

Planning for Geotourism through Geospatial Analysis: A Study of Lahaul & Spiti, Himachal Pradesh

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Abstract

Geotourism, a niche form of tourism focusing on geological features, presents a unique opportunity for sustainable development and conservation of geological heritage. This paper explores the geotourism potential of Lahaul & Spiti, Himachal Pradesh, India, a region rich in geological diversity yet largely overlooked in terms of geotourism development. Through a comprehensive inventory of geosites including lakes, waterfalls, glaciers, mountain passes, monasteries, fossil sites, and national parks, this study highlights the region's geological treasures. However, challenges such as remote accessibility, limited infrastructure, and the need for cultural preservation pose hurdles to geotourism development. The study advocates for collaborative engagement among stakeholders, the implementation of sustainable development frameworks, active participation of local communities, and substantial investments in infrastructure and educational endeavors. By addressing these challenges, Lahaul & Spiti can unlock its geotourism potential while safeguarding its natural and cultural heritage.

Keywords: Geotourism, Geoheritages, Geosites, Lahaul & Spiti

Introduction :

In recent years, there has been a surge in the popularity of various forms of tourism on a global scale. Among these, geotourism has emerged as a distinctive niche, centering its focus primarily on geological features and sites of notable significance. Geotourism, categorized as a specific form of nature-based tourism, champions the cause of preserving geographical diversity (Bhat et al., 2023). This unique form of travel is characterized by a deep appreciation for the Earth's history, as tourists engage in visits to attractions renowned for their geological significance (Cai et al., 2023).

As an emerging market within the tourism industry, geotourism highlights not only the geological aspects but also encompasses the broader spectrum of topographical, geomorphological, and environmental characteristics. Its core mission revolves around the preservation of significant geological sites, recognizing their intrinsic value to the natural landscape (Stokes et al., 2003; Henriques et al., 2011).

Geotourism, a multifaceted approach to tourism, nurtures an appreciation for geological diversity while facilitating education in Earth sciences. This involves a spectrum of activities, including independent exploration of geological

features, following designated geo-trails, participating in guided tours, engaging in geo-related activities, and visiting specialized geosite visitor centers. Hose (2012) further refines the concept, defining geotourism as the provision of interpretative and service facilities for geosites and geomorphosites, alongside their associated in-situ and ex-situ artifacts. This comprehensive definition underscores the role of geotourism in building constituencies for the conservation of geological heritage through appreciation, learning, and research. Geotourism intersects with other forms of tourism, such as cultural, heritage, eco-tourism, and adventure tourism, contributing to the preservation of geo-diversity and enhancing understanding of Earth sciences (Newsome and Dowling, 2010; Dowling, 2013). Consequently, geotourism plays a pivotal role in preserving unique geological features and raising awareness of their value, ultimately leading to their enhancement.

Over recent decades, there has been a notable expansion in the scope of geotourism worldwide, with various stakeholders increasingly interested in enhancing conservation efforts and safeguarding geological heritage (Newsome and Dowling, 2010). The geological and cultural heritage of a region has become a key attraction for

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tourists, offering opportunities to deepen understanding of the geology and geomorphology of landscapes (Singh and Anand, 2013). Despite historical challenges posed by urbanization and degradation of significant sites, there has been a growing awareness for the conservation of geological features since the middle of the twentieth century (Page and Wimbledon, 2009). Developed countries have made concerted efforts to identify and document significant geological sites, contributing to the broader concepts of geoheritage and geoconservation (Panizza and Piacente, 1993; Wimbledon et al., 1995; Wimbledon, 1996; Panizza, 2001; Reynard, 2004). These concepts are essential for safeguarding the Earth's natural heritage, encompassing a range of landforms, rock exposures, and sites crucial for understanding geological history (Brocx and Semeniuk, 2007).

The Indian subcontinent stands as a testament to a rich tapestry of cultural heritage, a storied historical background, and prominent geological features (Ahluwalia, 2006). It boasts a distinctive geodiversity, encompassing Precambrian formations in central and southern India, Gondwana basins, rift basins, and the Himalayan orogenic belts, offering significant potential for establishing geoparks (Chauhan et al., 2016). India's landscape showcases a myriad of geological features spanning from the Precambrian era to the present, including unique geomorphology, rock formations, fossils, tectonic processes, and mineral deposits (Chauhan et al., 2021; Wadhawan, 2021). However, despite its geological wealth, India lags in systematic establishment of geological heritage, protection of geosites, development of geoparks, promotion of geotourism, and implementation of geo-conservation concepts, underscoring the need for identifying and assessing geological heritage sites.

India's diverse landforms and landscapes include iconic features such as the towering Himalayas, the arid Thar Desert, the cold desert of Ladakh, and glacial landforms like the Nubra Valley and Lahul Spiti Valley. Additionally, the subcontinent boasts expansive riverine plains like the Ganga Plains, volcanic regions such as the Deccan Traps, and dramatic escarpments like the Western Ghats. Picturesque lakes and lagoons dot the landscape, alongside vast saline marshlands like the Rann of Kachchh and widespread granite formations exemplified by sites like Hampi in Karnataka (Kale, 2014). India's vast geodiversity gives rise to numerous geosites deserving recognition as heritage or monumental sites, yet many remain overlooked. Safeguarding and highlighting these sites as geotourism destinations is imperative for leveraging India's geological heritage to its fullest potential.

The Geological Survey of India (GSI), established in 1851 under the Ministry of Mines, plays a crucial role in collecting information related to Earth sciences and surveying. GSI has been entrusted with the responsibility of protecting and promoting India's physical attributes,

designating various sites across the country as "National Geological Monuments (NGMs)" (GSI, 2017). These NGMs hold national importance and heritage value, serving as focal points for maintaining, protecting, promoting, and enhancing geotourism. Despite the designation of 34 geoheritage sites and 12 geotourism sites by the GSI, it's notable that not a single geosite from Lahaul & Spiti has been included in this list, suggesting the need for broader recognition and conservation efforts in this region.

Lahaul & Spiti, nestled in the Indian Himalayas, boasts remarkable geological sites crucial for understanding the region's geological evolution. Yet, despite its geological significance, this region remains largely overlooked in terms of geotourism development. As a region endowed with rich cultural history and natural beauty, Lahaul & Spiti has the potential to emerge as a sustainable tourism destination, offering opportunities for local communities to benefit from geotourism initiatives. This paper aims to address this gap by inventorying geosites in Lahaul & Spiti and assessing their potential for geotourism development.

By showcasing the unique geological heritage of Lahaul & Spiti, this study seeks to underscore the region's potential as a geotourism destination and advocate for its conservation and promotion on both national and international platforms. Through a systematic inventory of geosites, this research endeavors to contribute to the broader discourse on geotourism development and sustainable heritage management.

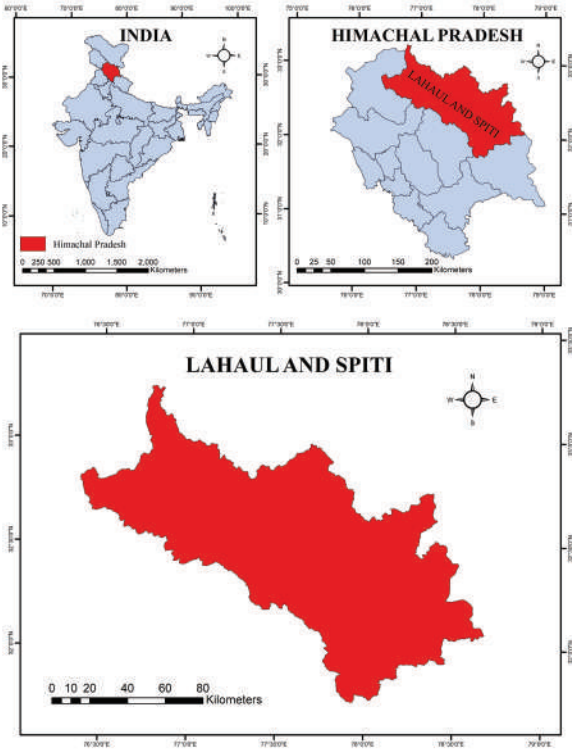
Study Area

Lahaul and Spiti, the largest district of Himachal Pradesh, was established as a district in 1960. Prior to that, it was a tehsil under the Kullu sub-division in the former state of Punjab (District Gazetteer, 1971). The Lahaul and Spiti district lies within the geographical coordinates of 31°44'57" to 32°59'57" north latitude and 76°46'29" to 78°41'34" east longitude. Covering an area of 13,841 square kilometers, it constitutes approximately 24.85% of Himachal Pradesh's total land area. Kunzam Pass, standing at an altitude of 4,520 meters, serves as the connecting link between the two valleys of Lahaul and Spiti, while Rohtang Pass provides access to Lahaul. Positioned in the northern and northeastern region of Himachal Pradesh, the district shares borders with Tibet to the east and Ladakh to the north. To the west and south, it is bordered by Chamba, Kangra, and Kullu districts, and to the southeast by Kinnaur district.

The study area holds significant geotourism potential due to its stunning landscapes, rich cultural heritage, and unique geological features. However, the construction of Atal Tunnel introduces both opportunities and challenges for the area. While, the tunnel enhances accessibility and connectivity, potentially attracting more tourists, it also raises concern about environmental impact, cultural preservation and sustainable tourism development.

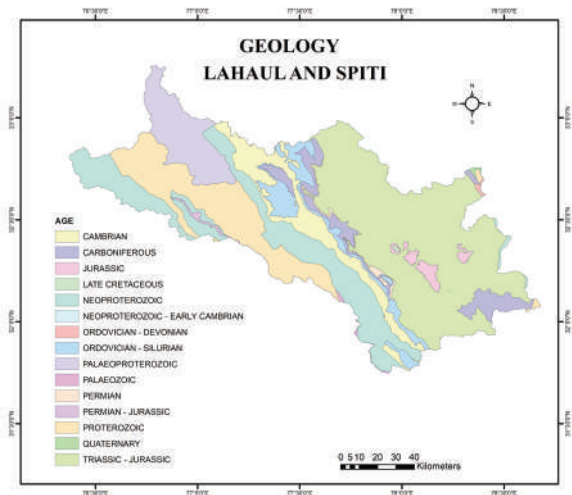
Balancing the benefits of improved connectivity with the need for responsible tourism practices and conservation efforts will be crucial for maximising geo-tourism opportunities while mitigating adverse effects on the region’s natural and cultural assets.

MAP OF STUDY AREA



Source: Survey of India

Geology of Lahaul & Spiti:



Source: Geological survey of India (GSI), 2019.

The geological formations within the Lahaul & Spiti District of the Northern Himalayan Region encompass

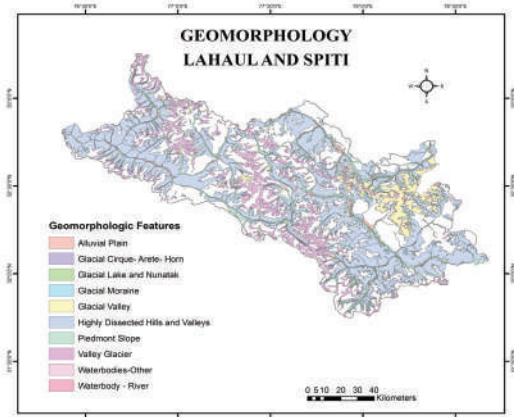
a diverse array of rock types and geological periods. Situated in the Tethyan Himalaya, the district's geological complexity is attributed to a wide range of rock complexes and minerals, along with faults exerting structural control over drainage networks throughout the area (Krishnanand, 2016). Notably, the Muth quartzite, characterized by its snow-white appearance, serves as a significant stratigraphic marker for the Devonian period in certain areas of Lahaul and Spiti, as well as Ladakh. Furthermore, the Lahaul valley features exposed black splintery shales, yielding coral specimens of probable Devonian age between Sissu and Tandi (Gupta et al., 1973).

In terms of the Middle Carboniferous period, the area is abundant in black carbonaceous shales containing fossils such as bryozoans and brachiopods, with the Tabo stage representing the lowest unit. Permian rocks, particularly the Sarchu limestone, sandstones, and grey shales, hold significance, with notable fossil-rich exposures near Sarchu bridge and certain parts of Spiti. The Triassic succession within the Spiti Valley, part of the Lilang system, is predominantly characterized by fossiliferous limestones interbedded with shales and quartzites, notably transitioning into the Jurassic System with the Kioto limestone (Krishnanand, 2016).

Distinctive geological formations such as the Spiti Shales, marked by black sandy shales rich in fossils, extend from the uppermost Jurassic to the lowermost Cretaceous periods, with notable exposures near villages such as Gete, Kibber, and Rangrik. Cretaceous rocks are primarily found in the Chikkim peak and Giumal Sandstone, with occurrences of fluvio-glacial deposits observed in certain areas of Spiti (Krishnanand, 2016).

The Spiti formation is characterized by pyritiferous black shales, while the Giumal formation consists of siliceous sandstone and shale. Quaternary deposits display variable distribution across river valleys and glacial regions (Central Ground Water Board, 2022).

Geomorphology of Lahaul & Spiti:



Source: Geological survey of India (GSI), 2019.

This region exhibits a complex landscape characterized by youthful mountains, deep valleys, and lofty hills. The underlying rock formations are ancient, contributing to the division of the area into structural hills and valley fills. The hills feature steep slopes adorned with cliffs and ridges, while the valleys encompass a mix of river deposits and glacial debris. River valleys situated at lower elevations host some vegetation, whereas those influenced by glacial activity at higher altitudes are broader, flatter, and devoid of vegetation. Glaciers are prevalent in the central and northern regions, serving as sources for river systems. Soil quality varies across the region, with thin layers observed in some areas, yet fertility is attainable due to the decomposition of plants and the presence of minerals derived from mountain rocks (Central Ground Water Board, 2013).

Objectives of the study

This study aims to create a comprehensive inventory of potential geoheritages/geosites in Lahaul & Spiti, HP, laying the groundwork for geotourism development. Additionally, this study seeks to identify challenges and provide strategic recommendations to enhance geotourism initiatives in the region. Through this endeavor, this study aims to promote sustainable tourism and deepen appreciation for Lahaul & Spiti's geological treasures.

Methodology

The methodology for this study involved gathering data from a diverse range of sources, including both online and offline resources. Geoheritages and geosites were identified through an extensive review of existing literature, analysis of toposheets, and examination of imagery from Google Earth Pro. To enhance precision and accuracy, ArcGIS 10.8 was employed to create detailed shapefiles and maps of these potential sites, providing a visual representation of their spatial distribution and characteristics. This comprehensive approach ensured the thorough exploration and documentation of geological features, enriching our understanding of the region's geoheritage and facilitating informed decision-making for conservation and management efforts.

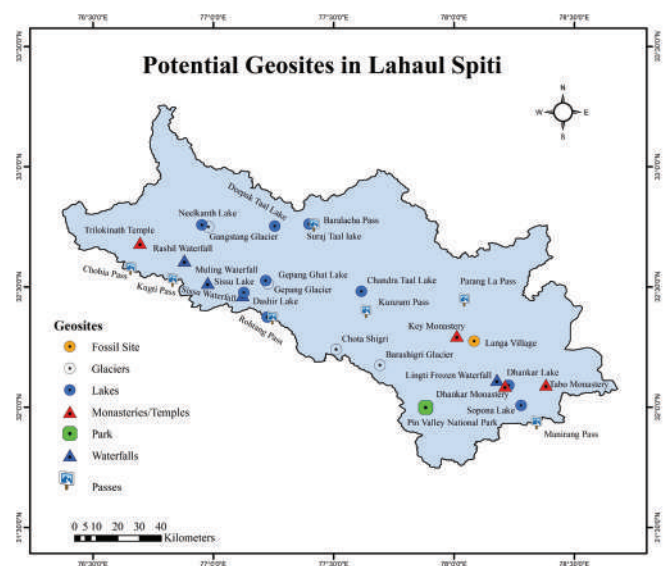
Potential Geosites in Lahaul & Spiti

Geosites, defined as areas of geological and scientific significance, play a crucial role in understanding Earth's history and processes. These sites, ranging from a few square meters to several square kilometers, are distinguished by their exceptional geological attributes, including mineral composition, structural features, and geomorphology (El Wartiti et al., 2008). Identifying geosites of significance involves evaluating specific criteria such as uniqueness, rarity, and representativeness of geological features (Predrag and Mirela, 2010; Brocx and Semeniuk, 2011). These criteria ensure the selection of sites worthy of preservation and study.

Despite its rich geodiversity, Lahaul & Spiti District is yet to receive recognition for its numerous geosites. The region, blessed with a plethora of unique geological formations, remains largely ignored in terms of heritage or monumental status designation. While the Geological Survey of India has identified and notified 34 geoheritage and 12 geotourism sites across the country, Lahaul & Spiti has not found representation on this esteemed list (National Geological Monuments of India, 2024). This oversight underscores the urgent need to protect and promote the district's geosites as potential geotourism destinations.

Lahaul & Spiti offers vast opportunities for tourism, spanning various sectors including ecotourism, tribal tourism, and archaeological tourism. The region boasts numerous natural and historical sites of geological significance, such as natural parks, caves, waterfalls, springs, glaciers, and mountain passes (Bhargava et al., 2010). Situated in a high-altitude terrain surrounded by enchanting mountain passes, Lahaul & Spiti presents visitors with mesmerizing geomorphological marvels waiting to be explored. Harnessing the potential of these geosites for geotourism can not only boost the local economy but also raise awareness about the importance of geological heritage conservation.

Potential Geosites in Lahaul & Spiti



Source: SOI Toposheets, Google Earth Pro.

1. Lakes

Lakes in Lahaul & Spiti are vital geological sites for geotourism due to their diverse geological settings, glacial origins, sedimentary records revealing environmental history, and support for unique biodiversity. They also hold cultural significance, enriching the visitor experience with insights into local traditions and beliefs.

| Lakes | Descriptions |
|---------------------------------|--|
| Chandra Tal (Moon Lake) | Chandra Tal, nestled at an altitude of approximately 4,300 meters (14,100 ft), captivates with its crescent shape and ethereal beauty, particularly enchanting under the moonlit sky. Renowned for trekking and camping, it stands as a cherished destination, inviting adventurers to immerse themselves in its serene and otherworldly allure. |
| Suraj Tal (Lake of the Sun God) | Suraj Tal, nestled at an elevation of 4,890 meters (16,040 ft), stands as India's third-highest lake. Revered as the source of the Bhaga River, it holds sacred significance and serves as a favored rest stop for travelers traversing the Baralacha La Pass. Its pristine beauty and spiritual aura make it a cherished destination amidst the rugged landscapes of the Himalayas. |
| Deepak Tal | Deepak Tal, nestled along the Chandra Tal trek, enchants visitors with its petite, heart-shaped form. Adorned by vibrant meadows teeming with wildflowers during the summer months, it offers a serene sanctuary for travelers seeking solace amidst nature's splendor. |
| D h a n k a r Lake | Situated close to the Dhankar Monastery, the biggest and oldest in Lahaul, this beautiful lake makes the monastery visit even more delightful, providing a lovely view amidst the mountains. |
| Neelkanth Lake | This lake, shaped like a pear, is close to Kibber village and is well-known for its breathtaking beauty. The bright blue water and snowy mountains around the lake make it look like a scene straight out of a picture postcard. |
| Sissu Lake | Close to Sissu village, this little lake is a favorite place for picnics and admiring the beautiful views around it. |
| Sopona Lake | This lesser-known lake is a hidden treasure, providing breathtaking views of the mountains that encircle it. |
| Dashir Lake | Dashir Lake, a lesser-known spot away from the usual tourist paths, is famous for its incredibly clear waters. When you look into the lake, you can see all the way to the bottom and enjoy the beautiful views all around. |

Source: SOI Toposheets, Google Earth Pro

2. Waterfalls:

Waterfalls in Lahaul and Spiti are geologically significant as they showcase the region's diverse rock formations and erosion processes. Serving as important geological and geoh heritage sites, they offer insights into the area's geological history and contribute to its cultural and natural heritage. With their scenic beauty and educational value, waterfalls have the potential to attract geotourists interested in experiencing these geological wonders firsthand.

| Waterfalls | Descriptions |
|-------------------------|---|
| Sissu Waterfall | Also known as Palam Dhara, this waterfall near Sissu village in Lahaul Valley is formed as the Chandra River cuts through the mountains. Its accessibility has increased with the opening of the Atal Tunnel, attracting tourists keen to admire its scenic beauty year-round. |
| Lingti Frozen Waterfall | The Lingti Frozen Waterfall, situated in the Spiti Valley of Himachal Pradesh, India, stands as a remarkable natural marvel. Renowned for its splendor, especially during the winter season when sub-zero temperatures cause the waterfall to freeze entirely, it captivates visitors from various regions. Originating from the Kunzum Pass area, the Lingti River traverses the rugged Spiti Valley terrain, sculpting this awe-inspiring ice formation as it cascades down the rocky cliffs. |
| Rashil Waterfall | Rashil Waterfall, nestled in the Pattan Valley of the Lahaul region, Himachal Pradesh, India, stands as a hidden treasure. While it may not boast the same renown as other waterfalls, its charm is steadily growing, aided by the increased accessibility of Lahaul year-round, courtesy of the Atal Tunnel. Additionally, the presence of sulfur springs in the vicinity adds another intriguing dimension to this picturesque locale. |
| Muling Waterfall | The Muling Waterfall, situated in the high-altitude Lahaul Valley of Himachal Pradesh, India, is a hidden gem waiting to be discovered. Found near Gondhla village along the Manali-Leh Highway, it offers a stunning spectacle for travelers passing through the region. Fed by the Muling Nullah, a stream originating from the nearby mountains, the waterfall enchants visitors with its cascading waters, particularly during the summer months when snowmelt enriches its flow. Top of Form |

Source: SOI Toposheets, Google Earth pro

3. Glaciers

Glaciers hold profound geological significance as agents of landscape transformation, sculpting terrain through erosive processes and sediment deposition over extensive temporal scales. Within Lahaul-Spiti, these glaciers emerge as pivotal geological landmarks, embodying geoh heritage sites owing to their distinctive formations and preservation of geological chronicles. Noteworthy glacial valleys such as Chandra and Bara Shigri Glacier emerge as promising geotourism locales, presenting avenues for adventure tourism and facilitating scientific inquiry into glacial dynamics.

| Glaciers | Descriptions |
|-----------------------|---|
| Bara Shigri Glacier | Bara Shigri, the largest glacier in Himachal Pradesh, spans over 27 kilometers (17 miles) and covers an expansive area exceeding 126 square kilometers (49 square miles). Serving as the primary source of the Chandra River, which later converges with the Bhaga River to form the Chenab River, its name, "Bara Shigri," translates to "Big Glacier" in the local dialect. Beyond its geological significance, Bara Shigri has attracted mountaineers and explorers for recreational and geographical pursuits. Notably, the glacier garnered attention for its valuable antimony deposits, prompting surveys by H. Walker and E.H. Pascoe of the Geological Survey of India in 1906. Situated within a transitional climatic zone, Bara Shigri straddles the boundaries of various climatic zones, ranging from cold and semi-arid to temperate and sub-alpine, as delineated by Rawat et al. (2009). |
| Chhota Shigri Glacier | Located on the northern slopes of the Pir Panjal Range, Chhota Shigri, meaning "Little Glacier," serves as a favored destination for skiing and other winter sports enthusiasts. Though smaller in scale compared to Bara Shigri, its scenic beauty and accessibility make it a sought-after spot for outdoor recreation in the region. |
| Gangstang Glacier | The Gangstang Glacier, positioned at the western border of the Lahaul region at an altitude of approximately 5,480 meters, flows into Shahsha nullah, ultimately merging with the Chandrabhaga River approximately 13 kilometers to the south. |
| Gepang Gath Glacier | The Gepang Gath Glacier, nestled in the Gepang Gath Valley of Lahaul, may not be as renowned as other glaciers in the area. However, it remains a valuable contributor to the region's water resources. |

Sources: SOI Toposheets, Google Earth Pro, Glaciers | District Lahaul and Spiti, Government of Himachal Pradesh | India (<http://lahaulspiti.nic.in>)

4. Passes

Mountain passes are geologically significant because they often mark areas where tectonic forces have created gaps in the landscape, revealing underlying geological formations. These passes can showcase various rock types, fault lines, and other geological features, providing valuable insights into the region's geological history.

In Lahaul and Spiti, mountain passes like Rohtang Pass and Kunzum Pass are not only important geological sites but also potential geotourism destinations. They offer stunning views of the surrounding mountains and valleys, and their geological features attract geotourists interested in learning about the region's unique geological heritage. Additionally, these passes serve as gateways to remote areas with diverse landscapes, making them ideal starting points for geological explorations and eco-adventures.

Some important passes are:

| Passes | Description |
|-----------------------------|---|
| Kunzum Pass (4,551 m) | This marks the entrance to Spiti Valley from Lahaul, presenting a picturesque journey with stunning vistas of the Himalayas and the Chandra River valley. Accessible typically from June through mid-October, the Kunzum Pass's availability hinges on weather patterns. |
| Rohtang Pass (3,978 m) | This mountain pass links the Kullu Valley to Lahaul and is a favored destination among tourists for its breathtaking views of nearby mountains and glaciers. The Rohtang Pass is typically accessible from May to November, yet its availability can be influenced by weather conditions. |
| Baralacha La Pass (4,890 m) | This pass serves as a vital link between Lahaul and the Zaskar Valley in Ladakh, known for its rugged terrain and picturesque landscapes. Baralacha La is usually accessible for travel from July to September, offering adventurers a chance to experience its beauty and challenges. |
| Kugti Pass (5,040 m) | Kugti Pass connects Lahaul Valley to Pangi Valley in Himachal Pradesh, India. Its challenging trek offers breathtaking views of snow-capped peaks and lush meadows, attracting adventurers and nature enthusiasts alike. |
| Parang La Pass (5,580 m) | This elevated pass lies along the Indo-Tibetan Border Police patrol route, presenting one of the toughest challenges in the area due to its severe weather conditions and rugged landscape. Parang La is open for a brief window during the summer months, offering a glimpse into its formidable terrain and harsh climate. |
| Manirang Pass (5550m) | The Manirang Pass links the Spiti Valley with the Ropa Valley of Kinnaur, characterized by its high altitude. On the Ropa Valley side, there's a five-kilometer snow-bed, while the Spiti side features about a three-kilometer snow-bed. Accessing the pass from the Spiti side, via the village of Mane, involves a gradual ascent. Conversely, descending towards the Ropa Valley side entails navigating a steep path through a narrow gorge. |
| Chobia Pass (4,980m) | Chobia Pass is a mountain pass located in the Pir Panjal Range of the Himalayas in Himachal Pradesh, India. It connects the Chamba Valley with the Lahaul Valley. The pass is known for its scenic beauty and challenging trekking routes, offering panoramic views of snow-capped peaks and picturesque landscapes. |

Source : SOI Toposheets, Google Earth Pro, Passes | District Lahaul and Spiti, Government of Himachal Pradesh | India (<http://lahaulspiti.nic.in>)

5. Built-up Geoheritages

Built-up geoheritages are features or sites of geological significance that have been incorporated into human-made structures or landscapes. These can include things like buildings constructed with unique geological materials, or even geological features integrated into architectural designs. They represent a merging of human creativity and geological history, often serving as educational or cultural landmarks that highlight the importance of geology in shaping our environment and societies.

Ancient monasteries, temples and structures contribute to the built-up geoheritages of Lahaul and Spiti. These religious structures, often constructed using locally sourced materials and traditional building techniques, form part of the cultural and architectural heritage of the region. They represent human interactions with the geological landscape, as their construction may have been influenced by the availability of geological resources such as stone and clay. From a geotourism perspective, monasteries and temples offer opportunities for visitors to explore the geological and cultural landscapes of Lahaul and Spiti. Some important monasteries of Lahaul & Spiti:

5.1 Key Monastery:

Key Monastery, established between 1008 and 1064 AD by Dromptom, a student of the renowned 11th-century teacher Atisha, is situated in Kee village atop a hill at an altitude of 4166 meters above sea level. It serves as the primary religious training center for Lamas in Spiti. Due to its strategic location, the monastery became a target for plunder by invading armies. The varied construction methods and architectural elements indicate that the complex has undergone numerous renovations and expansions over the years (Sharma and Sharma, 1997; Chaskar et al., 2023).

5.2 Tabo Monastery:

Tabo Monastery, situated at an altitude of 3050 meters in Tabo village, is renowned as the most esteemed and celebrated monastery in Spiti Valley. Often referred to as the "Himalayan Ajanta," it was constructed in 996 AD under the patronage of King Lah Lama Yeshe of the Guge Kingdom by the revered translator Lotsawa Rinchen Zangpo. This monastery played a pivotal role in the dissemination and proliferation of Buddhism in the western Himalayas and western Tibet (Klimburg-Slater and Luczanits, 1997; Verma, 2016).

5.3 Dhankar Monastery:

Dhankhar Monastery, also referred to as Tashi Choeling Gompa, stands as one of the most picturesque monasteries in Spiti, situated atop a rocky perch overlooking the confluence of the Spiti and Pin rivers. Positioned at an elevation of 3894 meters in Dhankhar hamlet, the former

capital of Spiti, its unique setting has captivated the interest of visitors from various backgrounds (Chaskar et al., 2023).

5.4 Trilokinath Temple:

Trilokinath is a revered temple, exemplifies the harmonious coexistence of Hinduism and Buddhism in Lahaul. It's home to several monasteries that house ancient murals, thangkas, wood carvings, and massive statues of Guru Padmasambhava, the missionary who introduced Buddhism to Lahaul, Spiti, and Tibet (Trilokinath Temple | District Lahaul and Spiti, Government of Himachal Pradesh | India (hplahaulspiti.nic.in)).

6. Langza village (Fossil Site)

Langza village, located at an altitude of 4437 meters above sea level in Spiti Valley, is celebrated as one of the highest villages accessible by road worldwide. It is renowned for its abundant ammonite fauna, earning it the local nickname "fossil village," attracting tourists in search of ancient cephalopod fossils (Krishnanand & Raman, 2019). Notably, Langza features a prominent Buddha statue atop a hill, and nearby Hikkim village, situated just 8 kilometers away, hosts the world's highest post office (Chaskar et al., 2023). Geologists and anthropologists are drawn to Langza due to its rich fossil deposits of marine creatures and plants, dating back millions of years.

7. Pin Valley National Park

Established on January 9, 1987, this site is nestled within the cold desert biosphere of the Himalayan region, offering a unique geological landscape. It serves as a gateway to explore a diverse geological sequence ranging from the Neoproterozoic to the Lower Jurassic periods. Particularly noteworthy is its distinction as the sole location in India where substantial Palaeozoic and Triassic sequences are exposed, making it a compelling candidate for recognition as a National Geoheritage and Geopark (Bhargava et al., 2021). Its rich geological diversity and historical significance make it an invaluable resource for geological research and education, attracting scholars and enthusiasts alike from around the world.

Challenges for Geotourism Development In Lahaul & Spiti:

Geotourism in Lahaul & Spiti faces unique challenges, despite the region's abundance of geological wonders and natural beauty. Many geosites are remote and difficult to access due to rugged terrain, limited infrastructure, and transportation options, hindering visitor flow and facility development. These sites offer glimpses into ancient prehistoric geological formations and Earth structures, but unethical human activity threatens their loss irreversibly (Singh and Anand, 2013)

Inadequate infrastructure, including interpretative facilities and geotourist guides, poses further challenges for geotourism development. Additionally, many

geosites are intertwined with local cultures and traditions, necessitating a delicate balance between tourism development and indigenous cultural preservation. The region's susceptibility to climate change impacts, such as melting glaciers and natural disasters, further complicates geosite preservation and conservation efforts. Limited public awareness and understanding of their geological significance often lead to underappreciation and ineffective geoconservation strategies due to communication gaps (Tripathi, 2020).

Establishing and enforcing policies for sustainable tourism practices, conservation, and geosite preservation are hindered by the involvement of multiple stakeholders. Addressing these challenges requires a collaborative approach involving government bodies, local communities, conservation organizations, and tourists. Sustainable development strategies, community engagement, eco-friendly tourism practices, and promoting responsible tourism are crucial for preserving Lahaul & Spiti's geoheritage.

Recommendations

Establishing geoparks within the region could be a significant step forward. These parks could serve as showcases for the area's rich geoheritages, offering educational opportunities and promoting sustainable tourism. Developing well-defined geo-trails that highlight unique geological features can attract geotourists interested in exploring natural wonders. Offering educational programs, guided tours, and workshops led by experts can enhance visitors' understanding of the area's geological significance.

Combining adventure tourism with geotourism can be appealing, with activities like trekking, rock climbing, and cave exploration providing thrilling experiences while showcasing geological formations. Involving local communities in geotourism initiatives can promote cultural exchanges and sustainable tourism practices. This engagement can include homestays, cultural demonstrations, and locally guided tours.

Collaborating with research institutions to conduct studies and research expeditions in the area can attract academics and researchers interested in the region's geological diversity. Enhancing infrastructure like visitor centers, accommodations, and access roads to geological sites can improve the overall geotourism experience.

Creating a tourist map with the positions of the most important geoheritage sites would draw attention to tourists and encourage their visits. This map should not only contain the exact positions of the sites but also detail their value and importance, allowing tourists to choose destinations based on their interests (Đurović & Đurović, 2010).

Implementing effective marketing strategies, both domestically and internationally, to highlight the unique

geological features and experiences offered by Lahaul & Spiti can attract geotourists from around the world. Emphasizing the need for conservation and preservation of geological sites is crucial in ensuring their long-term sustainability.

Conclusion

Lahaul & Spiti, nestled amidst the grandeur of the Himalayas, stands as an untapped reservoir of geological wonders, offering immense potential for geotourism development. The geological formations within the Lahaul & Spiti District of the Northern Himalayan Region encompass a diverse array of rock types and geological periods. Situated in the Tethyan Himalaya, the district's geological complexity is attributed to a wide range of rock complexes and minerals, along with faults exerting structural control over drainage networks throughout the area (Krishnanand, 2016), presents a compelling narrative of Earth's history waiting to be explored. However, despite its geological wealth, Lahaul & Spiti remains overshadowed by a lack of recognition and conservation efforts.

Lahaul & Spiti offers vast opportunities for tourism, spanning various sectors including ecotourism, tribal tourism, and archaeological tourism. The region boasts numerous natural and historical sites of geological significance, such as natural parks, caves, waterfalls, springs, glaciers, and mountain passes (Bhargava et al., 2010). Identifying potential geosites and geoheritages, such as the picturesque lakes, majestic waterfalls, expansive glaciers, rugged mountain passes, ancient monasteries, fossil-rich villages, and the unique Pin valley national park, lays the foundation for sustainable geotourism initiatives. These sites not only offer opportunities for adventure and exploration but also serve as educational platforms for understanding Earth's history and processes.

However, geotourism in Lahaul & Spiti faces several challenges, including limited infrastructure, environmental concerns, and the need for cultural preservation. Addressing these challenges requires a collaborative effort involving government agencies, local communities, conservation organizations, and tourists. Infrastructure development is crucial for enhancing the accessibility and facilities at geological sites. Improving visitor centers, accommodations, and access roads can significantly improve the overall geotourism experience (Krishnanand & Raman, 2019). Collaboration with research institutions can enhance scientific understanding of Lahaul & Spiti's geological heritage while attracting scholars and experts to study its unique landscapes (Singh and Anand, 2013). Furthermore, creating detailed tourist maps highlighting the positions and significance of geoheritage sites can attract more tourists and guide their visits effectively (Đurović & Đurović, 2010).

Addressing challenges such as inadequate infrastructure, environmental concerns and cultural preservation requires a concerted effort from multiple stakeholders (Dowling, 2013). Government bodies, conservation organizations, and tourists must collaborate to establish and enforce policies for sustainable tourism practices and geosite preservation (Panizza, 2001). Through collective action, Lahaul & Spiti can safeguard its geological heritage for future generations while reaping the economic benefits of responsible geotourism.

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