Economic valuation of a gallery landscape of ahuehuetes in Ciudad Mendoza Veracruz, using the AMUVAM method

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ABSTRACT

Objective: to determine the value, in monetary terms, of the landscape "Bosque de Galería de Ahuehuetes, in Mendoza, Veracruz", in order to have a reference for the purposes of planning and management of this environmental asset by the municipality.

Design/Methodology/Approach: the Analytic Multicriteria Valuation Method (AMUVAM) was used. A survey was made of 10 experts in the study area on the elements of the total economic value (VET) of the asset and the results were weighted to determine the importance of the components of the VET. The rent was determined based on the availability of the population to pay for the aesthetic enjoyment of the visit to the site; income updated by means of a Social Discout Rate (SDR) to environmental projects with a time horizon of more than 30 years.

Results: an estimation of 23,603,041.37 USD was obtained as monetary value. It was the result of the valuation of the landscape of this gallery forest in November 2022.

Study limitations/Implications: results were considered adequate. The main limitations of this type of studies are the time and economic resources needed in order to add other elements that could be considered beyond aesthetic enjoyment. Specific elements would allow to find an even more robust direct use value.

Findings/Conclusions: it can be noticed that the application of the method was adequate to determine the monetary value of this asset. Based on the determination of the willingness of people to pay for access to the aesthetic enjoyment of the analyzed landscape.

Keywords: valuation, environmental assets, landscape, total economic value.

Citation: Muñoz-Márquez, T. R. A (2024). Economic valuation of a gallery landscape of ahuehuetes in Ciudad Mendoza Veracruz, using the AMUVAM method. *Agro Productividad*. https://doi.org/10.32854/agrop.v16i10.2579

Academic Editors: Jorge Cadena Iñiguez and Lucero del Mar Ruiz Posadas

Received: April 28, 2023.
Accepted: December 16, 2023.
Published on-line: February 19, 2024.

Agro Productividad, 17(1). January. 2024. pp: 77-85.

INTRODUCTION

The bridge between economics and environmental sciences allows generating tools for the preservation of the environment and under the premise that valuation is the first step to achieve this (Ayala and Moysén, 2016). Environmental assets (ecosystems) produce

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a number of Environmental or Ecosystem Services (ES), which are relevant to society. Currently, the situation of these assets and the services they provide is compromising due to the degradation caused by human activity. Environmental valuation becomes relevant as an effort to determine the value of ecosystems in relation to all the services they provide, not only those related to their direct use (Aznar and Estruch, 2015).

This type of valuation makes it possible to recognize in monetary units the value of environmental goods and services that often do not have a market that allows the application of a comparative methodology. Consequently, society assumes them as infinite, and therefore their valuation is sometimes non-existent or indefinite. Environmental valuation also helps to understand the consequences of the lack or alteration of a good, through the establishment of parameters of similarity between the ecological and the economic, although without considering the value as a sale price. The ultimate goal is to provide information for decision-making in understandable language (Ayala and Moysén, 2016).

From the point of view of Environmental Economics (Klink and Escolano, 1994), the resulting value of an ecosystem or environmental value is structured based on the several components of what has been called the Total Economic Value (TEV) (Figure 1) (Costanza *et al.*, 2017). TEV can be expressed as follows:

$$TEV = UV + NUV = DUV + IUV + OV + LV + EV$$

where: TEV = total economic value; UV = use value; NUV = non-use value; DUV = direct use value; IUV = indirect use value; OV = option (or quasi-option) value; LV = legacy value; EV = existence value.

It follows that in the TEV there are components for which there is a market value, as well as others that do not (non-market values) (Bonner, 2022). In this sense, the comprehensive valuation of environmental goods requires this determination of "non" market values. Due to several characteristics of ecosystems and those services they provide to society cannot be exchanged in any existing market. In the determination of non-market values, the use of various valuation methods is proposed. The valuation of environmental goods can be grouped into four sets: 1) those that use market prices; 2) those that use expenditures as

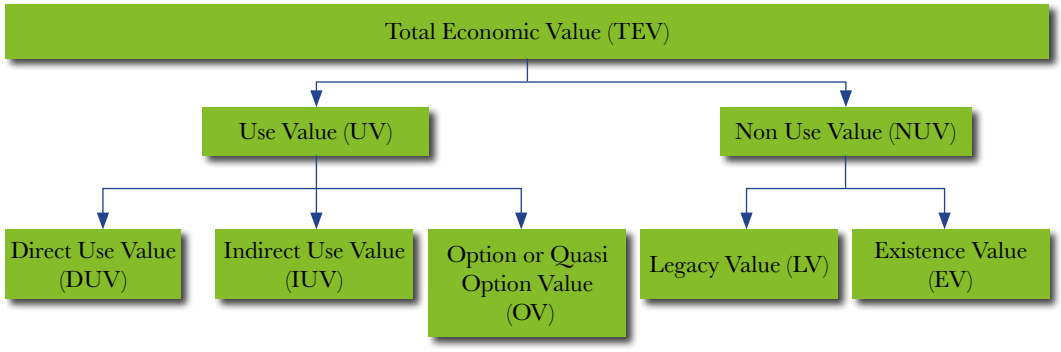

Figure 1. Components of the Total economic value (TEV).

an approximation of benefits; 3) those that use revealed preferences; and 4) those that use declared preferences (Eaton, 2017).

Aznar and Estruch (2015) proposed the use of multi-criteria valuation techniques; in particular, the technique called AMUVAM (Analytic Multicriteria Valuation Method) which is composed of the application of the hierarchical analytical process (AHP) and the application of the income update. This method allows, with the determination of criteria, alternatives, and the participation of experts, the weighting of the various components of TEV to generate a value in which all these components are represented, with their weighted contribution in the final value determined. To propose the valuation of a landscape, we cite the definition provided by the Council of Europe, which indicates that landscape "means any part of the territory as perceived by the population, the character of which is the result of the action and interaction of natural and human factors" (Consejo de Europa, 2000).

The space (territory) analyzed in this exercise can be perceived at least from sight, hearing, touch, and smell, so it constitutes a landscape according to that definition. Which is why this exercise is taken as the valuation of the gallery forest, through the perception of some ecosystem services that it provides which are components of the TEV. The general objective of this study was to determine the value, in monetary terms, of the landscape of the ecosystem called "Bosque de Galería de Ahuehuetes, in Mendoza, Veracruz", in order to have a reference for the purposes of planning and management of the natural good by the municipality. The specific objective was to apply the AMUVAM method as a broad framework for considering the variables related to the determination of the value of this ecosystem, based on the weighted contribution of each of the components of the TEV.

MATERIALS AND METHODS

This study is a case of application research. The study site was located in the so-called "Bosque de Galería de Ahuehuetes (a *Taxodium mucronatum* gallery forest landscape)", in Camerino Z. Mendoza, Veracruz, Mexico. It is an extent of the Blanco River of about 20 km long, and within there is the most visited section for scenic beauty and the physical possibility of access that it offers, which extends approximately over 5 km. Its main attraction is to see the Ahuehuete trees (*Taxodium mucronatum*), 30 to 40 m height and up to 4 m of diameter chest height (DCH).

To valuate this area, the multi-criteria assessment method called AMUVAM was applied (Aznar and Estruch, 2015). This procedure makes it possible to determine the weights and influence of the options and criteria that are established to arrive at a valuation of an asset, in this case, an environmental one. It is an alternative to other methods of valuation of environmental assets and liabilities that deliver a partial value of a broad spectrum of value that an environmental asset or ecosystem have. As mentioned before, AMUVAM is a method composed of the Hierarquical Analytical Process and the Income Update method.

Through the participation of a group of experts in (people who knows well) the area to be assessed, the technique makes it possible to determine the weight that each criterion

or component of the TEV has in its determination. Through a matrix process, where the weights determined by the experts are established by obtaining an Eigenvector for each evaluator. Then, with the aggregation of these vectors and their normalization, the participation of each of the component aspects in the final result of the TEV is weighed.

On the other hand, a process of updating the income values offered by the environmental good is applied, especially those of direct use value which, as already mentioned, are those for which there is a market. Therefore, those allow to obtain the price of what the environmental good produces; they can also be applied to those of indirect use, or even to other components of TEV. With this cost determination, after we calculated the weighting of each of the TEV components and considering this determined cost as a "pivot", the cost of each factor is determined. Finally, by summing them up, the value of the good in the present time is obtained.

For this reason, it is necessary to determine the update rate to be used, which in this case was the environmental rate or social discount rate (SDR). For this study, the use of a rate of 2.81%, calculated for Mexico by Aznar and Estruch (2015) in 2010, is proposed. It is worth mentioning that the Government of Mexico proposes in general, 12% for investment projects (SHCP, 2012), that is, almost 10% more than what Aznar and Estruch propose. According to several authors, this wide difference occurs because rates decrease as the time horizons of the analyzed projects increase (Castillo and Zhangallimbay, 2021; DGPI-MEF, 2011). The aforementioned authors support the need to visualize a decreasing rate in regard to time for environmental projects. As this project is considered to have a temporality of more than 30 years, the aforementioned rate of 2.81% was used.

For the case studied, it is proposed to determine the enjoyment of the landscape as a Direct Use Value (DUV) and the Willingness to Pay for access to it through Contingent Valuation (Penna and Cristeche, 2008; Sajurjo, 2001). This type of valuation attempts to construct a hypothetical market for a good that is not traded on the common market. This market is established through surveys applied to the population that uses the good, and tries to determine the willingness to pay for its use, or in other cases, to receive compensation for the loss of the good. In the first case, it is the maximum amount to be paid for it, and in the second, the minimum amount of money that would be accepted as its substitute.

Once the exercise is applied, the resulting average value is multiplied by the estimated population using the good, so that the total value of that use can be inferred. This value (rent) when obtained it becomes the pivot value, to which an updating rate is also applied and with the weighting of the TEV components, the resulting value of the asset is attained.

Here are the aspects that describe the general procedure in this application:

a. Establishment of the decision objective and description of the TEV elements.
b. Prioritization of the TEV components based on the importance and weight of each of the values, as well as the components of the use and non-use values.
c. Weighting of criteria and alternatives. At this stage, comparisons are made among all the TEV components. The scale proposed by Saaty (1980) is used, which rates

the importance of one aspect over another. This assessment or weighting is based on a survey applied to a selected group of actors or decision-makers who know the asset and understand the importance of one value or element over another (AHP).

d. Construction of paired matrices that determine the weights of each TEV component. This is done for each expert. The geometric mean of the weights that each person made for each component is obtained. The values are then normalized by the sum.
e. Application of contingent valuation and determination of DUV. This was developed through the application of a survey to a sample of the population that uses or is related to the good. It was estimated that 40 people would visit per day in the site visited directly (5 km); which generates a total of 14 400 annual visitors. Based on this data, and for the purposes of determining the sample size, with a margin of error of 8% and a confidence level of 95%, the number of 149 respondents was reached for this determination. The final interviewees were 177 people to determine their willingness to pay for access to this environmental asset, for the purpose of enjoying the landscape. The sample size was determined using the following formula:

$$N = \frac{\frac{Z^2 * p(1-p)}{e^2}}{1 + \left(\frac{Z^2 * p(1-p)}{e^2 N}\right)}$$

where, N = sample size; e = margin of error; p = probability of error; Z = z-score

f. Data analysis. They were performed with the Statistical Analysis System (SAS). Frequency tables were used with response ranges regarding the willingness to pay for access per person each time the site is visited.
g. Determination of the total number of users of the good (20 km). The frequency of visits observed in the field was considered. In this sense, an influx of 40 people per day was estimated in the section visited directly (5 km). This generates a total of 14 400 visitors per year for this section. For the rest of the property, this is 15 km, half of the influx (20 visitors per day) was considered for each 5 km section. So, the grand total of estimated visitors resulted in 36 000 per year.
h. Update of the DUV (rent), a rate of 2.81% was considered, suggested by Aznar and Estruch (2015) and applied to cash flow (rent); in this case it was the value of the willingness to pay (on the part of the total estimated visitors) for the enjoyment of the area.
i. Determination of which of the components becomes the pivot element. From this, the contribution of each TEV component, and its total result are determined.
j. Weighting of the TEV components and determination of the value of the good in monetary units; in this case, Mexican pesos.

RESULTS AND DISCUSSION

Description of the components of the TEV, for this landscape

Direct Use Value (**DUV**). In this case, aspects of direct use value are not clearly identified, since there is no obvious market for materials such as wood or fruit harvesting, for example. It is a gallery forest that occurs on the banks of the Rio Blanco; this is, a curtain of trees on each side of the riverbank, along an extent of about 20 km. Direct use was considered as the enjoyment of the landscape.

Indirect Use Value (**IUV**). Nitrogen fixation, rainwater harvesting, soil stabilization, natural barrier to the growth of urban development in the area.

Option Value (**OV**). It is an environmental and cultural resource. The species *Taxodium mucronatum* ("Ahuehuete") is a living monument, due to the long time it takes to grow. At the study site, there are specimens of considerable size. It is hypothesized that many people would prefer its conservation for these and other reasons.

Legacy Value (**LV**). Given the described characteristics of the OV, in this case, it is also considered important to conserve this resource for the next generations. So that they have reference to the specimens that were established long before and that bear witness to the passing of the history of the region.

Existence value (**EV**). This ecosystem has a long list of animal and plant species that survive despite the impact of the urban development of the municipalities it crosses. It is also an edge that contains to an important extent the increase of the urban sprawl, so it is important to guarantee its existence in the future.

The group of experts assembled to carry out the paired matrices was composed of four researchers in environmental and agricultural sciences, two members of civil society, two regular visitors to the site and two environmental managers.

It is important to clarify that, in the application of the paired matrices to the 10 experts and verification of the consistency ratios suggested by Saaty (1980), the answers of three experts (6, 7 and 10) were not consistent, so they were discarded for the weighting analysis of the TEV values.

Paired matrices applied to the experts resulted in these values in Table 1, which shows the Eigenvectors used and the aggregation of values obtained from the interviews.

The prioritization verified in this table was used for the determination of the VET values. In this case, from the willingness to pay for the visit to the site for scenic enjoyment (DUV).

Survey Results

After analyzing the surveys, the following frequency table was obtained (Table 2). It can be observed that most of the respondents (68.36%) were in the range of less than 2.5[1] USD per admission per person, per visit. For the purposes of this valuation, the value of 1.25 USD was taken as the average of that range of values for the calculation of the income obtained.

[1] An exchange rate of $19.50 Mexican pesos (MXN) per U.S. dollar (USD) was considered.

Table 1. Eigenvectors and aggregation values obtained.

	Eigenvectors experts							Aggregation	
	1	**2**	**3**	**4**	**5**	**8**	**9**		
DUV	0.0499	0.0740	0.0343	0.0289	0.0663	0.1924	0.0714	0.0615	0.0678
IUV	0.4096	0.2676	0.6139	0.4192	0.1605	0.1302	0.5202	0.3148	0.3474
OV	0.1728	0.0525	0.1131	0.0840	0.1694	0.1924	0.1361	0.1211	0.1337
EV	0.1626	0.2883	0.1257	0.2911	0.3335	0.2425	0.1361	0.2114	0.2333
IV	0.2051	0.3175	0.1131	0.1768	0.2704	0.2425	0.1361	0.1973	0.2177
$\sum$	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9061	1.0000

Table 2. Frequency table obtained in SAS® (through the FREQ procedure).

Price rango (USD$)	Frequency	%	Cumulative frequency	Cumulativo (%)
10.25-12.82	3	1.69	12	6.78
5.1-10.25	9	5.08	9	5.08
2.5-5.1	34	19.21	46	25.99
<2.5	121	68.36	167	94.35
Nada	10	5.65	177	100.00
Frequency Missing = 1				

Considering that the total number of visitors is 36,000 per year for all the river, and the value determined by the survey (a willingness to pay 1.25 USD per person) as the income, the determined rent results in the following:

$$36{,}000 \times 1.25 = 45{,}000 \text{ USD}$$

That amount would correspond to the determination of the value of direct use (DUV) which will be used as the pivot value.

Update of the rent obtained

To the amount determined in the previous section as rental income we assigned a rate of 2.81% (Aznar and Estruch, 2015).

$$VIU = \frac{45{,}000 \text{ USD}}{0.0281} = 1{,}601{,}423.49 \text{ USD}$$

Calculation of TEV considering DUV as a pivot value

Applying the determined weights and with the DUV as a pivot, it is obtained that the TEV of the ecosystem services of the landscape of the Ahuehuetes Gallery Forest amounted to 23,603,041.37 USD (November 2022).

Table 3. Prioritization of TEV values, values per component and the total determined.

Priorization of components of TEV		Values by TEV components (USD)
DUV	6.78%	1,601,423.49
IUV	34.74%	8,200,648.37
OV	13.37%	3,155,065.32
EV	23.33%	5,507,690.24
LV	21.77%	5,138,213.95
∑	100.00%	23,603,041.37

It is important to note that the result obtained does not correspond to the value of the environmental asset analyzed. But to a proxy indicator of the values that this landscape might reach as a necessary element for planning and management. The value determined is based solely on the aesthetic enjoyment of the landscape and yields a considerable figure, which shows the importance of this activity in monetary terms. The results obtained were based on only one element, which is scenic enjoyment. It seems that an even higher value might be achieved if a study with more time and resources were to include some additional elements in the annual cash flow (rental income) that would complement the DUV. As well as, estimating visitors in a more accurate way can vary the results.

CONCLUSIONS

The value obtained corresponds to the rental income obtained because of the asset, with a proposed update rate in a horizon of more than 30 years. But if it is considered that the useful life of the environmental asset is in perpetuity, then its value is invaluable.

The results show an adequate applicability of the AMUVAM method in the valuation of environmental assets. It is perceived that in the exercise, other aspects of DUV such as wood or others, might be considered and added to the aesthetic enjoyment, which would generate a value estimated even higher. Also, determining more precisely the number of visitors to the entire river would certainly change the results upwards.

The aggregation of more aspects related to DUV, as suggested above, requires more human and financial resources to determine it within a greater scope. However, the figure obtained clearly denotes the importance in monetary terms of the valued environmental asset.

Environmental valuation requires a longer time to run and at a higher cost than a valuation of other types, such as real estate. Since it requires, for example, techniques such as the application of surveys to a representative sample of the population that uses the asset, which requires more time. On the other hand, it demands a deeper and more detailed research on the qualities and aspects that compose TEV. It is important to consider this point for study-planning with this type of valuation.

As far as we are concerned, this valuation is an important contribution to the recognition of the value of this environmental asset, based on one indicator set in monetary terms.

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