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National Protected Areas in Mexico: The Case of Pico De Orizaba

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ABSTRACT: The present research focuses on the Orizaba peak, the tallest volcano in Mexico and one of the Natural Protected Areas of the Veracruz state. Without disregarding detailed information about the volcano's geographic location, climate, and the most representative species inhabiting the area, the environmental, social, and economic benefits that this protected area provides to nearby populations are highlighted. Additionally, the studies demonstrating how environmental conservation can have a positive impact on the local economy are specified. Likewise, the role of education in imparting knowledge related to volcanoes and the different aspects to be considered within the same topic is analysed.

KEYWORDS: Natural resources, Ecotourism, Endemic species, Public policies, and Environmental education.

I. INTRODUCTION

The Citlaltépetl, also known as Pico de Orizaba, is the highest volcano in Mexico. With an altitude of 5,636 meters above sea level and an area of 19,750 hectares, it is located between the municipalities of Calcahualco to the northeast, La Perla to the southeast, Tlachichuca to the northwest, and Chalchicomula de Sesma and Atzitzintla to the southwest, spanning the states of Veracruz and Puebla. This volcano was declared a Natural Protected Area (NPA) on January 4, 1937. The Citlaltépetl has a temperate subhumid, cold, and sub-cold climate. Several animal species inhabit its territory, including the wildcat (Felis silvestris), the weasel (Mustela nivalis), the rabbit (Oryctolagus cuniculus), the badger (Taxidea taxus), the raccoon (Procyon), the coyote (Canis latrans), the hawk (Falco), the bluebird (Sialia), the mockingbird (Mimus polyglottos), the hummingbird (Trochilidae), and others, according to information from the Ministry of Environment and Natural Resources (SEMARNAT).

Figure 1. View of the Pico de Orizaba. On the left, seen from the municipality of Esperanza, Puebla. On the right, seen from the municipality of La Perla, Veracruz

One significant aspect regarding the Citlaltépetl, Mexico's tallest volcano, is its role in generating the Blanco, Cotaxtla, Jamapa, Metlac, and Orizaba rivers, which gives it great importance in terms of regulating the region's hydrological cycle. However, it is important to note that the volcano also provides drinking water to at least 25 municipalities in the state of Veracruz. In terms of

vegetation coverage within its Protected National Area, a diversity of forest types can be found, including oyamel forest, pine forest, grassland, and high-altitude paramo, distributed between 3,200 and 3,600 meters above sea level. In particular, the pine forest (Pinus hartwegii) is located between 3,600 and 4,300 meters above sea level.

Furthermore, the Citlaltépetl stands out not only for its rich diversity of flora and fauna but also for offering visitors a unique panoramic view of the surrounding territory. This allows for various outdoor activities such as hiking, mountain biking, or simply walking, making this volcano a popular tourist destination. In addition to being the tallest volcano in the country, the Citlaltépetl is a tourist attraction that allows people to connect with nature and enjoy the breathtaking landscapes and panoramic views it offers. The main tourist attractions are located at an altitude of 3,400 meters above sea level, namely the Pico de Orizaba and Puerta del Cielo villages, situated on the southeast side, belonging to the municipality of La Perla in the state of Veracruz.

These places offer accommodation for those interested in witnessing a sunrise or stargazing, as they are located in an area free from light pollution, enabling optimal viewing conditions. However, it is important to consider that weather conditions can affect the realization of these activities. During winter, for example, snowfall can hinder their execution, while during the rainy season, hailstorms or landslides may make access to the Protected National Area difficult. Despite these potential challenges, the Citlaltepetl remains a popular tourist destination due to its natural attractions and the diverse range of activities that can be enjoyed in its surroundings.

Regarding the legal framework for the conservation of natural resources in Mexico, as established by the National Commission for the Knowledge and Use of Biodiversity (CONABIO), several laws have been enacted to protect the environment. These include the General Law on Climate Change of 2012, the General Law on Ecological Balance and Environmental Protection of 2012, the General Law on Sustainable Forest Development of 2018, the General Law on Wildlife of 2018, the Biosafety Law on Genetically Modified Organisms of 2005, the Federal Law on Rights of 2016, the Law on Sustainable Rural Development of 2018, and the Law on Sustainable Fishing and Aquaculture of 2018. Despite these laws, their enactment has occurred in the last 10 years, in a context of accelerated loss of natural resources in Mexico, which is particularly concerning in the case of Pico de Orizaba and its surroundings.

It is undeniable that numerous laws, both at the national and global levels, exist to preserve natural resources, especially in protected areas such as the country's highest volcano. According to the National Commission of Natural Protected Areas (CONANP, 2022), Mexico has a total of 185 natural protected areas, of which 148 are exclusively terrestrial, 31 are terrestrial and marine, and 6 are exclusively marine. Collectively, these areas cover an extension of 90,958,494 hectares or 1.964 million km² of Mexican territory. These spaces are conserved with the aim of protecting the different species that inhabit them, many of which are endangered, and they also represent an alternative to address the current consequences of climate change.

When it comes to deforestation in the territory of Pico de Orizaba, it is important to highlight that tree cutting is a common practice, but there are also other factors that contribute to the loss of forest cover, such as forest fires and the natural life cycle of trees. The lack of reforestation can have negative consequences in the affected area. That is why the National Commission of Natural Protected Areas (CONANP), together with the Government of the State of Veracruz, private actors, and the community in general, have carried out a campaign to reforest the area, with the aim of planting 250,000 high-altitude pine trees (Pinus hartwegii).

The practice of tree planting is carried out in stages, particularly during the rainy seasons that extend from May to mid-July and again from August to October. Reforestation is a critical measure to conserve biodiversity and maintain ecological balance in the deforestation-affected area, such as the territory of Pico de Orizaba. Additionally, tree planting is a key action to mitigate the negative impact that this practice has had on the environment in the region.

Furthermore, it is important to point that the Glacier of Pico de Orizaba has undergone significant changes in recent decades due to climate change. This phenomenon has led to an increase in glacier melting, with long-term repercussions that many are unaware of. These changes have both environmental and water security implications for residents on the slopes of the volcano. Figure 2 shows the comparison of the glacier change on Pico de Orizaba in the years 1958 and 2019. According to the displayed cartography, the remaining glacier is located above 5,000 meters above sea level.

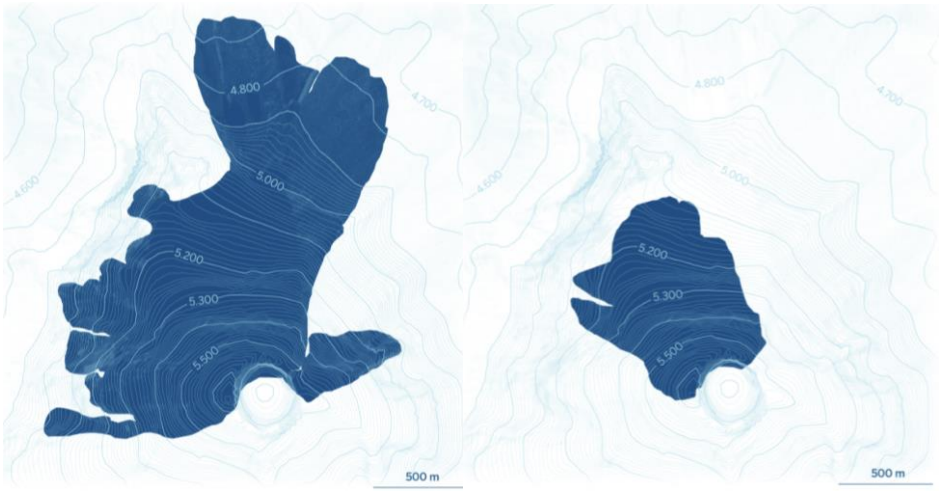

Figure 2. Comparison of the Pico de Orizaba glacier in the years 1958 (left) and 2019 (right), Taken (Guillen & De Miguel, 2021).

The figure depicts a comparison between the Pico de Orizaba glaciers in two different years: 1958 and 2019. The image likely shows two side-by-side photographs or maps representing the glacier during these two time periods. The purpose of the comparison is to illustrate the changes that have occurred in the glacier over several decades due to the effects of climate change. The comparison of the Pico de Orizaba's glacier in the years 2018 and 2019 is in figure 3.

Figure 3 depicts a comparison of the Pico de Orizaba's glacier in the years 2018 and 2019.

The melting of the Pico de Orizaba glacier would not only disrupt the ecological balance but also impact the surrounding soils, flora, fauna, and microclimate of the mountain, as the glacial meltwater plays a crucial role in these aspects. Experts such as Víctor Soto, who has also conducted research in the Nevado de Toluca and currently works on a project related to retrospective climate analysis in Cofre de Perote, have pointed out that the degradation of the glacier would have a domino effect (Reyes, 2023). This would result in severe impacts, especially on the water supply for communities near the volcano that rely on the natural glacier meltwater as a source of drinking water. The hydrological basins of Jamapa-Cotaxtla originate in the Pico de Orizaba, supplying water to over 2 million inhabitants in Veracruz and other regions in the neighboring state of Puebla.

Furthermore, the rivers Blanco, Cotaxtla, Metlac, and Jamapa, which have their source in the Pico de Orizaba, provide water to 31 municipalities in the Altas Montañas region. Important cities such as Córdoba, Orizaba, Huatusco, Coscomatepec, Puerto de Veracruz, and Boca del Río depend on the waters coming from the Jamapa glacier (Reyes, 2023).

II. DEVELOPMENT

Regarding the outline on protected areas, various research studies have been conducted in Mexico on designated National Protected Areas. These studies have covered diverse aspects such as biodiversity, conservation, management, and the significance of these areas for society at large. In particular, numerous investigations have been carried out on Pico de Orizaba, a mountain located in the state of Veracruz, Mexico. These studies have encompassed different fields, including social, ecological, scientific, and educational aspects.

For example, in a study conducted by García-Mendoza and Toledo-Aceves (2010), the importance of biodiversity in the area for the conservation of endemic species was analyzed. The authors emphasized the need to protect these areas to prevent the

extinction of endangered species. In another study, Sánchez-Sánchez et al. (2017) examined the tourist carrying capacity in the Pico de Orizaba National Park to assess its impact on the ecosystem. The authors found that the area was being visited by a greater number of tourists than the ecosystem could sustain, posing a risk to biodiversity conservation.

Furthermore, scientific research has also focused on understanding the ecological processes and dynamics within the Pico de Orizaba region. Studies have investigated the effects of climate change on the glacial retreat and the subsequent implications for water resources and the surrounding ecosystems (Soto et al., 2015). These investigations contribute to the understanding of the long-term ecological changes occurring in the area and provide valuable insights for conservation strategies.

Moreover, educational initiatives have been developed to raise awareness about the importance of Pico de Orizaba and its protected status. Environmental education programs, guided tours, and interpretive signage have been implemented to promote a deeper understanding of the ecosystem's value and the need for its preservation (CONANP, 2019). These educational efforts aim to foster a sense of stewardship among visitors and local communities, encouraging responsible behavior and sustainable practices.

In summary, the research conducted in the Pico de Orizaba area and its designation as a protected area have provided valuable insights into biodiversity conservation, the impacts of tourism, ecological dynamics, and the need for environmental education. These studies contribute to the ongoing efforts to protect and preserve the natural and cultural heritage of Pico de Orizaba, ensuring its sustainability for future generations.

In addition, efforts undertaken by other countries for the conservation of their protected areas have been studied. In this regard, the work carried out by the International Union for Conservation of Nature (IUCN), which has proposed various strategies for the conservation of protected areas worldwide, is worth mentioning. In conclusion, a wide range of research has been conducted on National Protected Areas in Mexico, including the Pico de Orizaba. These studies have covered different aspects and have significantly contributed to the knowledge and conservation of these areas, both at the national and international levels. It is essential to continue deepening our understanding of these areas and to promote their conservation through national and international proposals that seek to protect biodiversity.

On the other hand, Soto and Delgado (2020) conducted a study with the objective of examining air and soil temperatures on the northern side of the Pico de Orizaba over a two-year period, from January 1, 2016, to December 31, 2017. The authors also highlight that the volcano is composed of three stages of evolution and that there are human settlements surrounding the volcano that rely on water to meet their daily needs. According to the results obtained by the authors, "at higher altitudes, the soil is more susceptible to temperatures; this fact is manifested from 4584 m above sea level, where the winter season causes a greater drop in values compared to air records" (Soto & Delgado, 2020, p. 12). This suggests that soil temperature is more sensitive to climatic variations at higher altitudes, especially during the winter season. Figure 4 shows The Pico de Orizabaand its biodiversity.

Figure 4. The Pico de Orzaba and its biodiversity. It has an elevation of 5636 m above sea level. View from the State of Veracruz

It is important to highlight that the information obtained through this study can be highly useful for understanding the climatic conditions in the Pico de Orizaba and for making decisions regarding the conservation of this important protected natural area. Additionally, this study can be of great significance for future research on the impact of climate change in this area. The proximity of human settlements to a volcano poses a potential threat to surrounding populations. Volcanic eruptions can lead to

the release of lava and ash, severely affecting the quality of life of nearby communities and, in some cases, even jeopardizing their survival.

In Alcalá-Reygosa et al. (2020), they emphasize the importance of understanding the different eruptive phases of each volcano to prevent the risks associated with volcanic activity. The authors found that the most recent eruptions of the Pico de Orizaba date back to the 16th and 17th centuries, suggesting the need to be prepared for the possibility of future eruptions. Despite significant advances in understanding volcanic activity, it is not possible to predict when an eruption will occur, highlighting the need for a disaster prevention and response program.

Therefore, it is important to implement programs that enable communities near a volcano to take preventive and responsive measures in the event of a volcanic eruption. This entails not only training local residents about the risks associated with volcanic activity but also constructing safe shelters and developing clear emergency plans. Additionally, effective coordination among local authorities, scientists, and aid organizations is required to ensure a prompt and effective response in case of a volcanic emergency.

Studying the eruptive phases of a volcano and implementing disaster prevention and response programs are crucial to reducing the risks associated with volcanic activity and protecting nearby communities. Investment in research and proper preparedness can save lives and minimize the damage caused by extreme natural events such as volcanic eruptions. There are various studies focusing on the geomorphology of the Pico de Orizaba National Protected Area, specifically identifying different types of terrain and factors that may influence its morphology. Some studies have focused on observing tree positions, which can be useful in hard-to-reach areas where the presence of large rocks can hinder exploration. In this regard, Vázquez-Ríos and Franco-Ramos (2022) highlight the relevance of the results obtained in their research, which allow for the establishment of a more efficient working program for the Pico de Orizaba.

Furthermore, Morales-Martínez et al. (2016) conducted a study on mass movement caused by Hurricane Ernesto in 2012 in two municipalities in the state of Veracruz. These authors explored the different factors influencing the displacement of rocks and land masses and how they can affect the terrain morphology in the region. It is important to highlight that the study of geomorphology is crucial for understanding landscape evolution and the impact of natural and anthropogenic factors on them.

In this regard, identifying the characteristics of the terrain and its relationship with the processes occurring in the region is essential for implementing conservation measures and land management to ensure the preservation of species inhabiting these protected areas and the sustainability of the ecosystems they support.

In the current context, the need to reconsider intervention approaches in Natural Protected Areas (NPAs) is a crucial issue for environmental conservation. According to Vallejo-Román and Rodríguez-Torrent (2022), the increase in the number of NPAs worldwide has led to the need to rethink intervention strategies in these protected spaces. In this sense, co-management is an alternative that would allow for shared responsibility towards the environment and balance the interests among stakeholders, effectively contributing to combating climate change. The co-management proposal for NPAs suggested by Vallejo-Román and Rodríguez-Torrent (2022) is based on collaboration among different stakeholders, such as local communities, governments, researchers, and entrepreneurs. This strategy aims to enhance the management and conservation of NPAs, considering the diverse needs and perspectives of those involved.

It is important to highlight that co-management of NPAs would not only contribute to environmental conservation but could also generate economic and social benefits for local communities. According to the authors, the active participation of local communities in the co-management of NPAs could create green jobs and promote ecotourism, thereby contributing to the sustainable development of the regions. In conclusion, the co-management proposal for NPAs put forward by Vallejo-Román and Rodríguez-Torrent (2022) is a promising alternative for achieving more effective and sustainable management of these protected spaces. Collaboration among different stakeholders and the consideration of diverse needs and perspectives could contribute to environmental conservation while generating economic and social benefits for local communities.

In the study conducted by Gale et al. (2021), the researchers explored the perceptions of soundscapes in the Coyhaique National Reserve (RNC) in Chile. The authors used surveys to examine how visitors experience and respond to different sounds, including wind, birds, insects, forest noises, water, and voices. The objective was to gather information about how people perceive and react to the soundscapes of the reserve. Additionally, the study also assessed the differences between local visitors and national or foreign tourists in their reactions to these soundscapes. The authors found that local visitors perceived and valued the sounds of the reserve differently compared to tourists.

In their study, Filardo and Rossi (2021) focus on the integration process of the Montes del Queguay area into the National System of Protected Areas in Uruguay. The research aims to identify the conflicts that arise between stakeholders and their interests regarding the appropriation of ecosystem services. The authors conducted semi-structured interviews with key

informants to delineate the phases of the process and show how the configuration of conflict and the position of the stakeholders vary over time.

On the other hand, Durán et al. (2021) examine the control and possession of high-altitude environments located in the southernmost region of the Tawantinsuyu Empire, which encompassed parts of present-day Argentina, Chile, and Bolivia. The authors provide a detailed analysis of how these spaces were appropriated for political or economic purposes and discuss the social and cultural implications associated with this process. This study offers a deeper understanding of historical practices related to the use of protected areas and how these practices can impact the current understanding of natural resource management.

Continuing with research related to protected areas in order to conserve the environment and the species they host, not only in Mexico but also in different scenarios around the world, Ramírez-Terrazo et al. (2021) conducted a study on the traditional knowledge of mushrooms in the Antelá and Tziscao communities in the municipality of La Trinitaria, located within the Montebello Lakes National Park.

In this study, interviews were conducted with local residents to gather information about traditional knowledge of mushrooms, as well as the collection and taxonomic identification of specimens. The results showed a total of 31 different species among both communities, with some aspects sharing similarities with other regions of the country. Additionally, a previously unknown species was discovered, referred to as Lactarius aff. deliciosus (locally known as K'anchaya). This finding is relevant as it is crucial to understand the knowledge held by people living in the vicinity about these resources and whether they have any practices for their conservation. As stated by Ramírez-Terrazo et al. (2021), "Traditional knowledge is fundamental for the identification of species with economic, cultural, and ecological value, as well as for the development of strategies for the sustainable management and conservation of natural resources."

In conclusion, the identification and documentation of traditional knowledge held by local communities is an important tool for sustainable management of natural resources and environmental conservation. Such studies can also contribute to the identification of new species and the expansion of understanding of local biodiversity. Vallejo-Román and Rodríguez-Torrent (2020) conducted a case study in the Cofre de Perote National Park, Veracruz, Mexico, focused on analysing the relationship between common goods, environmental conservation, and peasant economy. The study aimed to discuss the tensions that arise among those who inhabit and those who designate, plan, organize, and control Protected Natural Areas (PNAs), including local or national governments, community or indigenous groups, as well as scientists and researchers.

On the other hand, López-Sánchez et al. (2020) conducted an assessment of the population structure of Alnus jorullensis (ilite) in Cofre de Perote National Park in Veracruz, Mexico. Ilite is an important species for the regeneration of temperate forests and a primary source of firewood for families living in the area. The study aimed to evaluate the population structure during April 2016 and 2017 in five localities within the national park and interviewed 80 families about their use of extracted firewood. The results of the study showed a significant decrease in ilite density from 2016 to 2017. Additionally, notable differences were observed between juvenile and adult individuals during both periods, although no significant differences were found between them.

Continuing with the outline of research on protected areas, Pérez-Amezola et al. (2020) conducted a study in the Cañón de Santa Elena Flora and Fauna Protection Area in Mexico. The objective of the study was to identify bird species, terrestrial mammals, fish, and vegetation found in the area using different monitoring techniques. A total of 166 species were recorded, including 73 birds, 24 terrestrial mammals, two fish, and 67 plants. Some species were listed by NOM-059-SEMARNAT-2010 and the International Union for Conservation of Nature's Red List, indicating their importance for conservation.

In the study by Rodríguez-Franco et al. (2020), social participation in the management of the Gulf of California Islands Flora and Fauna Protection Area is analyzed. The authors used direct observation techniques and interviews with various stakeholders, including government officials, specialists, and users of the protected area, to examine perceptions of social participation in the management of the protected area. The results of the study indicate that the National Commission of Natural Protected Areas lacks credibility due to the top-down implementation of strategies without properly considering affected communities. According to the authors, it is necessary to implement proposals to strengthen environmental governance in the management of protected areas. In this way, the perception of the various stakeholders could be improved, and their participation in the management and conservation of these natural areas could be encouraged. This study calls for reflection on the importance of integrating society into the management of protected areas to achieve effective biodiversity conservation and sustainable development in local communities.

Regarding Serna-Lagunes et al. (2019), an analysis of mammal diversity and conservation status was conducted in Pico de Orizaba National Park (PNPO) during the dry and rainy seasons. The study relied on the use of 14 camera traps to record the presence of 10 different species belonging to six families. The carnivore order was the best represented, with 60% of the

mammals detected in the camera traps. According to the authors, some of the recorded species are at risk and require conservation measures to improve their habitats. The results obtained in this study could be highly useful in planning appropriate strategies for the conservation of the park's ecosystem.

On the other hand, Vidal et al. (2019) focused on the perception of local residents regarding the socioeconomic and conservation impacts of dolphin tourism in Anavilhanas National Park, Brazil. A descriptive qualitative study was conducted using a semi-structured survey among 20 local residents to gather their opinions. The results indicated that the majority of the interviewees had a positive perception of dolphin tourism, as they believed it created employment and generated income, thus stimulating the tourism industry and facilitating access to natural resources in the area. According to the authors, these results suggest that dolphin tourism can be an important source of economic benefits for local communities, although appropriate measures need to be implemented to ensure the conservation of the park's biodiversity.

Furthermore, Alva-Rivera (2018) conducted research analysing how the conservation of natural resources is not perceived as a relevant issue among Mexican society. To achieve the objective of the study, qualitative techniques based on semi-structured interviews and secondary sources were used, focusing on the analysis of the public policy process through a case study. The main aim of this research is to find the appropriate balance to meet social needs and interests while preserving the environment.

On a different note, Buendía-Rodríguez et al. (2018) evaluated the effect of excluding a protected area on tree composition and structure. The authors measured normal diameter, height, basal area, total volume, and density in three selected sites. The results of their study showed that forests within the park require timber harvesting to regenerate the forest mass, while the forest outside the park is under forest management and fulfills this condition.

In summary, Alva-Rivera (2018) emphasizes the need to find an adequate balance between social needs and interests and environmental preservation in the public policy process, while Buendía-Rodríguez et al. (2018) highlight the importance of considering the exclusion of protected areas in forest management to ensure proper forest regeneration. Salazar et al. (2018) conducted an evaluation of the perception held by students from certain professional programs in the state of Nuevo León regarding the beauty of the landscape of the Cerro de la Silla Natural Monument, which is a representative symbol for the Metropolitan Area of Monterrey. The study focused on areas considered important by the National Association of Universities and Higher Education Institutions (ANUIES). The research aimed to assess students' perception of the landscape beauty and its importance in the conservation of the Natural Monument.

On the other hand, Cruz-paz et al. (2018) focused on multicriteria analysis to identify Priority Conservation Areas (PCA) within the Usumacinta hydrological basin, located in Mesoamerica. These PCAs are regions with higher aptitude for conservation based on vulnerability and irreplacability criteria. The authors used a multicriteria methodology to identify priority areas for conservation within the hydrological basin. The results of their study indicate that approximately 23.7% of the area is considered as PCA; however, less than half of them are protected by the 124 existing natural spaces. In summary, Salazar et al. (2018) highlight the importance of evaluating students' perception of landscape beauty and its impact on the conservation of natural monuments, while Cruz-Paz et al. (2018) emphasize the need to identify Priority Conservation Areas to ensure proper conservation of the Usumacinta hydrological basin.

The study conducted by Bobadilla-Jiménez et al. (2017) focuses on the success of the Cabo Pulmo National Park (CPNP) as a protected natural area. The research aims to examine the factors that contributed to the success of CPNP, including the support of the local community and key stakeholders, as well as the policy adopted by the federal government for its preservation. The authors highlight how CPNP has provided economic benefits and improvements in the quality of life for its inhabitants through sustainable tourism. The study explores the importance of environmental conservation and how sustainable tourism can be a tool for economic development and nature conservation. In conclusion, the work emphasizes the importance of community support and government policy in the success of protected natural areas like Cabo Pulmo National Park, and how sustainable tourism can provide economic benefits and improve the quality of life for the local population while promoting environmental conservation.

The study conducted by Larios-Lozano et al. (2017) focuses on the identification and enumeration of bird species within the Los Mármoles National Park, located in Mexico. The research objective is to use data collected over five years to identify and characterize the 195 bird species present in the area, including some that are at risk and others that are unique to Mexico. The authors highlight the importance of understanding the diversity and distribution of bird species within Los Mármoles National Park, as this can help improve conservation efforts. Additionally, they emphasize the need to continue monitoring the presence and behavior of these birds in order to implement effective protection measures. In conclusion, the work of Larios-Lozano et al. (2017) underscores the importance of knowing the diversity and distribution of bird species in protected natural areas like Los

Mármoles National Park, in order to implement effective conservation measures and ensure the survival of these species in their natural habitat.

On the other hand, Lebreton and Imbernon (2017) conducted an analysis of discursive practices surrounding a territorialized public action in the case of changing the protection category of the Nevado de Toluca Protected Natural Area, Mexico. Their study specifically focused on the discourse that led to the construction of the environmental problem of deforestation and its proposed solution: the reclassification of the protected area as a Flora and Fauna Protection Area, to allow for the exploitation of its natural resources. This approach allowed the authors to examine the discursive practices that underpin these public policy decisions.

While Torrescano-Castro et al. (2016) conducted a study on the impact of artisanal fishing in an unprotected marine area in Isla Isabel, Mexico. In this work, a one-year monitoring of fishing grounds was carried out with the aim of identifying the most commonly used gear and species in artisanal fishing. The results indicated a low species diversity in the area, with few species dominating the catches. This finding suggests a potential negative impact of artisanal fishing on species diversity in Isla Isabel.

In Ortiz and Romos (2016), a study was conducted on the social and environmental impacts derived from water management in the Cuatro Ciénegas Protected Area, Coahuila. The main objective of the study was to analyze the positive and negative effects of water management on the ecology and local human communities. To achieve this, the authors used a methodology of semi-structured interviews with key stakeholders in the area to gather relevant information about water management.

Lastly, Pallanez and Moreno (2016) conducted a study on the socio-environmental conflict that arose between miners and Mexican governmental institutions regarding the creation of a protected natural area called the Mavavi Biosphere Reserve. Their article examines the dynamics, actors, and strategies used by both parties to understand how the project ultimately failed. The authors point out that the elements employed by the opponents led to the lack of conservation policy, due to factors such as national and local politics, lack of public involvement, and lack of coordination among the government agencies responsible for the project.

III. METHOD

For the present research, a detailed analysis was conducted on subjects that address relevant aspects related to the Pico de Orizaba, such as volcanoes, protected areas, topography, climate, hydrology (rivers and lakes), vegetation, and other related topics. This search was carried out in freely available textbooks used in public primary education, with a specific focus on the state of Veracruz. Subsequently, a table is presented with the obtained information.

Table 1. Self-compiled data

Degree	Subject	Lesson	Activity	Pages	Indication
Third	Veracruz la entidad donde yo vivo.	Mi localidad en la entidad.	Action plan in risk situations.	107-109	Students are asked to make an action plan for a volcanic eruption. Putting before an example of before, during and after the natural disaster.
Fourth	Atlas de México	Placas tectónicas, regiones sísmicas y principales volcanes.	There is no activity, only the seismic zones and the main volcanoes of Mexico are analyzed	11	There is no activity, but students will be able to analyze the different volcanoes in Mexico, as well as their location in the territory.
Fourth	Atlas de México	Áreas Naturales Protegidas federales	There is no activity; only the analysis of different types of areas and their locations within the country.	23	There is no specific activity, but students will be able to locate the protected areas and identify their types.
Fourth	Atlas de México	Veracruz	Said map of the entity of Veracruz details data	125	There is no activity, but students can find various

			referring to economic activities, archaeological and historical sites, fauna, national protected areas, among others.		aspects that the entity of Veracruz has.
Fourth	Geografía	Regiones de climas y vegetación.	Draw on the map the vegetation symbols in the corresponding regions according to the table specified on page 32.	32-33	The students place the vegetation symbols according to the climate of the country.
Fourth	Geografía	Las regiones naturales de nuestro país.	The students will locate the type of vegetation according to the altitude that it has.	61-64	Students will be able to learn the type of vegetation that the regions have are according to the altitude in which they are located.
Fifth	Atlas de geografía del mundo	Componentes naturales	In this lesson students will address the movement of tectonic plates, seismicity and volcanism, and the relief of the continents. As well as the water and the rivers and lakes of the continents and the climates and the regions of the continents.	25-67	Students will be able to compare information on plate tectonics, seismicity, volcanism, and the relief of the continents. As well as the water, the rivers and lakes of the continents and the climates and the regions of the continents with Mexico.
Fifth	Geografía	¿Cómo localizó?	Latitude and longitude.	30-31	Students will be able to identify characteristics of longitude and altitude.

In relation to the educational levels of upper secondary education in the state of Veracruz, various study options were identified. Analysis of the content taught in different secondary school modalities was not included due to the presence of various educational institutions such as community secondary schools, telesecondary schools, general secondary schools, and technical secondary schools. Among the options for upper secondary education offered in the state, there are general high schools, the Colegio de Bachilleres del Estado de Veracruz (COVAEV), the Telebachilleratos de Veracruz (TEBAEV), the Colegio Nacional de Educación Profesional Técnica (CONALEP), the Bachillerato en Línea de Veracruz (BELVER), among others.

Considering the context of the municipality of Perla and the available educational options in the region, telesecondary school was considered the most suitable modality for secondary education. On the other hand, for upper secondary education, telebachillerato was considered a viable option. It is important to highlight that the choice of educational modality will depend on various factors, including the educational offerings available in the area, the needs and preferences of the students, and other relevant aspects. In the case of telesecondary school, first-year students take the subject of geography, which covers aspects such as volcanoes, topography, climate, vegetation, and others. It is similar to what is taught in primary school, but the content is adapted to the students' age. Similarly, for upper secondary students, geography is taught in the fifth semester, and it is considered that all three levels cover content related to volcanoes and related topics.

Based on the studies considered as supporting evidence, the importance of protected natural areas, particularly the Pico de Orizaba, stands out. These areas not only guarantee the conservation of species but also provide benefits to nearby populations. In this sense, it is evident that work in these areas is not only focused on environmental protection but also takes into account the social and economic impacts generated by spaces like the protected area of Pico de Orizaba. As specified in the studies, a space like this not only provides opportunities but also requires knowledge to face unexpected risk situations such as a volcanic eruption. Due to its significant significance, an interesting anecdote exists in the cartography of the Orizaba peak concerning its

geographical location within the states of Veracruz and Puebla. It was contended that due to the greater number of municipalities (extension) belonging to Puebla in the proximity of the Orizaba peak, it should rightfully belong to the State of Puebla, Redaccion, 2021. Finally, the peak of Orizaba was returned to the State of Veracruz, Lopez, 2021.

IV. RESULTS

The results found show a wide range of research on protected national areas that focus not only on conservation but also on the sustainable use of natural resources that benefit the immediate populations within the protected area. Additionally, the historical and risk aspects are considered to prevent accidents caused by a volcanic eruption, even though the last eruption of the volcano dates back to 1876. There are several aspects to consider for the study of the country's largest mountain, but it is considered that the relevant importance has been given to all necessary points, as there are precedents that support this aspect. However, it is essential for the population to have a better understanding of the role that this volcano plays in their daily lives, without disregarding the risks associated with living near it.

Regarding education, topics related to the present research article are addressed. These can be found in textbooks, specifically in geography or natural sciences, which students at different educational levels, from primary to high school, study. However, it is necessary to align the suggested knowledge with the knowledge that students possess. For example, a student living in a community near the volcano may describe it differently from another student who has only seen the volcano in photos and has researched it online or in textbooks.

V. DISCUSSIONS

The conducted research demonstrates the significance of national protected areas and the importance of the Pico de Orizaba in the high mountains region of Veracruz. However, it also highlights the need for methodologies and projects that involve multiple stakeholders, including governmental and educational institutions, as well as the general population. Each year, the loss of the Pico de Orizaba's glacier, water distribution, and the destruction of trees due to forest fires are reported, consequently impacting the species that thrive in the area. The development of a volcanic eruption evacuation plan should also be considered. It is important to note that this aspect specifically focuses on the municipality of La Perla. Although manuals of this kind exist, it is relevant to have one tailored to the specific needs of the municipality, enabling the specification of appropriate actions that residents can take in the event of such a disaster.

V. CONCLUSIONS

The Pico de Orizaba goes beyond being just the tallest mountain in Mexico. In addition to being an emblematic place in terms of nature and adventure, it has also become a cultural and social destination for visitors seeking a unique experience. The mountain offers a variety of activities and attractions for the whole family. Apart from enjoying the breathtaking view from the summit, visitors can immerse themselves in the rich local culture by interacting with the residents of nearby communities and savouring the delicious regional cuisine.

Furthermore, local inhabitants provide transportation and guiding services to tourists, allowing them to explore the area in a safer and more effective manner. Local guides are familiar with alternative routes that visitors may not discover on their own, making their visit even more exciting and enriching. In summary, the Pico de Orizaba is much more than just a mountain. It is a place where nature, culture, and adventure come together to offer a unique and unforgettable experience for visitors.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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