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RESEARCH ARTICLE

AMUVAM MODEL IN THE ECONOMIC VALUATION OF THE ENVIRONMENT AND ITS APPLICATION IN THE HIGH ANDEAN BASIN OF THE CHUMBAO RIVER IN ANDAHUAYLAS, PERÚ

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ABSTRACT

Environmental valuation allows calculating the value provided to society by the ecosystem services of the environmental asset generated by a natural space. The objective of the study was to determine the total economic value of the ecosystem of the high Andean of the Chumbao River basins, Andahuaylas province, Perú. For this purpose, the methodology of Analytic Multicriteria Valuation Method, which combines two methods: AHP (Analytic Hierarchy Process) and the method of updating rents; For data collection, a paired comparison questionnaire was used, in which 39 people with vast knowledge of the environmental asset in reference participated. In this way, the results are expressed that the total economic value associated with the ecosystem of the environmental assets of the high Andean basin of the Chumbao River the sum of $ 774,163,167.16 calculated with a relationship of random consistency acceptable, where the experts prioritized the value of direct use (42.43%), followed by value of indirect use (24.22%), In terms of option value and stock value are relatively similar that are below 13% and, finally, the legacy value was relegated (8.12%). Thus, quantifying and reporting the importance of environmental assets means providing a more effective tool for government management to achieve environmental conservation and sustainability goals.

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INTRODUCTION

It is our entire knowledge that environmental assets provide a diversity of goods and services to society such as the supply of food and raw materials, biodiversity, assimilation of resources and intangible elements that guarantee life and contribute to the well-being of an individual (Hernández & Campo, 2022). And as today's society is a market society that takes monetary value as a reference to gauge the importance of assets, so determining their value is the best way to transmit this importance to society. In recent years, the interest in knowing the value of things has led to the discovery of great discoveries and advances in the valuation of assets through methodologies for the valuation of goods with a high content of intangible variables (Aznar & Estruch, 2015). However, environmental assets have not been correctly estimated, so when making decisions both companies and the government have not taken them into account, which has caused serious damage and a great decrease in these assets, negatively affecting all living beings. Due to the unfortunate conditions of environmental assets, it is necessary to raise awareness of each and every one of the people of the irreparable damage that is being done to the environment and that the greatest harmed will always be human beings, who by acting in a selfish way a damage to the environment is encouraged (Barrial-Lujan *et al*., 2022; Hernández & Campo, 2022).

The terrestrial ecosystem of the headwaters of the Chumbao River basin as an environmental asset, is no stranger to the statistics of degradation and losses of Peruvian biodiversity, very much in spite of the fact that multiple high Andean terrestrial ecosystem services and goods are produced in that place, and as such, it offers important tangible and intangible benefits for Andahuaylina society and surrounding provinces in the Apurimac region.Therefore, knowing the economic value of environmental assets and resources would help foster their protection and help make government intervention more efficient. It is in this sense, with this research, recognition of environmental assets is generated, which establishes an economic value of the high Andean basin of the Chumbao River, by identifying the benefits provided by environmental assets and allowing to sensitize society and government institutions about the goods of public interest that motivate sustainable development.

MATERIALS AND METHODS

Description of study area: The geographical location of this study is located between the coordinates 73°41' and 73°14' west longitude and between 13°67' and 13°47' south latitude. The altitude varies from 2000 to 4800 meters above sea level, the territorial extension of which is 133.7 square kilometers. Politically, it is located in the Southern Highlands of the Andes of Peru which belongs to the province of Andahuaylas, Apurimac region as illustrated in figure 1. This territorial area is the support of the high Andean fauna and flora, in it you can find high Andean lagoons: Huachacocha, Pacococha, Antacocha and Pampahuasi(SENAMHI, 2010), It has a vegetation cover of grassland formation with extensive pastures, the physiography is characteristic of high mountain, its ecological floor is classified in altimontano by its physiognomy of vegetation, geographical distribution of plant and animal species, biodiversity, soils and climate; Its ecosystem is classified as Pajonal de Puna

Humid, with vegetation cover of Andean Pajonal; It presents wetlands, located in pluvial terraces, depressions flat and slightly inclined surfaces, whose main food is rainfall, which is part of a hydromorphic ecosystem distributed in this high Andean region(MINAM, 2015, 2019).

Method of economic valuation of environmental assets: The chosenmethodologyis AMUVAM (Analytic Multicriteria Valuation Method), which combines two methods: AHP (Analytic Hierarchy Process) and the income update method (Aznar & Estruch, 2015), Because it presents us with a way of valuing ecosystem services that have no market.

Selection of Experts: In this research, 39 experts in the area of study were selected, including: a) group of environmental engineers, agro-industrial; Directors of the area of Local Economic Development and Environment, workers in the tourism sector and farmers with extensive experience in agri-food crops.

The experts belong to the following decentralized institutions of the regional government of Apurimac, precisely from the functional areas of: Foreign Trade and Tourism, Chamber of Commerce and Industry; also by the workers of the local office of economic development and environment of both the regional government of Apurímac; as well as the municipalities of Talavera de la Reyna, San Jerónimo and Andahuaylas; and, by the farmers of Lliupapuquio, Chumbao and Chihuampata, this group is justified by its direct relationship with the agricultural activity, management and administration of water resources in the Chumbao Valley.

Analytic Hierarchy Process (AHP): The Hierarchical Analytical Process (AHP) was developed in 1980 by Thomas. L. Saaty. Saaty & Vargas, (2012). The AHP provides the objective mathematics to process the personal preferences and inescapable subjectivity of an individual or a group in the decision-making process. And it consists of developing criteria with their respective priorities that will be used to judge alternatives.

Usually, the criteria depend on the understanding of the decision-maker(s), which can be measured on different scales, such as weight and length; or they are even intangibles for which there is no scale. To carry out this assessment, the scales reflected in Table 1 were used. However, for correct weighting, the definitions of each VET component must be clear, as reflected in Table 2. The consistency of the paired comparison matrices of the collective group survey is known through the consistency relationship and is calculated as follows:

The consistency index or ratio (CI)

$$CI = \frac{\lambda\, max - R}{R - 1}$$

where R is the rank of the matrix. Knowing the consistency index, the consistency index (CR) is calculated as

$$CR = \frac{CI}{Consistencia\ aleatoria}$$

Beingtherandomconsistency, for a 5x5 matrix, equal to 1.11, CR ≦10%, and for a 3x3 matrixequal to 0.52, CR ≦ 5% (Aznar & Estruch, 2015; T. Saaty, 1980).

Rental update method: According to the analytical method, the value of an economic good is equal to the present value of the sum of the rents or future profits (Income-Expenses) that a good can generate for its owner. In this way, the usual value formula (V) is calculated as follows:

$$V = \sum_{i=1}^{n} \frac{Ri}{(1+r)^i} = \frac{R}{r}$$

Where:

V = Present value of the environmental asset by its Direct Use Value functions; R = Income generated by the good by its functions Direct Use Value; r = Update rate (Social Time Preference Rate); i = Period during which the good will generate profits. Cálculo del valor de pivot. As the update rate (r), we will take the Social Discount Rate r = 3.77 calculated for Peru in the medium term (Kamiche & Diderot, 2018; MEF, 2019), according to the equation described by Ramsey (Ramsey, 1928)formula (individual or pure time preference rate (0.88%); which represents the elasticity of the marginal utility curve of consumption.

$$DUV \text{ Value } = \frac{\text{Cash flowofthe services prVOided by VUD}}{\text{Discount rate}}$$

Calculation of the total economic value (TEV) and its related components: Once the pivot value of equation (4) is known, we proceed to the sum of the partial components of the TEV(Estruch-Guitart & Vallés-Planells, 2017) . In this way, the real value of the environmental assets of the geographical area in question is estimated.

$$\text{IUV} = \frac{\text{DUV}}{\text{VUD weight}} * \text{VUI weight} \quad (5)$$

$$\text{OV} = \frac{\text{DUV}}{\text{DUV weight}} * \text{OV weight} \quad (6)$$

$$\text{VE} = \frac{\text{DUV}}{\text{DUV weight}} * \text{EV weight} \quad (7)$$

$$\text{BV} = \frac{\text{VUD}}{\text{VUD weight}} * \text{VL weight} \quad (8)$$

$$\text{TEV} = \text{DUV} + \text{IUV} + \text{OV} + \text{EV} + \text{BV} \quad (9)$$

RESULTS AND DISCUSSIONS

Through the Hierarchical Analytical Process, the components of the Total Economic Value (TEV) were weighted. In this way, the monetary valuation of the environmental asset of the high Andean basin of the Chumbao River of Andahuaylasprovinceis composed of the value components for direct use value, indirect use value, option / quasi-option value, existence value and bequest value. Table 3 denotes the collective group of experts assigned a very high score to the direct use value (42.43%), followed by indirect use value (24.22%), in terms of option value and existence value are relatively similar that are below 13% and, finally, the bequest value was relegated (8.12%). Overall, the weight of UV was 79.46% and for UNV it represents 20.54%.

These weights assume that respondents have a utilitarian profile of the environmental asset and less altruistic towards future generations. That is, they prefer the current usufruct of the natural resources of the upper basin of the Chumbao River. something similar happened with the weighting of the components of the TEV for the Albufera Natural Park in Valencia, Spain, since one of the collective groups assigned a weight of 72% for UV and 28% for UNV respectively (Estruch& Vallés, 2017).For the Santa Elena Lagoon in Chile, the panel of experts consulted gave greater weight to the indirect use value (IUV) as the highest valuation component with 36.39% of score, followed by the stock value (EV) with 26.72% and

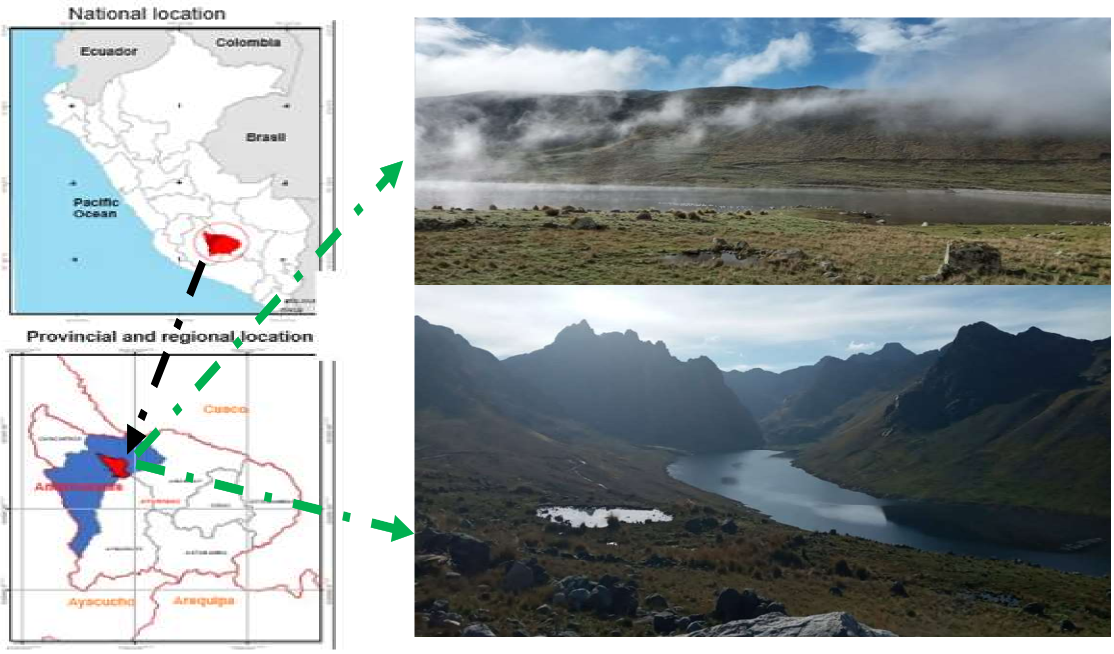

Figure 1. Geographical area of the study area-Andahuaylas

Table 1. Paired comparisonscale

Value	Verbal scale	Explicatión
1	Equalimportance	Two elements contribute equally to the property or criterion
3	Moderateimportance	Experience and judgement slightly favour one element over another
5	Strongimportance	Experience and judgement strongly favour one element over another
7	Verystrongimportance	Experience and judgement very strongly fa- vour one element over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6 y 8	Intermediate values between the abVOe, when it is necessary to qualify	

Surce.Saaty, (1980)

Table 2. Description of VET components

Abbreviations	CriteriaValues	Description
DUV	Direct Use Value	It represents the benefits produced by natural assets either as materials for production processes or as goods.
IUV	Indirect Use Value	Value of goods and services that are necessary to obtain direct use value and are not detected by the market.
OV	Option/quasi-option	Value of the asset with unknown functions or that is conditioned to possible future uses
EV	ExistenceValue	Value of the asset by allowing the conservation of the resource, such as flora or fauna or cultural values, landscapes, etc.
BV	BequestValue	It is the value of the environmental asset to bequeath the benefits to future generations..

Source: Own elaboration based on Aznar and Estruch (2015).

Table 3. Aggregate and normalized vectors

TEV	Geometric Mean	Normalization	Weighing
DUV	0.3660	0.4243	42.43%
IUV	0.2089	0.2422	24.22%
OV	0.1105	0.1281	12.81%
EV	0.1072	0.1243	12.43%
BV	0.0700	0.0812	8.12%

Table 4. Value of each TEV component

TEV	Components	Weighting	Values
UV	DUV	0,4243	$ 328.472.343,77
	IUV	0,2422	$ 187.498.077,18
	OV	0,1281	$ 99.157.547,35
UNV	EV	0,1243	$ 96.206.889,16
	BV	0,0812	$ 62.828.309,69
	Total		$ 774.163.167,16

the legacy value (BV) with 26.64%, leaving the direct use value (DUV) (market) at 4.07% and the option value (OV) at 6.17%, respectively (Romero *et al*., 2020). This point highlights the need to preserve natural resources in order to balance economic matters, implement strategies for the protection of living species and achieve a monetary profit with this exercise that encourages the implementation of this system (Hernández & Campo, 2022).

Once defined the weights assigned to the components of the TEV it was necessary to know the pivot value, for this it has been considered the direct use value (DUV). Since the headwaters of the Chumbao River basin are distinguished from other natural spaces by having a series of tangible and intangible assets that favor generating economic benefits from agricultural activity (cultivation of potatoes, corn, vegetables and alfalfa) and livestock (livestock and fishing).

And after making the cash flow of the economic activities described above, the amount of $ 12.383.407,36 was calculated. Thus, once the profit generated from the aforementioned economic activities was known, the amount calculated with the social discount rate of 3.77% assigned for Peru towards the year 2021 was updated (Kamiche & Diderot, 2018; MEF, 2019). In this way, the Direct Use Value corresponds to ($12,383,407.36) divided by (3.77%) which results in an amount of $ 328.472.343,77. Table 4 below details the weighted weight and partial and total economic value of the environmental asset of the headwaters of the Chumbao river basin. The use value (UV) amounts to $615,127,968.30, which is composed of direct, indirect and option or quasi-option use values. On the other hand, the non-use values (UNV) was valued at 159,035,198.85 dollars in both cases at a social discount rate of 3.77%. Thus, the collective group places a higher value on the VU compared to UNV.In the case of the valuation of the Albufera Natural Park of area 21,000 hectares, it ranges between 1,015 and 5,244 million euros, whose cash flow was updated by applying a rate of 3%Estruch & Vallés, (2017). Likewise, the economic values of ecosystem services associated with the Turia Natural Park, the values determined by the AMUVAM range between 163,946,752 and 481,549,597 euros, the pivot value was updated at a social discount rate of 2.91% (Estruch& Valls-Civera, 2018). For Laguna Santa Elena in Chile, the valuation through the AMUVAM method determined the monetary value of $ 17,780,686.00 at a social discount rate equal to 6%(Romero *et al*., 2020). In the case, of the Natural Park of Hoces de Cabriel, which has an area of 31446 hectares, was economically valued in two valuations 44,852,840.42 and 111,706,893.75 euros per year (Martin & Estruch, 2018), Experts agree that non-market services (i.e. non-use values) are more valuable than market services (use values), since support and cultural services have valuations with high weighting compared to other ecosystem services. This preference lies in the fact that experts associate them mostly with tourism, recreational and educational activities (Martin & Estruch, 2018). In this way, assigning a monetary valuation to the natural wealth both terrestrial, water, marine and among others, is to propose an instrument to quantify its importance and optimize its use (Romero *et al*., 2020). It is essential to take into consideration the social discount rate (SDT) (Edwards, 2016)Because the value assigned to an asset (object of study) depends on and affects it. the amount of the SDT may vary from year to year and from country to country. A high social discount rate means that current use of resources is more important to society than future use. In the case, to influence this scenario would mean a clear deterioration of natural resources over time, so that today's society would demonstrate its low empathy or sordidness towards future generations (Correa, 2008).

CONCLUSION

This study has managed to provide an estimate of the economic value of the ecosystem services of the environmental asset of the high Andean basin of the Chumbao River, which amounts to $ 774,163,167.16 of a territorial extension of around 134 km2 per year. whose methodology is a replicable framework for other high Andean areas and / or update the same quantification with the participation of other groups of experts and know their valuation perceptions. Quantitative approaches at the local level represent an opportunity to develop recommendations for sustainable management of high Andean environmental assets that are generally producers of water resources for the sustainability of life.

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