Unveiling India's Geological Treasures: Exploring the Concept of Geoheritage

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ABSTRACT

India's georesources are the least known in terms of geoheritage for sustainable economic growth from a scientific standpoint. Developing countries like India are clearly confronted with significant obstacles and hurdles to this kind of growth because of their increased reliance on natural resources. The reason for this is a lack of public knowledge and a disregard for the effects of sustainable development on resources designated as earth heritage. Despite this, India has an abundance of rich geological resources that span numerous notable rock landscapes from the Archean to the Recent era. The Indian Peninsula's cratons and sedimentary basins, the Eastern and Western Ghats, the Deccan Plateau, the Himalaya, and the Thar Desert are the most significant of these. With regard to Earth's geological past, each of these exceptional and diverse georesources bearing landscapes with their many distinctive traits is exceptional. on order to address the demands of the over a billion people who live on the subcontinent on a scientific, historical, cultural, archeological, artistic, and socioeconomic level, these landscape characteristics also have distinctive assets that should be acknowledged and preserved as geoheritage. Unfortunately, there hasn't been enough exploration and establishment of different terminologies, conceptions, and understanding of the concept of geoheritage in the Indian context to raise people's knowledge of these crucial components. Therefore, in order to address and comprehend these concerns, the current research reviews the evolution of numerous ideas and conceptions of geoheritage in the Indian context as well as embraces and analyzes them at the worldwide level. By using indigenous resources via geotourism, this would enable the general public and the geoscientific community realize the value of geoheritage and contribute to India's sustainable economic growth.

Keywords: Sustainable Economic Development, Georesources, Geoheritage, Geosites, Geo-conservation, Geotourism, Geopark

INTRODUCTION

The idea behind important geoheritage According to Joyce's work, georesources were first conceptualized in 1994.Further elaborating on the term, McBriar (1995) said that, broadly speaking, geoheritage refers to landforms as geological and geomorphological features that include the presence of a diverse range of minerals, rocks, fossils, and their petrogenetic characteristics, all of which point to the genesis of the Earth's landforms, or geosite. The preservation of the Earth's natural

resources is covered under geo-conservation as well. Geo-conservation has evidently gained importance on a worldwide scale in acknowledging that Earth systems have a past and are connected to a feeling of place, human progress, and the provision of resources for development along with its historical, cultural, aesthetic, and religious significance. Moreover, (2001) asserts that Earth systems are the foundation of ecological processes, which are likewise included in the legacy sciences. Still, both geoheritage and geo-conservation, as applied to India, are relatively new initiatives with limited scope and goals that have only recently acquired traction (GSI, 2001 a & b; Mazumdar, 2010). For example, in 2020, Mathur et al. offered a systematic technique for the first time to choose paleontological sites (fossils sites) and their conservation strategy to create a national fossil park or paleo park for India's geotourism industry. The rich geoheritage of India's many other notable locations, which include diverse physiographic divisions of landforms, apart from fossil sites, has not been well examined in this regard and still needs to be investigated and understood in relation to geotourism. Because of this, the history of how geoheritage has developed in India in comparison to other countries is covered in the present paper's first section. Many terms and concepts that are widely used internationally are crucial to comprehending the relevance of geoheritage in the Indian setting. This paper will also serve to disseminate information about the value of geoheritage in supporting sustainable socioeconomic development and to educate people, including students who will study it as part of their curriculum.

A SHORT HISTORY OF GEO-CONSERVATION AND GEOHERITAGE:

Georesources, geoheritage, and geo-conservation all refer to matters exclusively related to geology. It and Earth Sciences are often used interchangeably. A detailed analysis of geology and its different subdisciplines reveals significant similarities with other academic fields. For instance, the subdisciplines of Geology and Chemistry include Geochemistry and Crystal Chemistry, and Geology, Material Sciences, Physics, and Engineering are all involved in the research of crystal deformation and crystal lattice defects. Comparably, economic geography and economics are comparable in that they both contributed significantly to long-term, sustainable societal development.

Consequently, if we consider this angle, we find that many of geology's subfields are focused on studying the Earth for societal advantages. The current study argues that the field of geology should be broadened to include potential heritage values and conservation values of geological resources for socioeconomic development. In this sense, geoscientists in the United Kingdom—who are regarded as the birthplace of understanding the heritage values of georesources and their conservation—were the first to comprehend the geoheritage values of georesources (Anon 1991). Joyce (1994) first coined the word "geoheritage" subsequent to this idea. Subsequently, research published in international journals demonstrates that the primary emphasis of geoheritage is on geology and geomorphology. Nonetheless, a wide range of innovations created in the UK were exported, disseminated, and embraced worldwide, namely the inventory-based categorization scheme and the designation of locations as geosites of geoheritage importance (Duff 1994). Prosser and Hughes' (2001) concept of geosite tagging with national heritage was acknowledged as a significant advancement in the management and preservation (geoconservation) of geosites with geoheritage

value. The management of natural resources, land management, local cultural, historical, and archaeological elements, research, education, and tourism have all become more entwined with geosites as a result (Burek and Prosser, 2008).

Then, according to the worldwide literature, the type sections, minerals, and fossils, as well as the classic places, define geoheritage. These are mostly connected to places that serve as examples of Earth history and historical sites where certain geological concepts were first documented, such as the location of Hutton's angular unconformity in Scotland (Hutton, 1788). Furthermore, due to their scientific, educational, and artistic characteristics, as well as their rarity, present state, accessibility with special protected status, maintenance, monitoring, and tourist planning, geosites were established (Ruban and Kuo 2010). Subsequently, it was clarified that a geosite is fundamentally a place or region that has geological relevance for understanding Earth's past (ProGeo 2011; Wimbledon and Smith-Meyer 2012). Similar to this, Australian geologists from Tasmania coined the term "geodiversity" after the 1992 Earth Summit Biodiversity Convention in Rio de Janeiro. According to Sharples (1993)they proved that "biodiversity" and "geodiversity" both contribute to the idea that "Nature" is made up of equal parts of living and non-living things. These findings should be considered in tandem to support a more comprehensive approach to nature conservation. The word "geodiversity" has now expanded from Australia to many other nations, as well as to Scandinavia (Johansson et al., 2000), the United Kingdom, and other places (Gray 2004). Brilha (2005) proposed that inventorying biodiversity was the first and most important stage in any geo-conservation plan once the word geodiversity was coined. The foundation of a geoconservation strategy is comprised of many phases, including inventory, qualitative and quantitative evaluation, conservation, interpretation, promotion, and geosite monitoring. Following that, these elements gained traction in a step-by-step, worldwide investigation, where the inventory purpose was crucial to choosing the right approach and set of criteria for locating and choosing the geosites. Numerous publications on geoheritage (Wimbledon, 2011; Reynolds and Gray, 2013 and Brilha, 2016) developed and discussed these criteria.

As a result, numerous nations—primarily in Europe (Wimbledon and Smith-Meyer 2012), Poland (Alexandrowicz 1999), Portugal (Brilha et al., 2005) the United Kingdom (Wimbledon et al. 1995), Malaysia Nazaruddin, 2017), and many other nations—have concurrently developed national inventories of geosites.

Surprisingly, India has not yet created national geosite inventories, despite significant international effort (Mathur et al., 2020).

Following the creation of the inventory, several nations began to establish the two primary ways of evaluating geosites and geoheritage—qualitative and quantitative. The selection of geosites based on qualitative processes characterizes the first one. The need to rank the geosites is connected to the quantitative classification technique (Grandgirard, 1997).

Thus, concentrating on specificities found in geosites, several research groups have offered distinct methodological processes of both kinds of classifications (, 2009). Furthermore, according to Bruch

and Cendrero (2009), the development of the quantitative assessment of geosite takes into account best practices that have been previously published, including the important work of authors (Pereira, 2010). According to their respective geological types, the qualitative and quantitative approaches can be regarded as direct and indirect methods that can be used further to establish the geosite of educational and tourism values (Ruban, 2010); additionally, through biodiversity, the approaches can be used to establish significance of local, regional, national, and international significance (Brilha, 2019).

Previously, Sharples (1995) described geodiversity as "the range (or diversity) of geological (bedrock), geomorphological (landforms), and soil features, assemblages, systems, and processes." This definition of geodiversity was first given by Gray (2004). The evidences of previous life, ecosystems, and conditions throughout Earth's history, as well as a variety of atmospheric, hydrological, and biological processes now affecting rocks, landforms, and soils, are later defined as biodiversity (Luoto, 2010). Numerous scholars and practitioners worldwide have put forward varying approaches to the evaluation of biodiversity; thus, the notion has endured a protracted process of consolidation of utmost significance (Bruschi, 2007; Parks and Mulligan, 2010). Pereira et al. (2013) note that some important issues were left unresolved in these evaluations.

The biggest problem was how hard it was to develop a model that could be used in many contexts. In order to overcome this challenge, Forte (2014) did a fantastic job developing a Geodiversity Index Map, which overlays the Geodiversity Index Map to evaluate the effects of urban growth on the physical environment. The map displays the richness of geodiversity elements at a landscape scale and their distribution throughout the area (i.e. 40–50 years). This study is significant because it adds to the body of knowledge on biodiversity quantitative assessment techniques, which is new in this field and has applications in many domains. According to Santos et al. (2017), this novel and multifaceted methodology makes it possible to include geodiversity as a precise and objective metric in management plans for geosites. According to Melllli (2014), the question of whether or not to analyze all of the abiotic components simultaneously while mapping a geodiversity index is undoubtedly open. However, new methods for the quantitative analysis of abiotic diversity have been made possible by recent advancements in remote sensing and GIS technology, including the creation of new tools for spatial analysis and a new process for estimating biodiversity through the creation of a biodiversity index (Forte 2014). While many earlier research used a spatial grid system as a solution, these analyses are based on GIS methods instead (Santos et al., 2017).

In the past, a lot of these research used grid-based systems (Silva et al., 2015). Using this approach, square spatial units are created by superimposing a grid on a map, allowing the presence of biodiversity components to be quantified.

Following the creation of richness indices within each cell, a matrix showing the spatial distribution and richness of biodiversity inside an area is produced. Pellitero et al. (2014) claim that since distribution models cannot be computed on a pixel network and the distribution can be seen graphically on the resulting map, using a grid-based methodology eliminates the need for distribution

models—a statistical model that takes into account the richness and equitability of the element distribution.

However, instead of using a spatial grid system, a novel method based on kernel density and centroid analysis (Forte 2014) is used to understand the distribution, quantity, and frequency of the variables in addition. The geodiversity index calculation approach of Pereira et al. (2013) is being used with the subindex map idea, which has gained worldwide adoption (Brilha, 2018). Unfortunately, despite India's rich and substantial geoheritage, no biodiversity index maps have been created or made public as of yet. Geoscientists should, therefore, make an attempt to use this approach, which is based on GIS and remote sensing methods and is appropriate for calculating geodiversity in an Indian setting.

GEOTOURISM

When Gray, (2004) used the word "geotourism" to describe tourists who visited natural areas that were significant from a geological or geomorphological perspective, the phrase had already developed. Since then, geotourism has been used for a variety of naturally occurring aspects of biodiversity, and it has been thoroughly explained in three published books that examine the relationship between geological and geomorphological feature tourism (Dowling and Newsome, 2006).

Afterwards, Reynard (2008) examined the connection between geomorphology and tourism, namely the role of geomorphological sites as tourist attractions or as a foundation for tourism-related infrastructure and activities. These consist of things like instructional publications, guided tours, tools, didactic trails, and services that are designed to be effectively used in the tourist industry. In the end, these elements support the growth of environmentally friendly travel known as geotourism, which further advances the local economy (Migoń 2009). Geotourism has several definitions, although Dowling's (2013) term is likely the most often used.

Geotourism is a kind of travel that emphasizes using Earth's georesources to enhance the environment, culture, history, and conservation while also having a positive local impact. Interest in geological features and landscapes among tourists has grown rapidly in recent years. The discovery of geosites via geo-conservation initiatives and official acknowledgment of geoheritage led to the development of a sophisticated geotourism industry that offers travelers novel, distinctive, and educational experiences (Kirchner 2015). In this sense, geodiversity is very valuable for geotourism and geoeducational endeavors, as stated by Gray (2013); nonetheless, it is clear that geodiversity cannot be used for geotourism in its entirety. Nonetheless, the majority of how tourists use geodiversity is by taking advantage of special and undeveloped geosites (Pralong 2003). Following that, the historical, cultural, and archaeological concerns that are related to the geosites have a significant impact on the growth of geotourism (Panizza and Piacente 2008; Tomar et al., 2017). This is because these issues often make the geosites more appealing, which helps to boost geotourism via Geopark.

GEOPARKS AND GEOTOURISM

Through the creation of geoparks, geotourism has been growing rapidly around the globe for more than ten years (Pratyush et al., 2018). Compared to other types of conventional national parks, geoparks are unique. A geopark is a nationally preserved and protected region that houses many important geological heritage monuments, as per UNESCO criteria from 2006. These locations should be of special significance, uniqueness, or aesthetic appeal (with aspects of culture, history, and religion), and they should incorporate education, sustainable development, and preservation. Three primary strategies are used in a geopark: geotourism, education, and conservation (McKeever, 2010). Due to these factors, geotourism has been greatly pushed from 2004 via Geopark in both China and Europe at the same time (Dowling, 2008). Up to 2019, there were 147 UNESCO Global Geoparks spread across 41 nations, with 49 of them being in China, which accounts for its #1 ranking. But as of May 2020, India does not even have a single Geopark. Importantly, on a global scale, it includes the local community over time. A mix of enterprises and civic organizations collaborate to promote and provide unique services to guests at Geopark. It has been noted that the local community in Geoparks benefits much economically from geotourism as well. Along with new service and product options, it also generates cash via the creation of new jobs (Dowling, 2009).

Global Geoparks of UNESCO:

The idea of a geopark was initially introduced in 1991 at the Digne Convention as a means of promoting and protecting geoheritage via sustainable local development via a worldwide network of places with extraordinary geology. The idea for a Geopark Program was subsequently developed by UNESCO in 1997 in order to encourage the protection of important Earth resources on a national and worldwide scale. Four European nations came together in 2000 to address the issue of regional economic growth by promoting geotourism and protecting geological heritage. As a consequence, the European Geoparks Network (EGN) was established. Following that, in 2001, EGN and UNESCO inked a formal agreement for partnership. In 2004, it led to the creation of five Geoparks in Europe and one in China at the same time. Eight national Geoparks in China and seventeen Geoparks in Europe came together later in 2008 to establish the Global Network of Geoparks (GGN), which is run by UNESCO (Jone 2008). A single, cohesive geographic region on Earth where sites and landscapes of worldwide geological importance are administered with an all-encompassing concept of conservation, education, and sustainable development is what they also designated as a UNESCO Global Geopark. Geopark also involves the participation and support of the local community. Locals are taught to work as Geopark Rangers, Ambassadors, and Tour Guides in addition, where they may provide tourist services and accommodations, market local goods and crafts, and more, according to UNESCO charter from 2005.

In addition, geoparks located in tectonically active regions serve as hubs for disseminating information on the dangers of geohazards including earthquakes, tsunamis, landslides, and volcanic eruptions. All Geoparks are now under the Global Geopark Network's (GGN) governance and must adhere to UNESCO's 2010 guidelines for size and setting, management, local engagement, economic

development, education, and protection and conservation. As a result, the performance and administration of Geoparks are subject to four-yearly assessments. If, within two years, a Geopark fails to meet the standards, guidelines, and points highlighted by the Geopark evaluation committee, its name is withdrawn from the GGN list.

The Indian context of geoheritage:

Concerning the aforementioned talks, it is vital to examine geoheritage in the Indian context since, despite the country's abundant natural resources, no systematic attempts have been made up to this point to establish geoheritage and geotourism components in line with global standards. The rich geological riches of several rock settings ranging in age from the Archean to the Recent are well recognized to exist in India. According to Balasubramanian (2017), the most significant of these geological resources include the Deccan plateau, the Himalaya, the Eastern and Western Ghats, the Thar Desert, the Indian Peninsula, and the Indo Gangetic plains. Massive geological processes spanning millions of years have created these very valuable landscapes. If human actions lead to the loss of such landscape characteristics, such as the unchecked exploitation of earth's resources during the building of civic constructions, they cannot be artificially recreated or restored (Ahluwalia 2006). According to these geological conditions, the future of conservation of important Indian natural resources is dreadful and uncertain due to a lack of laws and regulations governing conservation; the sites are likely to perish by natural disaster (Mathur et al., 2020). In India, however, the Geological Survey of India (GSI) took the first move in this direction by designating thirty-three locations as National Geological Monuments (NGM) due to their importance. 10 sites total, two in Jodhpur (GSI 2001a & b) and one in Jaisalmer are located in Rajasthan.

There are ten paleontological sites among the thirty-three NGM; three of them are in Rajasthan, and only one is in Western Rajasthan. The site is Akal Fossil Park in Jaisalmer, which has petrified wood from the Jurassic period (Mathur et al., 2020). In spite of this announcement, no standardized categorization or process for choosing geosites in India in relation to geotourism and geoparks has been developed to far. A national fossil park or paleopark for geotourism in India was recently planned thanks to the recent establishment of a methodical technique by Mathur et al. (2020) to choose paleontological locations (fossils sites) and their conservation plan. Depending on the specific geological features of a certain location, this exact technique may be applied to a few different geosites. In spite of this effort, the NGM statement, and some other efforts (Mazumdar, 2010).

Conclusion:

Geoheritage within the Indian context provides a region with different geological wonders, theof which are, however, virtually untapped in the government in terms of context of geoconservation, geotourism and sustainable development. In contrast to the marine and land area prospering in natural resources as well as millions of years of Earth's history spanning from the ancient Archean to the more recent landscapes, India has not properly established geoheritage conservation and geotourism markers on a global scale.

The acknowledgement of thirty-three places as National Geological Monuments (NGM) by the Geological Survey of India (GSI) brings forth a prominent step forward in understanding the priority and the importance of preserving the geological heritage of India. Nonetheless, there is an insufficiency of specific guidelines for geosite selection methodology as well as a standardized methodology of localization with regards to both geotourism and geoparks.

Attempts, like to the recent development of the method of choosing paleontological sites by Mathur et al. (2020) are the way to the national fossil park improvement and development of geotourism in India. A wider effort is required to not only scale this to the other medical geographical divisions of our land but also to develop this approach further and improve patient outcomes in terms of heavy healthcare burden.

Development of geo-parks that can be found in varying places worldwide, is one of the possible avenues for the integration of efforts of the country in geo-heritage preservation, support to geo-tourism, geo-education and sustainable development. Meantime, UNESCO Global Geoparks are absent on the Indian list; the country has still the chances use the advantages of nature for entertainment and welfare growth. Cross-border collaboration of various stakeholders, including governmental bodies, conservation NGOs, academic institutions, and local communities, is essential to elaborate thorough geoheritage protection, geotourism promotion, and sustainable development strategies in India. Through exploration and extraction of the natural wealth that India possesses on its ditto wide territory, India can find the ways to have economic development, cultural interaction, environmental protection at the same time protecting the country's living and non-living resources.

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