Artículo

Valoración económica de los servicios ambientales del Monte Tláloc, Texcoco, Estado de México

Economic assessment of the environmental services of Mount *Tláloc*, *Texcoco*, State of Mexico

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Resumen

Se calculó el valor económico de los servicios ambientales del Monte Tláloc, Texcoco, Estado de México; montaña que forma parte del Parque Nacional Izta-Popo-Zoquiapan, misma que se incorporó a la red mundial de Reservas de la Biósfera por la UNESCO en 2010. El Monte Tláloc se maneja como un bien público puro, lo cual genera, principalmente, problemas ambientales como: sobrecarga de visitantes, contaminación por exceso de desechos, propensión a incendios y erosión alta. Con el propósito de hacer la gestión de sus recursos naturales para la conservación y recuperación del Monte Tláloc, en la actualidad se cobra una cuota de entrada a los visitantes, pero se desconoce si es una contribución óptima de acuerdo a la disposición a pagar (DAP) de los usuarios. Se usó la metodología de Valoración Contingente (MVC) para estimar la DAP de los visitantes; este método simula un mercado hipotético, por medio de encuestas a los usuarios, en el que se les pregunta por la cantidad máxima que están dispuestos a pagar por conservar dicho bien, para lo cual se realizaron 251 encuestas a los visitantes de dicho lugar. Los resultados indican que los usuarios están preocupados por la situación actual del Monte y están dispuestos a conservarlo. Con la información obtenida resultó una DAP de $9.00 M.N., en promedio. Las variables que más explicaron el modelo fueron: nivel de estudios, preocupación por el ambiente, percepción ambiental y nivel de ingreso familiar.

Palabras clave: Bien público, disposición a pagar, recursos naturales, servicios ambientales, turismo, valoración contingente.

Abstract

In the present research paper the economic value of the environmental services of Mount *Tláloc*, *Texcoco,* State of Mexico, which is part of the *Izta-Popo-Zoquiapan* National Park incorporated into the world network of Biosphere Reserves by UNESCO in 2010 was assessed. *Tláloc* Mount is managed as a pure public good, thus generating mainly environmental problems such as: visitor overload, pollution due to excess waste, fire propensity and high erosion. With the aim of managing the natural resources of the reserve, conservation and recovery of Mount *Tláloc*, currently an entrance fee is charged to visitors, however, it is unknown if it is an optimal fee according to the willingness to pay (DAP) of the users. The Contingent Valuation (MVC) methodology was used to estimate the DAP of visitors, this method simulates a hypothetical market, through user surveys, in which they are asked for the maximum amount they are willing to pay for preservation of the aforementioned good, to this end 251 surveys were conducted to visitors to that place. Results show that users are worried about the current situation of the mountain and are willing to conserve the place. The information obtained resulted in a DAP of MX$ 9.00 on average. The variables that most explained the model were: education, concern for the environment, environmental perception and family income.

Key words: Public good, willingness to pay, natural resources, environmental services, tourism, contingent valuation method.

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Introduction

Mount Tláloc, located in *Texcoco*, State of Mexico, was recognized in 2010 by UNESCO like a *Los Volcanes* Biosphere Reserve, based on the benefits on biodiversity, specifically because it is the habitat of some birds in danger of extinction; for its importance in the water balance of the place; and by the landscape value of the area, which is reflected in a tourist asset (Conanp, 2018).

It is an old volcano formed around 5 million years ago and was completed two million years ago. It has an altitude of 4 125 m and together with the *El Telapón* hill (4 065 masl), the *Papagayo* hill (3 640 masl) and the *Tlamacas* hill (3 170 masl) make up the *Sierra de Río Frío*, which is part of the Transversal Neovolcanic Axis that crosses the Mexican country from west to east over two primordial fractures and divides North America and South America (Montero, 2004) (Figura 1).
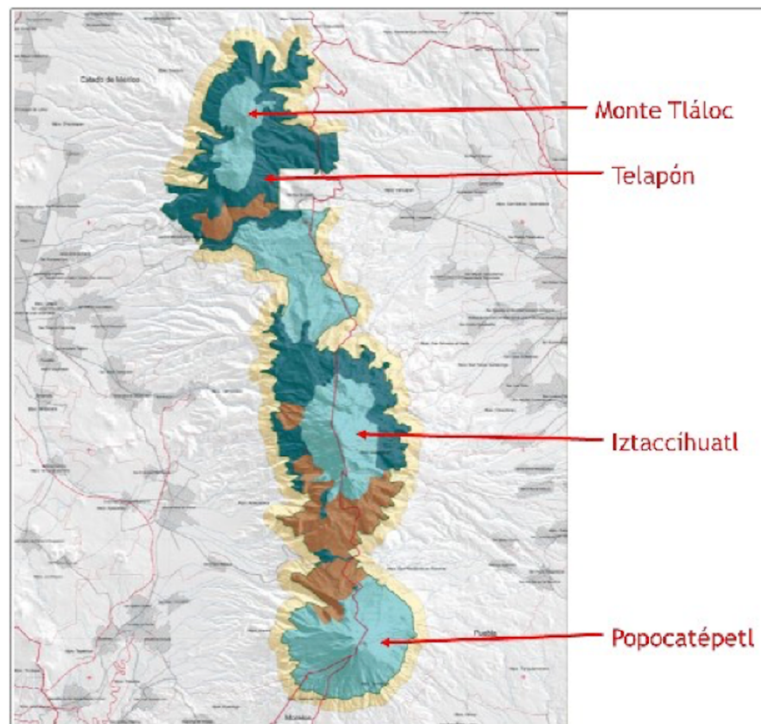
Source: Conanp, 2018.

Figure 1. Geographical location of Mount *Tláloc.*

The economic valuation of environmental goods and services is a guide for public policies that lead to a better management of resources, their efficient allocation, decrease the deterioration of the environment and increase the conservation of natural resources so that their use is sustainable (Aoun, 2015). However, the environmental services of natural systems do not have a market in which a price can be established for what they offer, that is. They are non-marketable goods (Vásquez *et al.,* 2007). Environmental services are treated as pure public goods, which constitutes a market failure that leads to their inefficient allocation (Stiglitz, 2000).

The ways of providing society with these goods have become unsustainable and the loss of well-being of society that causes pollution, deterioration and the lack of natural resources has increased, sufficient reasons to use valuation methods for environmental services (Glover, 2010), that guide the search for solutions that directly include their users.

Mount *Tláloc* is the most important in the *Texcoco de Mora* municipality; it has forests that offer tourist attractions such as camping areas, cabins, zip lines among others, in addition to allowing the use of ATVs, mountain bikes and mountain biking. It has various archaeological sites and an ancient sacred space in the form of a causeway, located in the highest part of the mountain, where the ancient inhabitants of Mexico performed ceremonies dedicated to their deity *Tláloc,* which is classified as one of the worship sites of highest elevation in the world (Neyra, 2012).

Soto and Sosa (2014) assessed the different attributes of forest areas expressed in the values of option, inheritance and existence, since they constitute spaces that can be used for the preservation of a significant number of plant and animal species that, on many occasions, are considered in danger of extinction.

Only from a visual perspective, on Mount *Tláloc* the problems of overloading of visitors in various areas are identified: the large amount of garbage that is thrown in the place without regard for its consequences, the recent forest fire that occurred in April 2017, the increasingly high erosion due to the continuous passage of motor vehicles, for example. It was also observed that some *ejidatarios* of the place have opted for

the change of land use by transforming their lands into agricultural fields to cultivate corn, potatoes, broad beans and oats, mainly due to the richness of the forest floor. However, this change in land use contributes to the generation of CO_2 and reduces the forest cover in the area; in the same way, the fire-wood and resins are used, without taking into account that these practices make the trees more prone to infection and fire; in the same way, immoderate logging for construction and firewood for the production of charcoal are one of the most common uses that are given to the natural resources of Mount *Tláloc*, resulting in erosion and a decrease in the groundwater level the main consequences (Montero, 2004).

Mount *Tláloc* is a pure public good, and therefore it is not exclusive. So, no, an individual should not be separated from his enjoyment. Nor does it present rivalry in consumption, since a good is not rival in consumption, if the consumption of additional units has a marginal cost of zero (Stiglitz, 2000; Nicholson, 2008). That is why he is mistreated so much and no one has incentives to take care of him; even governments can make policy failures by encouraging traditional cultivation rather than sustainable forestry (Panayotou, 1994). An assessment can contribute to correcting these failures and contribute to caring for the environment, even with economic growth (Glover, 2010).

This research seeks to know the economic valuation that visitors make of this natural resource. In order to create a sense of conservation and recovery of Mount *Tláloc*, currently a fee of MEX$ 10.00 is charged to visitors to the Mount, which is administered by the Union of *Ejidos de la Montaña "La Joya Monte Tláloc"*; however, many of the attendees avoid paying, in addition to the fact that it is unknown if this is an optimal fee according to their Willingness to Pay (DAP, for its acronym in Spanish), and how much they value Mount *Tláloc* and what general and environmental services could be improved.

With the study described here, the resolution of these doubts was intended, since to date there has not been an environmental economic assessment of the place as proposed here. The objective was to estimate the economic value of the environmental services of Mount *Tláloc* according to the perception of its visitors from their Willingness to Pay (DAP). The application of the Contingent Valuation Method

(CVM) allows to analyze the influence of socioeconomic variables and the environmental perception of users. In addition, with it you can identify and evaluate the improvements in environmental and tourist services that should be made, as well as suggest an access fee.

The hypothesis raised is that there is willingness to pay by most of the users of Mount *Tláloc* to maintain and improve the environmental and tourist services that the park offers.

Materials and Methods

In this study, the Contingent Valuation Method (CVM) was applied. This method allows valuing goods and services without a market and helps to grant people a certain environmental resource, for which a structured questionnaire is used that the selected individuals answer (Azqueta, 2007). This methodology has been used to calculate the DAP for protected natural areas (Almendarez *et al*., 2016; Gandini and Millones, 2019).

In this type of methodology, a market for a good or a set of goods for which there is no market is simulated by means of surveys and hypothetical scenarios, because there are no explicit prices (Mendieta, 2005). The analysis of data obtained through the survey allows us to infer the value of the environmental asset (Labandeira *et al.,* 2007).

The economic value is obtained from asking the DAP, for an improvement in the quality or quantity of the ecosystem good or service, in a hypothetical scenario. The selected format for data collection was a structured questionnaire divided into three parts: 1) Socio-demographic information: in this part of the observation instrument, information on the socioeconomic characteristics of the interviewees is obtained; 2) Environmental perception: the interviewee is provided with information about the property that is intended to be valued, in this way they can better understand the surrounding scenario, in addition to their own perception; and 3) Economic valuation: here closed questions are asked aimed at how much the visitor values the mountain and its environmental attributes.

Finally, the open format question is formulated to know the DAP and the dichotomous format.

For the design of the contingent assessment question, a mixed format was used. In a dichotomous way, a scenario was presented in the first instance in which an initial utility function of the original state of the ecosystem good or service is proposed, and a final utility function that represents the hypothetical scenario. The representation a = 0 would be the ecosystemic good or service in its current state and a = 1 would be the final situation; in it, the responses (with value 1 or 0) denote the state with and without the proposed scenario, respectively. Second, if the interviewee answered affirmatively, he (she) was asked, in an open format, the amount of money he (she) would be willing to pay to improve the conditions of the mountain; if the interviewee answered the dichotomous answer negatively, the reason for his answer was asked.

Since the *Union of Ejidos de la Montaña* or other institution has not an accounting record of the annual tourist visitors to *Tláloc* Mount, for the purposes of this research, statistical sampling was used and, starting from the great variability in attendance, it was considered an unknown target population. According to the statistical methods to define the sample size by which the population mean is estimated and the *N* (target population) is infinite or unknown, simple random sampling was used, better known as "MAS" (Cochran, 1984) which is obtained by the following equation:

$$n = \frac{Z_\alpha^2 * \partial^2}{\varepsilon^2}$$

Where:

n = Sample size

α = Significance level

Z = Confidence index

∂ = Variance

ε = Sampling error

A pilot sampling of 30 randomly selected participants was carried out to statistically deduce the variance of the sample and substitute it in the formula for obtaining the sample size. A significance level of 95 % was chosen, which gives a Z value of 1.96 determined from the accumulated probability tables; the variance of the pilot sample was $\partial = 0.19$ and a sampling error of 2.5 % (0.025). By substituting the data from the pilot sample, a sample size of $n = 230$ surveys was calculated, with an error of 5 % and a significance level of 95%. For the present research we worked with a sample of 251 surveys.

An econometric model of logistic distribution was applied to determine what factors explain the DAP of each visitor to *Tláloc* Mount and analyze the influence of socioeconomic variables and the environmental perception of users. The empirical model of the proposed logistic regression is the following:

$$DAP = \alpha + \beta_1 ESTU + \beta_2 YFAM + \beta_3 PA + \beta_4 PERD + \beta_5 SSUF + \beta_6 PERQ + e$$

Where:

DAP = Willingness to pay for conserving *Tláloc* Mount: "1" = DAP to improve it and "0" = No willingness to pay to improve it

α = Intercept of the function

β₁,…, β₁₂ᵦ = Coefficients of the respective explanatory variables:

ESTU = Education

YFAM = Family income

PA = Environmental concern

PERD = Perception of environmental degradation on *Tláloc* Mount

*SSUF* = The services you receive from *Tláloc* Monte are enough

PERQ =Perception of environmental quality in *Tláloc* Mount

e = Error

The model was estimated in the software "N logit" version 4.0.

Results and Discussion

In the sample of respondents, 55 % have university studies, 23 % finished high school and 9 % have a technical career, some even with postgraduate degrees. None of the respondents lacks studies, so it is considered that the level of education of the visitors to Mount *Tláloc* is generally high (Figure 2).
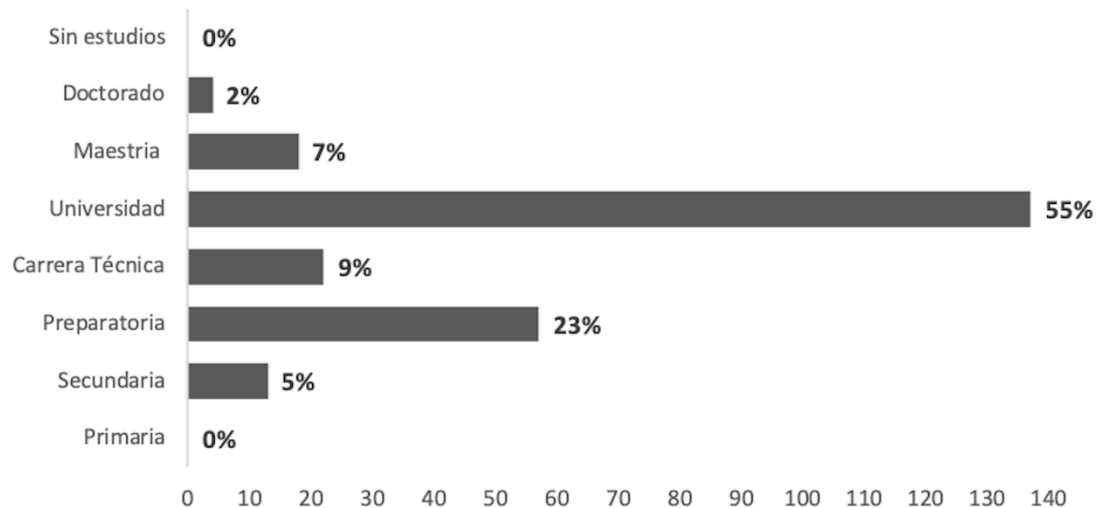

Sin estudios = Lack of studies; *Doctorado* = Doctorade; *Maestría* = Mater´s degree; *Universidad* = University; *Carrera técnica* = Technical career; *Preparatoria* = High school; *Secundaria* = Secondary School; *Primaria* = Elementary school.

Figure 2. Level of studies.

In regard to the occupation of the visitors (Figure 3), most of them are students (39 %), followed by professionals or technicians (30 %) and in the third place, merchants (12 %). If the main percentage of individuals are economic dependents, it is expected that the relationship with the DAP will be lower in monetary terms.
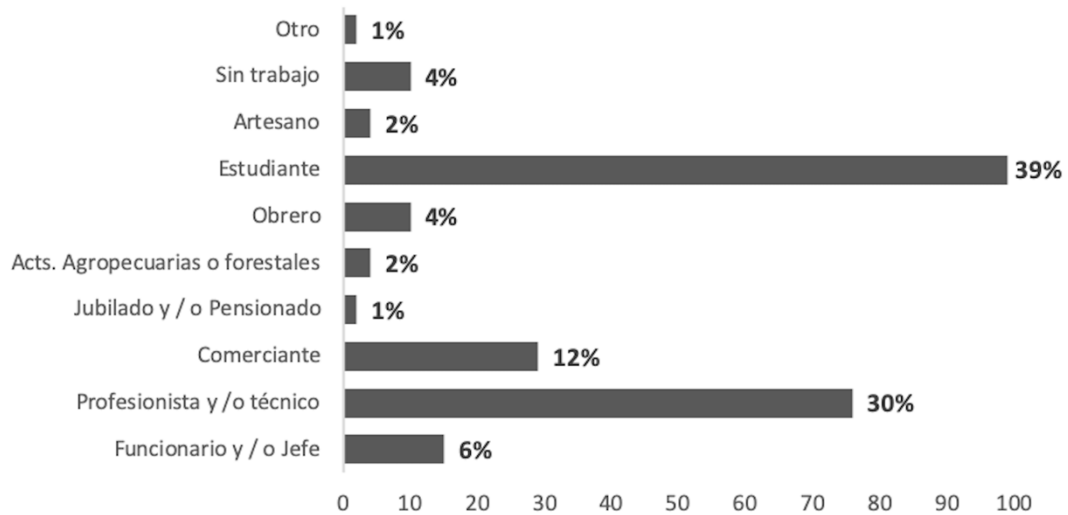
Otro = Other; *Sin trabajo* = Without job; *Artesano* = Artisan*; Estudiante* = Student; *Obrero* = Laborer; *Acts. Agropecuarias o forestales* = Agriculture and livestock or forestry activities; *Jubilado* y/*o Pensionado* = Retired and/or Retiree; *Comerciante* = Merchant; *Profesionista y/o técnico* = Professionals and/or technicians; *Funcionario y/ o Jefe* = Civil servant and/or Chief.

Figure 3. Employment.

The environmental perception of all the visitors to Mount *Tláloc* was of concern; however, 70 % of those interviewed stated that they were highly concerned and 30 % considered that they were regular or little concerned.

Within the context of global environmental problems that are experienced today, 31 % of those surveyed expressed concern mainly about overpopulation in the world; the second is pollution in general (23 %) and third, the loss of biodiversity (20 %). All three are present on Mount *Tláloc,* which undoubtedly affects the DAP.

The way in which the interviewee notices environmental degradation is important, as it influences their DAP, and by not doing so, they will not see the need to pay to improve the natural environment. Thus, 90 % of those surveyed did perceive this

situation, 57 % conceived it as medium degradation, 27 % as high degradation, 15 % as low degradation, and only 1 % without any deterioration in the place.

According to the environmental problems that affect the mountain, the interviewees considered that the main environmental problem is that of contamination by the waste left by visitors (43 %); the second cause for concern is the intense erosion (21 %) and 16 % considered deforestation on Mount *Tláloc.* This information is crucial for the resolution of the conflict situations most evident to visitors to the mount.

The main recreational activities carried out on Mount *Tláloc* are: walking, with a frequency of 29 %, enjoying the scenic beauty with 25 %, doing sports with 20 %, and camping with 14 %. According to this information, it is possible to discern which activities affect the environmental resource in question to a greater extent. Likewise, it can also be observed that visitors value the mountain as the theory establishes, since they assign it a value of direct and indirect use and of non-use of existence (Vásquez *et al.,* 2007).

Of the 20 % of those interviewed who mentioned sport as their main incentive, athletics was the most popular (37 %), the second was enduro (15 %) and the third was cycling (14 %). Special attention should be paid to these preferences to provide the appropriate conditions to practice them and simultaneously avoid environmental deterioration (Figure 4).
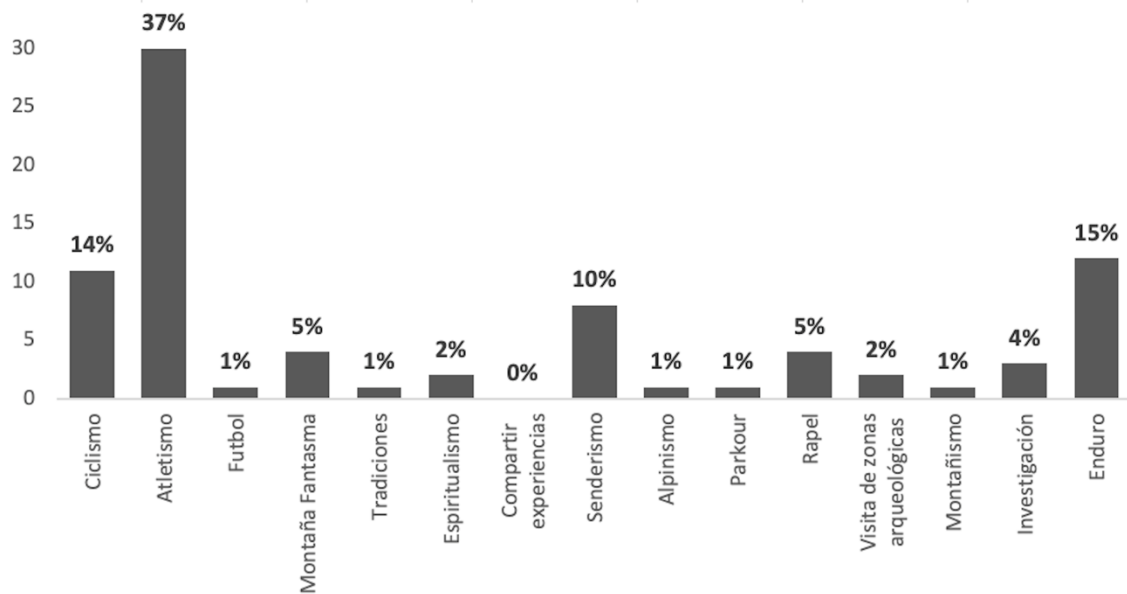
Ciclismo = Cycling; *Atletismo* = Athletics; *Futbol* = Soccer; *Montaña fantasma* = Ghost mountain; *Tradiciones* = Tradition; *Espiritualismo* = Spiritualism; *Compartir experiencias* = Share experiences; *Senderismo* = Hiking; *Alpinismo* = Mountain climbing; *Rapel* = Rapelling; *Visita de zonas arqueológicas* = Visit of archeological sites; *Montañismo* = Mountaineering; *Investigación* = Research.

**Figure 4.** Activities associated with the site   .

Visitors suggested improvements in general services within Mount *Tláloc* (Figure 5). The first is related to security, as 28 % indicated that it should increase; 21 % were concerned about the cleanliness of the area. The third improvement is related to the signs, directions and information of the place, to avoid getting lost, getting to know it better and becoming more aware of its value. This information would be useful for the administrative authorities of Mount *Tláloc* and the governmental institutions related to it, when carrying out actions that increase the coexistence, order, safety and ecological conservation of the site.
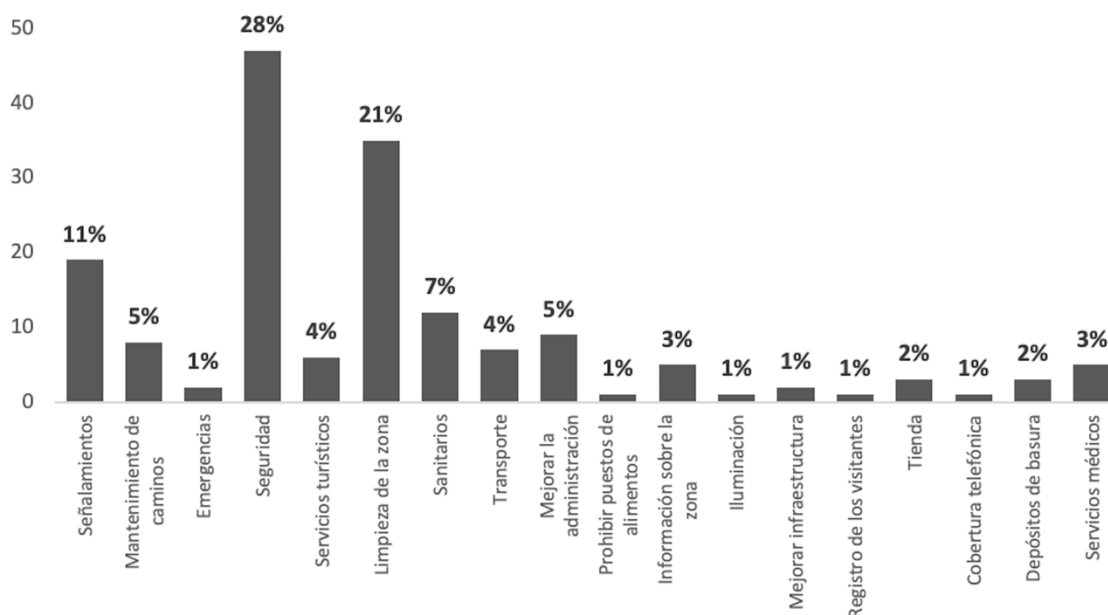
Señalamientos = Signs; *Mantenimiento de caminos = Road maintenance;*

Emergencias = Emergencies; *Seguridad* = Security; *Servicios turísticos* = Tourist

services; *Limpieza de la zona* = Cleanliness of the area; *Sanitarios* = Rest rooms;

Transporte = Transport; *Mejorar la administración* = Improve management;

Prohibir puestos de alimentos = Ban food stalls; *Información sobre la zona* =

Directions and information of the place; *Iluminación =Lighting; Mejorar*

infraestructura = Improve infrastructure; *Registro de los visitantes* = Visitors

registration; *Tienda* = Store; *Depósitos de basura* = Garbage dumps; *Cobertura*

telefónica = Telephone coverage; *Servicios médicos* = Medical services.

Figure 5. Opportunity areas.

The interviewee's appreciation of the environmental quality of Mount *Tláloc* (Figure 6) is not entirely unfavorable, since 55 % of them believe that it is good, 27 % that it is fair and 16 % that it is very good, and only 1% that it is bad and very bad. These levels of perception are a good incentive to respond positively in the DAP for conserving this recreational place.
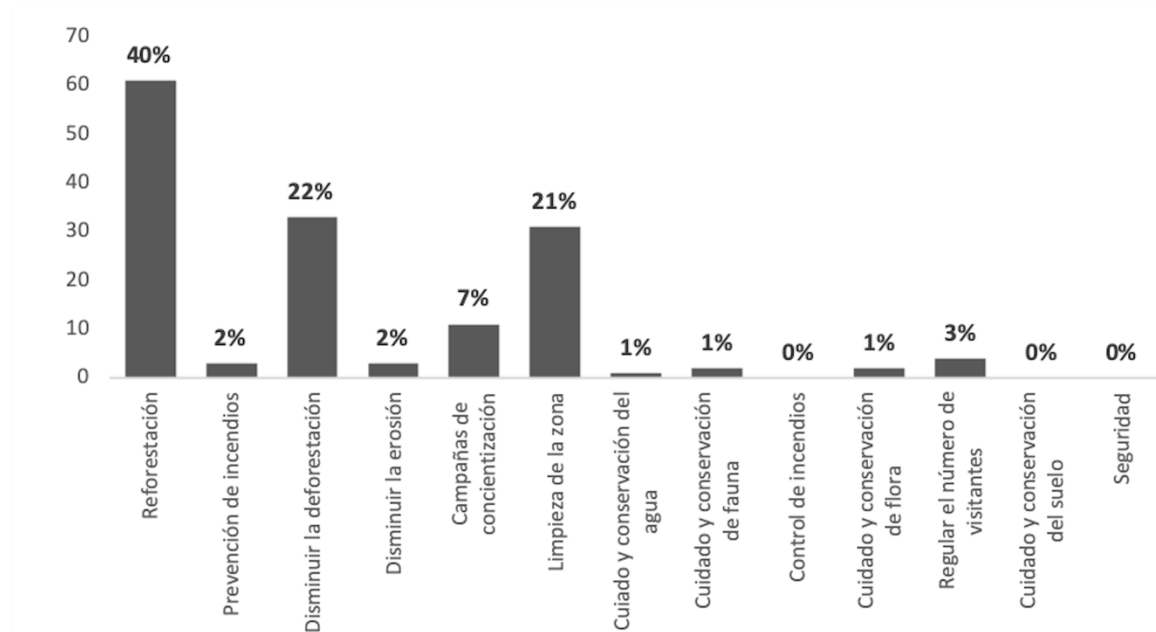
Reforestación = Reforestation; *Prevención de incendios* = Fire prevention; *Disminuir la deforestación* = Decrease deforestation; *Disminuir la erosión* = Decrease erosion; *Campañas de concientización* = Awareness campaigns; *Limpieza de la zona* = Cleaning the area; *Cuidado y conservación del agua* = Water care and conservation; *Cuidado y conservación de la fauna* = Fauna care and conservation; *Control de incendios* = Fire control; *Cuidado y conservación de la flora* = Flora care and conservation; *Regular el número de visitantes* = Regulate the number of visitors; *Cuidado y conservación del suelo* = Soil care and conservation; *Seguridad* = Security.

Figure 6. Environmental improvements.

The environmental needs demanded by the visitors are also important to carry out environmental care and conservation actions by the *ejidal* and governmental authorities. The average visitor agrees on the main environmental services that should be improved, because, according to the results obtained in the survey, 40 % suggest that reforestation should increase, 22 % mentioned that deforestation should decrease and 21 % were concerned by garbage and its effects on the mountain, as seen in Figure 6.

Finally, according to the willingness to pay to care for and conserve Mount *Tláloc*, most visitors expressed interest, since 82 % accepted the DAP and only 18 % gave a negative answer, a result that coincides with other cases (Amiri *et al.* , 2015).

Such a high level of positive response was to be expected, since it was observed that the average visitor is concerned about the environmental problems that affect the place, a high perception of its quality and its degradation, as well as direct, indirect and non-use values present. It should also be noted that there are biases related to negative responses known as protest responses, which means that the interviewee disagrees with the approach to solving the problem and does not mean that they do not value the environmental resource in question, as stated by Azqueta (1994).

In the six strata that were defined to classify the different levels of visitor income (Figure 7) it was determined that the individual income level is low, since 38 % is located in an interval between the absence of perceptions and the MX $ 3 000.00 per month; Stratum 2 followed with 22 % of those interviewed whose income ranges from MX $ 3 000.00 to MX $ 6 000.00 per month and in third place, 17 % have an individual income between MX $ 6 000.00 to MX $ 9 000.00 per month.
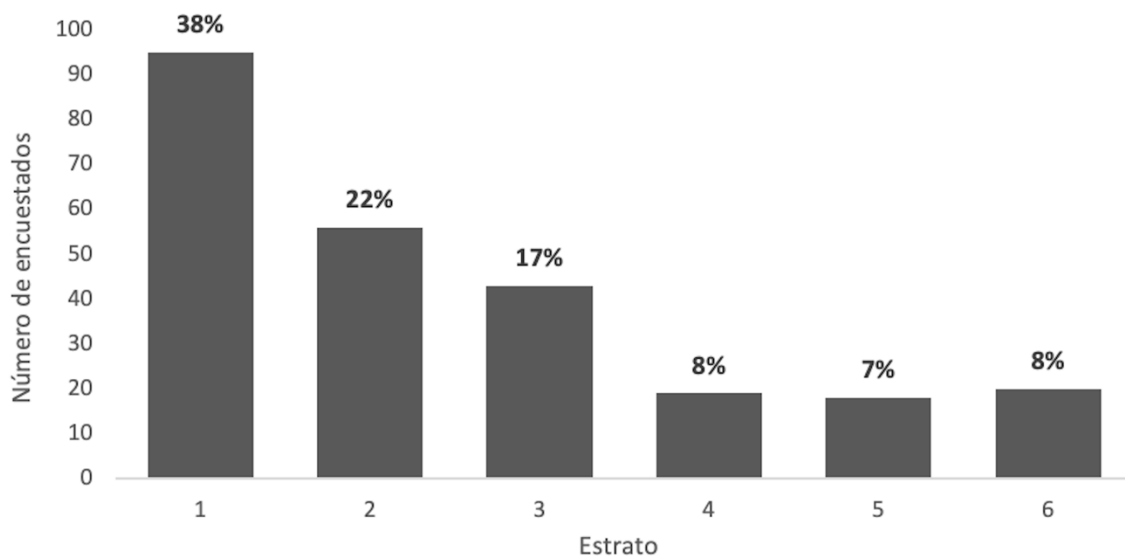
Número de encuestados = Survey respondents ; *Estrato* = Stratum.

Figure 7. Income level by stratum.

Estimated model

With the estimated parameters in Table 1, the following equation is constructed:

$$DAP = -.20026192 \quad + .3713ESTU + .1259YFAM + .4513PA + .2463PERD - .6327SSUF$$
$$- .3639PERQ + e$$

Table 1. Estimated coefficients of the model and marginal effects.

Variable	Coefficient	Standard error	P[|Z|>z]|	Marginales effects
Constante	-0.20026192	1.13175362	0.8595	-0.02718
ESTU	0.37130950	0.16279501	0.0226	0.05040
YFAM	0.12597118	0.15194752	0.4071	0.01710
PA	0.45130106	0.35484716	0.2034	0.06126
PERD	0.24635533	0.53270755	0.6438	0.03568
SSUF	-0.63271812	0.36533458	0.0833	-0.09341
PERQ	-0.36398739	0.23963428	0.1288	-0.04940

Source: Elaboration with the results of the Nlogit program.

ESTU = Education; *YFAM* = Family income; *PA* = Environmental concern; *PERD* = Perception of environmental degradation on *Tláloc* Mount; *SSUF* = The services you receive from *Tláloc* Monte are enough; *PERQ* =Perception of environmental quality in *Tláloc* Mount

The results of the logit model presented in Table 1 show that the signs of the coefficients that go with the variables are as expected. The model has a McFadden R^2 fit with a value of 0.0636683 and predicts correctly with a value of 82.86 % according to the prediction percentage. The joint significance level is not as high as expected,

since it presents a value of 15.03163, in terms of the Likelihood Ratio (LR) statistic, however it is accepted with a critical value of chi-square at 5 % with 6 degrees of freedom which is 12.59, which rejects the joint hypothesis that the coefficients of all the variables are zero, that is, that the variables have an important effect on the willingness to pay. Gujarati and Porter (2010) mention that the importance of goodness of fit should not be overestimated in models for which the dependent variable is dichotomous.

Willingness to Pay

With the estimated model (Table 1) the economic value that visitors give to Mount *Tláloc* expressed in the DAP was calculated, resulting in a DAP of MX $ 9.00 per person, with a maximum value of MX$ 11.19 and a minimum of MX$ 7.95 and a standard deviation of 0.5243 for entering the site. It is important to note that almost 20 % of those interviewed had a zero protest as a response, but indicated that they did not trust the group of people that was managing the resource obtained from the collection, or that because they were inhabitants of the towns that have rights to use the *Monte*, they should not pay.

Tecpan *et al.* (2016) estimated the willingness to pay for the conservation of the *Tezcutzingo* hill, which, in addition to being a cultural area, has an important vegetation cover, with the same methodology obtaining a DAP value of MX$ 41.89 per person.

Soto and Soza (2014) applied the CVM to evaluate the economic value of the native forest affected by the introduction of the American beaver in *Tierra del Fuego* in *Chile*; they found a total valuation at $ 7 282 197 per year.

Almendarez *et al.* (2016), in the *Sierra La Laguna* Biosphere Reserve (RBSLA), used the CVM to determine an additional amount to pay for access. The proposed DAP was estimated with the MVC probit models and the results show that the median additional DAP varies between MX$69.00 and MX$ 108.00 per person.

Hernández *et al*. (2019) carried out an economic valuation with the same method in the *Bosque de San Juan de Aragón* (BSJA), which is located within the *Gustavo A.*

Madero mayoralty of Mexico City. The results revealed that the DAP was MX$ 7.36 per person per ticket; While the economic value of the environmental services of the BSJA amounted to MX $ 25 620 000.00 per year, the results obtained in this study go in the same direction as those calculated by the aforementioned authors.

Conclusions

Based on the sample of visitors studied, 82 % are willing to pay to conserve Mount *Tláloc*; the average DAP is MX$ 9.00 per visitor. The variables that positively influence the DAP are the level of studies, family income, environmental concern and the perception of environmental degradation in the area, while those that decrease the probabilities of the DAP are the perception of the level of environmental services and that of the environmental quality of the area.

Just over half (55 %) of the consulted population perceive the quality of Mount *Tláloc* as good, however, 90 % consider that there is environmental degradation in the area, mainly due to contamination by garbage produced by visitors and the level of erosion noted as the most worrying factors for the average visitor. They also indicated a low level of security in the mountains, the lack of cleanliness in the area and the lack of signage on routes and sidewalks.

Conflict of interests

The authors declare no conflict of interests.

Contribution by author

All the authors participated in planning, research design, information analysis, writing, and review of the manuscript; although the first author had greater participation in the field phase and information capture.

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