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Visitor environmental impact on protected natural areas: An evaluation of the Huaytapallana Regional Conservation Area in Peru

Edith M. Maldonado-Oré [a], María Custodio [b,*]

[a] Universidad Nacional del Centro del Perú, Facultad de Antropología, Av. Mariscal Castilla, 3909, Huancayo, Peru
[b] Universidad Nacional del Centro del Perú, Centro de Investigación en Alta Montaña, Av. Mariscal Castilla, 3909, Huancayo, Peru

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ABSTRACT

Protected natural areas, especially regional conservation areas, are important for preserving biodiversity, ecosystem services and recreation. The Huaytapallana Regional Conservation Area in the Junín region of Peru is a mountain ecosystem providing hydrological, cultural, and tourism ecosystem services to the population. This study evaluated the environmental impact of visitors on two tourist trails (one vehicular and one pedestrian) and two ritual zones in this area using a Leopold matrix. Sample plots were previously installed of 20 × 25 m (subdivided into five sub-plots) systematically distributed. Organic and inorganic waste was quantified. The overall environmental impact of visitors in the natural environment was negative (−-532) with soil, air, and wild fauna the most affected; on the other hand, socioeconomic factors were positive overall (504).

Management implications

This study identified the impacts of tourism and cultural rituals on the flora, fauna, soil and landscape of the study area by the accumulation of organic and inorganic waste and other effects (such as noise and erosion). The results can be used to develop protected area management instruments such as a Visitor Impact Mitigation Management Plan, in order to minimise negative impacts and protect the biodiversity and scenic beauty required for recreation, tourism, and research. The results can contribute to the broader protection of the high alpine Huaytapallana region, which is very sensitive to climate change.

1. Introduction

Tourism in protected natural areas (PNAs) generates economic benefits for various sectors of the population but also affects resource conservation (Brenner, 2011). When management measures are not applied to fragile ecosystems, increased tourism activity and solid waste generation negatively impact vegetation cover, landscape beauty, and overall ecosystem health (Aragón, 2018; Romero, 2016). This impact makes carrying capacity analysis a potential strategy for reducing visitor impacts on tourist and recreational destinations; this is essential for environmental conservation and proper development of tourism activity (Gil, Gil, & Campo, 2014). Identifying impacts on the natural environment and estimating the tourist carrying capacity can lead to better management of visitor impact and improvements to infrastructure and services for ecotourism (García, 2005, 2013; Genchi & Rosell, 2010; Ibañez, 2016; Meave & Lugo-Morín, 2016; Perruolo & Camargo, 2017; Puente, Pérez, & Solís, 2011).

The analysis of tourism from an anthropological viewpoint is a product of modern industrial society, whose complex, interconnected, and interdependent nature has become infused throughout the global village (Maestre, 2001; Pereiro, 2015). The economic development generated by tourism should be balanced against subjective evaluations of the authenticity of traditions and other cultural aspects along with the aesthetic beauty of the landscape and its symbolic value (Figueira, 2011; Francesch, 2016; Rementeria, 2015). Cultural practices should contribute to solving the environmental problems of protected areas rather than contributing environmental deterioration (Beltran & Santamarina, 2016; Boege, 2015).

In Peru, research on the identification of tourism impacts and on the determination of management strategies in protected areas has increased in recent years in both national and regional contexts because many of these areas have been opened to tourism. Each protected area, circuit, resource, trail, or ritual zone requires a different management approach to achieve sustainable tourism development (Muguruza, 2015; Prado, 2014; Soria-Díaz & Soria-Solano, 2015, pp. 25–34).

Tourism generates economic, social, and cultural benefits, but is also

* Corresponding author.
E-mail addresses: maldonadooreedith@gmail.com (E.M. Maldonado-Oré), mcustodio@uncp.edu.pe (M. Custodio).

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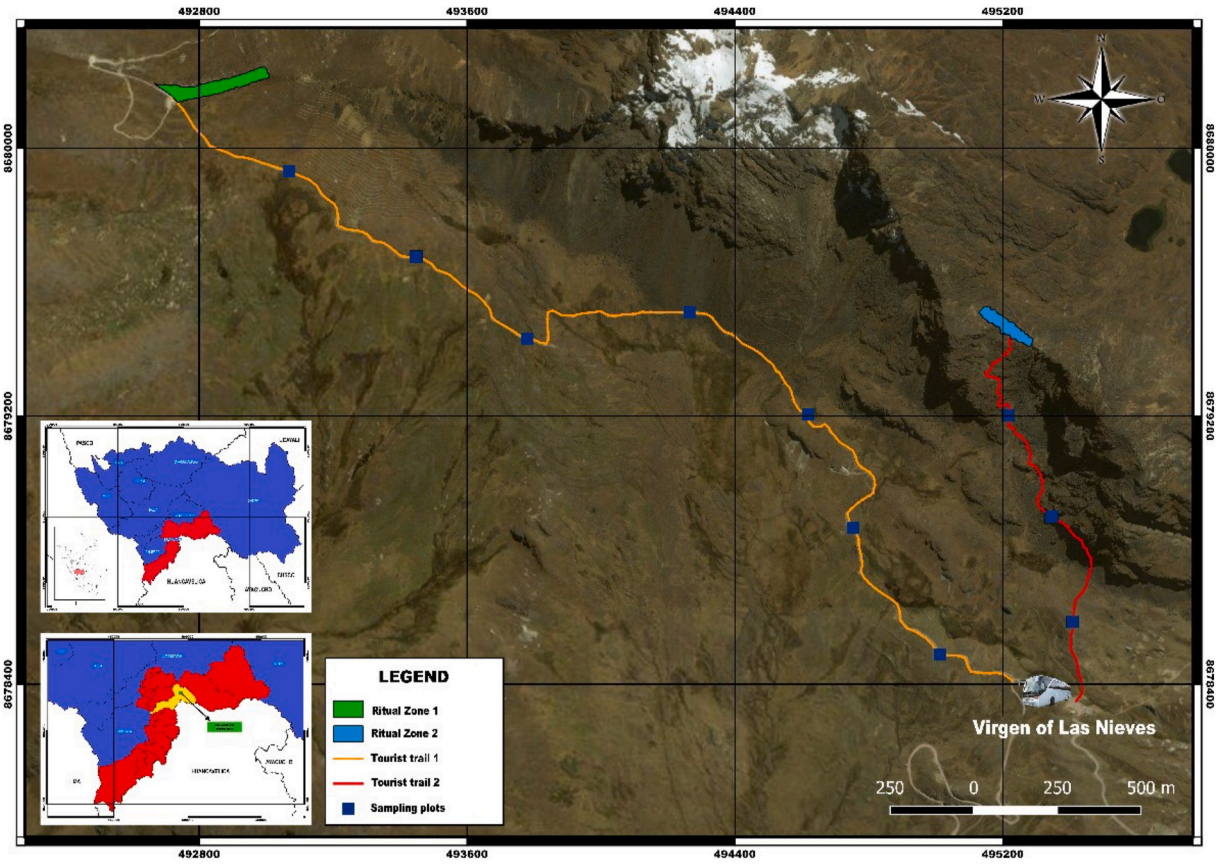

Fig. 1. Location of the Huaytapallana Regional Conservation Area along with the two tourist trails and ritual zones studied here.

responsible for many negative impacts when it occurs in protected areas with fragile ecosystems, such as the Huaytapallana Regional Conservation Area (HRCA) in Peru's Junín Region, where both cultural rituals and nature tourism take place. Research on visitor impacts has allowed the development of management plans for the affected areas while leading to better management of intense tourism in this protected area (Quintero, 2014; Vicencio & Bringas, 2014). The relationship between tourism, protected areas, and planning is essential for tourism to be understood as an important element in the promotion of sustainable development (Brenner, 2011; Figueira, 2011).

In the last two decades, PNAs have become a favourite destination of national and international tourists. The use of these areas generates economic benefits for local people as well as environmental problems that affect natural resource conservation, as is the case at the HRCA. Tourism impacts can be divided into three aspects (socio-cultural, environmental, and economic) based on research at the national and international levels. In this study, such impacts were evaluated in the HRCA by applying a Leopold matrix and proposed solutions were developed by determining the sustainable tourism carrying capacity (Bardín, 2014; Brenner, 2011; Jones y Phillips, 2011; McCool, Haynes, & Eagles, 2003; McIntyre, 1993; Wagar, 1964). Specifically, this study evaluated the environmental impact generated by visitors on two tourist trails (one vehicular and one pedestrian) and two ritual zones in the HRCA in order to identify and determine (a) the economic and social impact generated by visitors and (b) the impact on the natural environment generated by visitors.

2. Literature review

The effects of tourism in PNAs can be considered in terms of both positive and negative impacts on environmental and natural resources. Tourism generally benefits local residents but can also cause impacts on the natural environment when it becomes extensive, as in the HRCA, which is used more to perform rituals than for tourism.

2.1. Impacts of tourism on PNAs

Impacts are changes in environmental quality that can be positive or negative, with the consequences affecting the characteristics of the environment. Tourism impacts can affect ecosystem balance in terms of resource availability and environmental capacity (Tinoco, 2009). Poorly planned tourism causes serious negative impacts on the natural and social environment; instead, planning should based on the sustainable tourism paradigm such that tourism can contribute to the economic, social. And ecological development of PNAs that are tourist destinations (Flores & Parra, 2010).

PNAs are very important in the tourism industry, which has a large magnitude and impact. For successful tourism to occur, managers must work to understand the international context, where the global trend is toward cooperation in the conservation of NPAs through international initiatives and binding treaties, such as the World Heritage Convention, the Ramsar Convention, the Convention on Biological Diversity, the Man and the Biosphere Programme (Leung, , Spenceley, , Hvenegaard, , & Buckley, 2019).

In Peru, research on the impacts of tourism in the Lachay National Reserve and the ecosystem of the Lomas region (Romero, 2016) showed that tourist numbers significantly increased from 2008 to 2012 although tourism was seasonal (between July and November). The highest percentages of solid waste (32%) in the administrative zone, camping, and picnic zones accumulated in these months and the influx of tourists has negatively impacted the area, affecting the vegetation cover, the beauty of the landscape, and the ecosystem in general. Another study on tourism in Peru (Gonzales, 2017) emphasised the role of the Peruvian state in developing tourist destinations through private investment

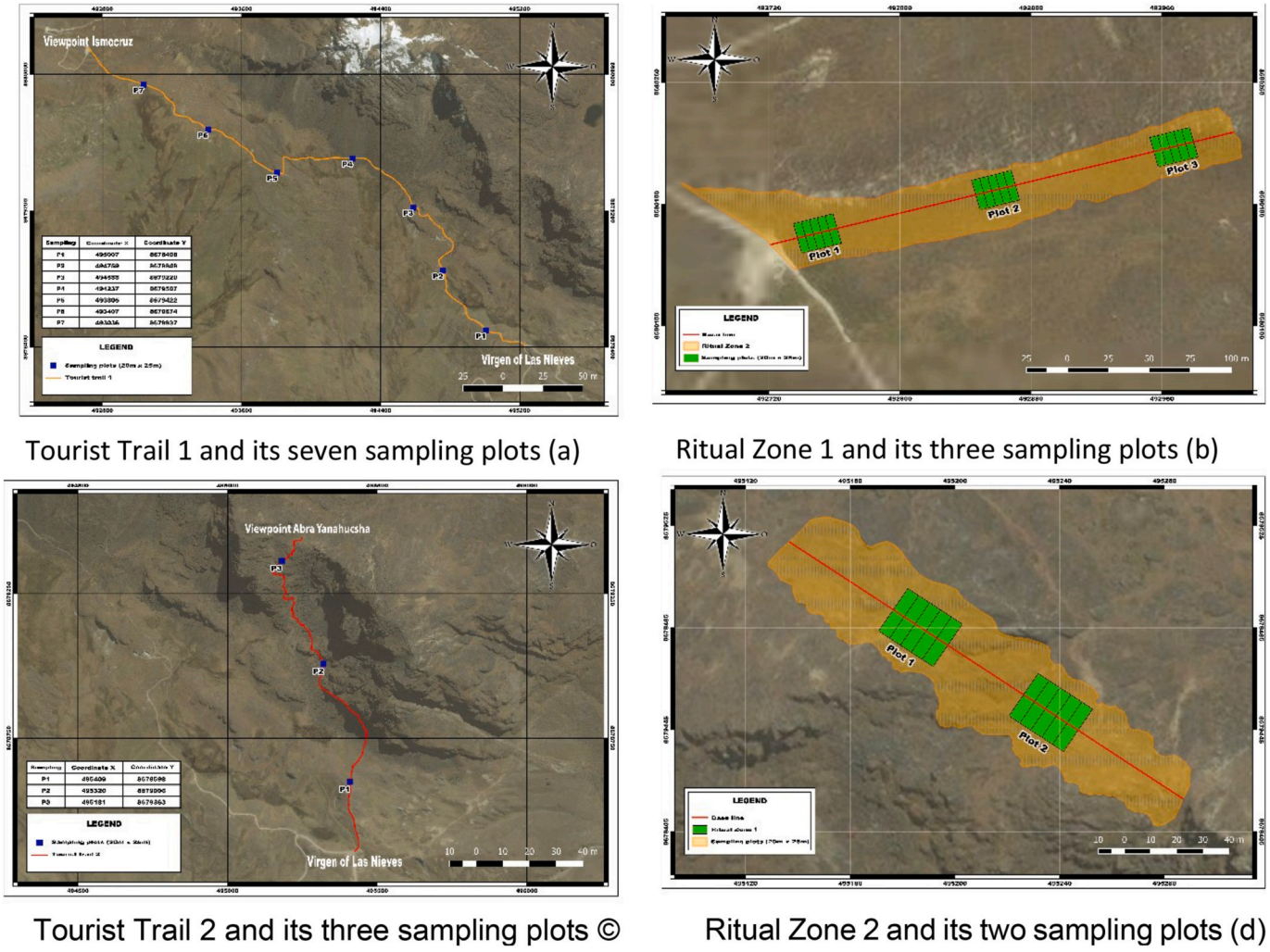

Fig. 2. Details of the two tourist trails and two ritual areas with their sampling plots (a,b,c,d).

along the country's north coast (Mancora district, Piura), analysed the Peruvian neoliberal tourism model by examining multi-scale ethnography and the tensions and problems occurring as a result of its implementation, and explored impacts on environmental policy and attempts to modify the current tourism model.

Comparative research carried out in the communities of Infierno in Madre de Dios (with an ecotourism venture) and Llachon in Puno (with rural community tourism) identified the environmental, economic, and social impacts of tourism by analysing the influence exerted on it by historical processes, new practices, and tourism management with the element of uncertainty as a transversal axis to the aforementioned dimensions (Aragón, 2018). Both modalities of tourism were considered by the inhabitants as elements that contributed to the environmental and cultural conservation while supporting the local economy.

2.2. Ecotourism in PNAs

Ecotourism, which takes place in PNAs with important and unique natural attractions, can provide economic resources for efficient management of PNAs. For this reason, government institutions should intensify measures to protect them and improve the living conditions of local populations within PNAs while reducing pressure on resources (Ceballos Lascurraín, 1996).

PNAs are key to conservation strategies worldwide. Modern tourism in PNAs is fundamental for promoting visitor connections with the environmental and cultural values of these areas, becoming a force for conservation, support, and care of local values. Tourism, unlike extractive industries, requires beautiful natural areas, healthy wildlife and nature, and authentic cultures. Therefore, the capacity of tourism to generate national income and employment can function as an important incentive to conserve and manage intact natural areas rather than modify or destroy them to produce other types of products (Leung et al., 2019).

In Costa Rica, tourism in conservation areas is preferred by tourists, causing tension between local economic benefits and resource conservation (Vargas, 2009). It is therefore necessary to reach an agreement regarding tourism and the use of nature, while developing and managing visitation patterns that do not affect resources and avoid negative impacts on ecosystems due to tourism overload.

In Mexico's Bahía de los Ángeles, an analysis of conflicts related to the conservation of PNAs (Vicencio & Bringas, 2014) showed that these areas are considered important spaces for the promotion of tourism that contributes to improving local quality of life while conserving nature. For example, the authors found that ecotourism was ideal for developing community improvement projects but that irregularities in land tenure and a lack of intergovernmental coordination allow those with greater purchasing power to prevail over the welfare of the community and natural resources.

3. Study area

The HRCA is located in the Central Andes of Peru and forms part of

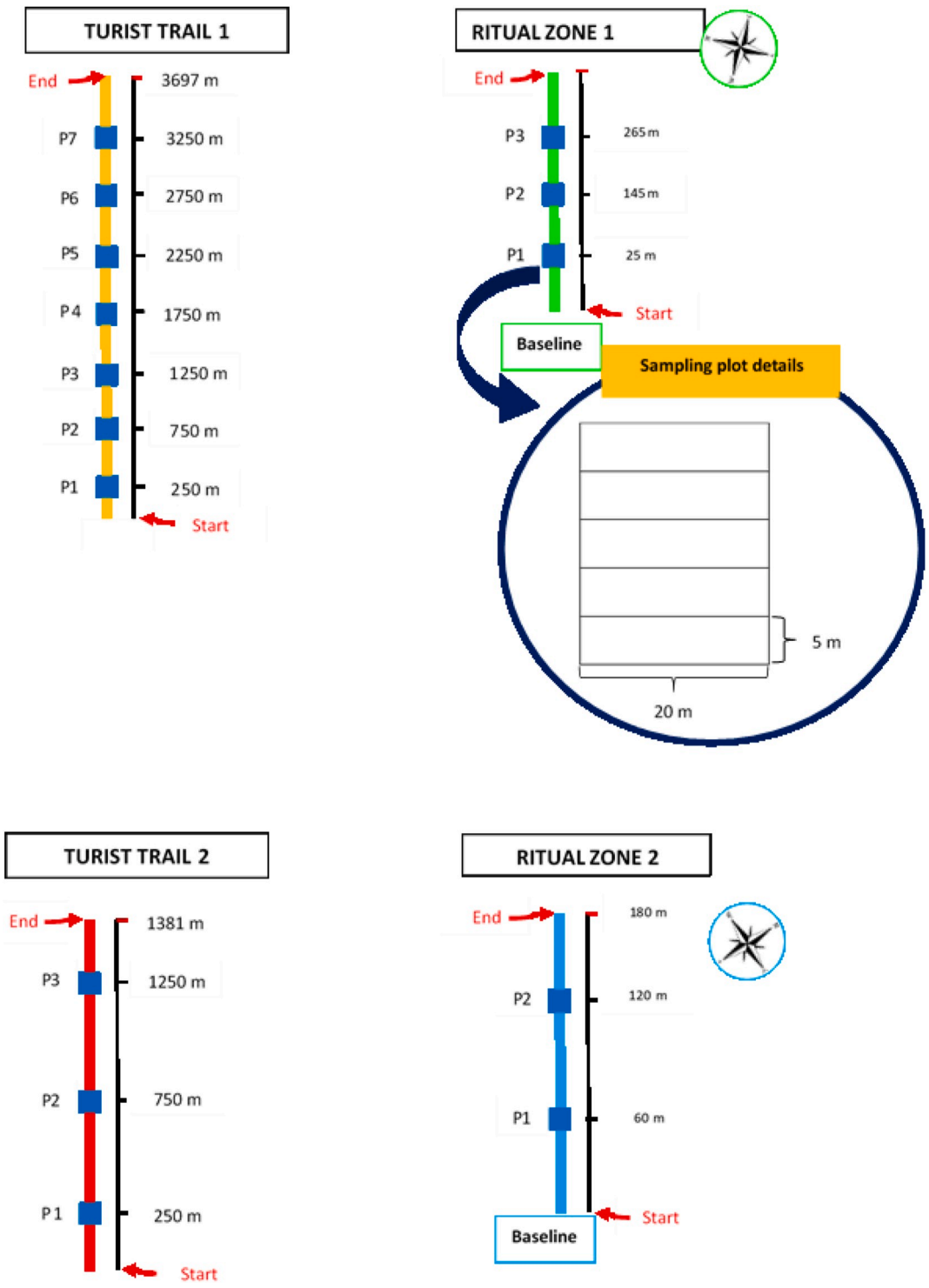

Fig. 3. Design and distribution of sampling plots for the two sets of trails and ritual areas.

the National System of Areas Protected by the Peruvian State (SINANPE). It is located to the northwest of the city of Huancayo between 11°35′ and 11°58′ south latitude and 74°48′ y 75°17′ west longitude, covering an area of 22,406.52 ha at an altitude of 4500–5768 m.a.s.l. (Fig. 1). The area's snow-capped mountains are the main natural and cultural attraction for tourism and rituals. Two tourist trails (Trails 1 and 2) and two ritual zones (Ismo Cruz (1) and Yanahucsha Viewpoint (2) were chosen as the focus of this study (Fig. 2) because they are the most used for vehicular traffic (Trail 1), pedestrian traffic (Trail 2) and ritual practices (Ritual Zone 1 and 2); the latter are also used for tourist visits.

The Huaytapallana mountain range is of great hydrological importance, giving rise to several important lakes including Huacracocha, Lasuntay, and Chuspicocha. These lakes in turn support an entire hydrological system including the Shullcas, Yuracyacu, Chiapuquio, Achamayo, and Acobamba Rivers. This snow-covered area is very susceptible to global warming, and snow cover has been decreasing, which has negative impacts on the lakes' water supply and the underground and surface water systems (INAIGEM, 2018; Pariona, 2015). This problem, along with impacts from tourism and ritual practices, affects

Table 1
Main environmental impacts of Trail 1.

Length (m)	3697	Unit	Plot 1					Plot 2					Plot 3					Plot 4					Plot 5					Plot 6					Plot 7					Average/sub plot (100 m2)
Description			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Organic residues	Fruits	kg																																				
	Cereals	kg																																				
	Breads and biscuits	Unit																																				
	Caramels	Unit																																				
	Flowers	Unit																																				
	Pieces of cardboard and paper	Unit	3	0	3	0	0	5	2	0	2	1	0	1	1	0	0	2	0	1	0	0	1	1	0	0	1	1	1	4	2	0	0	2	1	2	1	1.09
	Coke	kg																																				
Inorganic residues	metallic caps	Unit	4	3	3	3	4	2	2	2	4	2	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1.03
	Plastic caps	Unit	3	3	4	3	3	2	2	2	3	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	1.09
	Cork caps	Unit	3	4	1	5	3	3	3	4	3	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	1.26
	Cigar filter	Unit	12	14	21	20	16	21	18	8	14	17	4	9	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	9	7	12	6.34
	Plastic bags	Unit	4	3	4	2	4	3	1	2	3	2	0	3	2	0	1	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	2	3	1.31
	Plastic cups	Unit																																				
	Plastic bottles	Unit																																				
	Glass bottles	Unit	0	0	0	0	3	6	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0.57
	Glass fragments	Unit	12	26	29	30	31	16	23	25	21	18	17	8	15	10	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.29
	Beer cans	Unit																																				
	Pieces of metallic paper	Unit																																				
	Waxes and candles	kg																																				
Holes for payment ceremony		Unit	3	3	3	3	2	2	2	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	0.94

Impacts on the natural environment																																			**Absence (0) Absolute frequency**	**Relative frequency**
Water flooding	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	23	65.71
Vehicle Compaction	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	85.71
Human compaction	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	85.71
Alteration to vegetation	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	21	60.00
Disturbance to wildlife	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0.00
Sound	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0.00
Bad smells	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	85.71

Fig. 4. Severe deterioration of Trail 1 due to excessive vehicular traffic.

areas's flora, fauna, and water sources. The area requires proper management since its broader water system is very important for human consumption and agriculture in intermediate and lower basins (Ávalos et al., 2013).

The HRCA, located in this mountain range, was created to conserve biological and landscape diversity and to ensure the sustainable use of water and other natural resources with respect to the area's diverse ecosystems, which include lagoons, snow-capped mountains, wetlands, mountain forests, shrublands, and Andean grasslands (NIRGME, 2018). 104 species of wild flora have been identified in this area, including *Aciachne pulvinata* (consumed by South American sheep, cattle, and camelids), *Aegiphila muptiflor* (used in traditional medicine), and *Agrostis breviculmis Alchemilla* (eaten by camelids and domestic animals). 45 species of birds have been identified, including three endemics (*Upucerthia serrana*, *Metallura phoebe,* and *Asthenes virgate*). Nine mammal species have been identified, including South American camelids such as the alpaca (*Lama guanicoe pacos*), llama (*Lama guanicoe glama*), vicuña (*Vicugna vicugna*), viscacha (*Lagidium peruanum inca*) and others (Cano & Haller, 2018).

4. Methodology

4.1. Methods

The Leopold matrix method was applied to identify visitor impact on the natural and socioeconomic environment by identifying direct impacts caused by environmental, social, and cultural factors, then establishing cause-effect relationships. This is a subjective double-entry matrix that rates each cell by magnitude (±1–10) and importance (1–10) (Leopold, Clarke, Hanshaw, & Balsley, 1971). However, for improved quantification, sampling was conducted in systematically distributed plots in which quantitative data for organic and inorganic residues were obtained. The Leopold matrix is the first method designed to evaluate the environmental impact of projects or activities, consisting of an interactive matrix showing activities on one axis and the environmental factors or components affected on the other axis (Table 5).

4.2. Procedures

In order to obtain data for visitor impact on the natural environment, 25 × 20 m sampling plots with 5 × 20 m sub-plots were systematically distributed along the two trails and within the two ritual areas. Seven plots were installed along Trail 1, three plots along Trail 2, three within Ritual Zone 1. And two within Ritual Zone 2. In each sampling subplot, organic and inorganic waste were quantified along with visitor impacts on the natural environment. The data obtained in these plots formed the basis for applying the Leopold matrix and identifying the environmental impacts caused by visitors in the HRCA.

4.3. Data analysis

The data were analysed and processed using Excel software and a database was generated along with tables, matrices, and figures. QGIS software was used for spatial analysis of the paths and ritual areas using GPS data, maps, and altitudinal profiles.

Fig. 5. Identification of impacts in the Ismo Cruz ritual zone. Holes in the soil are a consequence of ritual activity.

Table 2
Main enironmental impacts in Ritual Zone 1.

Description	11,772	Unit	Plot 1					Plot 2					Plot 3					Average/sub plot (100 m2)	Standard error of the average	Frequency (%)
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5			
Organic residues	Fruits	kg	5	10	3	7	8	22	20	18	21	16	12	15	4	10	7	11.87	1.65	100.00
	Cereals	kg	2	1	0	4	1	11	10	9	10	8	3	4	1	2	3	4.60	1.00	93.33
	Breads and biscuits	Unit	14	11	16	30	7	5	5	6	5	7	2	30	12	40	14	13.60	2.89	100.00
	Caramels	Unit	35	0	13	21	7	6	7	9	2	1	0	16	10	0	0	8.47	2.52	73.33
	Flowers	Unit	21	0	0	0	0	12	6	15	4	6	25	10	5	0	0	6.93	2.10	60.00
	Pieces of cardboard and paper	Unit	4	5	3	6	4	15	10	5	0	8	8	5	4	7	11	6.33	0.95	93.33
	Coke	kg	1	0.5	0.5	1	0	0.5	0.5	1	1.5	1	3	2	2	1	0	1.03	0.21	86.67
Inorganic residues	metallic caps	unit	31	29	12	25	39	18	12	17	25	11	18	12	17	25	11	20.13	2.20	100.00
	Plastic caps	unit	0	0	0	0	6	0	4	17	2	8	0	4	3	2	2	3.20	1.17	60.00
	Cork caps	unit	2	6	0	0	6	0	2	2	4	5	0	2	0	4	5	2.53	0.59	66.67
	Cigar filter	unit	41	35	65	35	55	40	35	41	55	30	40	35	41	55	30	42.20	2.70	100.00
	Plastic bags	unit	8	0	0	2	13	0	10	4	2	6	0	10	11	2	8	5.07	1.19	73.33
	Plastic cups	unit	0	2	0	2	0	0	0	0	4	5	5	0	2	4	3	1.80	0.51	53.33
	Plastic bottles	unit	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0.13	0.13	6.67
	Glass bottles	unit																		
	Glass fragments	unit	20	24	105	90	125	13	18	38	0	37	13	23	38	18	37	39.93	9.50	93.33
	Beer cans	unit																		
	Pieces of metallic paper	unit	0	0	0	0	0	1	0	2	0	3	0	0	3	0	0	0.60	0.29	26.67
	Waxes and candles	kg	0	0	2	1	2	1	1.5	2	2	2.5	2	3	2	1	2	1.60	0.22	86.67
Holes for payment ceremony		unit	18	15	10	13	18	22	20	18	21	16	22	20	18	21	16	17.87	0.88	100.00

Impacts on the natural environment																	**Absence (0)**		**Presence (1)**	
																	Absolute frequency	**Relative frequency**	**Absolute frecuency**	**Relative frecuency**
Water flooding		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	100.00	0	0.00
Vehicle Compaction		0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	5	33.33	10	66.67
Human compaction		0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	5	33.33	10	66.67
Alteration to vegetation		0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	5	33.33	10	66.67
Disturbance to wildlife		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0.00	15	100.00
Sound		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0.00	15	100.00
Bad smells		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0.00	15	100.00

Fig. 6. Peak visitation in Ritual Zone 1 on 21 June of each year.

5. Results

The specific layout of the sampling plots is shown in Fig. 3. The results from these plots allowed the Leopold matrix to be applied to determine the impacts on the natural and socioeconomic environment.

5.1. Visitor impacts on the HRCA

7 sample plots and 35 sub-plots were installed on Trail 1 (Table 1, Fig. 4). The count of organic waste by subplot (100 m^2) found pieces of paper and cardboard (avg. 1.09 ± 0.21 units); that of inorganic waste found pieces of glass (avg. 8.29 ± 1.85 units), cigar filters (avg. 6.34 ± 1.27 units), and cork lids (avg. 1.26 ± 0.28 units).

As for holes for ritualic payment ceremonies, 0.94 ± 0.22 were found per subplot (Fig. 5). Likewise, disturbance to wildlife and noise generated by people, vehicles, and musical orchestras were found in 100% of the sub-plots, disturbance to vegetation (due to holes made for rituals and payments) was identified in 40% of the sub-plots, and flooding (as a result of surface runoff) was found in 34% of the subplots.

Trail 1 was very impacted by vehicle traffic and runoff from the mountains. In the first plots along the trail, very little waste was counted, but as we approached Ritual Zone 1, waste and holes in the ground increased. Water sources were also affected by inorganic waste.

In Ritual Zone 1, 3 plots and 15 sub-plots were installed (Table 2). Organic residues per subplot included fruit (11.87 ± 1.65 kg), bread and biscuits (13.60 ± 2.89), candy (8.47 ± 2.52 units), and flowers (6.93 ± 2.10 units). Inorganic residues per subplot included cigar filters (42.20 ± 2.70 units), pieces of glass (39.93 ± 9.50), metal lids (20.13 ± 2.20), and glass bottles (39.93 ± 9.50). In addition, 17.82 ± 0.88 holes were found per subplot (Fig. 6).

Ritual Zone 1 was heavily eroded as a consequence of holes dug to bury payments, which consisted of organic and inorganic products (Table 2). The space used for the rituals (Fig. 2) was a grazing area and was affected by loss of vegetation cover due to erosion. There was also extensive waste from glass bottles and cigarette butts that negatively impacted the vegetation cover. This area is very popular area because tourists use it as a viewpoint for the snow-capped Huaytapallana Mountains and Lasuntay Lake. The largest visitation by tourists and ritual performers occurs on 21 June each year.

Disturbance of wildlife, sounds caused by people, vehicles, and music, and bad smells caused by rotting organic waste (such as fruit) were found in 100% of the sub-plots. Soil compaction caused by vehicles and visitors and alteration of vegetation were found in 66.67% of the sub-plots.

3 sample plots and 15 sub-plots were installed along Trail 2 (Table 3). The most common organic wastes per subplot were paper and cardboard (2.40 ± 0.60 pieces), fruit (0.80 ± 0.28 kg), and cereals (0.53 ± 0.19 kg).

As for inorganic residues, cigar filters were the most abundant (7.20 ± 2.25 units), followed by pieces of glass (3.80 ± 1.23 units). 1.20 ± 0.35 holes were found in areas used for ritual ceremonies (Fig. 7). Disturbance of wild fauna was present in 100% of the sub-plots and alteration of vegetation in 60%.

Trail 2 is a pedestrian path with an average width of 1 m. This is a very popular trail every weekend, but on 21 June and 24 July it is especially overcrowded and prone to erosion and contamination. Wild animals are most affected, both by the presence of people and by music played by ritual performers.

2 plots with 10 sub-plots were installed within Ritual Zone 2 (Table 4). Organic residues were found in 100% of the subplot, with the highest occurrences being candy (29.90 ± 2.35), bread and biscuits (28.80 ± 4.30), and fruit (27.80 ± 5.14).

Inorganic residues were found in 100% of the sub-plots, including cigar filters (51.50 ± 9.43 units), metal lids (35.10 ± 6.08 units), and plastic lids (9.0 ± 1.28 units) (Fig. 8). The density of holes was also high (15.20 ± 2.62 holes per subplot). Alteration of vegetation and disturbance to wild avifauna were observed in 100% of the sub-plots, while bad smells occurred in 80%.

After quantifying these impacts, the reduced and modified Leopold matrix was applied according to the characteristics of the sites (Table 5). The magnitude and importance of impacts were rated from 110, where magnitude was related to intensity and effect while importance was related to duration and influence. Three visitor actions were considered: (a) ritual ceremonies (excavation of holes, burial of payments, use of drinks and cigars, and musical accompaniment), b) movement along trails (walking along Trail 2 and driving along Trail 1), and (c) observation of regional features (flora, avifauna, mountains, and administration and management).

Table 5 shows that visitor actions with negative impact include: ritual ceremonies (assessment of −87) and trail traffic (−80). For environmental factors, the natural environment was the most negatively impacted (−532) and the socioeconomic environment was positively impacted (504). The interaction between environmental factors and visitor activities in the studied areas generated a slight negative impact on the HRCA overall (−28).

6. Discussion

For Andean cultures, mountains are the home of their “Apu”“, which are mediators between the supernatural and the earthly, energizers of rituals, processions, and pilgrimages (Martin, 2017). In this context, Huaytapallana has great cultural and environmental importance for the population of the Mantaro Valley. It is a provider of ecosystem services and goods, especially water, recreation, and tourism. In addition, it has biological diversity in flora and fauna specific to this ecosystem, though in recent years these have been affected by intense visitation during June and July, along with visitors performing rituals year-round.

Cultural practices such as rituals generally contribute to natural resource conservation, but in this case the cultural practices are causing waste accumulation problems. This study was able to document and

Table 3
Main environmental Impacts along Trail 2.

Length (m)	1381	Unit	Plot 1					Plot 2					Plot 3					Average/sub plot (100 m2)	Standard error of the average	Frequency (%)
Descripción			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5			
Organic residues	Fruits	kg	0	2	0	0	0	0	0	2	0	0	2	1	0	3	2	0.80	0.28	40.0
	Cereals	kg	0	0.5	0	0	0	0.5	1	2	0	0	1	0	0	1	2	0.53	0.19	46.7
	Breads and biscuits	unit																		
	Caramels	unit																		
	Flowers	unit																		
	Pieces of cardboard and paper	unit	0	4	3	0	0	3	0	0	5	2	4	5	0	7	3	2.40	0.60	60.0
	Coke	kg	0	0.5	0	0	0	0.5	0	0.5	0	0	0.5	0	0	0.5	0.5	0.20	0.07	40.0
Inorganic residues	metallic caps	Unit	0	0	0	0	2	3	3	2	0	0	2	4	3	1	1	1.40	0.36	60.0
	Plastic caps	Unit	0	2	3	0	0	0	8	2	1	0	1	7	0	2	4	2.00	0.66	60.0
	Cork caps	Unit																		
	Cigar filter	Unit	7	0	5	0	0	17	32	12	0	0	0	10	7	10	8	7.20	2.25	60.0
	Plastic bags	Unit	3	2	0	0	0	0	6	2	2	2	0	2	0	1	1	1.40	0.42	60.0
	Plastic cups	Unit	2	0	1	0	0	1	1	0	0	0	0	0	3	2	1	0.73	0.25	46.7
	Plastic bottles	Unit	2	0	1	0	0	2	2	1	0	0	0	0	0	2	2	0.80	0.24	46.7
	Glass bottles	Unit	1	0	0	2	5	6	2	3	2	0	0	0	0	0	2	1.53	0.50	53.3
	Glass fragments	Unit	10	0	0	0	0	8	9	11	3	4	12	0	0	0	0	3.80	1.23	46.7
	Beer cans	Unit																		
	Pieces of metallic paper	Unit																		
	Waxes and candles	kg	1	0	0	0	0	2	2	1	0	0	1	0	0	1	1	0.60	0.19	46.7
Holes for payment ceremony		Unit	2	0	0	0	1	5	2	1	0	0	2	0	1	2	2	1.20	0.35	60.0
Impacts on the natural environment																		**Absence (0) Absolute frequency**	**Relative frequency**	**Presence (1) Absolute frecuency**	**Relative frecuency**
Water flooding			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	100.00	0	0.00
Vehicle Compaction			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	100.00	0	0.00
Human compaction			1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	11	73.33	4	26.67
Alteration to vegetation			1	0	0	0	1	1	1	1	0	0	1	0	1	1	1	6	40.00	9	60.00
Disturbance to wildlife			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0.00	15	100.00
Sound			1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	10	66.67	5	33.33
Bad smells			0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	12	80.00	3	20.00

Fig. 7. Erosion of Trail 2 as a consequence of massive visitor traffic.

Table 4
Main environmental impacts in Ritual Zone 2.

Length (m2)	6242	Unit	Plot 1					Plot 2					Average/ sub plot (100 m2)	Standard error of the average		Frequency (%)
Descriptio			1	2	3	4	5	1	2	3	4	5				
Organic residues	Fruits	kg	50	60	10	25	18	10	34	24	20	27	27.80	5.14		100.00
	Cereals	kg	12	10	5	8	3	5	4	8	7	3	6.50	0.96		100.00
	Breads and biscuits	unit	54	40	30	18	14	35	27	12	40	18	28.80	4.30		100.00
	Caramels	unit	36	42	31	35	29	30	34	21	18	23	29.90	2.35		100.00
	Flowers	unit	36	20	24	8	9	27	4	12	21	12	17.30	3.16		100.00
	Pieces of cardboard and paper	unit	23	3	10	11	13	6	5	2	4	7	8.40	1.98		100.00
	Coke	kg	13	10	8	4	4	7	4	3	4	4	6.10	1.05		100.00
Inorganic residues	metallic caps	unit	63	45	57	60	24	23	14	29	21	15	35.10	6.08		100.00
	Plastic caps	unit	18	10	7	13	9	7	8	8	7	3	9.00	1.28		100.00
	Cork caps	unit	0	12	14	16	8	4	4	10	0	7	7.50	1.76		80.00
	Cigar filter	unit	100	87	77	49	72	25	30	25	30	20	51.50	9.43		100.00
	Plastic bags	unit	25	12	4	4	6	0	3	7	11	1	7.30	2.32		90.00
	Plastic cups	unit	7	5	4	3	2	2	1	0	7	0	3.10	0.82		80.00
	Plastic bottles	unit	5	4	3	4	0	1	0	0	1	1	1.90	0.60		70.00
	Glass fragments	unit	10	7	7	0	9	7	13	5	24	4	8.60	2.04		90.00
	Beer cans	unit	0	6	0	2	3	0	1	1	0	2	1.50	0.60		60.00
	Pieces of metallic paper	unit	10	0	5	0	2	0	3	0	1	3	2.40	1.00		60.00
	Waxes and candles	kg	12	10	4	3	2	3	1	6	3	2	4.60	1.16		100.00
Holes for payment ceremony		unit	31	29	10	13	14	8	16	9	14	8	15.20	0.00	2.62	100.00
Impacts on the natural environment													**Absence (0) Absolute frequency**	**Relative frequency**	**Presence (1) Absolute frecuency**	**Relative frecuency**
Water flooding			0	0	0	0	0	0	0	0	0	0	10	100	0	0.00
Vehicle Compaction			0	0	0	0	0	0	0	0	0	0	10	100	0	0.00
Human compaction			0	1	1	0	0	1	0	1	1	0	5	50	5	50.00
Alteration to vegetation			1	1	1	1	1	1	1	1	1	1	0	0	10	100.00
Disturbance to wildlife			1	1	1	1	1	1	1	1	1	1	0	0	10	100.00
Sound			1	1	1	1	1	0	0	0	0	0	5	50	5	50.00
Bad smells			1	1	1	1	1	0	1	0	1	0	3	30	7	70.00

analyse the impacts caused by the presence of visitors in the HRCA. The large-scale nature of rituals contributes to the deterioration of the landscape, while in recent years, the disorderly increase in visitation and rituals has resulted in rising accumulation of organic and inorganic waste.

In particular, the large amounts of visitors who perform rituals on 21 June and 24 July each year generate significant amounts of organic and inorganic waste in addition to other impacts on the natural environment such as vehicle compaction, alteration of vegetation, disturbance of wildlife, sounds, and bad smells, both on trails and within ritual areas. Payments to the original land of gratitude (to Mother Earth) and requests for balance in nature have become payments for requests for health, work, travel, children, wealth, solution of marital problems, and many others; the essence of true payments to the land has been lost.

Table 5
Modified Leopold Matrix for identification of impacts along the two trails and within the two ritual zones.

Modified Leopold Matrix for identification of impacts along the two trails and within the two ritual zones

ENVIRONMENTAL FACTORS			RITUAL CEREMONIES				FOOTPATH TRANSIT		OBSERVATION OF TOURIST RESOURCES				POSITIVE IMPACTS	NEGATIVE IMPACTS	IMPACT BY SUBCOMPONENT	IMPACT BY SUB FACTORS	IMPACT BY FACTORS	TOTAL IMPACT OF THE VISITOR
VISITOR ACTIONS			HOLE EXCAVATION	RITUAL BURIALS	RITUAL USE OF DRINKS AND CIGARS	MUSICAL ACCOMPANIMENT	WALK ON TRAIL 2	VEHICLE TRANSFER BY FOOTPATH 1	FLORA OBSERVATION	BIRD WATCHING	OBSERVATION OF THE SNOWY HUAYTAPALLANA	ADMINISTRATION AND MANAGEMENT						
NATURAL ENVIRONMENT	AIR	LEVEL OF SMELL		-9 4	-8 4								0	2	-68	-126	-532	-28
		DUST	-2 1					-5 2					0	2	-12			
		NOISE				-8 4		-7 2					0	2	-46			
	SOIL	EROSIÓN	-10 3	-9 3			-5 2	-3 3					0	4	-76	-260		
		COMPACTATION					-1 1	-6 3	-2 2	-2 2			0	4	-27			
		FLOODING						-9 6					0	1	-54			
		ORGANIC RESIDUES		-9 4			-2 2	-1 1			-2 2		0	4	-45			
		INORGANIC RESIDUES		-5 4	-9 3		-3 2	-1 1			-2 2		0	5	-58			
	WATER	SOLID RESIDUES					-2 3						0	1	-6	-7		
		QUALITY					-1 1						0	1	-1			
	LANDSCAPE	QUALITY	-8 2	-8 2	-7 2			-4 2					0	4	-54	-54		
	WILDLIFE	WILD BIRDS		-3 3	-3 2	-2 4	-3 2		-2 2	-2 2	-2 1		0	7	-39	-81		
		WILD ANIMALS				-3 2	-3 2		-1 1	-1 1	-2 2		0	5	-18			
		DOMESTIC ANIMALS		-6 3			-2 2	-2 1					0	3	-24			
	WILD PLANTS	NATURAL PASTURES	-2 2										0	1	-4	-4		
SOCIAL AND ECONOMIC	ECONOMIC	JOB CREATION										6 9	1	0	54	504	504	
		COMMUNAL ECONOMY		9 4							9 4		2	0	72			
		SERVICE GENERATION		9 9		6 9	9 9				9 9		4	0	297			
		TRADE		6 9	3 9								2	0	81			

POSITIVE IMPACTS	0	3	1	1	1	0	0	0	2	1	9
NEGATIVE IMPACTS	4	7	4	3	9	9	3	3	4	0	46
IMPACT BY SUB ACTIONS	-52	9	-52	8	37	-117	-9	-9	103	54	-28
IMPACTS BY VISITOR ACTIONS	-87				-80		139				-28
TOTAL IMPACTS OF THE TOURIST VISITOR	-28										-28

Fig. 8. Accumulation of organic waste in Ritual Zone 2; soil is uncovered because holes have been dug to bury payments.

These payments are now made not only on specific traditional dates, but on any day of the year, which extends permanent impacts even at a larger scale. These patterns match those described by Korstanje (2009), who studied tourism from the perspective of social psychology and analysed individual and social behaviour in tourism activity from a phenomenological approach that allowed reflections on cultural and social practices as well as local values for the development of tourism.

These results are also in agreement with Oehmichen and De la Cruz (2019), who wrote that the use of traditions, ceremonies, dances, music, and other indigenous cultural expressions by the tourism industry is becoming more and more frequent in NPAs, giving them a spiritual and religious value (i.e., considering them sacred). This is the case in the Ismo Cruz and Yanahucsha ritual zones where religious and spiritual practices are carried out, but unfortunately these practices do not contribute to the responsible use or sustainable development of the area.

Yanahucsha is very crowded on 24 July and throughout the month of August due to payment rituals related to the Santiago festival. Many families from the districts of the Mantaro Valley make the ascent to Huaytapallana to ask for the celebration's blessing, during which they offer payments and ask favours of Huallallo Carhuincho, the Apu who lives in the mountain. The impacts they and their offerings cause negatively affect the landscape, soil, water, and wildlife (Molina, 2018).

The impacts caused by visitors to the HRCA is cumulative, affecting the beauty of the landscape, creating soil erosion due to excessive digging for ritual payments, increasing soil compaction caused by abundant vehicles on Trail 1 and people in Ritual Zone 1. Erosion also occurs in Ritual Zone 2 due to hole digging, where organic waste accumulates and generates bad odours due to putrefaction. Area management is difficult as the predominant visitor type is those who perform ritual activities (Mangano, 2005), but has led to the development of plans to avoid negative impacts on this ecosystem due to the overloading of used spaces (Brenner, 2011; Vargas, 2009).

Planning is essential for tourism in NPAs as tourism should contribute to sustainable development; Figueira (2011) and Quintero (2014) argued that tourism should become an opportunity for economic development and should contribute to raising awareness about sustainability. In this regard, the Regional Government of Junín has been implementing actions to reduce the accumulation of organic and inorganic waste. However, as Huaytapallana is considered a sacred mountain, visitors for cultural purposes have continued to increase every year, becoming responsible for the deterioration of this beautiful landscape. As mountains like Huaytapallana are also considered a territorial cultural resource, there is some social and economic recognition based on the concept that it also represents cultural heritage (Cebrián & García, 2016).

This accumulation of waste, although it does not cause contamination such as the presence of heavy metals in the soil or microbiological agents in the water, does affect the quality of the landscape and covers the landscape with metal plates, cigar filters, glass and plastic bottles, and other elements that take many years to decompose. Wildlife is also affected by the abundance of visitors and vehicles.

7. Conclusions

The vast territory of the HRCA includes different ecosystems containing diverse flora and fauna; this area should be more than a destination for rituals, it should be a natural destination for the development of ecotourism activities and the sustainable use of its landscape and biodiversity.

Visitors' actions on the two trails and within the ritual zones generate environmental and socioeconomic impacts. According to the Leopold matrix, the overall impact was −28 (slightly negative). Ritualistic ceremonies and their related elements had the most negative impact on the natural environment with a score of −532 (air −126, soil −260, water −7, landscape −54, and fauna −81). For socioeconomic factors, the impact was positive with a score of 504 that includes the job creation, economic improvement of the community, and generation of services and trade.

As a consequence of the impacts on the natural environment, the landscape beauty is losing its value due to erosion, destruction of vegetation, and contamination of water sources with paper and plastics; this is due to the high level of visitation and the excess organic and inorganic waste left by rituals. Wildlife is negatively affected by noise and other disturbances to their habitats created by visitors and vehicles, while excessive vehicular use generates extensive dust that covers pastures otherwise serving as food resources for both wild and domestic animals.

CRediT authorship contribution statement

Edith M. Maldonado-Oré: Conceptualization, Methodology, Data curation, Writing - original draft. **María Custodio:** Investigation, Validation, Writing - review & editing.

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Edith Maldonado. Anthropologist, Master Scientiae in Ecotourism, PhD in Environmental Sciences and Sustainable Development, professor at the Faculty of Anthropology, Universidad Nacional del Centro del Peru. Research on sustainable tourism, impact of tourism and ecotourism and conservation of biodiversity in natural protected areas used for tourism.

María Custodio. Biologist, Master Scientiae in Biotechnology, Doctor in Environmental Sciences and Sustainable Development, associate professor at the Faculty of Human Medicine of the Universidad Nacional del Centro del Peru, with experience in research on continental aquatic ecosystems. Her current research focuses on monitoring and evaluation of the quality of the aquatic environment, environmental impacts, environmental and human risk assessment for exposure to heavy metals. She is director of the Research Center for Medicine at Altitude and Environment and researcher of the National Council for Science, Technology and Technological Innovation-CONCYTEC.