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A SUSTAINABILITY MODEL OF GEOPARKS APPLIED TO THE TUNGURAHUA VOLCANO GEOPARK

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Abstract: The Tungurahua Volcano Geopark (GVT), is located in the center of the Ecuadorian Andes, and comprises an area of 2,397 km^2. The name-giving Tungurahua Volcano, which is one of the most active volcanoes in Ecuador, is only one of many other volcanic complexes to be part of the GVT. All these volcanic edifices are the result of the subduction of the oceanic Nazca plate below the South American continental plate, along the active continental margin. A novel sustainability model of geoparks has been applied to the GVT, of which methods consisted of revising secondary information from documents and interviews with experts and primary data collected and validated during field trips performed in two stages, where twenty Geosites were defined. Furthermore, we structured a scientific committee of seven Universities, two NGOs and other stakeholders. Additional elements of our management and assessment included to describe the evolutionary history of this particular area since the Lower Devonian, and, to elaborate a monitoring and conservation plan that includes the placement of signage, interpretive scripts and tourist mapping. The key has been the joint work and strategic alliances based on local development axes such as geoeducation, geoconservation and geotourism focused on the Sustainable Development Goals. To present a novel sustainability model for geoparks, applied in a case study in Ecuador. Review of information and guide questionnaires that directed the interviews with experts of other geoparks. Validation of obtained data in the field. Inventories of sites where geotourism were performed. A novel sustainability model of geoparks has been applied by the described methods. A scientific committee was structured. A description of the evolutionary history of the study area is given. A monitoring and conservation plan was elaborated and presented. We reached a joint work, focused on the SDG´s. Generation of economic income, creation of strategic alliances and protection of the given heritage; Networking with Global Geoparks; recognition and conservation of geological heritage within the SDG´s. Especially the consolidation of global collaboration networks, the professionalization of staff, and the acquisition of sustainable resources are aspirations that, for the present times, may not allow to be achieved in the short or medium term due to budgetary and management constraints.

Keywords: geopark, geotourism, UNESCO, Ecuador, Tungurahua, volcano, sustainability, natural heritage

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INTRODUCTION

A geopark is a territory with a remarkable geological heritage that promotes sustainable development through education and tourism (Carcavilla & Cortés, 2018). Since 2015, UNESCO has recognized Global Geoparks as key spaces for assessing the planet's geological heritage and evolution. Hereby, UNESCO began the proposal to create or support programs for the preservation of Natural and Cultural Heritage in 1945, Biosphere Reserves in 1971 and later Geoparks (Boylan, 2008; Henriques & Brilha, 2017). Thus, in the nineties, Germany, Spain, France and Greece were the first countries in Europe to have territories under the figure of experimental projects of geoparks (Fassoulas et al., 2013; Blersch et al., 2023; Hose & Vasiljevic, 2016; Golfinopoulos et al., 2022).

In 2000 the European Network of Geoparks was created, and later in 2004 the UNESCO legalized the Global Geopark Network, which currently has 213 Geoparks in 48 countries (Zouros, 2004; Ruban & Yashalova, 2024). In the Americas, there are 18 recognized Geoparks, of which ten are situated in South America. In Ecuador, besides the Imbabura UNESCO Global Geopark, there is an aspiring Tungurahua Volcano Geopark (GVT), besides others (Rosado-González et al., 2020; Simbaña-Tasiguano et al., 2024; Toulkeridis et al., 2025).

The GVT candidate in Ecuador covers 2,397 km² and is home to 1,049,484 inhabitants (National Council for Gender Equality, 2021). Its diverse climate, ranging from warm dry to cold high mountains, sets the stage for productive and

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tourist development. The GVT Project is a beacon of hope, aiming to forge a cultural identity rooted in the conservation of geological heritage and to promote geotourism and a sustainable territorial development model that enhances the quality of life for the local population. Prior to 2015, no comprehensive long-term strategies focused on regional sustainability. However, the future looks promising, given the potential economic benefits that this Geopark may be able to provide (Geoparque Volcán Tunguraua, 2023). This project predominant aims have been to secure the 'UNESCO Global Geopark designation to bolster local identity and development.

Therefore, the given objectives have been to include organizing and socializing the project, integrating education, tourism, and conservation axes from a geological perspective, and designing a sustainable management model that encourages collaboration between local actors such as academic institutions, governments, and communities (Sánchez, 2023). The Governance model, a key component, outlines the decision-making processes, roles and responsibilities, and mechanisms for stakeholder engagement. In addition, it promotes awareness and good practices in the rational use of resources, valuing geological heritage in tourist scripts (Nguyen & Kieu, 2024).

The project dossier was presented to UNESCO on April 8, 2024. Success lies in collaboration and strategic alliances based on pillars of local development (International Labor Office Geneve, 2010), such as geoeducation, geoconservation, and geotourism, oriented towards fulfilling the Sustainable Development Goals (Stephens, 2020). These actions promote economic opportunities, highlighting education (Martínez-Martín, 2022) as essential for disseminating and strengthening the Geopark and actively involving children, adolescents, and the local community (Zheng et al., 2024; Martínez-Martín et al., 2024; Zelenka et al., 2025; Randy et al., 2024; Kovacs et al., 2025).

Based on the aforementioned, the current research has been based on the presentation of a novel sustainability model of geoparks based on the assessments elaborated within the aspiring Tungurahua Volcano Geopark.

Hereby, the main key may be on the collaboration and joint work of local development axes such as geoeducation, geoconservation and geotourism focused on the Sustainable Development Goals. This will certainly allow to generate new and sustainable economic incomes, and subsequently also the protection of the given heritage. Furthermore, it is expected to enhance the networking with Global Geoparks on a regional and may global scale.

MATERIALS AND METHODS

Initially, the research process comprised reviewing secondary information from documents such as reports, theses, and others generated by the sectional governments and cooperating institutions, as well as guide questionnaires that directed the interviews with experts from Ecuador's main geoparks and allies in Latin America. Subsequently, data was meticulously collected and validated in the field, starting with a situational diagnosis of each Geosite (GS), focusing on the social, cultural, environmental, and economic aspects. This diagnosis was guided by two fundamental characteristics, being the dynamics that generated the current situation and its projections in the medium or long term and the causality, which identifies the positive or limiting factors that originated it (Hannel del Valle, 2005).

The first characteristic allows for implementing measures that adapt to the changing realities that occur in the future, and the second is aimed at eliminating deficiencies or enhancing favorable conditions (Secretaría Nacional de Planificación y Desarrollo SENPLADES, 2005). In addition, the situational diagnosis allowed to understand the reality of the GS by organizing the research in two project stages. The first comprised the geological vision based on the Geoheritage and Geodiversity that the territory has, while the second has been involving the territory within a historical, economic, sociological, and anthropological vision. Therefore, to complete stage one, inventories of sites where geotourism were performed using known methodologies (Brilha, 2018). Hereby, several geosites were valued and characterized, with their respective historical and geological inquiry. Furthermore, inventories of flora and fauna were realized due to the transect techniques that allowed data to be taken in the field (Gregoire & Valentine, 2003).

Finally, the use of GPS for the management of peripherals and mobile systems and data analysis using ArcGIS for the taking of geographic points and their respective mapping were also involved. To achieve the second aim, a bibliometric study and analysis of existing studies realized on geoparks to date was performed, with all their contributions to the evolution of the Tungurahua volcano and its historical, geological, anthropological, and sociological influence on nearby populations with the guidance of academics and experts from friendly institutions. Based on their analysis, we complemented the work of stage one to generate five decisive documents, being (1) the inventory of 20 Geosites with their inventory of Flora and Fauna (Geoatractivos, 2024); (2) the description of an evolutionary history of the earth since the lower Devonian, some 417 Ma; (3) a Monitoring and Conservation Plan (including informative signage, interpretive scripts, and tourist mapping (Galindo et al., 2009; Chávez González & González Guillén, 2015); (4) a document on the Sustainable Use of Mineral and a Governance model and (5) a Communication and Marketing Plan.

RESULTS

1. Inventory

1.1. Regional geology and corresponding remarkable Geosites

The regional geology of the GVT is composed of a wide geodiversity, which includes various geological processes that occurred from the Lower Devonian, passing to the Upper Triassic through a geochronological discontinuity, continuing towards the Lower, Middle and Upper Jurassic to advance to the Lower and Upper Cretaceous until a new geochronological discontinuity that marks the contact with the Miocene towards the Pliocene to finally encounter events located in the Pleistocene and Holocene of the Quaternary period, including lithotectonic terrains, formations, units and

geological deposits (Figure 1). It includes the units Agoyán (UAgy), Tres Lagunas (UTLg), Upano (UUpo), Cuyuja (UCyj), Cerro Hermoso (UCHm), Alao - Paute (UAPt), Misahuallí (UMsh), Maguazo (UMgz) and Peltetec (UPet), in addition to the intrusive bodies Abitagua granite (BAbt) and Azafrán granodiorite (UGAz). On the other hand, the Napo (FmNp), Hollín (FmHn) and Tena (FmTn) formations, in addition to the Zumbagua (VZmg), Pisayammbo (VPsy) and Cotopaxi (VCtx) volcanic formations that are located west of the Geopark (Toulkeridis, 2016; Noble et al., 1997; Pratt et al., 2005; Villares et al., 2021; Aspden & Litherland, 1992; Massonne, & Toulkeridis, 2012).

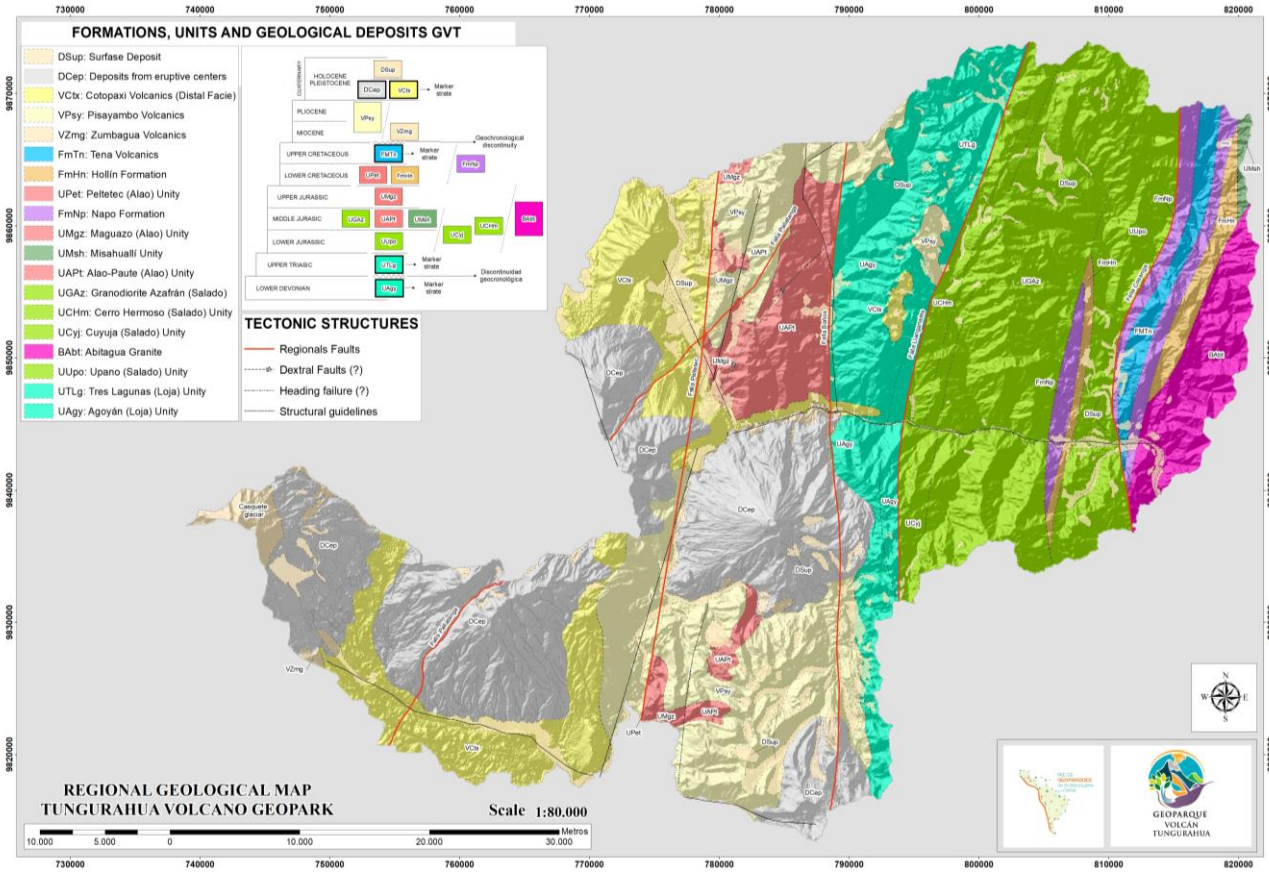

Figure 1. Map of Regional Geological Formations, Units and Deposits of the Tungurahua Volcano Geopark – CGVT, 2024 (Source: This map is based on Geological Map of the Republic of Ecuador, Scale 1:1000000, 2017; SIGTIERRAS, 2015; Geological Map of Ecuador, Scale 1:100000 – Chimborazo, Baños de Agua Santa (Tungurahua Volcano Geopark, 2023)

Finally, the eruptive center deposits (DCep) and surface deposits (DSup) represent the juvenile processes existing in the Geopark (Consorcio Geoparque Volcán Tungurahua, 2023). Likewise, it is possible to emphasize that the formations, units and deposits are in interaction with tectonic structures characterized as regional faults, dextral faults, strike-slip faults and structural lineaments. As previously mentioned, the geology immersed in the Geopark area includes diverse materials that have originated from approximately 417 Ma to the present (Mojzsis et al., 1996), so it houses an evolutionary history related to the formation of a section of the Cordillera Real, the Inter-Andean Valley and the Western Cordillera.

Geosites are areas that present a high geological, scientific, environmental, tourist, cultural, and conservation interest, which, due to their unique and representative nature, allow the study and interpretation of the origin and evolution of large geological domains, including the processes that have shaped them, past climates and their paleobiological evolution (Carrión et al., 2021; Toulkeridis et al., 2021). Therefore, it is necessary to consider that the impact caused by tourist visitation can have long-term effects. Thus, activities focused on their conservation and maintaining the interaction with various biotic factors that are part of the surrounding ecosystem must be performed (Factors affecting ecosystems, 2015). The code, name, and canton to which each Geosite (GS) belongs are described below. Five places have been added to the list presented in the 2019 application dossier, which currently has twenty GS representing the Geological Heritage of the GVT (Table 1; Figure 2). Within the listed twenty geosites, there are several morphologically outstanding sites being represented by voluminous volcanic edifices or complexes with a vast history of volcanic eruptive phases and often associated destruction of nearby areas, such as the active Tungurahua and Chimborazo volcanoes, besides the extinct El Altar, Igualata and Huisla volcanoes (Figure 3). The Tungurahua Volcano, also known as "the throat of fire" in the Kichwa language, is one of the most active volcanoes in Ecuador (Toulkeridis & Zach, 2017; Alvarado et al., 2023).

Located near the tourist city of Baños de Agua Santa, this andesitic stratocone has been forming and collapsing throughout its evolution to form Tungurahua I (293 to 79 ka), Tungurahua II (29,000 to 3,000 years) and the actual Tungurahua III (2,300 years to present) (Hall et al., 1999; Bablon et al., 2018).

Table 1. Geosite Matrix of the Tungurahua Volcano Geopark (Source: Soria et al., 2020)

Code	Geosite	Canton
GS-01	Tungurahua Volcano	Baños de Agua Santa
GS-02	Pailón del Diablo Waterfall	Baños de Agua Santa
GS-03	Las Juntas lava flow	Baños de Agua Santa
GS-04	Los Pájaros pyroclastic flow	Baños de Agua Santa
GS-05	San Martín canyon	Baños de Agua Santa
GS-06	La Virgen hot springs	Baños de Agua Santa
GS-07	El Salado hot springs	Baños de Agua Santa
GS-08	Puela hot springs	Penipe
GS-09	El Altar Volcano	Penipe
GS-10	Amariila Lagoon	Penipe
GS-11	El Gorila de Pelileo Waterfall	Pelileo
GS-12	Ojo del Fantasma Waterfall	Penipe
GS-13	Chimborazo Volcano	Guano
GS-14	Igualata Volcano	Guano
GS-15	El Templete volcanic dome	Patate
GS-16	Yamate viewpoint	Patate
GS-17	El Obraje de San Idelfonso macrosliding	Pelileo
GS-18	Mulmul Volcano	Pelileo
GS-19	Huisla Volcano	Pelileo
GS-20	Las Caras petrified roots	Pelileo

The most recent eruptive phase has been visible since October 1999 up to the summer of 2016, with initially phreatic to strombolian type of eruptions, later including sub-vulcanian explosions with eminent ash precipitations, frequent pyroclastic flows and lahars, besides minor lava flows (Hall et al., 2015; Toulkeridis & Zach, 2017). Due to this activity, social problems arose such as forced evacuations in 1999-2000 and failed, fatal alerts in 2006, 2008 and 2010 (Toulkeridis et al., 2007; Herrera-Enríquez et al., 2021; Wright et al., 2012). Culturally, Tungurahua has been a central figure in local myths. According to indigenous stories, Tungurahua is linked to the Chimborazo Volcano, with whom it has a symbolic relationship of love and conflict, representing masculine and feminine forces of nature (Pungaña, 2022).

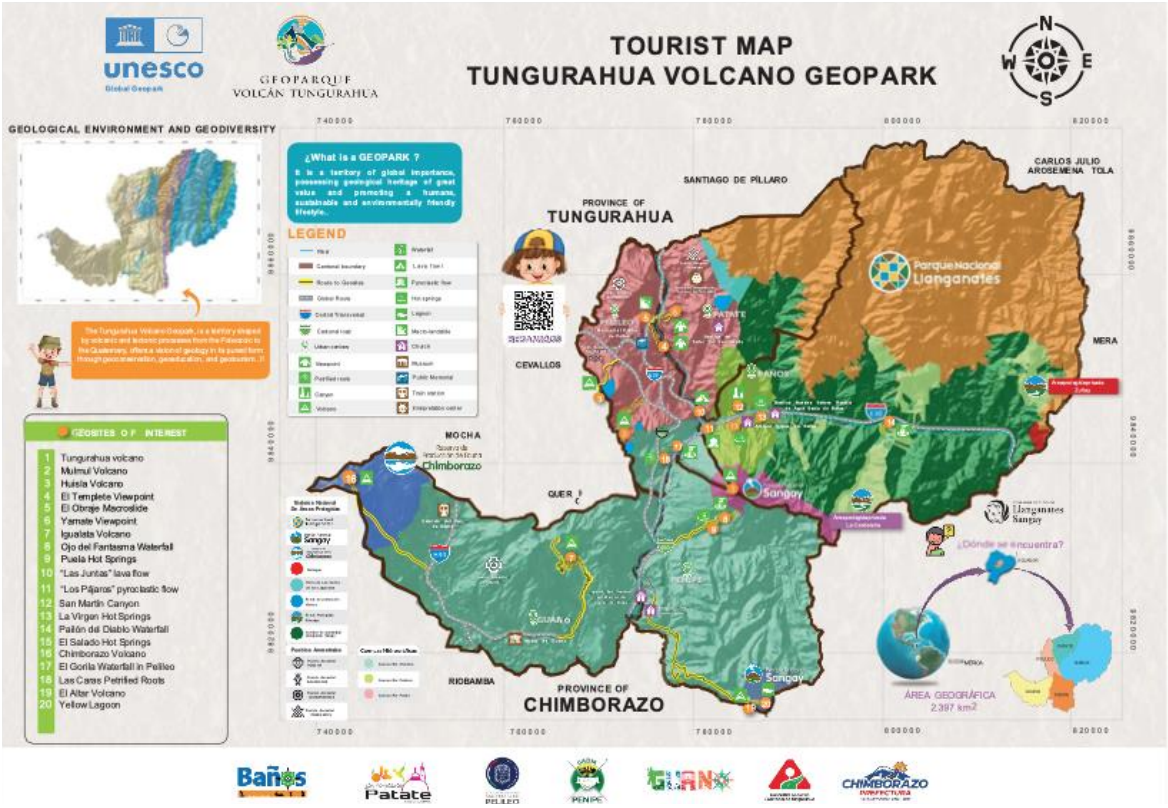

Figure 2. Map of geosites located in the GVT (Source: Tungurahua Volcano Geopark, 2023)

The Chimborazo volcano, Ecuador's highest summit, is 6,263 meters above sea level, and one of the most iconic mountains in the Ecuadorian Andes. In addition to being the highest dormant volcano in the country, its summit is the planet's closest point to the sun due to its equatorial bulge (Mora et al., 2022). The Chimborazo compound volcano, is

composed of three main edifices, named basal edifice (CH-I), intermediate edifice (CH-II) and the final young cone (CH-III) (Kilian et al., 1995; Barba et al., 2008). The CH-I was active between 120 to 60 ka, ending with a massive collapse and corresponding debris avalanche, while CH-II was active since up to 35 ka ago. The active, now dormant CH-III has regular intervals of activity, the most recent one being dated around 1250 years BP (Samaniego et al., 2012). Its slopes are covered with glaciers that feed several vital rivers, such as the Chimbo and Guano Rivers.

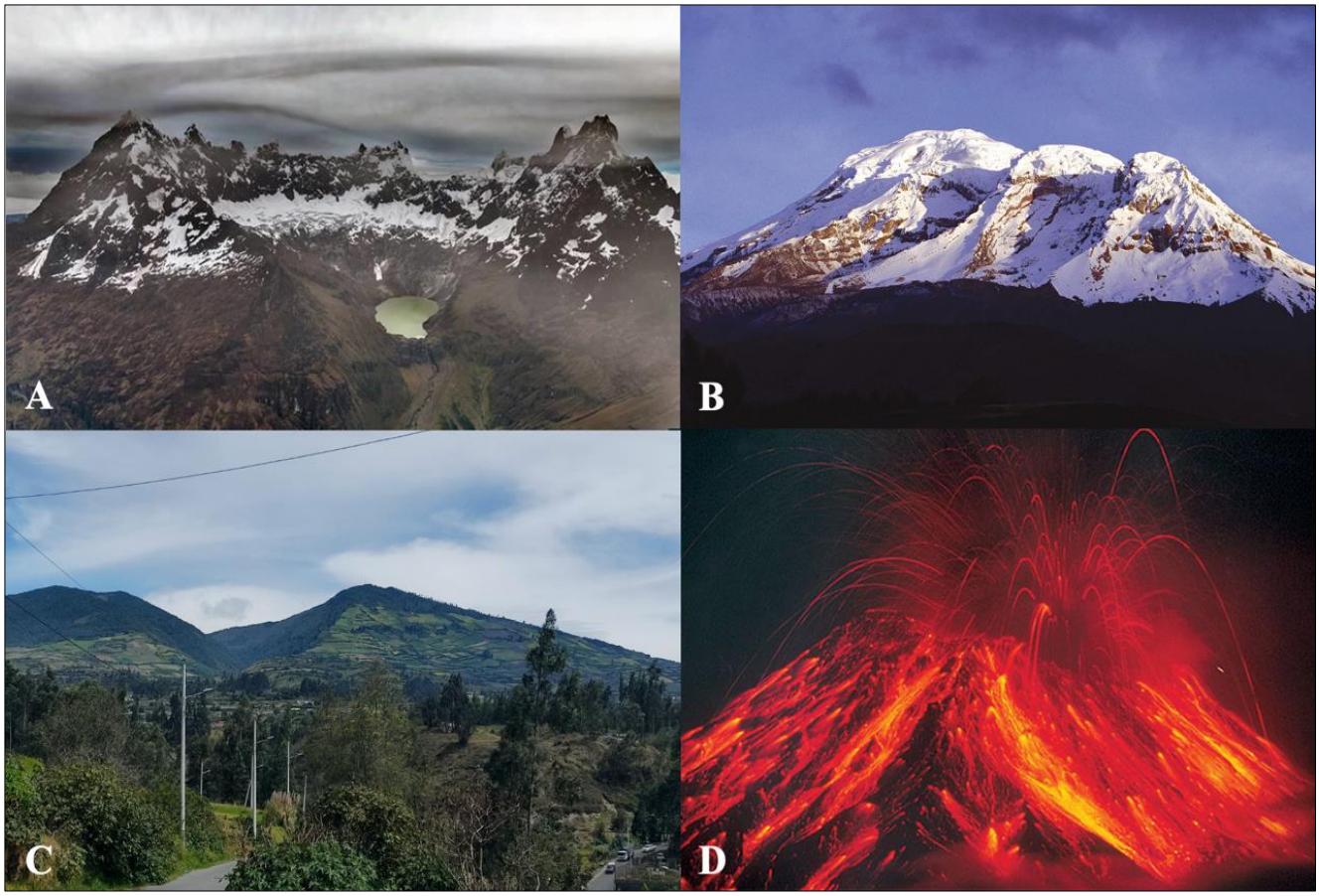

Figure 3. A: El Altar volcano in 2002 (credit Juan Anhalzer); B: Chimborazo volcano in 2001 (credit Alois Speck); C: Huisla volcano in 2024 (own picture); D: Tungurahua volcano in 1999 (credit Alois Speck)

However, climate change has significantly decreased these glaciers. In 1802, the explorer and scientist Alexander von Humboldt attempted to climb Chimborazo. Although he did not reach the summit, his expedition marked a milestone in the history of geography and science, contributing to understanding Andean altitude and ecosystems (Murray & Whimper, 1980). Chimborazo has a deep meaning in Ecuadorian identity. It is mentioned in the national anthem as a symbol of greatness and freedom. It is also associated with local myths, such as its relationship with the Tungurahua Volcano, considered its "companion" in the indigenous worldview.

The volcano is located within the Chimborazo Wildlife Production Reserve, a protected area home to species such as the vicuña, the Andean condor, and a wide variety of flora adapted to extreme altitudes. This unique ecosystem combines Andean moors and glaciers, offering an environment of great ecological and tourist value.

The 4430 m high, extinct Igualata volcano is a severely eroded and tectonically affected edifice, as it is crosscut by the Pallatanga fault (Baize et al., 2016). The main edifice has been formed approximately between 380 and 350 ka, with some later activity some 237 and 107 ka ago (Bablon et al., 2019). Later, this volcano been capped by a glacier during the Younger Dryas and/or Neoglacial periods (Clapperton, 1990). Similarly, the 3763 m high Huisla andesitic edifice, is a volcano with older to up to recent activities. Ages of lava flows of this volcano range from 621-147 ka, while some younger plinian eruptions occurred in the last 39 ka (Bablon et al., 2019). The plinian fallout deposits from this volcano are interbedded with the Carihuairazo volcano, which is situated equally right next to the Chimborazo volcano.

Later, this edifice experienced a massive sector collapse on its southeastern side. Finally, the El Altar volcano, also known locally as Cápac Urcu (the mighty one or the lord of the volcanoes), is part of the Eastern Volcanic Cordillera above the Cordillera Real. This volcano has a spectacular landscape, as due to several giant collapses, which formed horseshoe-shaped edifice, open to its west, prior to 35 ka (Bablon et al., 2019).

It forms some seven prominent snow-capped peaks of which the highest reaches some 5,319 m a.s.l. In its inner part is a colorful glacial lake, which experienced several glacial tsunamis of up to 125 m high waves, due to massive rock fall as a result of climate change and corresponding glacial retreat (Toulkeridis et al., 2022). In the inner part of the

caldera appears a gabbroic intrusion, which seems to represent part of the original magma chamber. There are also many are brecciated andesitic and rhyolitic lavas and dikes.

1.2. Flora and Fauna

Due to its location close to the foothills of the eastern mountain range, the area has a great variety of phylogenetic resources (Gobierno Autónomo Descentralizado del Cantón Baños de Agua Santa, 2014; Gobierno Autónomo Descentralizado del Cantón Penipe (2022-2026), 2022). Tungurahua Volcano Geopark in Ecuador stands out for its biodiversity, where fauna plays a key role in the ecological balance and sustainability of ecosystems. Its animal species, such as endemic birds, mammals and reptiles, are essential for natural processes and ecotourism. The conservation of these resources is crucial to maintaining the natural wealth of the geopark and its resilience to climate change.

2. A Monitoring and Conservation Plan

The monitoring and conservation plan for the Tungurahua Volcano Geopark is presented as a strategic document designed to ensure the preservation of its natural, cultural, and geological heritage and promote sustainable development in the area. The structure of the plan has been structures with the defined objective and the goals to be achieved within the monitoring and conservation plan were set out, considering the scope of application within the territories of geosites identified in the provinces of Tungurahua and Chimborazo and their consequent geographic delimitation and the elements subject to conservation, which are the 20 geosites identified to explain the geological, ecological and cultural value of the place. It also includes an initial diagnosis and a resource inventory, where the geological heritage is characterized, as well as the natural resources related to the flora and fauna characteristics of the place.

3. Cultural and archaeological heritage

Tungurahua Volcano Geopark in Ecuador stands also out for its cultural, archaeological, gastronomic and touristic wealth. Its geological heritage is complemented by the ancestral heritage of its communities, which preserve traditions, art and festivities. Local gastronomy and ecotourism contribute to the development and conservation of the region's natural and cultural heritage. In this respect, there are three main archeological sites, being Pacaicaguan, the Assumption Monastery Ruins and the Monoliths as well as Petroglyphs on Luishi Hill. The Pacaicaguan are archaeological sites of the San Gerardo parish, a ceremonial-funerary site associated with the Puruhá culture in the Integration Period (800 AD – 1530 AD) (Vela, 2025), while the Assumption Monastery Ruins are part of the first Franciscan Church built in Guano, which was affected by the 1797 earthquake and the August 5, 1949, earthquake. Furthermore, there are rhree monoliths with figures of the face of the Inca were carved by hand using the pickaxe as a tool by the artist Luis Reinoso in the 1940s.

There are plenty gastronomic and tourist sites, which include stone tortillas, apple, pear, small red plums and peach fruit orchards, fried pork, knife sweet, creole chicken broth, roasted guinea pigs with boiled potatoes, apple, blackberry and small red plums liqueur, as well as sugar cane juice with liquor and lime juice, reed, marshmallows and guava sweets. Furthermore, there are scenic places of mountains, waterfalls, rivers, trails, snow-capped mountains and hot springs in the El Altar Volcano, Paramito natural viepoint, Ojo del Fantasma geological formation, Pailón del Diablo, Manto de la Novia Waterfall, besides various natural viewpoints of Tungurahua Volcano and due to the geographic proximity to the Ecuadorian Amazon (Gobierno Autónomo Descentralizado del Cantón Penipe, 2022; FLACSO, 2005).

4. Hazards and risks

Identification of pressure factors as mass tourism, especially in Baños de Agua Santa the most touristic place of the area, considering that tourism attracts hundreds of thousands of tourists on each of the four main holidays annually (Herrera & Rodríguez, 2016). It is still a small number compared to other emerging destinations, however, there is evidence of an increase in the amount of waste generated by this demand and the subsequent difficulty of treating it without affecting the ecosystem, excessive noise, social problems such as crime and drug micro-trafficking (Ocaña et al., 2015). Additionally, the tourist carrying capacity is increasing in tourist places and protected natural areas within the Geopark area and local populations are not necessarily benefiting from the income generated by tourism and all the businesses associated with it such as food and beverages, lodging, agency and others related (Valdez et al., 2024).

The use of key indicators to measure conservation which were presented in the UNESCO application dossier and taken from various documents on Biodiversity present in the area, while soil quality and erosion, historical evolution of the geology of the area are described in depth in the proposal for Management of mining resources in the area.

5. Sustainable Use of Mineral and a Governance

5.1. Sustainable use of mineral

As established by UNESCO in the Statute of the international program of earth sciences and Geoparks in Part B in article 1. UNESCO Global Geoparks indicates that UNESCO Global Geoparks are the mechanism of international cooperation (Henriques & Brilha, 2017) with a conservation approach together with local communities that must adopt a sustainable approach to the development of the area.

Links of this document to Ecuadorian legal regulations, demonstrate that the Tungurahua Volcano Geopark Consortium does not participate directly or indirectly in the sale of geological materials, identify existing geological materials in the Geopark area, to establish their relationship between customs, traditions and their sustainable use.

The GVT has replicated the precepts set by UNESCO on the responsible management and use of resources by providing information to the population on the sustainable use of natural resources, while promoting respect for the environment, integrity and conservation of landscapes. However, due to its geological diversity and its wealth of mineral and stone resources, the economic, technological and social development of communities has required the use of these resources since ancient times (Flor, 2024), but despite technological evolution and socioeconomic advances, they are currently facing the problem of the sustainable use of these resources, due to several reasons such as lack of governance, poor regulations, lack of public policies, among others.

GVT also followed the guidelines proposed by UNESCO through the project "Mineral resources in UNESCO Global Geoparks in Latin America and the Caribbean" which aims to understand the current situation of Geoparks in terms of the use of mineral resources and their relationship with sustainable development, and proposes analysis, measures and promotes networking in experiences and learning of good practices applied to the guidelines of Geoconservation, Geoeducation, Geotourism and Sustainable Development (Rosado-González et al., 2020).

The use of the different geological materials of the Ecuadorian territory is regulated and controlled by the Mining Regulation and Control Agency (ARCOM) (Reglamento General de La Ley de Minería, 2017), therefore, the areas destined for the execution and development of mining investment projects, being regulated by this institution, are represented in the Mining Cadastre Geoportal (Ministerio De Energía Y Recursos Naturales No Renovables Viceministerio De Minas, 2024), in which it is possible to see the concessioned areas, name, owner, phase of the mineral resource, type of request, registration date, term, province, canton, parish, mineral of interest, current state, surface, type of mineral and the exploitation regime. Therefore, it is possible to observe the different concessioned areas in the Geopark area that are destined for the use of geological materials, whether metallic, non-metallic or stony.

Among the customs linked to the use of geological materials is the preparation of corn tortillas on volcanic rock in the cantons of Penipe and Baños (Aucancela, 2023), the production of stone crafts such as carved figures, mortars, cooking plates, among others, and finally, we may mention the tradition of the Guano stone cutters (Vargas, 2016). Baños de Agua Santa, being a national and international tourist center, mobilizes artisans from various parts of the country and the world, who bring mineral elements and rocks that do not come from the geological environment of the Tungurahua Volcano Geopark (Sánchez, 2023; Hernández-Medina et al., 2025). The artisans sell the crafts made with the materials (allochthonous to the GVT). The Tungurahua Volcano Geopark promotes sustainable use with artisans. However, it does not have the power to limit its commercialization because it is not its jurisdiction. In addition, the articles contemplated in the Mining and Commerce Law authorize the commercialization of crafts without obtaining a License for the sale of these products. The governance system is key to meeting the objectives set with clear strategies to manage the geological heritage for sustainable development through the formation of the Consortium for the Management of the Tungurahua Volcano Geopark. This management structure ensures the continuity and efficiency of work in the territory.

The consortium is a public law entity, with legal personality, administrative and financial autonomy, created to fulfill the specific purposes expressly determined in the creation agreement, which brings together the Honorable Decentralized Autonomous Provincial Governments of Tungurahua and Chimborazo and the Decentralized Autonomous Municipal Governments of Baños de Agua Santa, Patate and Pelileo in the province of Tungurahua as well as Penipe and Guano in the province of Chimborazo. The consortium has its mission, objectives, principles, organizational structure, legally constituted under the number CONS-067-2021-CNC, in the Public Registry of Associations and Consortiums of the National Council of Competencies, on January 6, 2022.

5.2. Governance Structure

In reference to the organizational structure, it is established that the Consortium must have the following staff: General Coordination, Secretary / Accountant, Geologist plus the Technical Support Team: Officials assigned to the Commissions of the member GADs. The Support Commissions are made up of the assigned officials of the Decentralized Autonomous Governments that make up the CGVT, such as Tourism, Cultural Strengthening, International Cooperation Management, Biodiversity and Environmental Protection, Productive Promotion, Research and Communication. The ancestral indigenous people's representative of the two provinces that are part of the Geopark are Salasaca of the Province of Tungurahua and Puruha of the province of Chimborazo belonging to the Kichwa Nationality of the mountains who have been incorporated into the social, political, environmental management, and gender context manifested in the full exercise of their citizenship (Maldonado-Erazo et al., 2021; 2023).

6. Communication and Marketing Plan

This plan not only seeks to promote the geopark itself, but also to establish a significant connection with all stakeholders, both internal and external. The main objective of this plan is to organize, systematize and enhance all communication activities, both internal and external, to strengthen the recognition and positioning of the Tungurahua Volcano Geopark at local, national and international levels. Through this strategy, we aim to raise awareness of the geological and cultural importance of the geopark, as well as promote sustainable and responsible tourism (Hardeman et al., 2017). The initial analysis shows that the importance of establishing a solid and coherent visual identity for the geopark is emphasized, as well as the need to develop educational and attractive content that involves diverse audiences, from students to potential tourists (Carrera et al., 2024). Furthermore, greater collaboration with local and national institutions, as well as with international organizations dedicated to conservation and sustainable tourism, is suggested.

The Plan defines a philosophical framework detailing its Mission and Vision, as well as strategic objectives, a SWOT study, Public Relations techniques that will allow the dissemination and projection of the values and activities of the Geopark with the intention of obtaining recognition from the stakeholders, the design of the Geopark's brand and slogan and finally an Action Plan to execute all the above (Scolozzi et al., 2014).

DISCUSSION

Based on the inventories of 20 GS, the inventories of flora and fauna biodiversity, and various sites and cultural manifestations as part of the region's heritage, it is demonstrated that in the Geopark area there was an important historical, geological and anthropological evolution, since the three areas are linked based on an integral and binary conception of territory, highlighting the dependence of physical geography and human geography subject to all the changes that nature presents. Therefore, it can be stated that the documented geological and biological wealth reaffirms the relevance of the Geopark as a space for conservation and education. It is also believed that the data obtained allow for the establishment of conservation priorities and serve as a basis for more precise monitoring plans. In the end, there are great challenges to consider, since there are still some areas that could not be fully studied due to their inaccessibility, which underlines the need for advanced technological methods such as drones or satellite images.

At the same time, the geology of the area demonstrates an evolutionary history that spans an analysis of approximately 417 million years, including processes such as volcanism, sedimentation and tectonics, supporting one more reason to understand the great biodiversity and landscape of the area. These findings strengthen the scientific narrative of the geopark, turning it into a natural laboratory for geological studies. In addition, there is the potential to develop more specific and attractive educational programs. However, the challenge is to continue developing firm conservation strategies because the conservation of areas with high geological exposure is at risk due to climatic factors such as erosion, landslides in winter and unregulated tourism.

Regarding the Monitoring and Conservation Plan, the highlighted results established key indicators for monitoring, such as the condition of soil, water, stability of geological formations and diversity of flora/fauna. Consequently, restoration strategies were established in degraded areas with a view to achieving regeneration of native vegetation and recovering degraded areas. The plan allows for systematic monitoring of the geopark's situation, which facilitates data-based decision-making. Local communities played a fundamental role in the implementation of conservation measures, demonstrating that their participation is essential. To ensure continuity of all this, it is necessary to ensure continued funding and strengthen the training of those responsible for monitoring. The sustainable use of minerals linked to the governance of the area is essential, since guidelines were developed for the sustainable extraction of minerals, reducing the environmental impact, and governance agreements were established between communities, companies and local authorities of the Geosites (Carrión Mero et al., 2018). The regulation of mining activity has reduced pollution and the alteration of the landscape, although there are still challenges in its effective compliance. Participatory governance improves the perception of justice and equity among the actors involved. Finally, it is observed that there are still tensions between economic interests and conservation priorities. It is necessary to strengthen the mechanisms for monitoring and resolving conflicts with spaces for periodic meetings to give prominence to all stakeholders.

Finally, some results are highlighted regarding the Communication and Marketing Plan of the GVT. Communication campaigns were designed to highlight the uniqueness of the geopark and its importance for sustainable development and the geopark registered a 2% increase in visits thanks to digital marketing strategies and alliances with tour operators. The strategies implemented are promoting responsible tourism and attracting a greater diversity of visitors, as well as effective communication has raised awareness among the local population about the importance of the geopark, encouraging their participation. It also remains to diversify communication tools to reach international audiences and improve tourism infrastructure using the internal situation and membership within the World Geoparks Network (Font et al., 2017).

The strategies implemented combine several fronts to strengthen the geopark and its ties with the community and visitors. These include the development of activities that promote tourism that respects the environment and local culture, while also designing products and experiences that appeal to different travel profiles. This not only protects the geological heritage but also expands the offering and prevents seasonality. Furthermore, through information campaigns, workshops, and guided tours, the local population has become aware of the scientific, educational, and economic value of the geopark. This has encouraged their direct involvement, from volunteering to the creation of community-based tourism initiatives. Taking advantage of the geopark's status as a member of a global network of Geoparks, the goal is to optimize trails, signage, interpretation centers, and basic services, adapting them to international standards and benefiting from collaborations, training, and funding linked to the network.

CONCLUSIONS

The GVT, as a UNESCO Candidate, has worked jointly with all stakeholders on the observations issued by the UNESCO Global Geoparks Council based on the axes of geoeducation, geoconservation and geotourism, focused on the SDG´s. Strategic alliances have been created with public institutions such as the Ministries to strengthen actions in the areas of Geotourism and Geoconservation, which has allowed the development of geotourism and scientific tourism as tools for the protection of natural and cultural heritage, generating sources of economic income for entrepreneurs in the territory.

The government projects contribute to the achievement of an inclusive, equitable and quality education, with education being the fundamental factor for the dissemination and empowerment of children and adolescents and local population.

Networking with Global Geoparks and Geoparks Network of Latin America and Caribbean "GeoLAC" has allowed the strengthening of the work team's actions by opening spaces for the exchange of experiences and advice to human capital and local population´s empowerment. The GVT has complied with the observations issued by the Global Geoparks Council thanks to the commitment of its stakeholders who have believed the area has an international geological value and its recognition will contribute to conserving the geological heritage within a line of sustainable development which will improve its inhabitant's quality life. One of the main limitations of the GVT's UNESCO nomination is the lack of adequate tourism infrastructure and communication tools that allow for international exposure. Although there is strong local commitment and a high geological value, the consolidation of global collaboration networks, the professionalization of staff, and the acquisition of sustainable resources are aspirations that, for now, cannot be achieved in the short or medium term due to budgetary and management constraints.

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