Exploring the geotourism wonders of central Nepal: Barhabise–Tatopani expedition

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Abstract: *The Barhabise–Tatopani section in eastern Nepal, located 80 km from Kathmandu, is being explored for geotourism development in the present study. Despite its fame for sightseeing, no prior studies have approached geotouristic site development. This study involves field observation and systematic mapping of natural and man-made wonders. The region consists of diverse rocks from the Lesser and Higher Himalayan succession, featuring low to high-grade metamorphic rocks. The region's rolling topography, shaped by perennial rivers, offers unique geomorphic features. Abundant mineral resources, including talc and magnesite, make it an attractive destination. Tatopani's famous hot springs lie in the geologically significant MCT region. The area is ideal for rafting and rock climbing, with renowned temples, Gumbas, and attractions like Bhairabkund, a natural lake at 4,200 m elevation, and the Hanuman boulder. Inhabited by ethnic communities like Tamang, Magar, Gurung, and Sherpa, the region presents a rich tapestry for geotourism enthusiasts.*

Keywords: *geotourism, rafting, Bhairabkunda, ethnic community, Tatopani, Nepal*

Introduction

Geotourism has been systematically defined as a part of tourism that mainly focuses on geology and landscape and thus promotes the geosites and conserve the geodiversity for sustainable tourism (Dowling, 2010; Hose, 2012). This combined field of geography, geology and tourism is newly defined form of tourism which has been recently recognized and is growing as a global emerging form of a tourism. This field of tourism studies the genesis, properties and characteristics of geological and geomorphological changes which has shaped the unique landform (Chen et al., 2015). The tourism is one of the most potential and growing business in Nepal which has created a job opportunities for more than about 20% of active population and hence contributes of about 3% on the Gross Domestic Product (GDP) (Gautam, 2011). Hence, geotourism can act as a vital part of tourism for the income generation in the developing country like Nepal which possesses varying landforms and mountainous terrain.

Himalaya is the large, concentrated landmass of mountains which lies on the southern part of the Asia, boarded by syntaxial bends on the east and west and Tibetan Plateau on the North. The Nepal Himalaya occupies central part of the Himalaya and covers an extension of about 800 km which has been classified into the Sub-Himalaya, Lesser Himalaya, Higher Himalaya and Tibetan Tethys Himalaya (Gansser, 1964). Each of these units are tectonically separated by the thrust faults and one of the northern units by the normal fault and stratigraphically distinct. As the Himalaya is the tallest and youngest mountain range, it has been shaped into a steep terrain, deep gorge and river valleys due to rapid erosion and rainfall. These landform has shaped the cultural diversities throughout the country.

The geology of the central Nepal comprises of rock units of the Nawakot Complex and the Kathmandu Complex

separated by the Mahabharat Thrust. The study area represents the rock units resembling to the Nawakot Complex which consists of low grade metasedimentary rocks that is about 12-kilometer thick and consists of eight lithostratigraphic units from the Kuncha Formation to the Robang Formation (Stöcklin, 1980).

Most of the study area is in the Sindhupalchok district and few parts of the Dolakha district of the Bagmati province, central Nepal (Fig. 1). The local administrative boundary of the area falls under Barhabise municipality, Balephi rural municipality, Bhotekoshi rural municipality, Jugal rural municipality, Sunkoshi rural municipality and Tripurasundari rural municipality. The area is about 80 km away and accessed easily through the Araniko Highway from Kathmandu, the capital city. There are numerous graveled roads accessed to many villages.

Geotourism of the study area represents the most potential geotouristic sites resembling on geoheritages, geohazards, geoinfrastructures and mineral resources.

Geotourism and geoparks are relatively new concepts within tourism that have experienced rapid growth over the past decade. Geotourism has emerged as a response to the imperative of mitigating the adverse effects of mass tourism in geologically and geographically unique tourist destinations. Simultaneously, it serves as a catalyst for sustainable rural development. The evolution of these concepts reflects a broader recognition of the importance of preserving natural and cultural heritage, promoting responsible tourism practices, and fostering local economic development (Ólafsdóttir & Dowling, 2014).

The main aims of geotourism are to protect an area's distinctive natural and cultural assets, promote ethical travel, and increase community involvement. This strategy can be implemented through guided tours that emphasize the region's customs, historical sites, and geological characteristics. Additionally, by generating possibilities for nearby companies and communities and concurrently advancing environmental awareness and conservation, geotourism can support economic development (Farsani et al., 2014; Stoffelen & Vanneste, 2015).

The Himalayas are among the world's youngest mountain ranges. In addition to the geologic processes of mountain building and erosion, they are also highly vulnerable to human influenced change, occurring at local, national, regional, and international scales (Nepal, 2002). Nepal is also a part of Himalaya with a mosaic of ethnicities, languages, and religions spanning from the Higher Himalayas to the Terai region, presents a captivating blend of natural and cultural attractions. From diverse flora and fauna, national parks, lakes, rivers, to historical sites and events, it stands as a sought-after destination for tourists. This study explores the patterns of tourist arrivals, their average length of stay, visit purposes, seasonal variations, and the demographics of tourists from major nationalities in Nepal. Similarly, the Nepal Himalaya is a geological gem, enticing geotourism with its diverse landscapes, unique features, and captivating trekking trails. Rich in biodiversity, cultural heritage, and adventure, it stands out as an unparalleled destination, drawing both visitors and investors eager to benefit from its distinct offerings (Gautam, 2011).

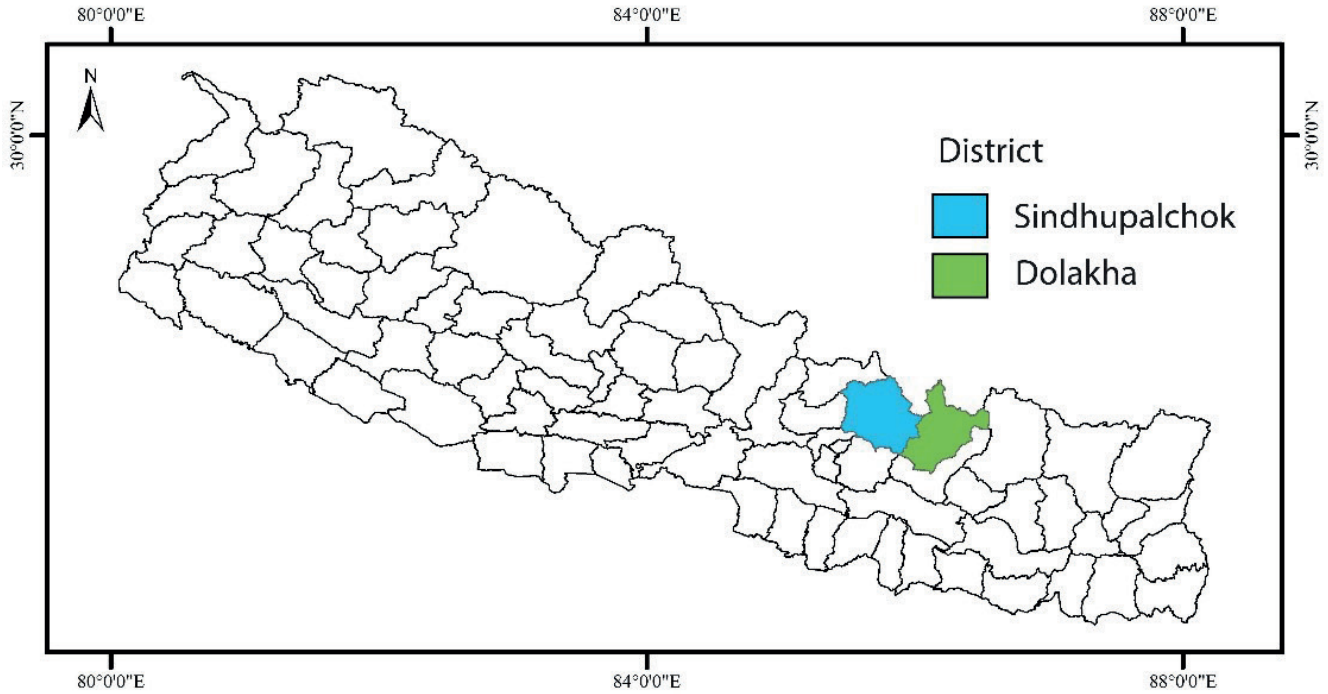

Fig. 1. Political map of Nepal showing the location of the study area

Nepal, as one of the world's disaster-prone countries due to geophysical and socio-economic conditions, is vulnerable to various natural disasters, including flooding, landslides, fire, earthquakes, gales, hailstorms, lightning, the bursting of glacier lakes, drought, epidemics, avalanches, etc., with flood, landslide, and fire hazards being particularly recurrent in the country (Poudyal Chhetri, 2001).

The Bhotekoshi area in Sindhupalchok district has untapped potential for adventure tourism but faces challenges due to low awareness and weak disaster preparedness. Disaster events have substantial impacts, underlining the need for improved resilience in local tourism businesses. Despite being a new concept, "resilience" involves crucial elements like capacity building and preparedness for post-disaster recovery. A resilient community is vital for sustainable tourism, especially in rural areas. The government leads in mitigation, preparation, and recovery, with businesses and community organizations playing specialized roles. Integrated approaches are increasingly recognized as crucial for effective disaster management (Subedi, 2017). Acharya and Paudyal (2021) identified the major geotouristic sites around the Kathmandu valley along the Chandragiri–Chitlang range and portrayed the potential destination for the development of geotourism along the Kathmandu valley, central Nepal.

Till the date, study focusing to the geotouristic wonders of the Barhbise–Tatopani area is not studied and published. Present authors while engaging to prepare the geological map with the aim to prospect the valuable mineral resources of the region, realized the beauty of the terrain in various aspects of the nature. The objective of the present research then equally diverted towards the prospection of the gems of the nature. Accordingly, the specific objective of the study is set to prepare a geotouristic inventory map and to find the potential sites for the geotouristic assessment in the region.

Methodology

The methodology of this research unfolds in three distinct phases, each carefully designed to comprehensively investigate and analyze the geotouristic potential of the selected area. In the preliminary phase, an exhaustive review of pertinent literature was conducted, encompassing studies relevant to both the overall topic and specific site selections. This literature review served as a foundation for understanding the existing knowledge landscape and identifying gaps that this research seeks to address. Subsequently, a month-long field expedition was executed as part of the second phase, aiming to identify and assess potential geotouristic sites. This involved an intricate field study, including detailed surveys, an in-depth examination of geotouristic sites, their characterization, and systematic photo collection for documentation. The research team engaged in reconnaissance traverses to explore the terrain thoroughly, strategically searching for sites with significant geotouristic potential. Throughout this phase, meaningful interactions were established through several meetings with local communities and political representatives. These engagements were pivotal in gaining insights into the local perspectives, understanding the cultural significance of the sites, and fostering collaborative relationships with the communities involved. The participatory approach aimed to incorporate community perspectives into the geotourism study, acknowledging the importance of local knowledge and ensuring the research's relevance and sustainability.

This methodological approach ensures a comprehensive and nuanced exploration of the geotouristic potential of the selected region, combining scholarly insights from literature with on-the-ground assessments and community consultations.

Results

Geology

The rock succession of the study area can be categorized into two main units: the Lesser Himalayan metasedimentary rocks and Higher Himalayan crystalline sequence. The different types of rock exposures and outcrops of the study area is shown in Figure 2. The Higher Himalayan crystalline rocks are thrusted over the autochthonous succession of the Lesser Himalayan rocks. The six formations that make up the Lesser Himalaya in the study area are the Kuncha Formation, Fagfog Quartzite, Dandagaon Phyllite, Nourpul Formation, Dhading Dolomite and Benighat Slates from bottom to top (Stöcklin, 1980).

This succession is dominantly represented by gneiss (Fig. 2A), high-to medium grade schist (Fig. 2B), calcareous metasandstone (Fig. 2C), dolomite (Fig. 2D), as well as quartzite (Fig. 2E) and paragneiss (Fig. 2F).

Structures

The rock sequence of the Dolalghat–Kodari section has been carved out by the Balephi and the Bhotekoshi rivers and gave the spectacular overview of the rock outcrop and geological structures (Fig. 3)

The rock units' lags fossils and primary structures but exhibits a good exposure of secondary geological structures, those who are into Himalayan geology or those who enjoys the structures would love to travel through this route.

The Sunkoshi River passes through the large regional anticline. Towards the Tatopani, metamorphic grade changes from chlorite to garnet grade. NNE lineation, foliation, boudinage, mesoscopic and megascopic folds, outcrop scaled fault and crenulation cleavage are major geological structures of the area. Crenulation cleavage, lineation and local scale displacement has been observed at different locations which has been shown in the Figure 4D–F. The Main Central Thrust (MCT) makes distinctive landforms and lines of episodic landslides that separates the Lesser Himalaya from the Higher Himalaya.

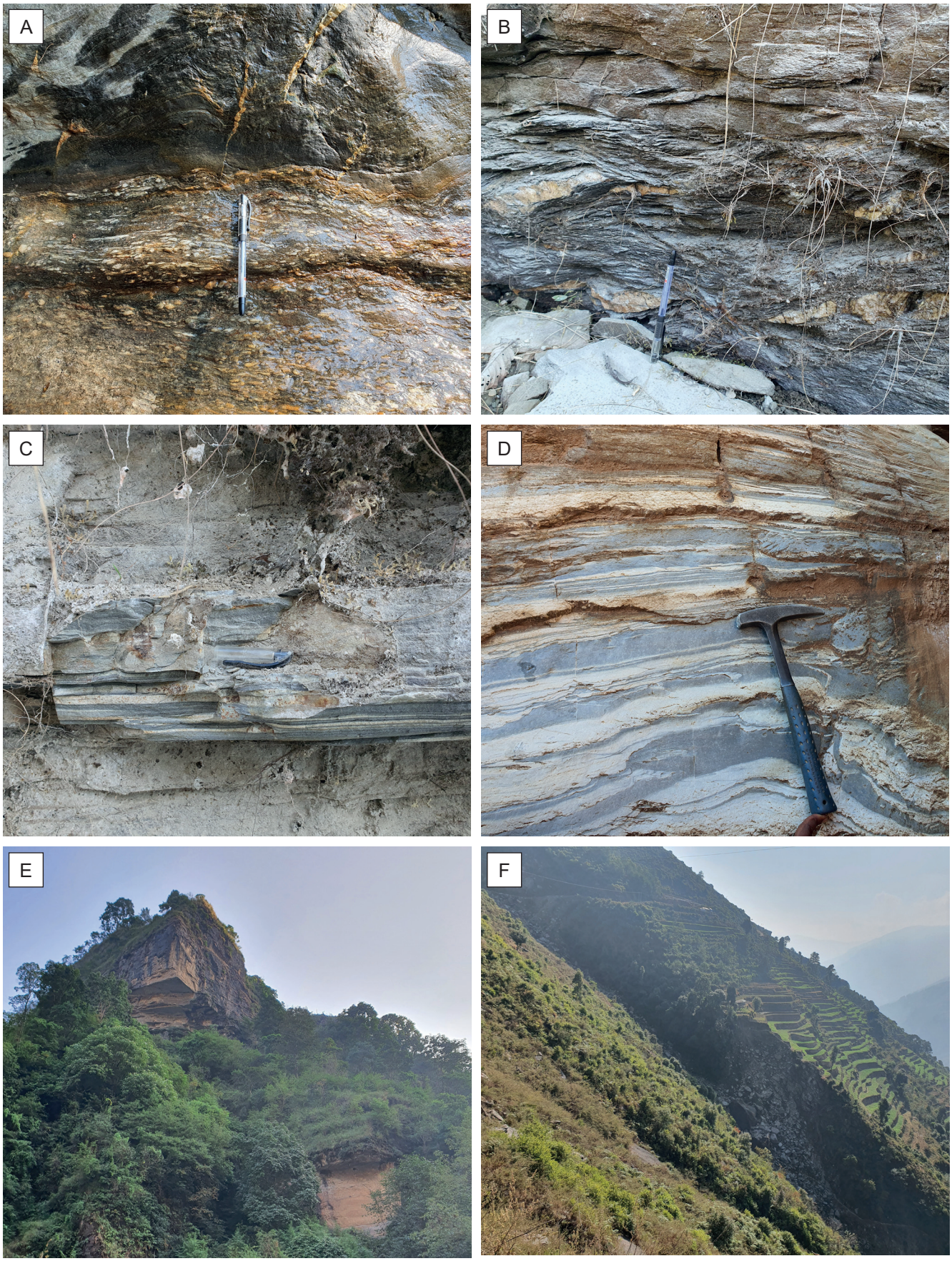

Fig. 2. Exposures and outcrops of the different rock types present on the study area: A – augen gneiss observed near Khadichaur; B – garnet schist observed near the Bahrabise; C – calcareous metasandstone observed near Chaku; D – laminated dolomite observed near Ghumthang; E – calcareous quartzite observed at Chaku; F – very steep terrain made by the paragneiss at Pangarpu

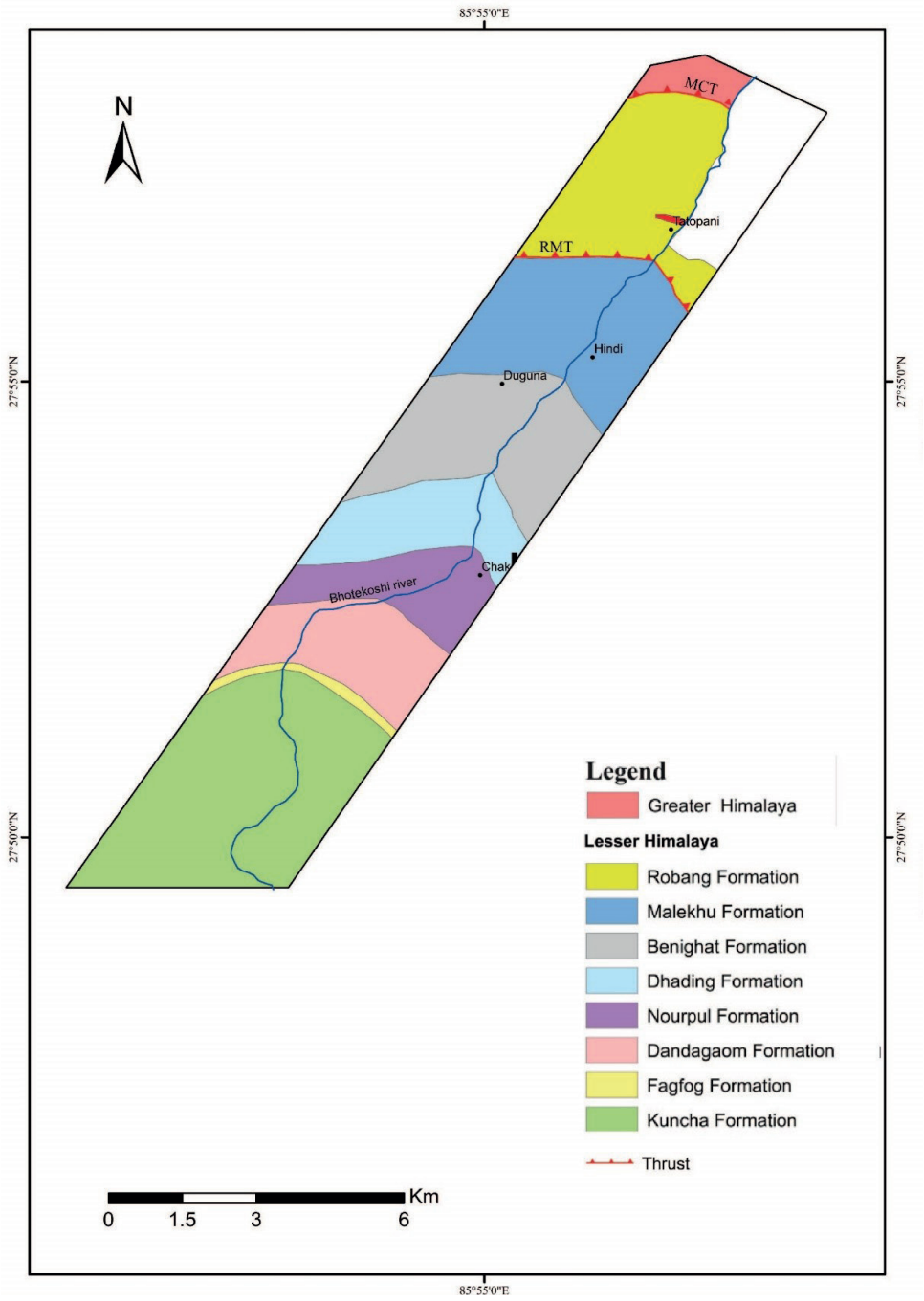

Fig. 3. Route map showing the major geological structures and rock units of the study area from Bahrabiase to Kodari (Khanal et al., 2015) (RMT – Ramgarh Munsiari Thrust; MCT – Main Central Thrust)

Mineral resources

The Dolalghat–Kodari section act as a very good destination for someone who is passionate about the mineral resources. The study area consists of both metallic and non-metallic mineral resources but rich in talc and magnesite. The old working adit of copper are present on many different places. The copper mineralization is present in hydrothermal vein and chalcopyrite is a major ore type as shown in Figure 4B. But talc and magnesite mineralization is the best for exploration. The study area consists of abandoned mine field of magnesite at Kharidhunga which is the largest magnesite deposit of the country. The magnesite mineral is concentrated within the rock dolomite and distribute on the both bank of the Bhotekoshi River (Fig. 4A). The mineralized band is about 30 or 40-meter thick and consists of magnesite with the lenses of talc.

Thin slab of quartzite (Fig. 4C) has also been mined as a dimension stone manually from the study area. Different kind of natural resources of the study area has been shown in the Figure 5.

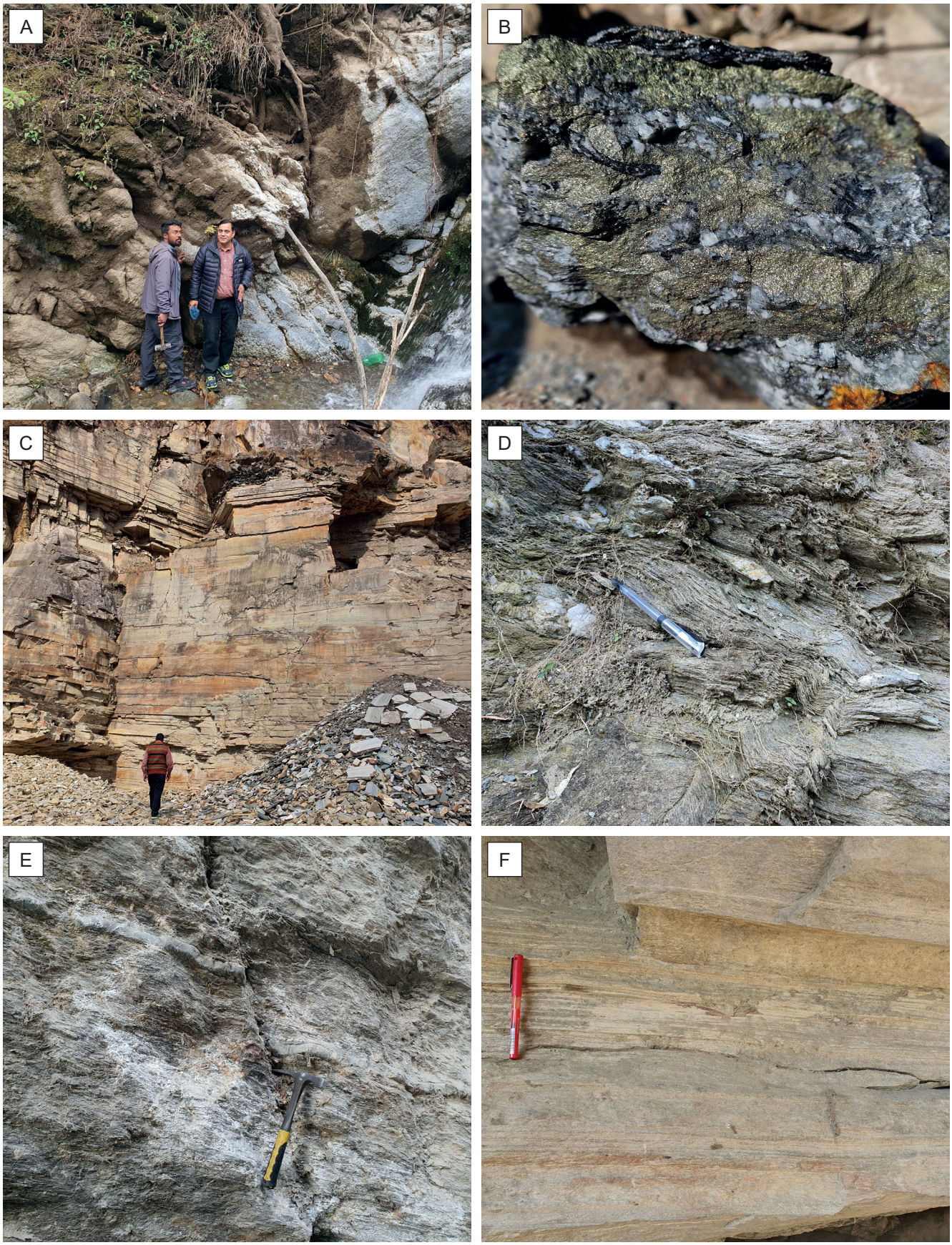

Fig. 4. Major geological wonders of the study area: A – outcrop of magnesite the magnesite at the Hindi village; B – copper ore (chalcopyrite) observed at the quartz vein near the Karthali village; C – slab stone (quartzite) quarry site observed at Bahrabise; D – well developed crenulation cleavage on phyllite observed near Tatopani; E – local scale displacement observed near the Hindi village; F – stretching lineation on phyllite at the Khadichaur

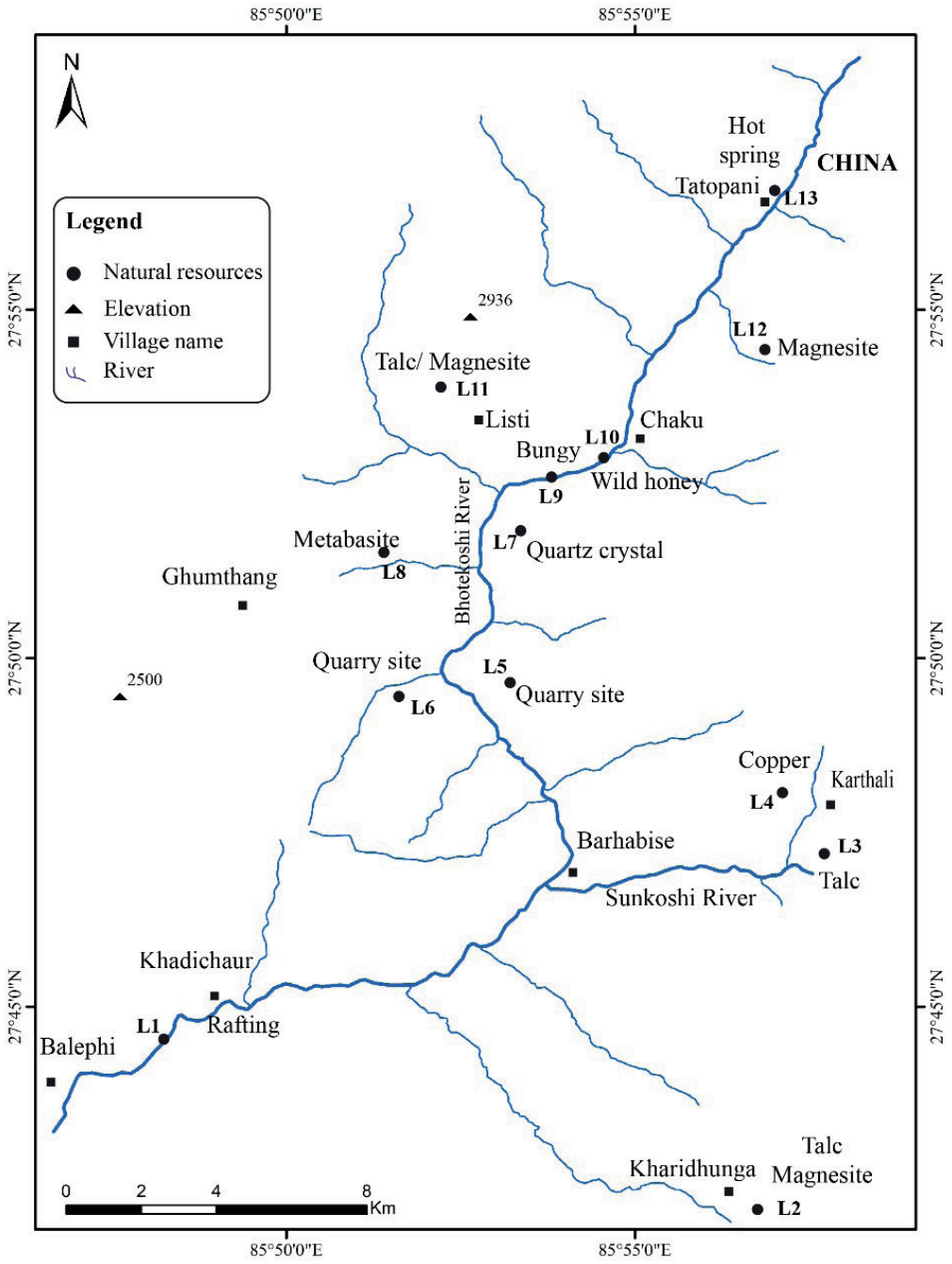

Fig. 5. Various natural resources sites around the Dolalghat–Kodari area

Geomorphology and natural environment

The Sindhupalchok district is nestled in the middle part of Nepal within the heart of Himalaya which exhibits a mesmerizing scene of geomorphology that captivate the senses. The geomorphology of the area has been shaped by earth's dynamic forces into a towering peak, deep gorge and rugged terrains which has formed beautiful landform and waterfall. Hence, the place is most famous in Nepal for rafting, bungee jumping (Fig. 6D), rock climbing and canyoning. There are more than one hundred waterfalls only along the Dolalghat–Kodari road sections. The Bhotekoshi River has carved the mountains so deeply that it has formed the very good river gradients. There are more than six hydropower project in the area hence the place has also acted as a natural laboratory for the study of geoinfrastructure where the observer can study about the underground powerhouse, hydropower tunnel and other engineering geological features.

Fig. 6. Geoculture, geoheritage and landscape of the study area: A – indigenous (thami) people performing their ritual; B – bird's eye view of the Deudhunga Temple; C – historic Dugunagadhi army camp; D – bungee jumping at the Jambu over the Bhotekoshi River; E – earthquake-induced landslide along the Bahrabise–Karthali road section; F – fully destroyed house by the earthquake and landslide at Kodari

Social and cultural aspects

Sindhupalchok district is a home for mix ethnic groups which includes majority of Tamang, Newar, Bramin, Chhetri with minority of the Gurung, Magar and Sherpa. The main occupation is agriculture along with tourism, trade and small business. Nepali is the common language but the different ethnic groups speak their own native languages. The district is bordered with the China (before Tibet) so Tibetan culture has also been adapted to the northern part of the study area. Hinduism and Buddhism are the predominant religion hence the area possesses many famous religious sites whereas thuppa is the most famous traditional food of this area. It is a noodle made from wheat flour mixed with the soup of meat, beans, Sichuan pepper and vegetables which reflects the Tibetan cuisine in Nepal (Fig. 7F).

Thami people are the endogenous ethnic group (Fig. 6A) of the area who resides dominantly on the northeastern part of the study area. They speak their own Thami language along with Nepali and the majority of them are engaged on traditional handicraft work of bamboo. They prepare different tools, basket and utensils by knitting the slices of bamboo wood.

Deudhunga Temple

This temple is located on the border between the Sindhupalchok and Dolakha district (Fig. 6B). This place is very interesting for the geologist too because the temple is located below the huge block of the Higher Himalayan gneiss. The temple was built during the Lichhavi period between 400 AD and 750 AD. One of the most unique practice of the temple is that it is believed that someone who successfully throws the money on the top of the rock, their wishes will be fulfilled by the god.

Dugunagadhi

Dugunagadhi (Fig. 6C) is a fort made by the Rana Prime Minister Jang Bahadur Rana in 1912 BS during Nepal–Tibet war to expand the territory of the country. The fort is built on the peak of the rock dolomite which gave steep geomorphology and rugged terrain. As the fort is located on the higher part than the surrounding area along with the steep geomorphology of dolomite, a natural way of defense has been built against enemy.

Nayanthan Gumba

The Nayanthan Gumba is the Buddhist monastery which has wall painting showing the posture of Buddha and its various forms (Fig. 7A). The gumba is famous for conducting several Buddhist ritual and is a place for long term meditations. It is also a school for Buddhism.

Bhairabkunda

It is a holy lake located in the Bhotekoshi rural municipality of the Sindhupalchok district at the elevation of about 4,200 m. The lake lies within the Langtang National Park and is about two days trekking distance from the Listi village. The beautiful view of Chhagam village can be observe on the way to Bhairabkunda. The pond is formed at the top of the mountain within the rock of the Higher Himalaya. As the Bhirab refers to the anger form of the Hindu god the Shiva, it is believed the god resides inside the pond. The alpine landscape and snowcapped peaks are the additional beauty of that place (Fig. 7B).

Balephi Temple

This temple is situated on the confluence between the Bhotekoshi and the Bramhayani rivers (Fig. 7C). This is a famous religious place as people has been worshipping hindu god Shiva since hundreds of years. This temple is famous for performing a marriage based on hindu culture as the temple as never get drowned even in the high flood so people has belief that performing a marriage on this temple will strengthen the relationship.

Kuri village

The village is situated on the Dolakha district within the Gaurisankhar Conservation area. The place is about 150 km north east from the Kathmandu via road and is a base camp of the Kalinchok peak. It is famous during winter season for its beautiful snow covered landscape (Fig. 7D) and Kuri village itself. The village is well facilitated hotels and people can enjoy the view of landscape from Kuri to Kalinchok via cable car. This is the best place for snow skating and camp firing also.

Kalinchok Temple

The temple is famous throughout the country and sacred place for Hindu pilgrimage. It is believed that the goddess kali possesses the temple. Nowadays, the place is famous also for tourist due to its beautiful scenario and snowfall during winter. It lies on the elevation of about 3,800 m and is a part of Gaurisankar national park. The temple itself is on the peak (Fig. 7E) and there are numerous geological cracks present at the location waiting for detail investigations. Along with its cultural importance, the area is very rich in diversified flora and fauna like varieties of rhododendrons, mountain oak, pines, vultures, hyena and one of the rarest animal called red panda are present on the area.

Listi Mai Temple

This temple is worshiped for the Hindu goddess Devi. Most significant feature of this temple is that it is built over a mineral magnesite mineral and all the sculptures are carved using the same mineral. It is on the elevation of about 2,200 m and is about three hundred years old. There is listikot close to this temple which is an arsenal where the weapons that had been used during the Nepal Tibet war have been manufactured and stored.

Fig. 7. Different geoheritages and geocultural resources of the study area: A – Narayanthan gumba at Naranthan village; B – Bhiarabkunda lake; C – Balephi Siva Temple; D – beautiful Kuri village; E – Kalinchok Temple; F – thukpa (Tibetan food)

Tatopani hot spring

The hot spring is located on the right bank of the Bhotekoshi River at Tatopani village. The discharge is about 2.5 l/s and temperature is about 51°C. The place is sacred for both the Hindu and Buddhist people and contains high potential of local and international tourism as the place is very close from Nepal–China border.

It is believed that the natural hot spring heals several rheumatic disease and skin problem. Geologically, the hot spring lies at MCT zone that separates the Lesser Himalaya and Higher Himalaya.

Bhimsen Temple

The Bhimsen Temple is located at the right bank of the Bhotekoshi River. On the top of the large boulder of augen gneiss, the temple of lord Bhimsen has been constructed below the pipal tree. The diameter of the gneiss is about 30 m. it is the largest boulder along the Sunkoshi River and is semi angular in shape which indicates the fluvial or glacial origin. The boulder is also called the Hanuman Dhunga due it its enormous size and giant shape.

The study area is full of beautiful geotouristic destinations which has been well represented in Figure 8.

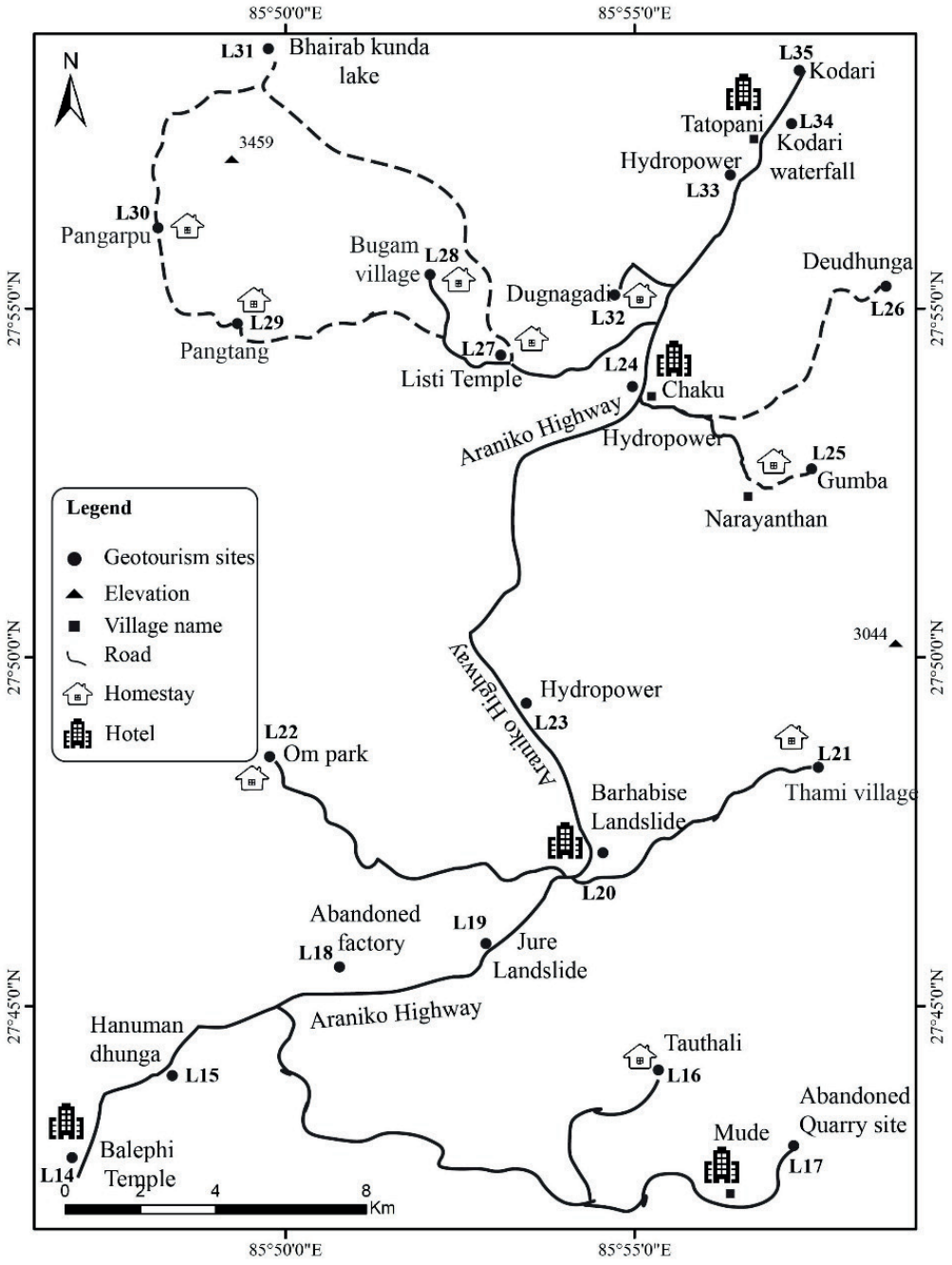

Fig. 8. Various geotouristic sites around the Dolalghat–Kodari area

Geohazards

Dolalghat–Kodari section is the best place to explore for the geohazards as the area consists of more than a thousand deep seated earthquake propagated landslides, glacier outburst and flood evidences and earthquake damaged city that has not been residence since then. The predominant geohazards of the study area is landslide. The study area consists of more than thousands of landslides with different nature, and understanding their characteristics is essential for mitigating potential risks and developing effective strategies for local communities and infrastructure. Moreover, the interesting rocks and hills in this area makes it a study place for people who love learning about Earth's surface. Most of the area has a steep slope, which are more susceptible to landslides, as the force of gravity can easily overcome the stability of the soil or rock. The well-known Jure Landslide (Fig. 8E) lies in this area which is slope failure type landslide and is triggered by the heavy rainfall. Various types of landslides has been present throughout the study area on the both banks of the Bhotekoshi and Sunkoshi River. Other common landslides along the study area are rockfall and debris flow.

In the study area, this phenomenon is triggered by various factors such as weathering, erosion, seismic activity, or human actions, leading to the detachment and downward movement of rocks. The geological setup in the study area, mainly made up of different types of rocks, creates an interesting environment for people interested in geotourism.

Mix lithology of like phyllites and schists, along with sturdy ones like quartzite and limestone, contributes to the occurrence of rock fall. It's a unique attraction for geotourism, offering insights into the natural forces that have influenced the region over time. Also, flood has been also a common geohazard of this area during the rainy season due to temporal blockage of rivers and heavy rainfall.

Seismic hazard

Seismic hazard plays one of the vital roles in context of geotourism. The cultural and natural features affected by the seismic hazard fascinate tourists to explore such areas. Some of the features related to the seismic hazards in Sindhupalchok, Barhabise area are described below.

Earthquake impact

The Gorkha earthquake in 2015 has completely damaged more than 10 cities on the study area. Among them, Kodari and Tatopani are the most affected area as shown in Figure 8F. The Kodari village that lies on the border between Nepal and China has been completely abandoned after earthquake. The earthquake in that area had destructed the village as well as the old heritages such as the temples, monasteries and so on. The remarkable sceneries that attract tourists are reshaped which in overall impacts the experience of the visitors.

Discussions

The research presented in this scientific manuscript sheds light on the vast geotouristic potential of numerous sites, which, despite their extraordinary appeal, remain largely undiscovered by both national and international tourists. Situated within less than a hundred kilometers from Kathmandu, the study area is linked by the Nepal–China trade route, boasting well-equipped hotels at various points. However, the existing infrastructure may take some barriers for exploration and tourism development. The proximity to Kathmandu and accessibility through the Nepal–China trade route make the Dolalghat–Kodari section a prime location for geotourism development. While the region features hot springs, potential geohazards, valuable mineral resources, and an abundance of geoheritage sites, there is an imperative to undertake efforts for their preservation and effective promotion. To unlock the full potential of this region, it is crucial to undertake strategic initiatives such as targeted advertising, the creation of comprehensive guidebooks, and the establishment of essential infrastructures. By facilitating these approaches, the Dolalghat–Kodari section has the potential to evolve into a premier geotouristic destination and contributing to the sustainable development of the region.

Conclusions

The following conclusions are drawn from the present research:

1. The Dolalghat–Kodari section in Nepal holds immense promise for geotourism.
2. Various aspects like geology, structure, mineral resources, social and cultural elements, geomorphology, and the natural environment contribute to its appeal.
3. The Kharidhunga magnesite mine, although abandoned, remains a notable deposit, alongside other minor deposits like talc deposits and copper mineralization.
4. The area is home to a diverse mix of ethnic groups, including Tamang, Newar, Brahmin, Chhetri, Gurung, Magar, and Sherpa. These communities are primarily engaged in agriculture, tourism, and trade, with a cultural blend influenced by both Nepali and Tibetan elements. Hindu and Buddhist religious sites adorn the region. The Thami people, indigenous to the northeastern part, contribute to the local economy through traditional bamboo handicrafts.
5. The district boasts striking geomorphic features such as towering peaks, deep gorges, and numerous waterfalls along the Dolalghat–Kodari road.
6. With over six hydropower projects, the region serves as a natural laboratory. This provides a unique opportunity for studying geoinfrastructure, contributing to a holistic understanding of the area's geological and environmental characteristics.

Recommendations

To transform the region into a geotourism destination, it is important to protect various sites, including mineral resources, architectural structures, social and cultural elements as well as geomorphological features. The development of essential facilities such as rock gardens, geoparks, picnic spots, information centres, efficient transportation, local awareness programs and guided tours is crucial for its growth.

Immediate efforts should be directed towards creating an environment that not only preserves these unique geological attractions but also facilitates their exploration and appreciation by visitors.

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