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GEOTOURISM AS A STRATEGY OF SUSTAINABLE RURAL DEVELOPMENT OF THE PAIPA - IZA VOLCANIC COMPLEX IN THE EASTERN ANDES OF COLOMBIA: AN INNOVATIVE APPROACH¹

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EL GEOTURISMO COMO ESTRATEGIA DE DESARROLLO RURAL SOSTENIBLE DEL COMPLEJO VOLCÁNICO PAIPA EN LOS ANDES ORIENTALES DE COLOMBIA: UN ENFOQUE INNOVADOR

Abstract

Geotourism is an emerging discipline based on experiencing the Earth's geological elements. This paper highlights the role that geotourism can play as a strategy that helps boost sustainable rural development of the Paipa municipality in Boyacá Department, Colombia. The need for the development of infrastructure for geotourism is urgently required as its natural and cultural heritage can be destroyed by anthropogenic activities. Geotourism in the Paipa-Iza Volcanic Complex (Colombia) has an extraordinary potential to be designated as a territory for aspiring to UNESCO Global Geopark status.

Keywords: Paipa, geotourism, heritage, rural development, geoparks.

Resumen

El geoturismo es una disciplina emergente, basada en experimentar las características geológicas de la tierra. Este documento destaca el papel que puede desempeñar el geoturismo como estrategia que ayuda a impulsar el desarrollo rural sostenible del municipio de Paipa, departamento de Boyacá (Colombia). El desarrollo de infraestructuras para realizar actividades de geoturismo es urgente, ya que su patrimonio natural y cultural puede ser destruido por actividades antropogénicas. El geoturismo en el Complejo Volcánico Paipa-Iza

(Colombia) tiene un potencial extraordinario para ser designado como un territorio para aspirar al estatus de Geoparque de la Unesco.

Palabras clave: Paipa; geoturismo; patrimonio; desarrollo rural; geoparques.

Introduction

Colombia is moving towards sustainable tourism, which could become one of the leading drivers of economy in the next years. This country is focusing by international tourists and tourism offer is increasing quickly. The natural and cultural heritage is an undisputable national asset, with isolated initiatives focused on improving its infrastructure and strengthening the production chain from an increasingly varied offer, which would favor the increase in the flow of tourists to the country. Tourism is now one of the World's largest industries and one of its fastest growing economic sectors (Creaco & Querini, 2003). However, tourism growth cannot be separated from sustainability and must contribute to the socio-economic local community's development, with conservation of natural and cultural resources (Dong *et al.*, 2014). On the other hand, Colombia occupies the second place in biodiversity worldwide (Andrade, 2011). This implies thorough responsibilities and, therefore, be aware with the importance of developing environmentally friendly tourism (ecotourism) and respectful with cultural and historical heritage.

Since 2005, the Externado de Colombia University was appointed by the Ministry of Commerce, Industry and Tourism, through an agreement signed with Colombian Institute of Technical Standards and Certification, as the coordinating entity of the Sectorial Unit for Standardization in Sustainable Tourism, as a strategy aimed touristic services (Ochoa & Rueda, 2016). Colombia has a valuable potential for tourism industry development and is becoming one of the most attractive tourist destinations for foreign tourists.

The term "Geotourism" as National Geographic Society (NGS) defined is a relatively new concept emerged around the world as a rapidly growing form of tourism (Turner, 2006). Geotourism was first defined by Hose (1995), as geological and geomorphological tourism (e. g. Hose, 1995; Ollier, 2012). Includes nature tourism focused on geological sites (e. g. Newsome & Dowling, 2010; Gray, 2011) with emphasis on "geological" element (Newsome *et al.*, 2012) and geo-interpretation (e. g. Vasiljevic *et al.*, 2011; Newsome *et al.*, 2012). On the other hand, the definition of geotourism, according to National Geographic (2013), corresponds to a tourism that contributes to the sustainability or improvement of the geographical character of a place: its environment, culture, aesthetics, natural and cultural heritage and the well-being of its inhabitants. The prefix "geo" in geotourism is related to geography and does not necessarily relate to geology or geomorphology. However, every place on Earth has a geographical location, this use of "geo" is non-informative (Ollier, 2012). There were a summarized and refined definition of geotourism:

The provision of interpretative and service facilities for geosites and geomorphosites and their encompassing topography, together with their associated in situ and *ex-situ* artifacts, to constituency-build for their conservation by generating appreciation, learning, and research by and for current and future generations. (Hose, 2012, p. 11)

Geotourism promote geoconservation and understanding of Earth Sciences through observation and learning through environmental education, which achieved through visits to geological sites, use of geo-trails and viewpoints, guided tours, geo-activities and patronage of geosite visitor centers (Dowling & Newsome, 2006; Newsome & Dowling, 2010). The aim of geotourism is to enjoy geological elements as geosites. Geotourism sustainably geology and landscape to educate and inform visitors in an environmentally friendly way. Geotourism also needs to be integrated into the entire natural profile value, protected area with geology becoming an essential component of existing scenic, botanical, or bird watching and other wildlife values and tourism-oriented interests (Newsome *et al.*, 2012).

The aim of this work is to promote the geotourism as a strategy of sustainable rural development of the Paipa municipality, in the northeastern Andes of Colombia. To do this, we used a marvelous scenario as the Paipa-Iza Volcanic Complex (Colombia), which can be used as a natural laboratory, considering the importance that rural and nature geotourism has achieved. In recent years, more and more local communities have been pointing to this activity among their socio-economic development strategies.

Natural and cultural heritage

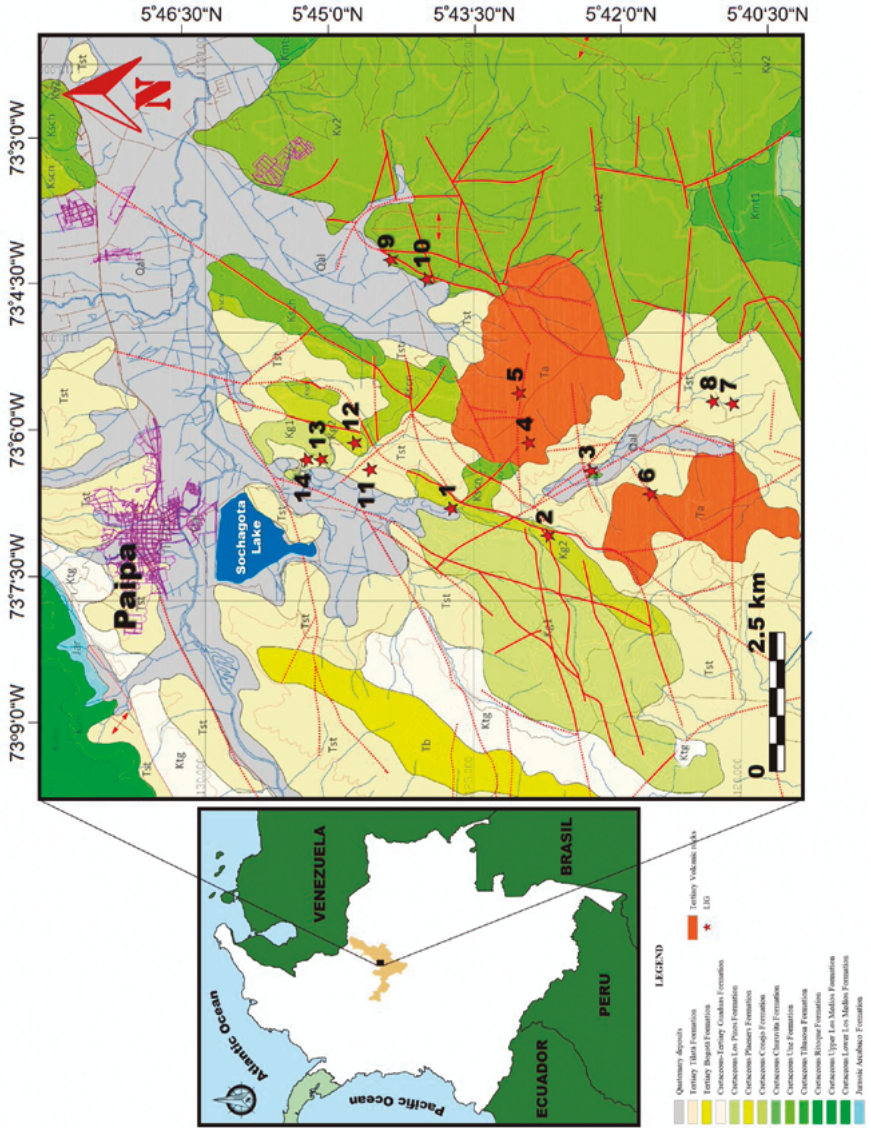
Due to the exceptional natural and cultural heritage present in this region, it is important to advice of experts to promote a future aspiring of this territory as UNESCO Global Geopark, which can be a novel strategy for socio-economic development of Boyacá (Colombia). However, the optimal use of this territory, it is necessary to have a network of trails that ensure connectivity between sites of heritage interest, allowing not only observe the valuable natural and cultural heritage of the region but also learn from it in order to promote outreach and conservation. This region not only has a valuable natural and cultural heritage but also represents an excellent scenario for preserving a valuable geological history, rigorously recorded through rocky outcrops, mineralization, fossil findings and marvelous landscapes.

Geoheritage

Colombia has been making progress in the implementation of geoconservation strategies in accordance with the characteristics of the national territory and the guidelines established in Decree 1353 of 2018 of the Republic of Colombia, by which Chapter 10 is added to Title V of the part 2 of Book 2 of the Single Regulatory Decree of the Administrative Sector of Mines and Energy in relation to the integral management of the geological and paleontological heritage of the Nation. This constitutes a legal tool of great importance, since it contemplates a set of affirmative measures and actions that promote the safeguarding, conservation and transmission of scientific knowledge of the geological and paleontological heritage of the nation. The Colombian Geological Service (CGS), the scientific agency of the Colombian government, through the issuance of Resolution 732 of 2018 regulated the development of each of the procedures contemplated in Decree 1073 of 2015 of the Republic of Colombia, added by Decree 1353 of 2018, with the aim of establishing the requirements and procedures for the integral management of the geological and paleontological heritage of the Nation.

Paipa is a Colombian municipality of the Boyacá Department located in the Eastern Cordillera at *ca.* 2525 masl (figure 1). The main geological features of this region are described as follows. The Boyacá Fault separates two distinct morphostructural provinces. The study area shows short and narrow folds notoriously overturned by gravity (Farelo & Parra, 2004). Recent studies have been performed in Paipa-Iza Volcanic Complex focusing structural geology (e.g. Ujueta, 1993; Velandia, 2003), volcanic structure (e.g. Pardo *et al.*, 2005) and geothermal features (e.g. Alfaro *et al.*, 2010; Moyano & Vallejo, 2015). The geological units cropping out in the Paipa region are mainly Cretaceous sedimentary rocks, although Paleogene and Neogene sedimentary rocks and Quaternary unconsolidated deposits are observed (Alfaro *et al.*, 2010). This territory has an exceptionally rich a vibrant and diverse range of geological features, which can be defined as geosites (table 1), which form part of a preliminary inventory of sites of geological interest defined by their scientific, didactic and touristic values after assessment procedures as suggested by several authors (Brilha, 2016; García-Cortés *et al.*, 2019), highlighting that some of them are potential and have international relevance. An inventory should identify the location of the selected sites, and their relevance within their geological framework (García-Cortés *et al.*, 2019), although it sometimes can include an assessment of the state of conservation (e.g. Strasser *et al.*, 1995; Bertacchini *et al.*, 2003). Since 2016, the CGS began the National Inventory of immovable geological and paleontological heritage, with the domain “Cordillera Oriental”, based on the geodiversity of numerous sites of geological interest for the understanding of the geological development of the national territory, mostly with a considerable degree of vulnerability (especially type sections and paleontological sites) to the development of anthropic activities. Therefore, it is essential to carry out their recognition and assessment, for geoconservation purposes. According to the CGS (2021), the development of this inventory has allowed the identification of 57 geotopes of stratigraphic (51%), paleontological (26%), geomorphological (11%), petrological (5%), tectonic-structural (5 %) and volcanological (2%) interest. Several sites of geological interest that constitutes the geoheritage observed in the Paipa-Iza Volcanic Complex (Colombia), which can be identified, taking into account its geological, geomorphological, mineralogical, stratigraphic, tectonic-structural, volcanological or paleontological interest, which are of scientific, didactic or touristic value after assessment.

Figure 1. Left, the location of Paipa in the department of Boyacá (Colombia). Right, a generalized geological map showing the Geosites 1 to 14 (see table 1 to a description of each site)



Source: Adapted and modified by authors from Velandia & Cepeda (2005) and Calderon & Vargas (2019).

Table 1. Geosites in the Paipa-Iza Volcanic Complex (Colombia)


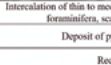



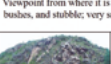








Geosite	Characteristic	Typological category	Heritage category	Value criteria	Main characteristics
Geosite 1	El Batán Fault	Point	Structural geology (fault, folds, shear)	Scientific, Educative, Touristic	 Riding fault with vergence to the northeast that affects the sedimentary sequence, developing folds in chevron and showing intense shear (Figure 2a).
	Plañers Formation	Point	Stratigraphy (sedimentary rocks)	Scientific, Educative, Touristic	 Interrelation of thin to medium layers of intensely fractured siliceous lodolites with levels rich in phosphoric rock, foraminifera, scales, and fish remains, which reflects evidence of tectonism with deformation.
	Erosive discordance	Point	Stratigraphy (pyroclastic and sedimentary rocks)	Scientific, Educative, Touristic	
	Hot springs	Point	Natural resources (thermal waters)	Aesthetic, Scientific, Touristic	Deposit of pyroclastic flows rests on the sedimentary rocks of the Plañers Formation. Recreation center for tourists who want to take a bath in hot springs.
Geosite 2	Landscape	Point	Geomorphology	Aesthetic, Scientific, Educative, Touristic	 Viewpoint from where it is possible to observe an excellent landscape and characteristic geomorphs (Figure 2b).
	Plañers Formation	Point	Stratigraphy (sedimentary rocks)	Scientific, Educative	 Siliceous cherts or lodolites of the Plañers Formation (Figure 2c), which locally present highly porous levels with tubular and radial structures due to the probable dissolution of diatoms and radiolaria.
	Fossiliferous limestones	Point	Paleontology	Scientific, Educative	 Approximately one kilometer in the direction of El Tunal, there are banks of fossiliferous limestones (Figure 2d) with a presence of calcite veins.
Geosite 3	Landscape	Point	Geomorphology (valley)	Aesthetic, Scientific, Educative, Touristic	 Viewpoint from where it is possible to observe pyroclastic deposits covered by abundant vegetation such as grasses, bushes, and stubble; very smooth slopes and flood plains where a trachy-andesite dome stands out; vegetation type: pastures (low zones) and natural forest (high zones).
	Trachy-andesite dome	Point	Geomorphology (dome)	Aesthetic, Scientific, Educative, Touristic	
Geosite 4	Landscape	Point	Geomorphology (valleys, fluvial channels)	Aesthetic, Scientific, Educative, Touristic	 Viewpoint from where it is possible to observe the geomorphological expression of different contacts of lithologies and geomorphs of soft slopes, valleys, fluvial channels, among others (Figure 2f).
	Ignimbrites of the Los Godos High	Point	Igneous petrology (ignimbrites)	Scientific, Educative	 Ignimbrites (Figure 2g) show a porphyritic texture and an intense weathering, particularly towards the lower parts, showing a mottled appearance.
	Puzolane mines	Point	Mineralogy (minerals)	Economic, Scientific, Ecological	Exploitation front accelerates in an area covered by coniferous forest.
Geosite 5	Matarredonda feldspar mine	Area	Mineralogy (minerals)	Economic, Scientific, Ecological	 Open-cast exploitation of feldspar (Figure 2h) through open-pit mining, which has played an important role in the transformation of the landscape.
	Matarredonda feldspar mine	Area	Igneous petrology (igenous rocks)	Scientific, Educative	 This mine presents a great didactic value regarding its lithology (Figures 2i-2j), interacting with the visitors in a way that generates schemes of an overview of the mine, taking the different fronts of exploitation that it had while its activity. Besides, all outcrops are found fresh which helps us to a more detailed assessment of the minerals we find, structures that are observed as folds and desiccation cracks.
Geosite 6	Oltas stream's pyroclastic deposits	Point	Stratigraphy (pyroclastic rocks)	Scientific, Educative, Touristic	 Deposit of a flow of volcanic origin (unclassified) (Figure 2k), with fragments of different composition, standing out the presence of coal. According to Pardo et al. (2004), five poorly selected flow units were formed.
	Oltas stream's pyroclastic deposits	Point	Stratigraphy (pyroclastic rocks)	Scientific, Educative, Touristic	
	Landscape	Point	Geomorphology (dome, ridges, rounded peaks)	Aesthetic, Scientific, Educative, Touristic	Viewpoint from where it is possible to observe an igneous dome, slopes with high slopes, ridges, rounded peaks, from which visitors can identify the greatest number of geomorphological features and make a scheme of them.
Geosite 7	Labyrinth of an erosive carcass	Area	Geomorphology (erosion forms as furrows, gullies and estorages)	Aesthetic, Scientific, Educative, Touristic	 Spectacular development of stacco from erosive gullies that have carved a level of tuff (Figure 2m), which is located below stratigraphically of the level currently in operation for obtaining iron from the Quebrada Honda Mine.
	Stratigraphy of volcanic rocks	Point	Stratigraphy (pyroclastic rocks)	Scientific, Educative	
	Landscape	Point	Geomorphology (highs, steep structural slopes, valleys, ridges, rounded ridges)	Scientific, Educative	Excellent site to establish the stratigraphic relationship and the contact between the level of lavas (tuffs) and the iron deposit. Viewpoint from where it is possible to observe the Alto de Los Volcanes. Geomorphologically, there are steep structural slopes, valleys, ridges, rounded ridges, among others. Ash deposits are found in large quantities forming a soft relief (low angle of inclination). Soil can be highly eroded by external agents such as air and water, developing very interesting medium scale geomorphs from the geological and tourist point of view.
Geosite 8	Quebrada Honda iron mine	Area	Mineralogy (minerals)	Economic, Scientific, Educative	 Open-cast mining of iron ore minerals by a cement company in an almost horizontal horizon. According to Manosalva and Naranjo (2007), the deposit originated by chemical processes in oxidizing environments, which directly precipitated the "swamp iron" in closed basins (Figure 3a).
	Quebrada Honda iron mine	Area	Mineralogy (minerals)	Economic, Scientific, Educative	 Oxides, hydroxides, carbonates, sulfides, and silicates are also found (Figure 3b). Minerals such as goethite were formed from the acidic volcanic fluids that transported the iron in solution through fractures, subsequently precipitating it by oxidation as hydroxide.

Table 1. Geosites in the Paipa-Iza Volcanic Complex (Colombia) (continuation)

Geosite	Characteristic	Typological category	Heritage category	Value criteria	Main characteristics
Geosite 9	Vargas Swamp	Point	Hispanic architecture, History (Historical center)	Cultural, Historical, Educative, Touristic	The Vargas Swamp is a site of great tourist importance thanks to its cultural and historical attraction, which forms part of a narrow valley of freshness and tranquility of approximately 4 km of length in north-south direction x 1.5 km of width in an east-west direction.
	Vargas Swamp	Point	Stratigraphy (pyroclastic rocks)	Scientific, Educative, Touristic	Excellent view of quaternary coluvial-fluvial deposit interrupted by deposits of pyroclastic flows (in the background) bordering the Vargas Swamp developing hills of gentle slopes (Figures 3c-3d).
	Vargas Swamp	Point	Geomorphology (units of erosional-structural origin)	Scientific, Educative, Touristic	Viewpoint of geomorphological interest to define units of erosional-structural origin, represented by high mountains, which owe their morphology to the folding and faulting of the Jurassic to Tertiary sedimentary rocks, followed by prolonged weathering processes and fluvio-erosional and gravitational denudation of the resulting interlites, sculpting dense and deep drainage nets, in the point of modifying and, in many cases, crossing the original structural features.
	Historical Museum House	Point	Museography, Archaeology	Cultural, Historical, Scientific, Educative, Touristic	Municipal center of memory through which arrangements have been advanced for the acquisition of collections and pieces (paintings of the Battle of the Vargas Swamp, Santísima Trinidad and Nuestra Señora de Tutaza, and artifacts and weapons used at the time), with the participation of the inhabitants of the region who donated elements found by them in the Bolívar Hill and its surroundings.
Geosite 10	La Libertad route	Area	Archaeology (royal road)	Cultural, Historical, Educative, Ecological, Touristic	Historical royal road (Figure 3e), which has an excellent tourist value for the history of the battle of the Vargas Swamp.
	Deposit of pyroclastic flows	Point	Stratigraphy (pyroclastic rocks)	Scientific, Educative	Deposit of pyroclastic flows with subangular red sandstone blocks due to oxidation of up to 10 cm occurs; the development of small erosion gullies stands out here.
	Landscape	Point	Geomorphology (plains, hills, slopes)	Aesthetic, Scientific, Educative, Touristic	Viewpoint from where it is possible to observe different geomorphs (plains, hills, slopes, among others) (Figure 3f), highlighting the Pan de Azúcar Hill, with an elevation of about 80 m, which consist of igneous rocks of andesitic to basaltic compositions.
Geosite 11	Coal mines in the Guaduas Formation	Area	Stratigraphy (sedimentary rocks)	Economic, Scientific, Educative	Underground coal mining is developed (Figure 3g) in which the tunnels undermine rocks of the Guaduas Formation, which constitutes the transition from the upper Cretaceous to the Tertiary.
	Structural plane with active erosion	Point	Structural geology (structural plane)	Aesthetic, Scientific, Educative, Touristic	Viewpoint from where it is possible to observe an excellent landscape and structural planes displaying intense erosion, which is manifested by the presence of erosive gullies that line the rocks (Figure 3h).
	Guaduas Formation	Point	Stratigraphy (sedimentary rocks); Mineralogy (minerals)	Scientific, Educative	Interlayered sandstones (undulating stratification and intense oxidation) and mudstones; on the structural plane, ferruginous fractures and nodulations with limonite and hematite are observed (Figure 3i).
Geosite 12	La Cascadera mine	Area	Mineralogy (minerals)	Economic, Scientific, Educative	Exploitation of different construction materials has been developed by open-cast operations, including material for way filling, being the Placeres Formation the lithostratigraphic unit with greater potential for its obtaining.
	Landscape	Point	Geomorphology (dome, ridges, rounded peaks)	Aesthetic, Scientific, Educative, Touristic	Viewpoint to observe the transformation of the landscape due to mining (Figure 3j), generating large gaps with ecological consequences by the disappearance and change of the sources and channels of water, the force of the winds and the extinction of native flora and fauna.
	Placeres Formation	Point	Stratigraphy (sedimentary rocks)	Scientific, Educative	Placeres Formation, which is characterized by a parallel plane stratification and consists predominantly of siliceous conglomerates in thin, half-intensely fractured layers, with levels rich in phosphories with foraminifera (silicogeneritids), scales and fish remains.
	Folds in chevron and intense shear	Point	Structural geology (folds, shear)	Scientific, Educative	Outcrop displaying folds in chevron and intense shear.
Geosite 13	Churuvita Formation	Point	Stratigraphy (sedimentary rocks)	Scientific, Educative	Geosite characterized by the occurrence of an outcrop of sedimentary rocks of La Forma Churuvita (Figure 3k), which, according to Elyso-Serna (1968), consists of quartz gray sandstones to the base with arcillolites, limolites, sandstones and limestones with exogrins and ostreres towards the intermediate part, of Cenomanian age.
	Thalassinoides of the Churuvita Formation	Point	Paleontology	Scientific, Educative	Intercalations of quartz sandstones of fine grain, yellowish brown color, very friable, in benches approximately 50 cm thick showing surfaces of violet oxidation, some levels with abundant glauconite, muscovite, fossil remains of bivalves, fish scales and icnofossils (Thalassinoides, Figure 3l), thin to thick layers of black shales with continuous parallel plane stratification, and few layers of limestone.
Geosite 14	Tilatá Formation deposits	Point	Geomorphology (ridges, pediments)	Aesthetic, Scientific, Educative	Viewpoint from where it is possible to observe units of fluvial-erosional origin can be recognized, particularly ridges and pediments in sediments of the Pliocene-Pleistocene Tilatá Formation arranged in horizontal layers, some with crossed stratification, on which the denudation processes have worked, determining a landscape of soft hills, with slopes of less than 100 m, as well as inclined pediments.
	Tilatá Formation deposits	Point	Stratigraphy (sedimentary rocks)	Scientific, Educative	Tilatá Formation, which is composed of gravels, conglomerates, sands and clays, and rests discordantly on older units. It is characterized by the scarcity of organic profiles, scarcity of vegetation and presence of furrows and deep gullies in varying degrees (Figure 3m). Although it cannot be considered as accelerated erosion, a multi-temporal study should be considered to establish its evolution.
	Oxidation of the Tilatá Formation deposits	Point	Stratigraphy (sedimentary rocks); Mineralogy (minerals)	Scientific, Educative	Intense oxidation and development of ferruginous crusts. Figure 3m shows different aspects of the occurrence at the outcropping scale of the Tilatá Formation, which consists of layers of quartz sands, with clay matrix, medium to fine grain, yellowish white to orange or reddish according to their degree of oxidation, which shows an incipient lithification, and occasionally in layers of gravel and clays.
	Active erosion	Point	Geomorphology (erosion)	Scientific, Educative	Low-bound terrain with elevated slope through which the action of wind and water drags the materials forming large furrows called gullies that converge in larger furrows called ravines as a result of accelerated erosion, developing on a small scale characteristic morphologies called "erosion pillars".

Source: Authors.

Biodiversity

We highlight the landscape species identified for site-based conservation (Coppolillo *et al.*, 2004). Specifically, for birds we followed Ocampo-Peñuela & Winton (2017), by selecting some “high-value birds” of particular avitourism interest (endemic, near-endemic, threatened or near threatened) based upon a rapid ecological exploration in 2013. The Paipa region has extensive and unique fauna and flora (figure 2 and table 2) representative of the tropical Andes (Stattersfield *et al.*, 1998; Fjeldsa & Krabbe, 1990)

Figure 2. Flora and fauna landscape species in the Paipa region



Source: Photos by Francisco Fajardo (a-i) and Jörg Jonas (j-r).

The Paipa region includes two essential ecosystems differentiated from each other in structure and composition: the páramos and the high Andean forests. The páramos stand out for their exceptional diversity of frailejones (figures 2a-2f), the common name of the most of the *Espeletia* species, within an open grassland landscape with high level of endemism of species, which means that the species that are there are not to found anywhere else in the world. In contrast, the high Andean forests are mostly cloudy forested areas, reaching a canopy of 15-20 m tall, with abundant epiphytes on logs and branches, and in some cases, may be dominated by encenillo (*Weinmannia tomentosa*), laurel (*Ocotea calophylla*, figure 2g) or oak (*Quercus humboldtii*, Vulnerable) (Cárdenas & Salinas, 2007). Other important species correspond to *Paramiflos glandulosus* (figure 2h) and *Podocarpus oleifolius* (figure 2i).

In general, both ecosystems have been highly affected by the increase of anthropic activities such as cattle ranching or agriculture (potato crops). Specifically, the study area includes conservation sites such as the Forest Reserve of Paipa and the Ranchería Natural

Municipality Park (NMP) contained within the former reserve. Elsewhere, the Ranchería NMP plays an essential role as a constant provider of ecosystem services to Paipa (Gutiérrez-Chacón *et al.*, 2013). The Ranchería NMP hold 103 vertebrate species (Vásquez & Serrano, 2009), but in a recent exploration, the local biodiversity information increased to 290 species of six taxonomic groups (Díaz *et al.*, 2016). Of these, 181 were plants, 3 fishes, 3 amphibians, 5 reptiles (i.e. *Anolis heterodermus*, figure 2j), 84 birds (i.e. *Anas andium* (Andean Teal), figure 2k; *Oxyura jamaicensis andina* (Ruddy Duck - Colombian), figure 2l; *Eriocnemis cupreovertris* (Coopery-bellied Puffleg), figure 2m; *Coeligena bonapartei* (Golden-bellied Starfrontled), figure 2n; *Campylopterus falcatus* (Lazuline Sabrewing), figure 2o; *Synallaxis subpudica* (Silvery-throated Spinetail), figure 2p; *Cinnycerthia unirufa* (Rufous Wren), figure 2q; *Coniurostrum rufum* (Rufous-browed Conebill), figure 2r), and 14 mammals. Additional species (hummingbirds) were found by Tolosa-Moreno *et al.* (2014), extending an overall of 14 “high-value birds” (table 2). Furthermore, Díaz *et al.* (2016) recognized as landscape species for site-based conservation in Paipa 19 species at the regional and 17 species at the local scale (figure 2, table 2). Of particular interest, the endemic Paipa frailejon (*Espeletia paipana*), a critically endangered species (García *et al.*, 2005) with less than 30 individuals (Bohórquez-Quintero *et al.*, 2016). Reforestation and protection within a community and education-based developed must be mandatory to enhance a good society-nature relationship (e. g. Garzón, *et al.*, 2020).

Table 2. Landscape species at regional (OdC-R) or local scale (OdC-L) for Paipa region

Taxa	Criteria	Taxa	Criteria
Plants		Fishes	
<i>Cedrela montana</i>	OdC-R, NT	<i>Astroblepus</i>	OdC-L
<i>Espeletia argentea</i>	OdC-R	<i>Trichomycterus</i>	OdC-L
<i>Espeletia barclavana</i>	OdC-R	Reptiles	
<i>Espeletia boyacensis</i>	OdC-R	<i>Anolis heterodermus</i>	OdC-L
<i>Espeletia congestiflora</i>	OdC-R	Birds	
<i>Espeletia paipana</i>	OdC-R, CR	<i>Nothocercus julius</i>	NE
<i>Espeletiopsis jimenez-</i>	OdC-R	<i>Anas andium</i>	NE
<i>Espeletiopsis muiska</i>	OdC-R	<i>Oxyura jamaicensis</i>	OdC-R, EN
<i>Espeletiopsis pleiochasia</i>	OdC-R	<i>Chalcostigma</i>	NE
<i>Espeletiopsis</i>	OdC-R, EN	<i>Oxygogon guerinii</i>	NE (E)
<i>Espeletiopsis</i>	OdC-R	<i>Eriocnemis</i>	OdC-L, NE,
<i>Paramiflos glandulosus</i>	OdC-R, VU	<i>Coeligena bonapartei</i>	NE
<i>Puya nitida</i>	OdC-R, NT	<i>Chlorostilbon</i>	NE
<i>Puya boyacana</i>	OdC-R, CR	<i>Campylopterus falcatus</i>	NE
<i>Puya trianae</i>	OdC-R	<i>Pyrrhura calliptera</i>	OdC-L, E,
<i>Ceroxylon quindiuense</i>	OdC-L, EN	<i>Hapalopsittaca</i>	OdC-L, NE,
<i>Magnolia arcabucoana</i>	OdC-L, EN	<i>Synallaxis subpudica</i>	OdC-R, E
<i>Spirotheca rosea</i>	OdC-L	<i>Cinnycerthia unirufa</i>	NE
<i>Ocotea calophylla</i>	OdC-L	<i>Coniurostrum rufum</i>	OdC-L, NE
<i>Podocarpus oleifolius</i>	OdC-L, VU		
<i>Quercus humboldtii</i>	OdC-L, VU		

Besides, bird species considered as “high-value birds” for ecotourism (E, endemic; NE, near-endemic; NT, near threatened; CR, critically endangered; EN, endangered; VU, vulnerable).

Source: Authors.

Historical, cultural and religious territory

Paipa forms part of the history of Boyacá, where the freedom of the Republic of Colombia was forged, and this is the reason why it has several monuments, such as the Monument to

the Lancers of the Vargas Swamp, churches in renaissance and baroque styles, monasteries, chapels and mansions signs of the pre-hispanic period. There are several historical sites (figures 3a-3f) of great importance, however, there is nothing better than visiting the Hacienda El Salitre, whose architecture dates from 1772 and nowadays it is an inn with attractive balconies, a bullring and a chapel, and it was declared National Monument in 1975 (Moreno, 2009). This imposing historic building features a colonial style architecture, was the site of important historical events during the Liberation Campaign when it served as headquarters and received the Liberator Simón Bolívar.

The Vargas Swamp Historical Museum House dates from the independence period and is a colonial-style construction of more than 200 years that was recently restored, with the construction of the exterior gardens, where nature has been harmonized with the magic historical surroundings, which surrounds it. It was inhabited by the Vargas family, who was massacred during the battle by the Spaniards, and is now a museum house. This represents a municipal center of memory through which arrangements have been advanced for the acquisition of collections and pieces. According to Rodríguez & Borrero (2014), the Battle of the Vargas Swamp was the most important war event of the War of Independence, since it cleared the way of the patriots towards Santa Fe, discouraged to the realists and represented the bloodiest combat, given the number of casualties in both sides, although his parts of war are confusing and imprecise. The territory is crossed by a network of trails, giving the opportunity to appreciate its natural beauties and its historical-cultural features (figure 3g).

The Route of La Libertad is the product of the joint efforts of the municipalities of Paipa and Duitama that translate into a route of 2.3 km whose construction amounts to approximately 220 million pesos, through an improvement project, which is innovative as it extends the specifications of soil resistance and waterproofing of the route. This route recreates the route taken by the Liberator Simón Bolívar's army during the liberation campaign, which begins in the Silva Battalion squares passing through the paths of Bonza, Romita and ends in the municipality of Paipa. The National Festival of Ruana and Pañolón, Almojabana, and Amasijo pay tribute to the traditional clothes of Paipa: the ruana and pañolón, and the traditional techniques of shearing. In addition, the event promotes various manifestations of boyacense folklore such as handicrafts, gastronomy and traditional dances.

Popular handicrafts are one of the richest traditions of Boyacence folklore. Commercial development is based mainly on the supply of basic necessities and, of course, the trade in handicrafts (figure 3h) and milk products (figure 3i) that are highly related to tourism. In the primary sector, agriculture (oats, barley, maize, wheat, potatoes and legumes), livestock (milk and meat) and mining (coal, sand and rocks) are managed. In the secondary sector some activities, such as textile, chemical, food, ceramic, wood and construction, stand out. In the tertiary sector, tourism is one of the main economic activities presented by the municipality, standing out as one of the largest sources of employment, without neglecting the transport sector as it is the means of connection between the tourist and the attractions.

Figure 3. (a) Hacienda El Salitre. (b) San Miguel Arcángel Church. (c) Northeast Railway Station. (d) House of the Six Windows. (e) Monument to the Lancers of the Vargas Swamp. (f) Museum House of the Vargas Swamp. (g) The Route of La Libertad. (h) Producer family of Paipa cheese. (i) Handicrafts



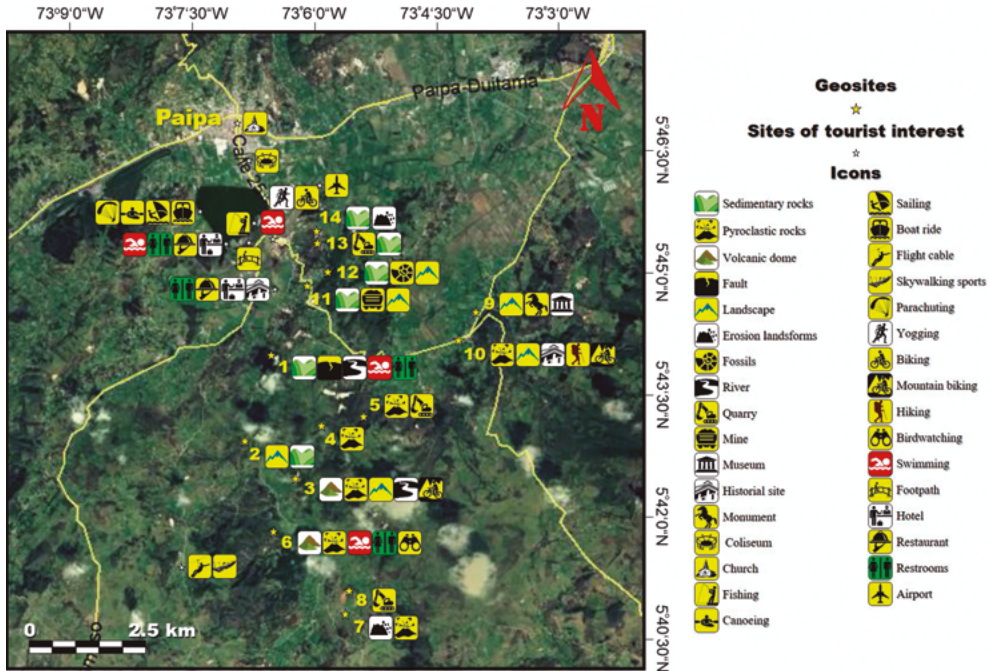
Source: Authors.

Figure 4 illustrates several sites of interest, including geosites, to visit around the Paipa-Iza Volcanic Complex (Colombia), which allow not only to enjoy wonderful natural landscapes, with spectacular waterfalls and rivers, different climates and great biodiversity, but also historical, cultural and religious traditions, among others, which attracts different types of tourism. The geosites, in particular, encourage the improvement of the geological knowledge of this region, enriching its geodiversity and generating a culture of valuation and learning of its geology; taking advantage of the tourist value that has the municipality of Paipa.

According to García-Cortés *et al.* (2019), these geosites reveal the aspects described below. They have good accessibility through paved or uncovered roads with easily accessible outcrops. In general, although the outcrops of volcanic rocks correspond mainly to little consolidated deposits, it is possible to establish field relationships despite the geological complexity of this volcanic system. The various manifestations of local daily life are the living sustenance of the identity of a region as part of the ancestral customs and traditions of the Cundiboyacense highland region. Throughout its territory the cobbled streets, facades, squares and stages belonging to the colony are preserved. When walking through this town, you can taste the gastronomy of this region, as well as explore and shop in its traditional crafts. Its natural landscape is characterized by combining humid forests, plains and paramo, which give it an environmental and conservationist value, where flora and fauna landscape species coexist. Paipa presents a tourist tradition par excellence, thanks

to its hot springs to which they attribute therapeutic benefits, as well as its wonderful climate and landscapes. On the other hand, the region has the best hotel infrastructure in the department of Boyaca, being one of the most attractive places for its tranquility and location to seek. Paipa participates extensively with various products in each of the economic sectors. In the primary sector agriculture, livestock and mining are handled. Within agriculture, the crops of oats, barley, corn, wheat, potatoes and legumes as well as fruit trees are highlighted. Products such as milk and meat are obtained in livestock. On the other hand, there are artisanal mining of coal, sand, puzzolan and stone ore. In the secondary sector, the industries of textiles, chemicals, food and construction stand out. In the tertiary sector, tourism stands out as one of the largest source of employment. The commercial development is based mainly on the supply of necessities and, of course, the trade of handicrafts and products derived from milk that are highly related to tourist activity.

Figure 4. Image of Google Earth (2020) showing the main places of interest, including geosites, around the Paipa-Iza Volcanic Complex (Colombia) and the corresponding icons



Source: Authors.

Geotourism and rural development

Tourism occupies a special place not only in Boyaca but also in Colombia taking into account its landscape, natural resources and the fact that is considered like the tourist capital of Boyacá. It represents one of the economic activities that have the greatest potential to generate new sources of wealth and employment and prevent the abandonment of rural areas. According to Rico (2005), because rural tourism promotes the creation of new

services, whether they are rural accommodation, centers of recreational-environmental activities, recovery in the trade of handicrafts, and others.

Paipa is recognized nationally and internationally for its cradle of first-class athletes in different sport disciplines, mainly in cycling and athletics. However, other sports are practiced here, such as mountain biking, horseback riding, tennis, swimming and water sports. Without a doubt, one of the main attractions of Paipa is the Sochagota Lake, which is an artificial lake created in 1956 when General Gustavo Rojas Pinilla was president of the Republic of Colombia, being of great importance for the development of tourism as it is a stage suitable for the practice of water sports, being surrounded by important hotels. Figure 5 illustrates the outdoor tourism, sports and health attractions. In addition to these activities, the ecotourism such as hikes and birdwatching will support other outdoor activities and extra-economic input to the local population (Ocampo-Peñuela & Winton, 2017). Paipa offers an excellent hotel infrastructure for the development of congresses, conventions, business events, family or group tourism, etc. Restaurants offer exquisite typical national and international foods.

Although Paipa is known for being a tourist site, traditional tourism of large hotels should promote rural tourism, as well as its local products (milk and cheese). For this reason, companies that produce artisanal cheeses saw the importance of continuing and promoting the Paipa cheese route. On the other hand, this local product is close to other sectors, such as gastronomy and tourism. The Paipa Cheese dairy chain also includes other milk derivatives such as yogurt or different cheese varieties. In this way, rural tourism is intrinsically linked to the culture, customs and traditions of its inhabitants, as well as gastronomy and crafts, which is complemented by the different forms of tourism that this municipality already has. Besides, it is essential to value local products as tourist resources, as well as their dissemination in order to know the production processes of products such as cheeses, sweets, “chicha” (beverage produced by corn undistilled fermentation), honey, crafts, typical foods, among others. Geotourism festivals can promote a variety of presentations and exhibitions of local products to offer tourists the opportunity to taste and buy local products.

Geotourism has emerged as a credible sustainable tourism industry, which offers new development and employment opportunities for local communities. It can generate several economic benefits, including creation of income, generation of jobs, diversification and improvement of infrastructure, which are distributed through the local economy. Net benefits from tourism accrue from the balance of economic, social and environmental interactions of tourists with a destination (Greiner *et al.*, 2004). However, geotourism can generate positive or negative economic impacts (Eusébio & Lima, 2011). Any geotourism initiative should only be considered successful if local communities have some degree of control over them and if they equitably share the benefits that arise from geotourism opportunities (Dowling, 2013). Therefore, it is necessary that municipal administration, the Boyaca Government, the Republic of Colombia and the environmental authorities implement strategies that integrate the principles of sustainability, responsibility and quality in the tourism sector, through articulation and commitment of the different governmental, economic and social sectors, with the participation of local communities, to develop a high quality tourism offer, which generates more socio-economic and environmental benefits.

Geotourism is often presented as a mechanism having the potential to offset the local opportunity cost of protected natural areas and cultural sites (Dowling, 2013), which can specifically focus on geology and landscape. It promotes tourism to geosites and the conservation of geodiversity and an understanding of Earth sciences through appreciation and learning, which can be developed through visits to geosites, use of geotrails, viewpoints and visitor centres, guided tours and geoeducation activities (Newsome & Dowling 2010). Political support for conservation is best generated where protected areas demonstrate tangible economic benefit to local communities (Goodwin *et al.*, 1998). Where people gain more from the use of landscapes (units of relief of erosional-structural, piedmont agraddational and valley agraddational origin) through tourism, they are more likely to protect their asset and may invest further resources into it. One of the most obvious and immediate benefits of sustainable geotourism associated with local communities is the increase in employment opportunities and income generation for the host region (Dowling, 2013), which includes direct employment (associated service industries such as hotels, restaurants, concessions); indirect employment (generated as a result of increasing industry inputs such as employment at a retail souvenir outlet); induced employment (generated as a result of increased spending capacity of local residents due to increased receipts from tourism; consumption of goods, for example). However, the inclusion of local communities in the development of geotourism is a complex task. Therefore, the development of inclusive geotourism for local communities requires investing time and effort, knowledge transfer, education, active participation and conflict resolution. It is necessary to make partnerships linked to educational institutions (elementary and secondary school to university, or research institutes in occasion), tour companies, restaurants and lodgings, non-governmental organizations, companies of unique goods and so forth, together with the construction of consistent master plans including the preservation and management plans of geoheritages (Koh *et al.*, 2014).

The geotouristic values of the Paipa-Iza Volcanic Complex (Colombia) are based on the assessment of the sites of geological interest (or also called geosites), which can be evaluated according to several criteria as accessibility, representativeness, state of preservation, rarity, scientific knowledge and education value (e. g., Brilha, 2016). This region includes several interesting sites for the knowledge and the interpretation of the geological heritage (geosites) and that allow discovering the fascinating evolution history of this region. Including sites of geological interest with many different types of rocks; sites of geomorphological interest to observe the forms and processes of a great scientific value; sites of mineralogical interest with metallic and non-metallic ore mining deposits; sites of palaeontological interest to appreciate the history of life evolution of our planet; sites of archaeological interest which show traces to reconstruct the history of the battle of the Vargas Swamp; and sites of biodiversity interest to ecotourism and outdoor activities.

Why tourism in Paipa-Iza Volcanic Complex is special? This region is safe and peaceful, and people are friendly with traditional values and a variety of cultural heritage. However, its geology makes this region to be special, which shows a diverse regional variety. People lifestyle has been shaped by geology and climate and land is adapted to provide life. Together people, cultural and natural heritage create a unique destination. It is necessary to plan a vision as part of long-term strategy to develop nature-based tourism to work with

local communities to develop tourism awareness. The Paipa-Iza Volcanic Complex is well placed to capitalize on this through geotourism.

The value of geotourism is well understood and already stimulating product development and thinking on geoparks, marketing and planning for visitor services (Al Mamari, 2011). This region has enormous potential to utilize distinctive geological attractions and to add value to existing nature-based tourism product such as trekking, climbing, trails, and other adventure activities. Geotourism is a strong element at the Paipa-Iza Volcanic Complex, which has an increasing role in the product offer of this region, which can deliver sustainable geotourism outcomes and is an active stakeholder in developing and increasing it. Because of its geological diversity and geoheritage value, geotourism can play a crucial part in promoting the sustainable rural development of the Paipa municipality. The rural geotourism can be developed when rural culture be a key component of the product offered, and the distinctive feature of rural geotourism products is the desire to offer visitors a personalized contact, to provide them with the opportunity to discover its own natural and cultural heritage of rural (and urban) areas and, as far as possible, to appreciate the authenticity of the local communities.

Figure 5. Outdoor tourism, sports and health attractions



Source: Authors.

Geoeducation

Paipa and its surroundings have great potential to carry out educational activities dealing with ecological issues, nature preservation and sustainable development strategies, as well as to preserve the local knowledge traditions and the historical-cultural values of a territory. The existence of forested and paramo areas and their associated ecosystems is proof of the will to achieve this type of sustainable future, preserving and improving the value of the precious characteristics of the natural world and rediscovering that man and his traditions are also part of it. However, this region requires the implementation of visitor centers and information points, geo-trails, guided walks, thematic exhibitions, special publications and guides, training courses, activities of scientific research, and environmental

education programs in order to carry out the transfer of geological knowledge of its territory. In this way, it is necessary to undertake innovative initiatives for the development of educational programs (e. g. Garzón *et al.*, 2020). The teaching-learning process of the geosciences can be transferred to primary and secondary public and private schools of the region through formal education (educative activities related to school lectures) and participation in workshops and guided tours, where students would learn about minerals and rocks, and fossils, offering a valuable opportunity to strengthen the student’s knowledge of geology and develop geoeducation activities (Figures 6a-6c), which are very important for promoting the geoconservation.

In Colombia, several important sites as the interest area have been affected by the anthropic activity, although, according to Gray (2019, p. 232), this is something that also happens in developed countries, due to the lack of knowledge about geoheritage and its significance as well as regulations for environmental impact assessment, for example, and laws for nature protection including geoheritage. From the educational point of view, one of the most important justifications to promote the protection of sites of geological interest is to preserve them for the development of geoeducation activities and training of students of geology. Research projects would bring together experts, students of geology and community volunteers through training seminars to assess sites and to contribute understanding and conservation of the geoheritage. On the other hand, it can support the development of several environmental education activities (figures 6d-6f) in the classroom and outdoor kindergartens, primary and secondary schools. School tourism could become a very important activity as long as there is synergy between government agencies, public and private educational institutions, and teachers and students who are increasingly responsible for environmental problems. On the other hand, it is essential to participate in the processes of social organization for its conservation, in order to establish the articulation between the actors. Therefore, it is necessary to carry out a transfer of scientific knowledge in order to promote the conservation of the natural and cultural heritage of this region, based on the social inclusion of local communities in order to make it a unique place for enjoyment of the tourists.

Figure 6. (a)-(c) Geoeducation and (d)-(f) environmental education activities



Source: Authors.

Conclusions

The Paipa-Iza Volcanic Complex, in the Eastern Andes of Colombia, forms part of a volcanic arc associated to the subduction of the Nazca Plate underneath NW South America, resulting in a majestic landscape, which has become an interesting region for the development of geotourism. Paipa is a touristic municipality, which is famous for its thermal waters to which they attribute therapeutic benefits, for the goodness of its surprisingly rich geoheritage, climate and the beauty of its landscapes. However, the urban transformation of this region, as occurs in many cities, has been the result of anthropic intervention on the natural environment. For instance, the development of mining of metallic and non-metallic raw materials, which has accelerated the antropogenic erosion and deterioration of the landscape. In this way, such threats to the natural heritage of this beautiful territory reflects the little importance that has been given to the heritage as a consequence of the non-application of policies aimed at its conservation. Geotourism could become a socio-economic engine for this region, increasing the possibilities for employment, investment and business opportunities. This region has enormous potential for promoting geotourism initiatives through the geological heritage inserted in the rural and urban areas. The initiative of a UNESCO Global Geopark for this region would provide a great opportunity for the development of a sustainable tourism in Paipa, contributing to the protection and conservation of its geological heritage and geodiversity as well as its fauna and flora, from teaching, research and awareness of local communities. However, to fulfill this mission, it is important to establish a regulation through governmental policies.

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