




Economic valuation of the environmental services of the Coata river basin, Puno-Peru

Valoración económica de los servicios ambientales de la cuenca del río Coata, Puno-Perú

Avaliação econômica dos serviços ambientais da bacia do rio Coata, Puno-Peru


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ABSTRACT. The objective of the research was to economically value the environmental services of the Coata River watershed; Likewise, determine the willingness to pay for the improvement of environmental services and identify the socio-economic variables that determine the willingness to pay. The contingent valuation method and the binomial logit econometric model were applied, with a sample of 369 households living around the basin, for this the primary source data collection technique was used and the survey on the population was used as an instrument. that resides in the basin, using the statistical packages SPSS 25.0 and Stata

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services, economic valuation.

16.0 for the estimation and contrast of hypotheses. It was determined that the economic value of the DAP amounts to 4.88 soles per month, thus evidencing the existence of full willingness to pay by the families that live in the vicinity of the river basin. Finally, the DAP is explained by age in 2.77%, education in 3.1%, frequency of use of the environmental service in 2.3%, and distance to the river in 2.3%.

PALABRAS CLAVE

Cuenca hidrográfica, disponibilidad a pagar, servicios ambientales, valoración económica.

RESUMEN. El objetivo fue de valorar económicamente los servicios ambientales de la cuenca del río Coata; así mismo, determinar la disponibilidad a pagar por la mejora de los servicios ambientales e identificar las variables socio-económicas que determinan la disposición a pagar. Se aplicó el método de valoración contingente y modelo econométrico logit binomial, con una muestra de 369 hogares que viven alrededor de la cuenca, para esto se utilizó la técnica de recolección de datos de fuente primaria y como instrumento se utilizó la encuesta, sobre la población que radica en la cuenca, utilizando los paquetes estadísticos SPSS 25.0 y Stata 16.0 para la estimación y contraste de hipótesis. Se determinó que el valor económico de la DAP asciende a 4.88 soles mensuales, por lo que evidencia la existencia de una plena disponibilidad a pagar por parte de las familias que habitan en las cercanías de la cuenca del río. Finalmente, la DAP es explicado por la edad en 2.77%, la educación en 3.1%, la frecuencia de uso del servicio ambiental en 2.3% y distancia al río en 2.3%.

PALAVRAS-CHAVE

Bacia hidrográfica, disposição a pagar, serviços ambientais, valoração econômica.

RESUMO. O objetivo era valorizar economicamente os serviços ambientais da bacia do rio Coata; da mesma forma, determine a disposição a pagar pela melhoria dos serviços ambientais e identifique as variáveis socioeconômicas que determinam a disposição a pagar. Foram aplicados o método de valoração contingente e o modelo econométrico logit binomial, com uma amostra de 369 domicílios residentes no entorno da bacia, para isso foi utilizada a técnica de coleta de dados de fonte primária e utilizado como instrumento o inquérito populacional. que reside na bacia, utilizando os pacotes estatísticos SPSS 25.0 e Stata 16.0 para a estimação e contraste de hipóteses. Foi apurado que o valor econômico do DAP é de 4,88 soles mensais, evidenciando a existência de plena disposição a pagar por parte das famílias que moram no entorno da bacia hidrográfica. Por fim, a DDP é explicada pela idade em 2,77%, educação em 3,1%, frequência de uso do serviço ambiental em 2,3% e distância ao rio em 2,3%.

1. INTRODUCTION

The contamination of rivers is a problem of hundreds of years, when the world population increased, these problems are due to the bad actions of the human being (Ortiz-Paniagua & Bonales, 2017; Ouverney et al., 2017), these waters have trajectory of ending up in the oceans putting the survival of various marine species at risk (Haro-Martínez & Taddei-Bringas, 2014; SS Silva et al., 2012). Studies indicate that in 2019 just over 80% of the world's rivers are polluted, in these rivers you can find industrial waste, chemical products, wastewater, among others (Haro-Martínez & Taddei-Bringas, 2014; Malte & Cazares, 2017; Monroy & Valdivia, 2011). Similarly, contaminated water resources have negative impacts on flora and fauna, as well as the various ecosystems that depend on them (Gallego-Álvarez, 2018).

The pollution problems in our country are diverse, a country with extensive natural resources and a great variety of biodiversity, but the improper use of water resources by the manufacturing industry for years (Huenchuleo & De Kartzow, 2018; Jabbour, 2015), effect of climate change, growing population, inappropriate agricultural practices have increased water scarcity (Fernandes et al., 2020; Hernández, 2019) and hindering the sustainable development of biodiversity (Cattaneo et al., 2007; Cohen et al., 2007; Cohen et al. al., 2013).

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Lissarrague (2015) shows that water pollution, which comes from the presence of high levels of arsenic, lead and cadmium and consequently the inhabitants suffer from cancer, diabetes mellitus and cardiovascular diseases (Da Silva et al., 2017; Moreno et al., 2017; Moreno et al. al., 2015), such as the cases of the districts of Lima, La Oroya and Juliaca, the range of inorganic arsenic concentration was from 13 to 193 mg / l for groundwater and surface water, higher than the limit of 10 mg / l as recommended by the WHO (Bergstrom & Loomis, 2017; Cristeche & Penna, 2018). Therefore, it is established that contamination in river basins has not only affected Puno, according to the director of science at WWF Peru, 70% of all Andean and Amazonian rivers cannot be used as drinking water (Dourojeanni & Jouravlev, 2001; Dourojeanni, 1998; Vargas, 2015; Guzmán, 2015). As we mentioned previously, pollution due to extractive activities, as well as the consumption habits of the population, are the main causes that rivers cannot be used for these purposes (Cerdeira, 2011; Conforti, 2014).

According to the characteristics of the Coata River, it is a tributary of Lake Titicaca that runs through the Peruvian territory, specifically in the Puno region (Huacani, 2019); where pollution has become a determining environmental problem, since said ecosystem is in a critical situation due to high levels of pollution caused by the discharge of sewage, mining activities and the inappropriate use of solid waste that They are developed in the cities surrounding it, mainly in the upper and middle zone (Huacani, 2013). This fact was repeatedly denounced by the inhabitants of the area, who sent their request to the provincial municipality of San Román, EPS SEDA-Juliaca, the Regional Health Directorate and environmental evaluation and inspection agencies, in order to control the dumping of sewage, waste and polluting residues and mining wastes, since these damage the health and environment of the inhabitants who live near this basin, mainly affecting the use of water for human and agricultural quality purposes (Lipa Vilca, 2019; Tovalino, 2019; Gallego-Álvarez, 2018; Jabbour, 2015). In addition, these conditions decrease the river's capacity to host flora and fauna in it, affecting biomass (Quispe et al., 2020; Sullca, 2013; Alarcon et al., 2016; Franz & Freitas, 2012).

Therefore, according to the observed analysis, the research questions are: What is the economic value for the improvement of environmental services for the inhabitants of the Coata River basin? How much are the families willing to pay? live in the vicinity of the river basin, for having a better environmental service? and finally, what are the main determinants that explain the willingness to pay for the environmental service in the basin? (Table 1).

Based on the questions raised, the objectives of this research are: to economically value the improvement of environmental services for the inhabitants of the Coata river basin, to determine the willingness to pay of the families that live in the vicinity of the river basin, for having a better environmental service and explaining the variables that determine the willingness to pay for the environmental service in the basin (Table 1). The research hypotheses are that the economic value for the improvement of environmental services for the inhabitants of the Coata river basin is less than 7.00 soles per month; There is full willingness to pay by the families that live in the vicinity of the river basin, for having a better environmental service with an average price of less than 7.00 soles per month and the main determinants that explain the willingness to pay for the environmental service in the basin are: family income, level of education, age, sex, environmental perception, distance to the river.

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Therefore, it becomes important due to the efficient results obtained with the contingent valuation method (CVM) in other investigations, where the case of Bergstrom and Loomis (2017) determined that 70% of the surveyed population is willing to pay for the restoration of environmental services in the river basins of the different countries of Europe and the US (Tovalino, 2019), like Rahman, Alam, Karim, and Karimul Islam (2017) who managed to determine that 65% of those surveyed they are willing to pay for the improvement in water quality. Thus, arriving to determine that on average households are willing to pay 3.64 soles on a monthly basis. Therefore, the environmental services that a basin provides is important for its territorial development, since according to the research carried out by Huayhua (2015), 95.7% of the interviewees are willing to pay the amount of 2.00 soles for not counting on the contamination of the water resource in the city of Pichari.

2. METHOD AND MATERIALS

Types of research

The research has a quantitative approach, since the data is collected, that is to say, from a primary source and the statistical estimates will allow us to test the hypothesis raised, to determine its behavior pattern (Cazau, 2006; Echenique & Sedano, 2017). In addition, it uses the contingent valuation method that allowed specifying social, environmental and economic characteristics of the study population. The research also uses the binomial logit econometric model, which searches for the relationship between the dependent variable (willingness to pay) and the independent variables (Age, frequency of service use, level of education and distance) for which the data will be used. corresponding econometric models (Mendoza, 2014).

Information sources

This research work uses cross-sectional data, which is collected through the “survey” collection instrument, which is planned, corrected and prepared according to the objectives set, inviting the participation of people from the districts. from Caracoto, Coata, Huata and Capachica (Valencia, 2020). Finally, in the systematization phase, all the information generated in the field will be subjected to the statistical estimation of the information for the respective analysis in order to implement the diagnosis of reality, for which descriptive statistics will be used (Pérez, 2005).

Population and sample size

Population

The study population in the present investigation covers 5 districts of the department of Puno which are involved in the Coata river basin. The population is obtained from the 2017 census surveys by the National Institute of Statistics and Informatics (INEI, 2017). Likewise, the number of households within the aforementioned districts was analyzed (Table 1).

Table 1. *Población por distrito del departamento de Puno*

Districts	Urbana y Rural
Huata	1240
Coata	2525
Capachica	3122
Caracoto	2526

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Santa Lucia	2032
Total	11 445

Fuente: Elaboración propia en base a información de INEI.

Sample

The corresponding type of sampling is simple random, where it is established that a known population under study and applying the formula to calculate the sample size (Lacort, 2014), the number of 369 people surveyed was obtained, from the Coata river basin.

Econometric Models

Bivariate estimation models

In the binary response models that we will develop for the Logit Probit models, it is according to the author Davidson and Mackinnon (2004) in their book on econometrics where they develop these econometric models. In binary response models, developing the value of the dependent variable y_t can take only two values 0 and 1. On the other hand, P_t represents the probability that $y_t = 1$ conditional on the information set in Ω_t , which consists of variables exogenous and predetermined (Achulli, 2016). Binary response models are used to model this probability condition. Given the values 0 and 1, it is clear that P_t is also the expectation of y_t conditional on Ω_t :

$$P_t \equiv \Pr(y_t = 1 | \Omega_t) = E(y_t | \Omega_t)$$

Any reasonable binary response model must ensure that $E(y_t | \Omega_t)$ is in the range 0-1. Thus, we find two widely used models that we will detail later (Pérez, 2005). These two models ensure that $0 < P_t < 1$ by specifying the following:

$$P_t = E(y_t | \Omega_t) = F(X_t \beta)$$

Here $X_t \beta$ is an index function, which shows from the values in the vector X_t of explanatory variables and the vector β of the parameters, and $F(x)$ is a transformation function which has the following properties:

$$F(-\infty) = 0, \quad F(\infty) = 1$$

$$f(x) = \frac{dF(x)}{dx} > 0$$

The properties for these models tell us that $F(x)$ is a non-linear function.

El modelo Probit

In the same way, according to the author Davidson and Mackinnon (2004), the Probit model is developed. In the Probit model, the first of the two widely used options for $F(x)$ is the cumulative standard normal distribution function (Pérez, 2005).

$$\Phi(x) \equiv \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x \exp\left(-\frac{1}{2}x^2\right) dX$$

When $F(X_t\beta) = \Phi(X_t\beta)$, then the following equation $P_t = E(y_t|\Omega_t) = F(X_t\beta)$ is called the Probit model. Although there is no exact form for $\Phi(x)$, it is easy to evaluate numerically and its first derivative is simply the density function of a standard normal distribution $\phi(x)$.

One reason for the popularity of the Probit model is that this can be derived from a model involving an unobserved or latent variable y_t° suppose that:

$$y_t^\circ = X_t\beta + \mu_t, \quad \mu_t \sim NID(0,1)$$

We observe that only the sign of y_t° , which determines the value of the observed binary variable y_t according to the relation.

$$y_t = 1 \text{ si } y_t^\circ > 0; \quad y_t = 0 \text{ si } y_t^\circ \leq 0$$

Together y_t° and y_t define what we are calling as the latent variable of the model. Now let's see P_t , as the probability that $y_t = 1$, then:

$$\Pr(y_t = 1) = \Pr(y_t^\circ > 0) = \Pr(X_t\beta + \mu_t > 0)$$

$$\Pr(y_t = 1) = \Pr(\mu_t > -X_t\beta) = \Pr(\mu_t \leq X_t\beta)$$

$$\Pr(y_t = 1) = \Phi(X_t\beta)$$

In accordance with this equality, he makes use of the fact that the standard normal density function is symmetric close to zero. The final result is what we would obtain from letting $\Phi(X_t\beta)$ be considered as the transformation of the function $F(X_t\beta)$.

The Logit model

The Logit model is very similar to the Probit model. The only difference is that the function $F(x)$ is now a logistic function (Galeano et al., 2010).

$$\Lambda(x) = \frac{1}{1 + e^{-x}} = \frac{e^x}{1 + e^x}$$

Which is derived in the following way:

$$\lambda(x) \equiv \frac{e^x}{1 + e^{-x}} = \Lambda(x)\Lambda(-x)$$

The first derivative is obviously symmetric close to zero, which implies that $\Lambda(-x) = 1 - \Lambda(x)$. The Logit model is easier to derive assuming that:

$$\log\left(\frac{P_t}{1 - P_t}\right) = X_t\beta$$

Which tells us that the logarithm of the probability (which is a ratio of the two probabilities) is equal to $X_t\beta$. Now let's solve for P_t we define

$$P_t = \frac{\exp(X_t\beta)}{1 + \exp(X_t\beta)} = \frac{1}{1 + \exp(-X_t\beta)} = \Lambda(X_t\beta)$$

The results that we would obtain letting $\Lambda(X_t\beta)$ be considered as the transformation function of $F(X_i\beta)$.

Pearson's Chi-Square

According to the author Iglesias (2012) who develops Pearson's Chi Square statistic in the following way, Pearson's Chi square that compares observed and expected frequencies in a binomial scenario, is defined as follows (Solano & Álvarez, 2005):

$$x^2 = \sum_{j=1}^J \frac{(y_j - n_j\hat{p}_j)^2}{n_j\hat{p}_j(1 - \hat{p}_j)} = \sum_{j=1}^J \frac{n_j(y_j - \hat{y}_j)^2}{\hat{y}_j(n_j - \hat{y}_j)}$$

It has the same asymptotic distribution as the deviation, that is, a Chi square with the same degrees of freedom. Thus, the null hypothesis will be rejected for the significance level α when $x^2 \geq x_{J-(R+1);\alpha}^2$, is equivalent to the p-value of the test being less than the level fixed α fixed. This statistic above can also be calculated as the sum of the squares

$$x^2 = \sum_{j=1}^J r_j^2$$

Where

$$r_j = \frac{y_j - n_j\hat{p}_j}{\sqrt{n_j\hat{p}_j(1 - \hat{p}_j)}}$$

Which were called Pearson's residuals. Both in order to apply the test based on the deviation and for the statistic x^2 , it must be verified that the number of observations for each combination of the explanatory variables is large, which is why these methods are not applied in the case of continuous variables or ungrouped Bernoulli models.

Analysis of variables

The study variables are (Table 2):

- Willingness to pay (DAP); Binary dependent variable that represents the probability of answering YES to the question of availability to pay or otherwise No; by the study population.
- Hypothetical price; continuous independent variable that represents the hypothetical price to pay for the improvement of the environmental services of the basin.
- Family income; Independent variable that represents the average family income of the population, being a determining variable that affects willingness to pay, which will be obtained through the survey data.
- Educational level: continuous independent variable that represents the years of study of the interviewee, which will show the level of environmental culture on the part of the study population.

- Age; Continuous independent variable that represents the age groups that are affected by the contamination of the Coata basin, which will be obtained through the survey data.
- Gender; Binary independent variable that represents the gender of the interviewee, in order to establish a relationship between the people who are more likely to get sick, women or men, which will be obtained from the survey data.
- Environmental perception; categorized independent variable that represents the environmental perception referring to the environmental problem that currently affects the Coata basin.
- Distance to the river; independent variable that represents the distance between the residence of each interviewee with respect to the Coata basin.

Table 2. Variables operationalization

Variable name	Representation	Indicator	Categorization or type of variable
Willingness to pay	DAP	yes No	1=Yes the user responds positively to the DAP. 0=NO if you respond negatively to the DAP
Hypothetical price to pay	PH	soles	Whole number (in soles)
Family income	IF	soles	1 = Less than 500 soles 2 = 501 - 930 soles 3 = 931 - 1200 soles 4 = Greater than 1200 soles
Education level	NE	Education	1 = No education 2 = Primary 3 = Secondary 4 = Technical 5 = Superior
Age	Age	Years old	1 ≤ 20 years 2 = 21 - 35 years 3 = 36 - 45 years 4 = 46 - 55 years 5 = over 56 years
Sex or gender	Gender	Male Female	0 = If you are a woman 1 = If you are male
Environmental perception	PA	Yes No	1 = Measurements are taken 0 = No action taken
Pollution level	PA	visual	1 = Very low 2 = low 3 = High 4 = Very high
Distance to the river	DA	Metres	1 = <500 meters 2 = 501 - 1500 meters 3 = 1501 - 2500 meters 4 => 2501 meters
Service	S	farming Consumption Recreation Others	1 = Livestock / agriculture 2 = Water consumption 3 = Recreation 4 = Other services

Source: self made.

3. RESULTS

Descriptive analysis

Analyzing the sex of the surveyed population, of the total of 369 people, there is a greater representation of men than women (Table 3).

Table 3. *Number of participants in the survey application in the Coata river basin, 2020*

Gender	Frequency	Percentage
Male	119	32%
Female	250	68%
Total	369	100%

Source: self made.

This part details the age of the respondents parameterized at the following levels such as, under 20 years old, between 21 and 35 years old, between 36 and 45 years old, between 46 and 55 years old, and over 56 years old, of which you can see the frequency and the percentage that they represent of the total of surveyed households (Table 4).

Table 4. *Age of Respondents in the Coata River Basin, 2020*

Age	Frequency	Percentage
≤ 20 years	5	1%
21 - 35 years	227	62%
36 - 45 years	85	23%
46 to over 55 years	52	15%
Total	369	100%

Source: self made.

Performing the analysis of the level of income received from the people surveyed, there is a greater group of people with economic income between 0 to 930 soles, followed by people who receive an income between 931 to 1200 soles; Due to the fact that the people surveyed are dedicated to a large extent to livestock and agriculture (Table 5).

Table 5. *Family Income of the inhabitants of the Coata River basin, 2020*

Description	Frequency	Percentage
Less than 500 soles	95	25.7%
Between 501 to 930 soles	94	25.5%
Between 931 to 1200 soles	99	26.8%
Greater than 1200 soles	81	22.0%
Total	369	100%

Source: self made.

In the case of the educational level of the surveyed population, most of the population has a secondary education level, followed by technical studies, and a low percentage is those with higher education (Table 6).

Table 6. *Educational level of the inhabitants of the Coata river basin, 2020*

Education level	Frequency	Percentage
Without education	7	2%

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Primary	21	6%
High school	139	38%
Technique	109	30%
Higher	93	25%
Total	369	100%

Source: self made.

Regarding the level of perception of pollution in the Coata River basin, only a minimal percentage of the surveyed population indicates that, if measures are taken to combat environmental pollution, while a large part shows that necessary measures are not taken to promote the decrease in pollution (Table 7).

Table 7. *Villagers' perception of environmental pollution in the Coata river basin, 2020*

Case	Frequency	Percentage
No action taken	336	91%
If action is taken	33	9%
Total	369	100%

Source: self made.

Regarding the level of contamination, most of the population that the contamination of the Coata river basin is very high to high, followed by a particular group that considers that the contamination is low (Table 8).

Table 8. *Villagers' perceptions of the level of environmental pollution in the Coata river basin, 2020*

Leven	Frequency	Percentage
Very low	8	2%
Low	52	14%
High	146	40%
Very high	163	44%
Total	369	100%

Source: self made.

In the case of the distance to the river, it was detailed in the operationalization of variables that the distance is measured in meters and parameterized, where most of the surveyed population is between 501-1500 away from the river (Table 9).

Table 9. *Distance of location of residents' homes with respect to the Coata River, 2020*

Description	Frequency	Percentage
<500 meters	100	27%
501 - 1500 meters	109	30%
1501 - 2500 meters	87	24%
> 2501 meters	73	20%
Total	369	100%

Source: self made.

In the case of the frequency of use of environmental services, a population group indicates their daily use, followed by those they use weekly (Table 10).

Table 10. *Frequency of use of environmental services by families in the Coata river basin, 2020*

Frequency	Frequency	Percentage
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Daily	146	40%
Weekly	141	38%
Monthly	65	18%
Annual	17	5%
Total	369	100%

Source: self made.

In the case of the variable types of environmental services, it can be seen that the largest environmental service is livestock / agriculture, followed by the consumption of water and other services (Table 11).

Table 11. *Environmental services by productive activity in the Coata river basin, 2020*

Description	Frequency	Percentage
Livestock / agriculture	142	38%
Water consumption	78	21%
Recreation	67	18%
Other services	82	22%
Total	369	100%

Source: self made.

Therefore, a large part of the population considers that the competent authorities do not take measures to mitigate the contamination of the basin, on the other hand, a small group considers that the authorities take some actions to avoid the contamination of the aforementioned river basin (Table 12).

Table 12. *Mitigation Measures for Pollution of the Coata River Basin, 2020*

Description	Frequency	Percentage
No	336	91.1%
Yes	33	8.9%
Total	369	100%

Source: self made.

Finally, when analyzing the willingness to pay, of the total of respondents, all of them indicated that they are willing to pay, while a minimum percentage indicates that they are not willing to pay for the improvement of the Coata river basin (Table 13).

Table 13. *Willingness to pay of the inhabitants for the improvement of the Coata river basin, 2020*

Disponibilidad	Frecuencia	Porcentaje
If you have to pay	342	93%
You do not have to pay	27	7%
Total	369	100%

Source: self made.

Analysis of results by objectives

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Overall objective result

In order to determine the general objective which is "To determine the economic value for the improvement of environmental services for the inhabitants of the Coata river basin." The potential economic value collected is obtained by multiplying the WTP which is 4.88 soles, therefore, the monthly economic value is 45,935.44 soles and annually amounts to 551,225.28 soles (Table 14). The equations with which the results were obtained are shown below:

$$VE_m = 4.88 * 9413 = 935.44 \text{ soles}$$

$$VE_a = (4935.44) * 12 = 551,225.28 \text{ soles}$$

According to the data obtained, we say that the economic value of the environmental services of the Coata river basin is 551,225.28 soles annually (Table 14).

Finally, it is concluded that the null hypothesis is rejected and the alternative hypothesis that we propose in the general specific objective is accepted, which mentions that: H_1 = The economic value for the improvement of environmental services for the inhabitants of the Coata river basin is lower to 7.00 soles per month, of which the general hypothesis raised in the general objective is accepted (Table 14).

Result of specific objective 1

For objective 1, which is "Determine the willingness to pay of families living in the vicinity of the river basin, for having a better environmental service", the Pearson Chi-Square test was carried out, in order to obtain the relationship between willingness to pay and distance to the river. We will detail the results obtained below in the following table:

Table 14. *Pearson's Chi-Square for the relationship between willingness to pay and distance to the Coata River, 2020*

DAP	1501 -	500 - 1..	< 500 m..	> 2500 ..	Total
No	6	5	1	8	20
yes	81	106	101	61	349
Total	87	111	102	69	369
Pearson chi2(3) = 9.6044			Pr = 0.022		

Source: self made.

The significance level of the p-value can be observed, which is 0.022, with which the null hypothesis is rejected and we affirm that the variables are dependent, that is, the DAP variable varies between the different levels of the distance variable. In accordance with this, we can affirm that the WTP is associated with the distance between their homes and that according to this, the price that the residents are willing to pay is obtained (Table 14).

In order to obtain the results of specific objective 1, which is to determine the availability due to the improvement of household environmental services that is associated with the distance from the Coata river basin, the mean statistical tool was used, where will be detailed below.

$$Monto = \frac{1826}{369} = 4.88$$

Carrying out the corresponding operations, the result obtained for the general objective tells us that the maximum price that residents are willing to pay based on the distance they are from the basin for the improvement of environmental services is 4.88 soles per month. This average price helps us determine the economic value of the environmental services of the Coata river basin that is observed in the general objective (Table 14).

As a conclusion of the specific objective 1 we reject the null hypothesis and accept the alternative hypothesis which mentions that: $H_1 =$ There is a full willingness to pay by the families that live in the vicinity of the river basin, for having a better service environmental with an average price of less than 7.00 soles per month. Likewise, the full availability to pay is a function of the distance that the residents' homes are with respect to the river basin. The monthly average raised will be analyzed in the discussion section with the authors who propose similar hypothetical prices in the availability to pay that they study.

Result of specific objective 2:

For this objective, which is to "Identify the main determinants that explain the willingness to pay for the environmental service in the basin", different regressions were carried out, in order to find the best model; Likewise, non-significant variables were discarded and the remaining significant ones were analyzed. Next, the regressions and their respective econometric interpretations will be presented.

The following table shows the four models, in which the most used criteria were used; Therefore, the logit2 model was selected, which was disaggregated from the logit1 model by selecting the significant variables. The logit2 model has its minor aic and bic criteria, the Logit 2 model is the one that contains the lowest value in terms of aic, however, for the likelihood statistic, the Probit2 model is the one with the highest value in terms of absolute values, with this We can see that according to the likelihood the best model is the probit2 but the logit2 model complies with the lowest aic and the most adjusted R2, thus showing that it is better compared to the others in order to perform the corresponding analysis.

Table 15. *Comparación de modelos para establecer las determinantes que expliquen la disposición a pagar por el servicio ambiental en la cuenca de río Coata, 2020*

Variable	Logit1	Logit2	Probit1	Probit2
Edad	.68836336*	.7341698*	.3335446	.34513821*
Sexo	-.96074837		-.46932749	
Educación	.74646462**	.81880031	.35922123	.40735381**
Empleo	.05192681		.02688895	
Ingreso	.45536324		.20880054	
Percepción	-1.3519517*	-1.2076189*	-.72297302	-.64811045*
Contaminación	-1.10542692		-.04999343	
Frecuencia	-.7437248*	-.61105069*	-.34231735*	-.28111469*
Distancia	-.67490146	-	-.32539902**	-.29338295**
		.61192738**		
Servicio	.21635227		.10139169	
_cons	1.2160284	1.0025499	.74639811	.61666119
r2_p	.24072343	.19666407	.22887586	.19162971
Aic	168.67871	167.19019	170.96745	168.16274

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Bic	211.69747	190.65497	213.98621	191.62752
ll	-73.339354	-77.595097	-74.483725	-78.081371
N	369	369	369	369

Leyend: * p<0.05; ** p<0.01; *** p<0.001

Source: self made.

As seen in the previous table, the logit2 model will be developed because it is one of the models that best fits and the level of significance of the variables is better, for the analysis of specific objective number 2, which is Identify the main determinants of willingness to pay since this turned out to be the best model that would explain the variables to be studied.

Logit regression for the specific objective 2, we will have:

Table 16. *Logit Model Estimation to explain the determinants of the willingness to pay for the environmental service in the Coata river basin, 2020*

Logistic regression					Number of obs =	369
					LR chi2 (5) =	37.99
					Prob > chi2 =	0.0000
Log likelihood = -77.595097					Pseudo R2 =	0.1967
DAP	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Age	.7341698	.3328509	2.21	0.027	.0817941	1.386546
Education	.8188003	.2554253	3.21	0.001	.318176	1.319425
Perception	-1.207619	.5251821	-2.30	0.021	-2.236957	-.1782809
Frequency	-.6110507	.268977	-2.27	0.023	-1.138236	-.0838654
Distance	-.619274	.2316718	-2.64	0.008	-1.065996	-.157859
_cons	1.00255	1.3057	0.77	0.443	-1.556575	3.561675

Source: self made.

For the estimation of the Logit model, 5 iterations were necessary (Table 16).

- The value of “Prob> chi2 = 0.0000”, which represents the value of P for the likelihood ratio test that tests the null hypothesis (H0) that all the beta coefficients of the model (the effects) are equal to zero, taking into consideration a confidence level of 95%, the null hypothesis of model 1 is accepted.
- The interpretation of McFadden's “Pseudo R2” indicates that approximately 19.67% of the variation in willingness to pay (WTP) can be explained by the variation of the independent variables of the model (age, education, perception, frequency and distance) . The model fits well when the Pseudo R2 approaches one, in this case specifically the model is moderately, some authors suggest that the R2 should be between 20% and 60% for them to fit well.
- Then in the table we see “P <|z|”, the P value of the test that tests the null hypothesis, that the coefficient of each variable is equal to zero. In this case, with 95% confidence we accept the H0 for all the variables of the model, since they all present data that are less than 0.05.
- For two of the five independent variables, the relationship with willingness to pay (WTP) is direct, since the signs of the coefficients of each of the independent variables (age and education) are positive. The remaining independent variables (perception, frequency and distance) have an inverse relationship, because the signs of the coefficients are negative. It should be noted that the coefficients only show the relationship that the dependent variable has with the independent variable.

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- The “z” values test whether the independent variables analyzed are significant, if said value is greater than 1.96 (with a 95 percent confidence level) it tests that each coefficient is different from zero and to reject said value it must be lower 1.96. Higher values of “z” mean that there is greater relevance of the variables, it should be noted that the values of “z” have to be greater than 1.96 in absolute value for the model to maintain these variables (significant). In this regression specifically, it can be observed that all the values of "z" are greater than 1.96, which means that all the independent variables are significant.

Analyzing the marginal effects for the Logit model, the following table shows that the average probability that if there is a full willingness to pay for the environmental service in the Coata basin is 96.08% (Table 17).

Table 17. *Analysis of the marginal effects of the determinants of the willingness to pay for the environmental service in the Coata river basin, 2020*

Marginal effects after logit							
$y = \text{Pr}(\text{dap})$ (predict)							
$= .96081525$							
Variable	dy/dx	Std. Err.	z	P> z	[95% C. I.]	X	
Age	.027641	.1192	2.32	0.020	.004284 .050998	2.5388	
Education	.0308273	.0099	3.11	0.002	.011423 .050231	3.70461	
Perception	-.073794	.04898	-	0.132	-.169794 .022206	.089431	
Frequency	-.0230056	.01016	-	0.024	-.042914 -.003098	1.87263	
Distance	-.0230386	.00869	-	0.008	-.040067 -.006011	2.36043	

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Source: self made.

The results allow us to see in the column "P> z" where the P value of the test that tests the null hypothesis is observed, that the beta coefficient of each variable is equal to zero. In this case, with 95% confidence, we accept H_1 for the independent variables (age, education, frequency, and distance), since these present data less than 0.05. While the perception variable, after applying the marginal effect, turned out to be not significant for the model (Table 17).

The remaining significant coefficients of the model estimate reflect the average marginal effects (dy / dx) of each independent variable on the probability of response, which indicate the following:

- The older the person or head of the family is, the probability that they are willing to pay (DAP) will increase by 2.77%.
- The higher the degree of education, the probability that they are willing to pay will increase 3.1%.
- The greater the frequency of use given to the services of the Coata river basin, the willingness to pay will decrease 2.3%.
- As long as it increases 1 meter away from the Coata River basin, the probability of willingness to pay decreases by 2.3%.

Finally, in specific objective 2, it is concluded that the null hypothesis is rejected and the alternative hypothesis proposed for this specific objective is accepted, which mentions that: $H_1 =$ Determinants that explain the willingness to pay for the environmental service in the basin are: Level education, age, sex, environmental perception, distance to the river. According to the econometric estimation carried out, the hypothesis proposed is corroborated.

4. DISCUSSION

The results obtained in the present research work are contrasted to the previous research by Silva (2011), which concludes that the average and expected value for an improvement in the services of the Coata River by the inhabitants is between 4.00 and 6.00 soles, but it differs from the statement it makes, that most of the families interviewed have a monthly income of less than 500.00 soles since in our results we see that most of the population earns between 931 to 1200 soles; on the other hand, the second largest population is less than 500.00 soles and the result of Silva's previous research (2011) can be explained. The assimilation of Huayhua (2015) is also rescued, which explains that the analysis of relationships causes an effect that has shown important effects between the variables of age and gender, where it tells us that this has a great impact in terms of the amount, they are willing to pay.

In addition, the research determines that 92.68% of the population in the study area is willing to pay and an average of 4.88 soles per household for the improvement of environmental services in the Coata river basin, this percentage is very significant as work de Bergstrom and Loomis (2017) who, in their valuation research related to the restoration of rivers in the United States and Europe, found that the willingness to pay is 70%, but it determines the amount to pay. When noting the results of specific 1 that indicates that if there is a direct relationship between the families' willingness to pay and the distance to the Coata river basin, the investigation by Salas (2014) confirms that the DAPT depends on their investigation significantly from distance. Therefore, it is important to mention that it is also confirmed that those most interested in having an improvement in the environmental service of the basin are the inhabitants who live in the vicinity of it (Perevochtchikova & Oggioni, 2014; Perni & Martínez-Paz, 2012; Ribeiro & Cherobim, 2017).

Also, Rahman et. to the. (2017) determined that only 65% responded affirmatively to the willingness to pay for the improvement in water quality with 3.64 soles per month. The present investigation, unlike the aforementioned authors, studies the population that lives both near and far from the Coata river basin, for this reason a higher amount of 4.88 soles is determined, where people who do not live nearby are very willing to contribute economically for the improvement of environmental services. In the same way, the present investigation has a significant percentage with the study by Huayhua (2015), where the willingness to pay is 92.68% and the second 95.7%, both investigations have a high percentage of willingness while the first has a higher amount of 4.88 soles and the other of 2 soles, amounts that differ greatly. On the other hand, Guzmán (2015), determines that the willingness to pay for the improvement of the quality of the water and the landscape is 5 soles per family per month, the difference to this research is that the author investigates an urban area of which the provision to pay is higher, finally there is a difference between the two studies that the first has a willingness to pay of 83% with 5 soles and the second with a DAP of 92.68% with 4.88 soles.

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The results that were obtained contrast with the previous studies that were developed in the antecedents, that with higher education there is greater willingness to pay, as pointed out by Acolt et al. (2016) in their studies, the more educational instruction an older person has, they will be willing to pay (Rowlands, 1995; Wälti, 2004). Likewise, Rojas (2019) maintains that one of the most significant variables is education. On the other hand, our research shows that one of the outstanding variables for which the Chi-square test was performed showed that the distance from the river is a determinant for the availability to pay and the hypothetical price. On the other hand, Tudela-Mamani et al. (2018) contrasted that age is one of the variables that most influence the willingness to pay, as obtained in the results of their research.

Regarding the results obtained from objective 2, they contrast with previous research such as that of Tudela-Mamani et al. (2018) which indicates that the main determinants or have the greatest influence that explain the willingness to pay for the environmental service are age, education and income level, in addition, especially the age variable was one of the most significant, which influenced the willingness to pay (DAP).

Likewise, the result is contrasted with Salas (2014) and Huacani (2013) that indicate that DAPT depends significantly and positively on education and age; on the other hand, they also mention that the DAPT depends significantly and negatively on the hypothetical price and on the distance.

On the other hand, according to previous studies that were developed in the antecedents, it was found that the higher the education there is the greater willingness to pay, as pointed out by Acolt et al. (2016) in their studies, the more educational instruction an older person has, they will be willing to pay (Salas Tapia, 2014; Serrano, 2015; Sertzen, 2016). Likewise, According to Rojas (2019) also maintains that one of the most significant variables is education.

Likewise, Aguilar-Sánchez and De la Rosa-Mejía (2018) argue that one of the variables analyzed that most influence this type of study (CVM) is the educational level, which in the present work had a positive impact in relation to the disposition to pay (DAP); thus being one of the most significant variables developed in the model.

Environmental improvements focused on improvements in water quality and improvements in the quality of the urban landscape commonly called environmental services. These empirical results of the study will help to provide some relevant economic instruments for the design of payment schemes for environmental services in the Puno region that allow a significant environmental improvement in the contour of the Coata River in the long term (Elliff & Kikuchi, 2015; Ferrer & Torrero, 2015; Gallego-Álvarez, 2018).

Additionally, Guzmán (2015) performs an analysis similar to the present investigation, considering the importance of the environmental services of the Huatanay river basin, demonstrating that the willingness to pay for having a better water quality and the landscape amounts to 5 soles monthly per household, complemented by the economic value that they are willing to contribute by having better environmental conditions for the river, which amounts to 5.4 million soles per year.

Finally, it is necessary to mention that the novelty of the present investigation is that an application of the contingent valuation model and the binomial logit econometric model is applied to the environmental services of the basin, a question that is little applied to date, the results obtained will serve to decision-making by current and future authorities for the critical remediation of the negative environmental impact that has been affecting the Coata River basin and / or similar in Peru and the rest of the world. The weakness identified in the research is the application of econometric models to hydrographic basins, an issue little handled in other similar investigations and that can continue to improve in future investigations; just as it is necessary to continue developing research similar to the present one, but emphasizing the economic value that natural resources, the landscape and the environmental elements of nature can have, but applied to integral systems of basins.

5. CONCLUSIONS

The potential economic value collected is obtained by multiplying the DAP which is 4.88 soles, therefore, the monthly economic value is 45,935.44 soles and annually amounts to 551,225.28 soles. These results were obtained through statistical analysis, using a χ^2 Pearson model, they are also confirmed with a simple average of the results.

For the first specific objective, the results show that the closer the family is to the river and is willing to pay for the improvement of environmental services, the amount of money also increases, that is to say that being within a small radius of the river its disposal to pay increases. Determining in this way that there is full willingness to pay by the families that live in the vicinity of the river basin, for having a better environmental service with an average price of less than 7.00 soles per month.

The variables age, education and frequency of use of the environmental service determine the willingness to pay for the environmental service in the Coata River basin; Since the older the person or head of the family is, the probability that they are willing to pay (DAP) increases by 2.77%, while the higher the level of education, the probability that they are willing to pay will increase by 3.1 %, the higher the frequency of use that is given to the services of the basin, then the willingness to pay will decrease by 2.3% and while it increases by 1 meter away from the river, then the probability of willingness to pay is reduced by 2.3%.

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