himalaya zone	Precambrian, Paleozoic to Mesozoic	Tectonic upliftment, weathering, erosion, and slope failure
6	Fore Himalaya	20-150	2000-5000	Gneisses, schists, phyllites and marbles mostly belong to the northern edge of the lesser Himalaya zone	Precambrian	Tectonic upliftment, weathering, erosion and slope failure
7	Higher Himalaya	10-60	>5000	Gneisses, schists, migmatites, and marbles belonging to the higher Himalaya zone	Precambrian	Tectonic upliftment, weathering, erosion (rivers and glaciers), and slope failure
8	Trans Himalaya	5-50	2500-4500	Gneisses, schists, and marbles of the higher Himalaya zone and Tethys sediment (limestones, shale, sandstone, etc.)	Precambrian and Cambrian to Cretaceous	Tectonic upliftment, wind, and glacial erosion, and slope degradation by rock disintegrations

Geology of Nepal

The Himalayan range is the result of the collision of the Indian and Tibetan plates, which began 55 million years ago and is still ongoing. That is why the Himalayas is known as the world's youngest mountain. The collision actions continued, and this process, together with accompanying phenomena, gave rise to the Himalayas. Nepal is in the central Himalayas and covers up to one-third of the 2400 km long Himalayas. The dynamics of this continent-continent collision result in surprisingly different geological environments within Nepal's short width of about 250 kilometers. The plate movement dynamics combined with other geological and geographical conditions with a high degree of topography change make Nepal Himalayas complex and unique and contribute to geological hazards such as earthquakes, landslides, and slope failure [6]. Nepal Himalayas is divided into different tectonic zones, and each tectonic zones has separated by thrust faults shown in Figures 2 and 3.

Terai zone: Terai zone is a completely plain area, less than 200 m above sea level, and has a thick layer of alluvial sediments (nearly 1500 m) primarily containing boulders, gravel, silt, and clay. Terai zone extends from the Indian Shield in the south to the Siwalik zone in the North. Terai zone ranges in width from 10 to 50 kilometers and forms an almost continuous belt from east to west, although it has been interrupted by the Siwalik zone in two places. The active fault system MFT (Main Frontal Thrust) with Siwalik in the north.

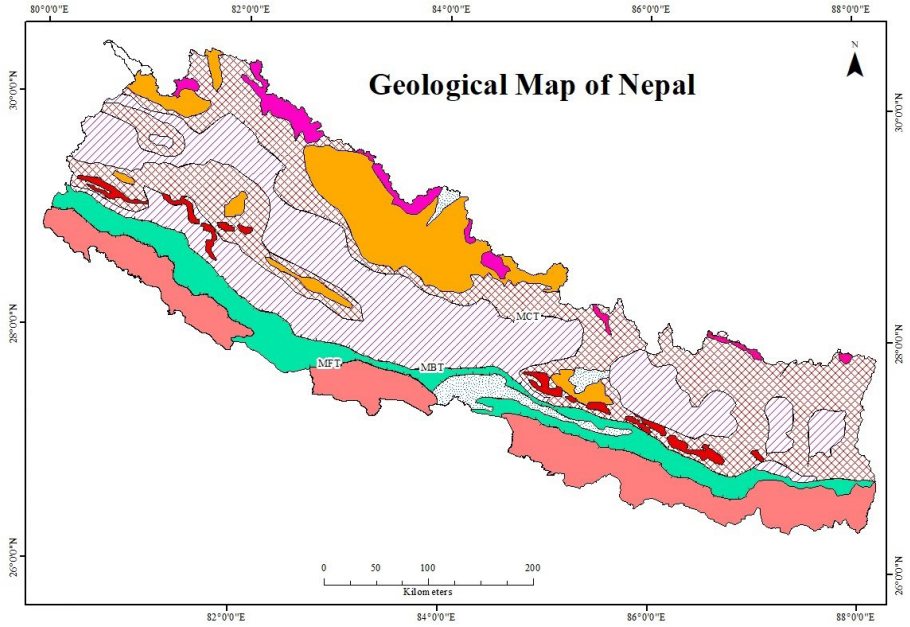

Figure 2: Geological division of Nepal. **Note:** Digitized after Upreti, [3], Dahal [5], and Dhital [6]. **Note:** (—) Thrust, (□) No data, (■) Tertiary leucogranite, (■) Tibetan-Tethys zone, (■) Higher Himalaya zone, (■) Lesser Himalayan zone, (■) Palaeozoic granite, (■) Recent deposits, (■) Sub-Himalayan (Siwaliks), (■) Terai Zone.

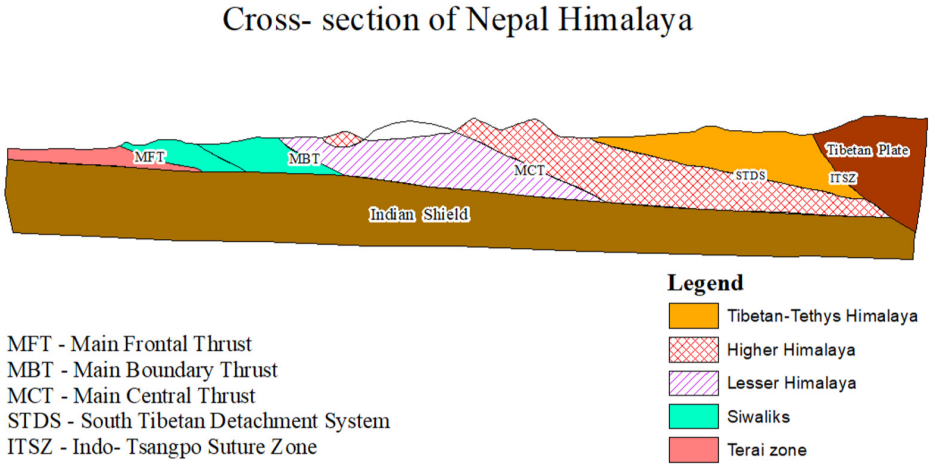

Figure 3: Geological cross-section of Nepal. **Note:** Digitized after Dahal [5]. MFT: Main Frontal Thrust; MBT: Main Boundary Thrust; MCT: Main Central Thrust; STDS: South Tibetan Detachment System; ITSZ: Indo-Tsangpo Suture Zone; **Note:** (■) Tibetan-Tethys Himalaya, (■) Higher Himalaya, (■) Lesser Himalaya, (■) Siwaliks, (■) Terai Zone.

Sub-Himalaya (Siwalik) zone: Siwalik zone mainly consists of fluvial deposits of the neogene to quaternary age, which is 23 million years to 1.6 million years old [5]. This zone is bounded by MFT (Main Frontal Thrust) in the south and MBT (Main Boundary Thrust) in the north. It extends from east to west, having a width of 8 km to 50 km and an altitude of about 300 m to 2000 m.

Lesser Himalaya zone: Lesser Himalaya zone is bounded by MCT (Main Central Thrust) in the north and MBT (Main Boundary Thrust) in the south. Mostly, this zone is made of unfossiliferous, sedimentary, and metasedimentary rocks such as slate, phyllite, schist, quartzite, limestone, and dolomite ranging in age from precambrian (about 1800 million years old) to eocene (about 40 million years old) [3], where rocks are highly folded and faulted and have developed complicated structures.

Higher Himalaya zone: Higher Himalaya zone is bounded by MCT (Main Central Thrust) in the south and a normal fault system in the north called STDS (South Tibetan Detachment System). This zone includes rock lying north of the MCT and below the highly fossiliferous Tibetan-Tethys zone and consists of an approximately 10 km thick succession of strongly metamorphosed coarse-grained rocks. High-grade metamorphic rocks, for instance, gneisses, migmatites, schists, quartzites, and marbles, can be found in the basement of Tethys Himalaya, and young granites are also found in the upper part of the unit.

Tibetan-Tethys zone: Tibetan-Tethys zone adjoins the higher Himalaya zone with normal fault contact STDS (South Tibetan Detachment System) and extends to the north into Indo-Tsangpo Suture Zone which is the contact knot between the Indian plate and the Tibetan (Eurasian) plate. This zone is made up of sedimentary rocks like shale, limestone, and sandstone that range in age from Cambrian to Eocene. This zone is a rain shadow zone and is typically dry throughout the year (Table 2).

Table 2: Geologic and physiographic units in Nepal, Source-Upreti, [3].

Geologic unit (South to North)	Physiographic unit (South to North)
Terai	Terai
Siwalik zone	Siwalik hill range and Dun valleys
Lesser Himalaya zone	Midlands, Mahabharat zone, and parts of Fore Himalaya
Higher Himalaya zone	Higher Himalayas and parts of the inner Himalayan valleys
Tibetan-Tethys zone	Some parts of the Higher Himalaya, Inner, and Trans Himalayan valleys

CONCLUSION

The complete explanation of each physiographic and geologic division was described with the help of some articles, books, and the author's knowledge. The given figures were developed in ArcGIS 10.6 and geo-referenced through the predefined geographical coordinated system WGS 1985 UTM zone 45. Based on the study, the physiography and geology of Nepal are diverse and complex, with various landforms and geological features formed by the convergence of the Indian and Eurasian tectonic plates. The converging movement between two tectonic plates still contributes to geological hazards like earthquakes and landslides. In a nutshell, the plain land in the south through small and fragile hills in Siwalik, rough, hard, and sharp crest hills in the Mahabharat zone, wide river valleys in Midland and extremely rugged terrain, very steep slopes, deeply cut valleys, and high snow peaks mountain in the north within an average 250 km distance illustrates the uniqueness and complexity of the physiography and geology of Nepal.

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AUTHOR CONTRIBUTION

Author had the original idea for the paper and took overall responsibility for the study, including data collection and analysis, preparation of figures, and finalization of the manuscript.

CONFLICT OF INTEREST

The author reported no potential conflict of interest.

DATA AVAILABILITY

The data that support the finding of this study are available from the corresponding author.

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