

Research Article

Unlocking Ethiopia's Geoheritage: A Comprehensive Review of Geotourism Potential, Constraints, and Development Directions

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Abstract

Ethiopia possesses one of the world's most remarkable geological landscapes, shaped by the East African Rift System and marked by active volcanism, extensive escarpments, deep gorges, alkaline lakes, and globally significant paleoanthropological sites. Despite this exceptional geoheritage, geotourism remains an underdeveloped niche within the country's tourism sector, which has historically focused on cultural and ecological attractions. This systematic review synthesizes existing academic, policy, and geological literature to assess Ethiopia's geotourism resources and critically examine their actual and potential contributions to Local Economic Development (LED). Using an integrated Sustainable Geotourism Development Framework, the study classifies geotourism assets, evaluates current development conditions, and analyzes socio-economic benefits, constraints, and future opportunities. Findings indicate that geotourism can significantly enhance LED by generating employment, stimulating micro- and small-scale enterprises, improving infrastructure, promoting gender-inclusive livelihoods, and strengthening cultural and geological stewardship within local communities. However, the sector is constrained by severe infrastructural gaps, weak geo-interpretative services, environmental degradation, policy fragmentation, and limited community participation. Case studies from the Simien Mountains and the Afar Depression highlight both the transformative potential of geotourism and the persistent challenge of revenue leakage away from host communities. Despite these constraints, Ethiopia holds substantial opportunities to position geotourism as a strategic pillar of sustainable development through policy reform, institutional coordination, UNESCO Global Geopark initiatives, technological innovation, and community-based enterprise models. The review concludes by proposing a comprehensive set of policy, institutional, and community-level recommendations aimed at embedding geotourism within Ethiopia's broader economic and conservation agendas. Overall, geotourism represents a promising, yet underutilized pathway for inclusive, resilient, and place-based development in Ethiopia.

Keywords

Geotourism, Geoheritage, Sustainable Tourism, Ecotourism

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1. Introduction

Tourism is universally recognized as a powerful driver of socio-economic development, particularly for developing nations rich in natural and cultural capital [16, 24]. Ethiopia, a country of profound historical significance and staggering ecological diversity, has long positioned tourism as a strategic sector within its successive Growth and Transformation Plans (GTPI & II). Traditionally, Ethiopia's tourism appeal has been anchored in its exceptional cultural heritage exemplified by the rock-hewn churches of Lalibela, the castles of Gondar, and the ancient stelae of Axum, as well as its unique biodiversity within national parks such as the Simien and Bale Mountains [35]. However, a third, equally magnificent pillar of attraction remains critically underexploited: its geoheritage.

Ethiopia sits astride the geologically dynamic East African Rift System (EARS), an active continental rift zone that is gradually separating the African plate [13]. This tectonic setting has sculpted a landscape of dramatic extremes and remarkable geological diversity, ranging from the below sea-level Danakil Depression, home to the hydrothermal features of Dallol and the persistent lava lake of Erta Ale, to the alpine heights of the Simien Mountains. The landscape encompasses extensive rift valley floors dotted with alkaline lakes, towering escarpments, deep river gorges, and vast cave networks. It also includes sites that have yielded some of the world's most important hominid fossils documenting the story of human evolution [14, 21]. These geological features form the fundamental foundation upon which the country's ecosystems and human civilizations have evolved.

Despite this immense geological potential, systematic assessment, conservation, and promotion of geological assets for tourism commonly referred to as geotourism remain at an early stage in Ethiopia. While concepts such as ecotourism and cultural tourism are widely discussed in policy frameworks and academic literature, the concept of geotourism is still relatively underrepresented, resulting in fragmented understanding and management of non-living natural resources. Strategically developing geotourism presents a transformative opportunity for Ethiopia. It can diversify the national tourism product, reduce seasonality, distribute tourism benefits to remote and geologically unique regions, promote scientific literacy, and foster a conservation ethic while contributing significantly to Local Economic Development (LED) in communities that are often marginalized from mainstream economic growth.

The concept of geotourism has evolved significantly since its early definitions. Early interpretations emphasized the provision of interpretive services to help tourists understand geological and geomorphological features [20]. Over time, the concept has expanded to incorporate broader elements of sustainability and community well-being. A widely accepted contemporary definition describes geotourism as tourism that sustains or enhances the geographical character of a place, including its environment, culture, aesthetics, heritage, and the well-

being of local residents [27]. This holistic definition highlights the interconnected relationship between geological landscapes, ecological systems, cultural heritage, and local communities.

A parallel conceptual development emerged from the geo-conservation movement, particularly through initiatives such as UNESCO Global Geoparks, where geotourism is viewed as a tool for celebrating geological heritage, promoting geo-education, and achieving sustainable local development [39]. Within this framework, a geopark is defined as a unified geographical area where sites of international geological significance are managed with an integrated approach to protection, education, and sustainable development.

Geotourism can therefore be understood as a form of sustainable, place-based tourism that focuses on the appreciation, education, and conservation of geological and geomorphological features within their broader ecological and cultural contexts, while simultaneously promoting the well-being of host communities.

Importantly, geotourism does not function as an isolated tourism sector but rather as a complementary niche that interacts strongly with other sustainable tourism forms. While ecotourism focuses primarily on living ecosystems and biodiversity, geotourism emphasizes the abiotic foundations of those ecosystems [29]. In many cases, geology and culture are closely intertwined as geo-cultural heritage, such as in the rock-hewn churches of Lalibela, where cultural architecture is directly influenced by the geological properties of volcanic rock formations [22]. Consequently, the development of geotourism in Ethiopia does not require the creation of an entirely separate tourism industry; rather, it involves adding interpretive value and diversification to existing tourism experiences, thereby enhancing their sustainability, educational value, and economic contribution.

The rationale for this comprehensive review is fourfold. First, there is a clear absence of a synthesized nationwide assessment of Ethiopia's geotourism resources and their economic potential, as existing studies are often localized or embedded within broader tourism literature [36, 37]. Second, with a large youth population and an economy heavily reliant on agriculture, Ethiopia needs to identify new and sustainable drivers of job creation and Local Economic Development, particularly in peripheral regions where many geosites are located [17]. Third, many of Ethiopia's unique geoheritage sites face increasing threats from activities such as uncontrolled mining, quarrying, and deforestation [4, 8]. Properly managed geotourism can provide strong economic incentives for their conservation. Finally, policymakers and tourism stakeholders require a comprehensive and evidence-based analysis to guide future strategies, policies, and investment decisions in this emerging tourism sector. Consequently, this review provides an essential foundation for researchers, policymakers, tourism planners, conservation practitioners, local communities, and investors seeking to integrate geotourism into Ethiopia's

broader sustainable development agenda.

2. Research Objectives

The overarching aim of this paper is to conduct a systematic review to assess Ethiopia's geotourism resources and critically evaluate their contribution and potential to Local Economic Development.

Specific objectives are to:

- 1) Systematically inventory and classify the major geotourism resources of Ethiopia based on a coherent typology.
- 2) Assess the current state of development, use, and conservation of these geosites.
- 3) Analyze the existing and potential contributions of geotourism to local economies, including employment, enterprise development, and infrastructure.
- 4) Identify and critically examine the key challenges and constraints hindering the development of sustainable geotourism.
- 5) Explore the opportunities and strategic directions for leveraging geotourism for sustainable LED.
- 6) Propose an integrated framework and actionable recommendations for stakeholders.

3. Structure of the Review

This review is structured to logically flow from conceptual foundations to empirical assessment and finally to strategic recommendations. Following this introduction, Section 2 details the methodology. Section 3 provides essential geological background. Section 4 presents the core inventory and assessment of geotourism resources. Section 5 analyzes the LED linkages. Section 6 and 7 delve into challenges and opportunities, respectively. Section 8 proposes a development framework. The paper concludes with a summary, implications, and specific recommendations in Sections 9 and 10, followed by an extensive reference list.

4. Methodology

This study adopts a systematic literature review design, recognized as a rigorous, transparent, and replicable methodology for identifying, evaluating, and synthesizing existing research around a clearly defined question [31]. Given the exploratory character of geotourism in Ethiopia a relatively nascent field this approach is particularly suitable for mapping the current knowledge landscape, highlighting areas of consensus, revealing critical gaps, and establishing a solid evidence base to inform future investigations.

Data were collected from diverse secondary sources to promote triangulation and ensure comprehensiveness.

Primary sources included major academic databases such as Google Scholar, ScienceDirect, Scopus, ResearchGate, and JSTOR; grey literature comprising government reports from the Ethiopian Ministry of Tourism, the Ethiopian Wildlife Conservation Authority (EWCA), and regional bureaus, alongside policy documents (e.g., Growth and Transformation Plans [GTP] and the Tourism Development Policy) and publications from international organizations (UNWTO, UNESCO, World Bank); geological publications from the Geological Survey of Ethiopia; and relevant theses and dissertations from both Ethiopian and international universities.

The search strategy proceeded in multiple phases. Phase 1 involved broad keyword searches using combinations such as ("geotourism" OR "geo-tourism" OR "geological tourism" OR "geoheritage") AND ("Ethiopia" OR "East African Rift"). Phase 2 refined the focus by integrating specific geographical and thematic terms, for example, ("Ertale" OR "Dallol" OR "Danakil") AND tourism, or ("Simien Mountains" OR "Bale Mountains") AND geomorphology AND tourism, as well as ("Lalibela" OR "rock-hewn church") AND geology. Phase 3 employed citation chaining (snowballing) from the reference lists of key publications to identify additional relevant sources.

Table 1. Major Geotourism Sites in Ethiopia and Their Tourism Potential.

Geosite / Area	Geological Significance	Tourism Potential	Current Development Status
Danakil Depression	Active rifting zone, salt flats, hydrothermal features	Very High	Limited infrastructure, emerging tourism
Ertale Volcano	Persistent lava lake, active volcanism	Very High	Partially developed, safety and access constraints
Simien Mountains	Volcanic plateau, escarpments, geomorphology	High	Relatively developed, protected area
Bale Mountains	Volcanic landforms, Afro-alpine landscapes	High	Moderately developed, conservation-focused
Blue Nile Gorge	Tectonic incision, stratigraphic exposure	Moderate–High	Underdeveloped, limited visitor facilities

Geosite / Area	Geological Significance	Tourism Potential	Current Development Status
Afar Rift Valley	Plate tectonics, geothermal features	Very High	Poor accessibility, minimal services
Lalibela Rock-Hewn Churches	Rock-cut geomorphology and cultural integration	High	Well-developed cultural tourism site

Table 1 This section synthesizes Ethiopia's major geotourism assets, highlighting their geological significance, tourism potential, and current development status. The comparison illustrates the country's strong geoheritage base alongside uneven levels of tourism development.

The inventory and classification of geosites in this review were guided by established methodological frameworks for the systematic identification, selection, and quantitative evaluation of geological heritage assets. In particular, the approach draws on comprehensive procedures for developing national or regional geosite inventories, including criteria for assessing scientific, educational, and touristic values [9]. This ensures a transparent and replicable process and addresses common limitations in prior Ethiopian studies where geosite prioritization has often been qualitative or ad hoc.

To ensure relevance and scholarly quality, strict inclusion and exclusion criteria were applied. Included materials encompassed publications from 2000 to 2023 that directly addressed geological features in Ethiopia in relation to tourism or economic development; studies on Ethiopian tourism that, even without explicitly using the term "geotourism," described activities or sites aligning with its core definition (e.g., volcano tourism or trekking in geologically significant landscapes); research on community-based, sustainable, or eco-tourism initiatives in geologically rich areas; and documents in English or with English abstracts. Excluded materials included purely technical geological studies lacking connections to tourism, conservation, or socio-economic dimensions; non-analytical marketing brochures; and pre-2000 publications, except for seminal works.

Data extraction involved compiling relevant information from each source into a standardized matrix capturing details such as author and year, study location, geosites discussed, key findings on resources and attractions, economic contributions, challenges, opportunities, and methodological approaches.

Given the predominantly qualitative and descriptive nature of the literature, a thematic synthesis approach was employed to identify recurring themes, patterns, and relationships [33]. This inductive coding process helped organize the findings in line with the study's objectives, particularly regarding resource typologies, contributions to local economic development (LED), challenges, and opportunities.

The analysis was structured around a Sustainable Geotourism Development Framework adapted from established mod-

els in the field [15, 29]. This framework integrates five interconnected pillars:

- (1) Geoheritage Inventory and Conservation,
- (2) Interpretation and Education,
- (3) Community Involvement and Benefit,
- (4) Tourist Management and Experience, and
- (5) Strategic Planning and Partnerships.

Through this analytical lens, the study evaluates the current state of geotourism in Ethiopia and its implications for fostering sustainable Local Economic Development.

Despite the comprehensive scope of this systematic review, several limitations must be acknowledged. The existing literature on geotourism in Ethiopia is overwhelmingly qualitative and descriptive, with a pronounced lack of consistent and site-specific quantitative data. Empirical statistics on geotourism-related visitor numbers, revenue generation, employment creation, and local economic retention are either fragmented, embedded within broader tourism datasets, or entirely absent. This scarcity of quantitative evidence limits the ability to conduct comparative economic analyses, model multiplier effects, or rigorously estimate the contribution of geotourism to Local Economic Development. In addition, the absence of standardized indicators across studies constrains longitudinal assessment and cross-site benchmarking. As a result, this review relies primarily on qualitative synthesis and case-based inference, highlighting the urgent need for future field-based and mixed-methods research that systematically collects and analyzes quantitative geotourism data.

This study followed a systematic literature review procedure guided by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles to ensure transparency and methodological rigor. A comprehensive literature search was conducted using major academic databases, including Scopus, Web of Science, Google Scholar, and relevant institutional repositories. Search strings combined keywords such as geotourism, geoheritage, geosites, sustainable tourism, and Ethiopia.

The initial search yielded a broad set of records, which were subsequently screened through a multi-stage process. First, duplicate records were removed. Second, titles and abstracts were reviewed to exclude studies not directly related to geotourism, geoheritage, or tourism development in Ethiopia. Third, full-text assessments were conducted to evaluate eligibility based on predefined inclusion criteria, including relevance to the research objectives, academic quality, and empirical or conceptual contributions to geotourism studies.

Only peer-reviewed journal articles, academic books, book chapters, and authoritative institutional reports published in English were included. Studies lacking sufficient methodological clarity or relevance were excluded. The final set of publications formed the basis for qualitative synthesis and thematic analysis. The overall selection and screening process is illustrated in [Figure 1](#), which presents a PRISMA-style flow diagram summarizing the identification, screening, eligibility, and inclusion stages.

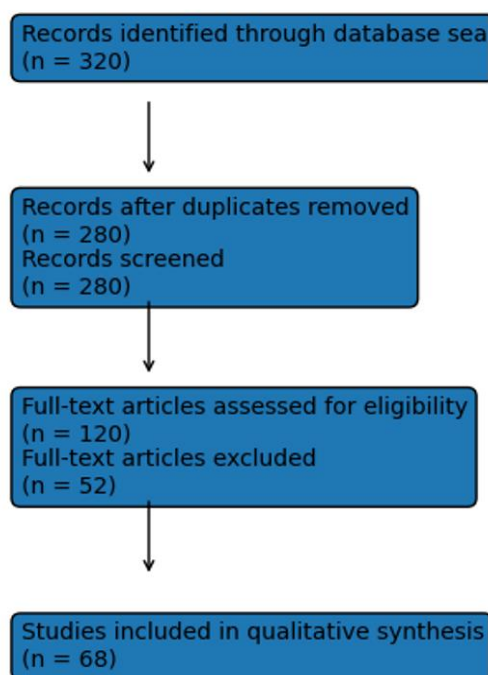


Figure 1. Systematic Review Procedure.

5. Overview of Ethiopia's Geological Setting and Geoheritage

Ethiopia's dramatic and diverse landscape is fundamentally shaped by its complex geological history, spanning over a billion years and dominated by Precambrian basement rocks, Mesozoic sedimentary sequences, and extensive Cenozoic volcanism and rifting associated with the East African Rift System (EARS) [2, 23]. The country's geological foundation comprises Precambrian metamorphic rocks formed during the Neoproterozoic East African Orogeny (ca. 880–550 Ma), overlain by thick Paleozoic–Mesozoic sedimentary successions, particularly within the Ogaden and Mekele Basins [2]. However, Ethiopia's modern physiography is primarily the result of geological processes beginning in the Oligocene (ca. 30 Ma), driven by the Afar mantle plume and the uplift of the Ethiopian Plateau [23]. This uplift triggered voluminous flood basalt eruptions collectively known as the Ethiopian Traps, which covered vast areas with thick tholeiitic basalts and evolved volcanic products, setting the stage for subsequent

crustal extension that initiated the ongoing rifting of the Afro-Arabian Dome and established Ethiopia as one of the most geologically dynamic regions on Earth [10, 11].

Within this tectonic framework, the East African Rift System in Ethiopia forms a triple junction in the Afar Depression, where the Red Sea Rift, Gulf of Aden Rift, and Main Ethiopian Rift (MER) converge at the intersection of the Arabian, Nubian, and Somalian plates [11]. This configuration produces three distinct rift arms: the Main Ethiopian Rift (MER), a seismically and volcanically active southwest–northeast trending valley characterized by chains of alkaline lakes such as Ziway, Langano, Abijata, Shala, and Awasa, as well as young silicic volcanoes and prominent fault scarps; the Afar Depression, a hyper-arid, sub-sea-level basin transitioning from continental rifting to incipient oceanic spreading, featuring active volcanoes including Erta Ale with its persistent lava lake, extensive salt flats such as the Dallol hydrothermal field, and intense geothermal activity; and the Southeastern Rift extending toward Kenya and influencing the Bale and Arsi mountain systems [10, 25]. The rifting process has generated classic horst–graben topography, with uplifted fault-bounded blocks forming mountain ranges and down-dropped grabens creating rift valley floors, illustrating the region's active tectonic evolution [19].

Building on this tectonic setting, Ethiopia's major physiographic regions each possess exceptional geoheritage significance, providing valuable opportunities for scientific research and geotourism development. These include the Western and Northwestern Highlands, dominated by the uplifted Ethiopian Plateau and deeply incised gorges of the Blue Nile (Abbay) and Tekeze rivers, with the Simien Mountains representing a spectacular erosional remnant of the plateau; the Main Ethiopian Rift, characterized by alkaline lakes, hot springs, young volcanoes, and dramatic escarpments; the Afar Depression, which serves as a natural laboratory for active rifting and volcanism; the Southeastern Highlands, including the Bale Mountains, a high volcanic plateau with evidence of past glaciation; and the Southern and Western Lowlands, including the Omo River Basin and Gambella region, which preserve important sedimentary sequences and paleoanthropological records [19].

Beyond its tectonic and scenic importance, Ethiopia's geoheritage holds profound global scientific value as the “Cradle of Humankind,” due to major paleoanthropological discoveries that have significantly contributed to understanding human evolution [7, 21, 38]. Notable discoveries include early hominid fossils from the Omo Valley and Afar region, most famously the discovery of “Lucy” (*Australopithecus afarensis*) at Hadar in 1974, as well as continuing excavations in the Awash Valley, Dikika, and Ledi-Geraru areas that have yielded important Pliocene and Pleistocene fossil evidence attracting researchers and educational visitors [7, 38]. In addition to its paleoanthropological significance, Ethiopia's volcanic landscapes also provide important opportunities for geochemical and volcanological research. Investigations of

high-temperature fumarolic gases at Erta Ale have revealed extreme enrichment in trace elements and distinctive degassing processes, highlighting the site's importance as a natural laboratory for active volcanism and its strong potential for scientific geotourism [40]. Collectively, this geological framework underpins Ethiopia's remarkable landscapes and positions the country as a global hotspot for geoheritage conservation, scientific research, and sustainable geotourism development, with important implications for local economic growth and cultural preservation.

6. Major Findings

6.1. Geotourism Significantly Enhances Local Economic Development (LED)

LED as a Community Centered Development Process:

Local Economic Development (LED) in the context of geotourism is conceptualized as a participatory and community-driven process in which economic gains are intentionally retained within the locality rather than flowing outward to external operators or investors. As emphasized in the paper, LED is not simply a by-product of national tourism expansion but a deliberate developmental practice rooted in local empowerment, community ownership, and pro-poor tourism principles [30]. This framing is particularly relevant in Ethiopia, where many geosites are located in economically marginalized regions that stand to benefit from locally anchored value chains. By ensuring that income generated from visitation, geoheritage conservation, and site management circulates within the community, geotourism supports equitable development and sustainable livelihood diversification. This approach aligns well with Ethiopia's policy emphasis on inclusive growth and community participation in natural-resource management, as demonstrated in studies highlighting the importance of local involvement and benefit-sharing in tourism and conservation initiatives [3, 32]. Consequently, geotourism serves as a strategic pathway for bottom-up territorial development in Ethiopia.

Direct Contributions: Employment and Revenue Generation:

Geotourism directly stimulates employment creation across diverse sectors including specialized guiding, hospitality, local transportation, and artisan production, thereby expanding economic opportunities in remote and low-income regions. Empirical evidence from the Simien Mountains and the Erta Ale volcanic landscape shows that local youth are engaged as scouts, guides, pack-animal handlers, cooks, and camp assistants, providing critical income for households with limited agricultural productivity [36].

Revenue generation is similarly significant: entrance fees, guiding charges, campsite fees, and income from locally owned accommodations ensure that economic gains remain within the community. In the Simien Mountains National Park,

for example, a designated portion of entrance fee revenue is reinvested into community development projects, demonstrating a functioning model of local revenue retention [32]. These mechanisms underscore geotourism's role as a direct and reliable source of local income that complements traditional livelihoods.

Indirect Contributions: MSME Growth and Infrastructure Development: Beyond direct employment, geotourism catalyzes indirect and induced economic benefits by stimulating micro- and small-scale enterprises (MSMEs) engaged in supplying agricultural products, construction materials, handicrafts, and transport services. Hotels, campsites, and restaurants near major geosites rely heavily on local supplies of teff, vegetables, livestock products, honey, and coffee, integrating rural producers into the tourism value chain and strengthening backward linkages. Geotourism also attracts substantial public and private investment in infrastructure such as road improvements, electricity expansion, telecommunications networks, and water systems, especially near gateway towns like Debark, Arba Minch, and Semera [2, 34]. These improvements not only enhance visitor experiences but also elevate the quality of life for residents, reinforcing the developmental ripple effects of tourism-centered infrastructure development.

Non-Monetary Social and Cultural Contributions:

Geotourism contributes meaningfully to socio-cultural revitalization, indigenous knowledge preservation, and community empowerment. Recognition of geological landscapes strengthens the importance of cultural traditions that are geographically anchored, such as the Oromo Gada system, whose sacred sites often coincide with distinctive geological formations [12, 28]. Interpretive programs and geo-education initiatives further promote geo-literacy, instilling stewardship values among local communities and fostering collective responsibility for landscape preservation. Additionally, geotourism expands opportunities for women as craft producers, lodge managers, cooks, preparers of traditional foods, and even as emerging local guides, enhancing gender equity and improving women's social and economic status. These non-monetary contributions enrich community cohesion, cultural pride, and long-term conservation ethics.

Case Studies Illustrating LED Impact: The Ethiopian case studies of the Simien Mountains and the Afar Depression offer clear evidence of geotourism's LED potential while also highlighting structural challenges. In the Simien Mountains, community-guided trekking supported by mandatory scout systems ensures that a substantial portion of tourist spending directly benefits local households, providing sustainable income opportunities in a region where agricultural capacity is limited [36]. In contrast, the expedition economy of the Danakil Depression and Erta Ale demonstrates both opportunities and vulnerabilities: while Afar communities benefit from employment as guides, camel handlers, and logistics providers, a significant share of high-value revenue flows to tour operators based in Addis Ababa, illustrating persistent leakage [17]. These contrasting cases reveal the importance of community

ownership, transparent revenue-sharing frameworks, and locally embedded tourism enterprises to ensure that geotourism functions as an effective LED mechanism.

6.2. Multiple Structural and Environmental Constraints Undermine Geotourism Development

Infrastructural and Accessibility Deficiencies:

Despite Ethiopia's exceptional geoheritage potential, the development of geotourism remains constrained by a combination of infrastructural, institutional, socio-political, and environmental challenges. One of the most persistent barriers is inadequate infrastructure, particularly poor road accessibility, limited accommodation facilities, and insufficient visitor services in remote yet geologically significant areas such as the Danakil Depression, the Afar Rift Valley, and the Blue Nile Gorge. Similar constraints have been widely identified as critical limiting factors for geotourism development in developing countries, where high geoheritage value often contrasts sharply with weak tourism infrastructure [16, 20].

Governance- and policy-related challenges further limit the effective utilization of Ethiopia's geoheritage resources. The absence of a dedicated national geotourism policy, weak institutional coordination among tourism, environmental, and cultural authorities, and limited integration of geoheritage conservation into national tourism planning frameworks constrain strategic implementation [39]. In Ethiopia, tourism development policies have traditionally prioritized cultural and wildlife tourism, leaving geotourism marginally addressed despite its strong alignment with sustainable development objectives [7, 36].

Community participation also remains uneven across geotourism destinations. Although local communities are the primary custodians of geological heritage, their involvement in planning, management, and benefit-sharing mechanisms is often limited. This lack of meaningful engagement reduces local ownership and may lead to resistance or unsustainable resource use [29]. Furthermore, environmental management challenges such as inadequate site monitoring, limited conservation funding, and the absence of site-specific management guidelines pose significant risks to fragile geological landscapes, particularly in volcanically active and erosion-prone areas [36].

Knowledge and Interpretation Gaps:

A major constraint to geotourism growth is the absence of a systematic national geosite inventory, leading to fragmented planning, uneven site prioritization, and missed opportunities for conservation and market positioning [37]. Furthermore, most guides at national parks and local sites are trained in wildlife or cultural tourism rather than geology, limiting the interpretive depth and educational value of tourist experiences. The lack of interpretive signage, panels, and visitor centers with geological content further diminishes site quality [26].

These knowledge and interpretation gaps restrict Ethiopia's

ability to position itself competitively in the global geotourism niche, where educational and knowledge-based experiences are central to market demand.

Threats from Mining, Quarrying, and Unregulated Development:

Geotourism's long-term sustainability is threatened by competing land-use activities, particularly mining, quarrying, geothermal development, and unregulated construction. In regions such as Afar, mineral exploration and industrial extraction threaten globally significant sites including hydrothermal fields, salt flats, and volcanic craters. Unregulated quarrying of basalt, limestone, and sandstone for construction creates irreversible scars on landscapes with high scientific and tourism value. Infrastructure projects such as roads, dams, and geothermal plants, when poorly planned, disrupt geological integrity and scenic quality. These pressures highlight the urgent need for Ethiopia to develop a dedicated geoconservation policy supported by strong regulatory enforcement.

Environmental and Climate-Related Vulnerabilities:

Environmental degradation poses significant risks to the landscapes that underpin Ethiopia's geotourism sector. Deforestation, overgrazing, and agricultural expansion on steep slopes accelerate soil erosion and trigger landslides, particularly in areas like the Simien escarpment [9]. Meanwhile, Rift Valley lakes including Tana, Abijata, and Shala are experiencing sedimentation, eutrophication, and pollution from agricultural runoff and urban waste, reducing their ecological and aesthetic appeal [1, 18]. Climate change intensifies these challenges by altering hydrological cycles, reducing waterfall flows, accelerating desertification in arid environments like Afar, and increasing the frequency of extreme weather events. These vulnerabilities complicate tourism planning and require climate-resilient geotourism strategies.

Policy and Governance Constraints:

Fragmented governance remains a persistent challenge to effective geotourism development. Although several policies touch on tourism, conservation, or natural-resource management, Ethiopia lacks a unified framework specifically addressing geotourism or geoconservation. Overlapping mandates among the Ministry of Tourism, Ethiopian Wildlife Conservation Authority (EWCA), regional bureaus, and the Geological Survey result in coordination gaps and regulatory inefficiencies [7]. Limited budgets and the absence of sustained financial mechanisms further impede activities such as geosite inventory development, geological guide training, and interpretive infrastructure investment. These policy and governance weaknesses hinder strategic planning and long-term site protection.

Community-Level and Market-Related Challenges:

Local communities often face barriers to meaningful participation in geotourism due to limited awareness, inadequate business skills, and conflicts with traditional livelihood activities [33]. Resource competition between tourism operations and pastoralism, farming, or grazing is particularly visible in

Borana areas, where access to water and land remains a contentious issue [5]. In addition, Ethiopia's geotourism sector suffers from weak branding, low visibility in niche markets,

and seasonal fluctuations in demand driven by rains and regional insecurity [6].

These dynamics restrict consistent visitor flows and reduce local income reliability.

Table 2. Key Constraints Affecting Geotourism Development in Ethiopia.

Constraint Category	Description	Affected Geosites	Implications for Geotourism
Infrastructure	Poor road access, limited accommodation, weak utilities	Danakil, Afar Rift, Blue Nile Gorge	Limits visitor numbers and length of stay
Safety and Security	Volcanic hazards, political instability in some regions	Danakil, Erta Ale, Afar	Restricts market confidence and tour operations
Governance and Policy	Weak coordination, lack of geotourism-specific policy	Nationwide	Hinders strategic planning and investment
Community Engagement	Limited local participation and benefit-sharing	Rural geosites	Reduces sustainability and local support
Environmental Management	Lack of conservation guidelines and monitoring	Protected and fragile geosites	Risks degradation of geoheritage
Promotion and Marketing	Low international visibility of geosites	Nationwide	Underutilization of tourism potential

Table 2 summarizes the major structural, institutional, and environmental constraints limiting geotourism development in Ethiopia, emphasizing the need for integrated planning, infrastructure investment, and community-based management.

7. Synthesis and Implications

Addressing the identified constraints requires an integrated and multi-level development approach that balances tourism growth with geoheritage conservation. Improving basic infrastructure, especially transport access, visitor facilities, and safety services, should be prioritized in high-potential geotourism destinations, while ensuring that infrastructure development adheres to environmental sustainability principles [15, 39]. Strategic investment in low-impact infrastructure can significantly enhance accessibility without compromising geological integrity.

Strengthening governance frameworks is equally critical for sustainable geotourism development. The formulation of a national geotourism strategy, embedded within Ethiopia's broader tourism and sustainable development policies, would provide clearer institutional direction and improve coordination among key stakeholders. International experience demonstrates that well-defined governance structures and policy integration are essential for effective geotourism planning and management [7, 20].

Community-based geotourism models offer a viable pathway to enhance local participation and equitable benefit dis-

tribution. Capacity-building initiatives, local guiding programs, and transparent revenue-sharing mechanisms can strengthen community ownership while contributing to conservation outcomes [29]. In addition, targeted marketing and branding strategies that emphasize Ethiopia's unique geoheritage, such as active volcanism, rift valley tectonics, and rock-hewn geomorphology, can improve international visibility and diversify the country's tourism portfolio beyond traditional cultural and wildlife attractions [16, 36].

8. Conclusion

This comprehensive review has established that Ethiopia is endowed with a geoheritage of exceptional diversity, scale, activity, and scientific importance, positioning it as a potential global leader in geotourism. This resource base, encompassing volcanic wonders, tectonic landscapes, deep gorges, karstic caves, and paleoanthropological treasures, offers a compelling foundation for sustainable tourism development.

The contribution of this nascent sector to Local Economic Development is both tangible and promising. It holds the potential to create employment, stimulate local enterprises, improve infrastructure, and foster cultural pride in some of Ethiopia's most remote and economically marginalized regions. However, this potential is currently constrained by a formidable array of challenges. These range from acute infrastructural deficits and a near-total absence of geo-interpretation to profound policy and institutional gaps, environmental threats, and insufficient community engagement and benefit-sharing.

The path forward is not one of simple promotion, but of integrated and strategic development. The opportunities from policy alignment and UNESCO geopark potential to digital tools and growing niche markets provide a clear roadmap. Central to success is a paradigm shift from viewing geology merely as a scenic backdrop to recognizing it as a core, interpretable, and conservable heritage asset that can drive sustainable and inclusive development.

Realizing the vision of geotourism as a pillar of Ethiopia's economy and a force for LED requires deliberate, coordinated, and patient action from all stakeholders. It demands investment not just in roads and lodges, but in knowledge, capacity, governance, and, most importantly, in the people who are the true stewards of these magnificent landscapes.

9. Recommendations Policy and Strategic Recommendations

For Federal and Regional Governments

- 1) **Initiate Policy Reform:** Mandate the Ministry of Tourism to lead the development of a comprehensive *National Geoconservation and Geotourism Strategy and Action Plan* within two years, ensuring alignment with national development and conservation frameworks.
- 2) **Pilot a UNESCO Global Geopark:** Establish an inter-governmental working group to prepare a nomination dossier for a proposed Danakil Afar Global Geopark, elevating it as a flagship national initiative.
- 3) **Fund Strategic Infrastructure:** Allocate dedicated capital budgets to upgrade critical access roads and essential services for priority geotourism destinations such as the Simien Mountains, Bale Mountains, and Dallol trailheads.
- 4) **Strengthen Institutional Coordination:** Legislate the formation of a National Geoheritage Council comprising federal agencies, regional bureaus, academia, and community representatives to harmonize geosite planning, oversight, and enforcement.

For Local Communities and Local Administrations

- 1) **Build Local Capacity:** Engage actively with government institutions, NGOs, and technical partners to receive training on establishing and managing Community-Based Tourism Enterprises (CBTEs), cooperative models, and financial management.
- 2) **Document Indigenous Knowledge:** Collaborate with researchers and universities to systematically document indigenous geological knowledge, oral histories, and cultural narratives for integration into interpretive materials and guided experiences.
- 3) **Develop Local Agreements:** Establish clear, written community protocols governing relationships with tour operators, including guiding rights, campsite usage, revenue-sharing, cultural performances, and environmental responsibilities.

For the Private Sector and Investors

- 1) **Adopt Best Practices:** Commit to internationally recognized sustainability principles such as those of the Global Sustainable Tourism Council (GSTC) and prioritize local hiring, local sourcing, environmental protection, and fair partnership agreements with communities.
- 2) **Invest in Geo-Interpretation:** Integrate high-quality interpretive content (digital apps, AR tools, guidebooks, training programs, and certified guides) as a core component of tourism product development rather than an optional add-on.
- 3) **Explore Innovative Finance:** Utilize emerging financing models including impact investment, blended finance, and public-private-community partnerships to support community-owned tourism facilities and small-scale infrastructure.

For Academia and Research Institutions

- 1) **Lead the National Geosite Inventory:** Mobilize geology, geography, and tourism departments to undertake a nationwide geosite inventory and assessment, ideally structured as a coordinated series of graduate research projects.
- 2) **Develop Targeted Curriculum:** Design and implement certified short courses, diploma programs, and professional development modules in Geotourism and Geoheritage Management, tailored for guides, park rangers, tourism officers, and local administrators.
- 3) **Establish a Research and Training Center:** Create a Center for Geoheritage and Sustainable Tourism to serve as a national hub for research, training, innovation, and evidence-based policy advisory services.

For Development Partners and NGOs

- 1) **Strengthen Community Institutions:** Provide grants, mentorship, and technical assistance to build the capacity of community cooperatives, women's associations, youth groups, and CBTEs operating in or near geosites.
- 2) **Fund Integrated Pilot Projects:** Support multicomponent pilot projects in two to three regions that combine geosite assessment, community enterprise development, guide training, small-scale interpretive infrastructure, and conservation activities.
- 3) **Facilitate Knowledge Exchange:** Sponsor professional exchanges, study tours, and cross-learning opportunities for Ethiopian practitioners to visit established geoparks in Iceland, Jordan, Vietnam, and other successful models, while hosting international experts in Ethiopia.

10. Final Remark

Developing geotourism in Ethiopia is inherently a long-term, multi-stakeholder endeavor. Success depends on integrating scientific rigor, community empowerment, and sustainable management principles. By adopting these recommendations, Ethiopia can ensure that its extraordinary geological landscapes are not only visited, but also *understood, valued, and*

preserved transforming them into engines of shared prosperity for generations to come.

Recommendations for Future Research and Monitoring

To address existing quantitative data gaps and strengthen evidence-based planning, future geotourism research in Ethiopia should adopt standardized and measurable indicators. These should include site-specific visitor numbers (by season and visitor type), revenue generated from tourism activities, employment created within host communities (direct and indirect), local income retention rates, and investment in geosite conservation and management.

Systematic monitoring of these indicators would support more accurate economic impact assessment, enable comparison across geosites, and inform adaptive policy and investment decisions in Ethiopia's developing geotourism sector.

Abbreviations

AHTI	Addis Ababa Hospitality and Tourism Institute
BMC	BioMed Central
CHM	Cultural Heritage Management
EARS	East African Rift System
EWCA	Ethiopian Wildlife Conservation Authority
GSTC	Global Sustainable Tourism Council
GTP	Growth and Transformation Plan
IGGP	International Geoscience and Geoparks Programme
LED	Local Economic Development
LSE	London School of Economics
MER	Main Ethiopian Rift
MSME	Micro, Small, and Medium Enterprises
ORCID	Open Researcher and Contributor ID
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNWTO	United Nations World Tourism Organization

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Conflicts of Interest

The authors declare no conflicts of interest.

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