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Original Article

Determination of the Willingness to Pay for Drinking Water in the City of Puno

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Abstract *- The present research has been carried out in the city of Puno, involving the inner bay of Lake Titicaca, to consider the services provided by the ecosystem, with the objective of determining the economic value of drinking water in the city of Puno. The scientific method, direct observation, applied research, explanatory level, and non-experimental design have been used. The willingness to pay was determined by the contingent method using the Nlogit 3.0 software and the determination of the variables that most affect the willingness to pay. As results have the discharge of water punctually and diffusely, and there is no sewage treatment, the values exceed referring to water quality according to the supreme decree N° 004-2017-MINAM. There is a willingness to pay an additional S/. 1.90 soles monthly in water bills, with an average of S/. 0.60 soles per month. The variables that influence the willingness to pay of domestic water users are income, education level and household size. Finally, the water quality in the inner bay of Lake Titicaca has deteriorated, exceeding some maximum values established by the supreme decree N° 004-2017-MINAM, and there is a clear willingness to pay for a better drinking water service.*

Keywords *- Contingent, Economic valuation, Inland bay, Quality and water.*

1. Introduction

The rapid urbanization and escalating urban expansion over recent decades have led to a notable decline in green and natural spaces within our cities [1]. Among Puno's myriad challenges, urban population growth stands out as a significant issue. This predicament is closely tied to the encroachment upon natural areas, the depletion of natural resources, and environmental degradation [2]. This is exacerbated by the limited understanding, handling, and administration of these resources, the lack of public policies safeguarding them, the absence of forward-looking perspectives, and comprehensive planning and land management [3].

The aforementioned contribute to inequality and lack of opportunity for the most vulnerable population due to the limited participation of the population and the different actors in decision-making (authorities) under an organizational and institutional approach in the processes required by the drinking water service for decision-making.

Regardless of our location, our daily routines rely heavily on goods and services sourced from ecosystems and water-related activities [4]. With the global population continuing to expand, the availability of forests and other natural resources is diminishing [5]. Consequently, many of our requests for natural products will go unfulfilled [6]. This is due to the fact that while our desires and necessities are boundless, the capacity of natural resources to satisfy them has become constrained [7].

Likewise, the problem of the drinking water system, as well as the sewage system of the city of Puno, is a current problem since Lake Titicaca is becoming more and more polluted every day. The main catchment for the drinking water supply for the city of Puno, the water to be collected, is increasingly polluted; where the catchment source is Lake Titicaca, the water collected requires high treatment costs. Adding to this problem, it can be said that the operational and administrative parts are factors that determine a good quality service of drinking water to the citizens of the city of Puno. These reasons make it necessary to value the water resource.

The supply of drinking water to the city of Puno has three sources: Chimu catchment (surface source) of water from Lake Titicaca with a maximum flow capacity of 450 liters per second (l/s), is currently operating with a flow of 310 l/s by

provisions of the EMSAPUNO; the pipeline, leads 92% of the water produced, next to this is the old catchment, currently inoperative due to cavitation problems; Totorani catchment that supplies water through filtering galleries from springs with a contribution of 2% of the water produced [8].

The coverage of the services was carried out considering the population as of 2016, estimated in the 2013 - 2018 tariff study approved by SUNASS and EMSAPUNO S.A. Through EMSAPUNO, 83.72% of the population under its purview is supplied with drinking water service, and 78.08% with sewerage service in the city of Puno; prior to the tariff update, drinking water coverage was 89.95%, and sewerage coverage was 84.71% due to the cost update made with the total number of sewerage use units in the city of Puno [8].

At present, Lake Titicaca and the inner bay of Lake Titicaca, called the Titicaca National Reserve (RNT), are being polluted day by day by direct discharges of sewage and solid waste; such discharges are degrading every day by widespread pollution, that is seriously affecting the bay of Puno [9].

The most important benefit of the conservation of natural resources, which requires maintenance and intervention in the medium and long term, the ecosystem involving the water resource; in addition, it is required as soon as possible the organization of the main actors for decision-making in order to take advantage of the ecosystem services produced by the inner bay of Lake Titicaca as recreational services; tourism, consumption, among others. The same requires research and/or economic valuation studies of these benefits through the implementation of environmental management policies; such research should be implemented by the political authorities to generate a change and impact on society.

However, the difficulty in measuring the valuation of natural resources, which are often not market-driven, where property rights are not yet clearly defined [1, 10, 11], has led to the use of the methodology based on hypothetical markets, as is the case of the contingent method, which uses socioeconomic factors to determine the willingness to pay for an environmental benefit and/or service required to tolerate a cost in the use of a resource, under a hypothetical market scenario [12-16].

Among the problems presented by the Sanitation Service Provider Companies in Peru (EPS), these companies represent a public company owned by the municipality [13, 17-21]. According to the framework law for the management and provision of sanitation services - Legislative Decree No. 1280, there are management problems such as collection, delinquency ratio and the amount of tariffs [22].

The research problem analyzed is the poor service of drinking water and the lack of conservation of the ecosystem in view of the fact that it provides many environmental services and the lack of valuation for its conservation. Anthropogenic actions include pollution, environmental degradation, indiscriminate use of water resources, and bad habits of coexistence with nature and environmental assets. These actions mean that the goods and services of the ecosystem that develops in the inner bay of Lake Titicaca in the city of Puno are not valued.

The problem of drinking water service in the city of Puno is latent because citizens consume water from Lake Titicaca, catchment Totorani and Aracmayo catchment; these catchments are located in Chimu and Totorani, respectively. The distribution is very irregular due to a lack of technical staff with skills in hydraulic systems of drinking water distribution [23]; it is also due to poor administration by EMSAPUNO officials. For the reasons given above, it is necessary to implement new strategies to value the water resource, to help conserve and recover the inner bay of Lake Titicaca, rationalizing resources and having a water culture in the city of Puno [22-27].

Nowadays, it is unavoidable to economically value water in its productive functions, either from a “supply” approach based on the costs produced or from a “demand” approach, reflecting the value of the productivity or profit generated [19, 28, 29].

Water is the most important resource for the development of socioeconomic activities in Lake Titicaca's inner bay; however, it depends on variables such as quality, quantity, and final availability for the proper development of socioeconomic activities that depend on how other natural resources such as vegetation, soil, and biodiversity are managed, managed, and valued under a systemic approach, considering the interactions of these resources with human activities [20, 30, 31]. Some studies have already been carried out, but they are not implemented, and there should be public policies that establish a baseline for monitoring and evaluating natural resources to support decision-making. There is no economic valuation of water resources in the inner bay of Lake Titicaca.

Water, often referred to as the essence of life, is an indispensable natural resource that sustains all forms of life on our planet [32]. Its availability and quality directly impact human health, agriculture, industry, and the environment. Recognizing the critical role water plays in our daily lives, it becomes imperative to assign an economic value to it [33]. This process, known as the economic valuation of water, enables us to understand and quantify the various dimensions of water's worth, extending beyond its immediate utility [2].

This essay elucidates the significance of the economic valuation of water resources in comprehending its broader socioeconomic and environmental implications [15]. Through this, we can make informed decisions regarding water

management, conservation, and sustainable use, thereby ensuring the well-being of present and future generations [34].

This research aims to contribute to the entire population and the EMSAPUNO that are developing environmental activities, management and management of drinking water service in the city of Puno. The study contributes to the operation of the same so that they are really effective and respond to the real needs of the population and their environment, in view that the study will have the study of how much are willing to pay for the population in order to improve or implement a new project, concerning the drinking water service for population use and the services provided by the water resource in the inner bay of Lake Titicaca.

2. Materials and Methods

Puno, also known as San Carlos de Puno, was founded on November 4, 1668. It serves as the principal city in southeastern Peru and holds the distinction of being the capital of both the department and province of Puno. Situated at approximately 15°50′15″ S latitude and 70°01′18″ W longitude, it occupies a strategic geographical position.

The inner bay of Lake Titicaca is located on the shores of the city of Puno, in the department, province, district and city of Puno; being located in southeastern Peru, it is located between the geographical coordinates 15°50′15″ S 70°01′18″ W. It extends between the promontories of Chulluni, to the North, and Chimú, to the South.

The bay has an area of about 16 km², with an approximate volume of water of 43,000 m³. Within the bay of Lake Titicaca are the islands of Esteves and Espinar, which are rocky and firm morphological units and have an attractive landscape for recreation and tourism, which is currently deteriorated by bad odors due to the discharge of untreated sewage.

According to the National Institute of Statistics and Informatics, the city of Puno is the twentieth most populated city in Peru and had a population of 145,179 inhabitants in 2017 [35].

2.1. Description of the Method

2.1.1. Study Period or Sampling Frequency

The study period was developed in 2021, and the scientific method, direct observation, applied research, and explanatory level with the non-experimental design have been used [36]. The willingness to pay has been determined by the contingent method using the Nlogit 3.0 software and the determination of the variables that most affect the willingness to pay. The scientific method is part of a sequence of steps, methods, tools and techniques to solve research problems and test the hypothesis proposed.

Fig. 1 Location map of the study area

2.1.2. Detailed Description of the Materials, Inputs and Instruments

The economic valuation of the demand for the protection of the water Environmental Service (E.S.) was based on the Contingent Valuation Method (CVM), which allows estimating, in a hypothetical market, the willingness to pay for improvements to an environmental good or service, based on the stated preferences of the demanders [37, 38].

The sample size of the inhabitants of the city of Puno has been calculated, which is 384 heads of family of each household interviewed; in order to reduce the error, it has been determined to survey 429 heads of the family of each household surveyed, for the determination of the economic valuation; considering the following variables (Table 1).

Table 1. Identification of variables for the contingent method

Variables	Presentation	Explanation	Quantification
Prob (YES)	Probability of answering YES	Binary dependent variable that represents the probability of answering YES to the willingness to pay question.	1 = If the user responds positively to the DAP question. 0 = If the user responds negatively.
PREC	Hypothetical price to pay	Independent variable that takes the value of the fee asked for improving the appearance of the inner bay of Lake Titicaca.	Whole number (S/. 0,10; S/. 0,50; S/. 1; S/. 2 y S/. 3)
PA	Environmental perception	Independent binary variable that represents the perception of the degree of deterioration of the inner bay of Lake Titicaca.	0 If not considered deteriorated, 1 = If considered deteriorated.
ING	Income	An ordered categorical independent variable that represents the total monthly income of the head of household or person in charge of the household.	1= Less than S/ 400, 2= S/ 401 - S/ 1000, ...7 More than S/2500.
EDU	Education	Ordered categorical independent variable that represents the educational level of the respondent	1= Elementary 2= Secondary 3= Technical 4= University 5= Postgraduate
GEN	Gender	Independent binary variable representing the gender of the respondent.	1= If male 0= If female
TAH	Household size	Continuous independent variable representing the size of the respondent's household.	Whole number
EDA	Age	Ordered categorical independent variable representing age in years of the respondent.	1= 18-25 years old 2= 26-35 years old 3= 36-45 years old 4= 46-55 years old 5= 56-89 years old

Once the study variables were considered, the following question was asked:

To the surveyed households, the following question has been asked: considering your income, expenses and personal preferences, would you be willing to pay S/. _____ as an additional amount to the drinking water bill for the execution of the improvement of the 24-hour drinking water service, decontamination and conservation of the natural resources of the inner bay of Lake Titicaca?

YES ☐ NO ☐

Approach of the *logit* model to be estimated

$$psi(y=1) = F\begin{pmatrix}\beta_1 + \beta_2 prec + \beta_3 ing + \beta_4 edu \\ +\beta_5 pa + \beta_6 gen + \beta_7 tah + \beta_8 edad\end{pmatrix} + \varepsilon$$

$$psi(y=1) = \frac{1}{1 + exp^{-\beta_1+\beta_2 prec+\beta_3 ing+\beta_4 edu+\beta_5 pa+\beta_6 gen+\beta_7 tah+\beta_8 edad}}$$

B_0, B_1, B_2, B_3, B_4, B_5, B_6, y B_7, Coefficients to be found

$\mathcal{E}_i$, Error to be estimated

To achieve this objective, the sample size of the inhabitants of the city of Puno was calculated [38-40], and the economic valuation was estimated by the contingent valuation method in order to see the environment, where it has been analyzed based on a survey, with the variables that have the greatest impact and considering the following variables:

Amount willing to pay in addition to the monthly water rate (in Soles)

- Level of education (primary, secondary, higher)
- Family income (in Soles)
- Family size (number of family members)

The logit model was used, considering the variables with the highest incidence to determine the DAP.

2.1.3. Variables Analyzed

Economic valuation of the water resource

Dimension 01: Socioeconomic Factors

For the collection of data on socioeconomic factors, the survey has been applied by visiting households, considering the sample size, where it has been stratified by each

neighborhood of the city of Puno, where information has been collected on the following variables:

- Price (PREC): Monetary value that the drinking water user of the population of the city of Puno is willing to pay additionally in their water bill for the best drinking water service on a monthly basis for each family/household.

- Age (EDA): Age corresponding to the head of household.

- Gender (GEN): Gender corresponding to the head of household and/or respondent.

- Household size (TAH): Number of persons in the respondent's household.

- Education (EDU): Represents the education level of the head of the family interviewed.

- Income (ING): Represents the average monthly household income of the respondent.

- Environmental Perception of Drinking Water (P.A.): represents the interest that the person has in the care of water and its environment.

Dimension 02: Probability of willingness to pay P (Yes)

- Represents the probability that the respondent answers affirmatively (YES) or negatively (NO) to the willingness to pay (DAP) question.

2.1.4. Applied Statistical Test

The research design is non-experimental [41]; the present figure shows the variables to be studied.

The data processing techniques were given as follows:

- To see the location of the drinking water system network - water resource, Geographic Information System (GIS) was used, which allowed visualizing the locations of the dwellings to be surveyed.
- For data pre-processing, Microsoft Office Excel was used, using the statistical program *Infostat* and *NLogit* 3.0.
- For the economic valuation, Data processing was carried out using *NLogit* 3.0 and Excel 2019 for data management, both in their free trial version.

The descriptive analysis of the data was performed at the end of the surveys containing the socioeconomic variables, making a clean matrix of errors, proceeding to analyze the data obtained as the probability of affirmative or negative response to the DAP (PSI), the variables studied are the hypothetical price to pay (PREC), Age (EDA) of the respondent, gender (GEN), Household Size (TAH), Level of Education (EDU), Family Income (ING), and Environmental Perception of Drinking Water (P.A.). The variables obtained were through the surveys. The calculation of descriptive statistics was performed using *NLogit* 3.0 software.

- Analysis of the economic valuation using NLogit 3.0 software and Excel 2021 for the economic valuation of the drinking water resource for the city of Puno, using the contingent valuation method, using the Logit model through an econometric model, 429 surveys were carried out with the heads of family of the households surveyed in the city of Puno.

- The methodology used was estimating the economic valuation through the Willingness to Pay (WTP).

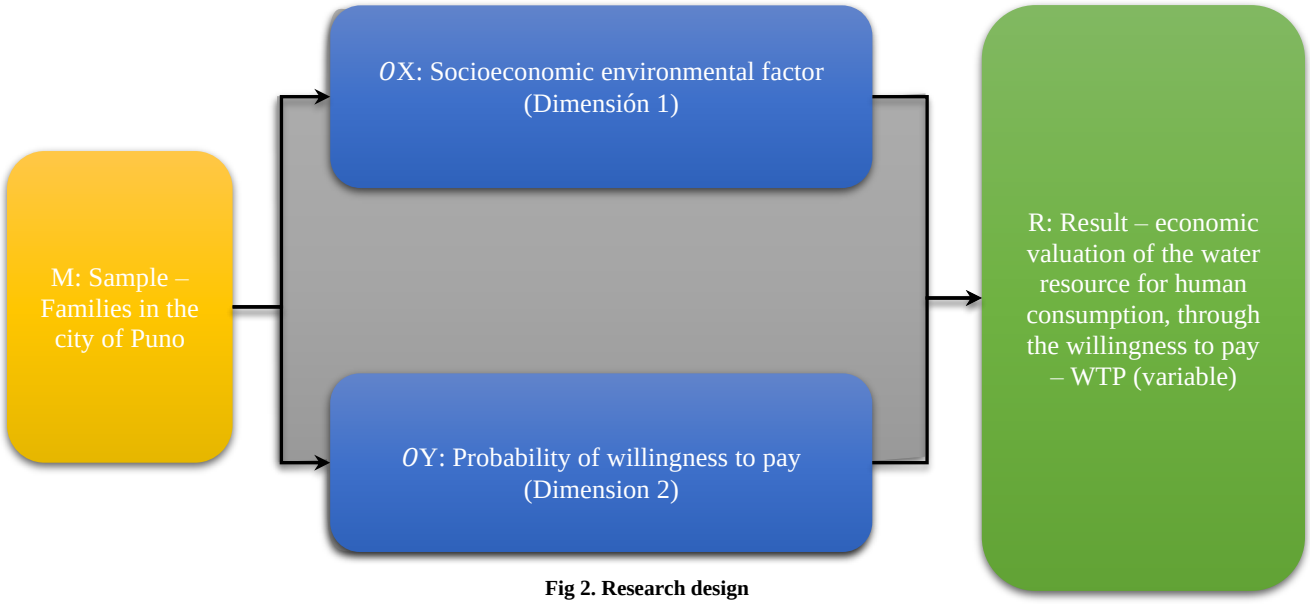

Fig 2. Research design

Application of the Probabilistic logit Model for WTP Estimation

To determine the willingness to pay of the inhabitants of the city of Puno, the probabilistic model was used as a function of socioeconomic factors; the *logit* model, the function used is logistic, according to the following probabilistic equation:

$$P_i\left(y=\frac{1}{X_i}\right)=Y_i=\frac{1}{1+e^{-\alpha-\beta_k*X_{ki}}}+\epsilon_i = \frac{e^{\alpha+\beta_k*X_{ki}}}{1+e^{\alpha+\beta_k*X_{ki}}} \quad (1)$$

Where:
$P_i\left(y=\frac{1}{X_i}\right)=Y_i$ probability of saying Yes to the willingness to pay (WTP).
X_i: matrix of variables that explain the probability.
Substituting the equation $z_i=\alpha+\beta kXk_i$, then have:

$$P_i=\frac{1}{1+e^{-z_i}}+\varepsilon_i \quad (2)$$

The above equation is the logistic distribution function. For the verification, we have used the measure of Z_i, between the following values $(-\infty\ \alpha+\infty)$, Y_i lies between the values 0 to 1, and P_i is not linearly related to Z_i (i.e. to X_i).

If P_i is the probability of WTP, then 1- P_i is the probability of no WTP.

$$1-P_i=\frac{1}{1+e^{-z_i}} \quad (3)$$

The equation can be written in the form:

$$\frac{P_i}{1-P_i}=\frac{1+e^{z_i}}{1+e^{-z_i}}=e^{z_i} \quad (4)$$

Where $\frac{P_i}{1-P_i}$ is the odds ratio in favor of the willingness to pay (WTP), considering the natural logarithm to the odds ratio is obtained:

$$L_i=\ln\left(\frac{P_i}{1-P_i}\right)=z_i=\alpha+\beta kXk_i \quad (5)$$

Where L_i represents the logarithm of the odds ratio, considering that it is not necessarily linear in X_i, but also (estimation) linear in the parameters L represents the probabilistic *logit* model. βk is the contribution or impact of Xk_i, corresponding to the explanatory variables; said parameters measure the change in L by varying a unit change in Xk_i [23].

Willingness to Pay as a Function of Socioeconomic Characteristics

Considering the linear equation of the econometric model used is:

$$Z=\alpha\pm\beta_1PREC\pm\beta_2EDA\pm\beta_3GEN\pm\beta_4TAH\pm\beta_5EDU\pm\beta_6ING\pm\beta_7PA\pm\beta_8EDAD \quad (6)$$

Analysis will be performed:

$\beta_i = 0$; explanatory variables are irrelevant.
$\beta_i \neq 0$; explanatory variables are significant.

The logit Type Model to Estimate its Parameters with Binary Variables are

$$Prob=P(SI)=\frac{e^z}{1+e^z}\ or\ also\ expressed\ as\ Prob=\frac{1}{1+e^{-z}} \quad (7)$$

This is the *logit* equation.

3. Results and Discussion

The results presented for the determination of the economic value of water to improve the quality of drinking water supply service for domestic use in the city of Puno.

The existing contamination in the inner bay of Lake Titicaca in the city of Puno is generalized according to Tudela and Leos [18], Tudela [42]; this is reaffirmed by the present investigation where it can be said that each time the contamination by the dumping of wastewater and solid waste is greater; the same that reaches the political agenda on the pollution of the inner bay of Lake Titicaca, since it has become a major social problem, as it generates discomfort to the Puna population, the most affected are the people living near the inner bay of Lake Titicaca.

In order to determine the degree of correlation of the variables studied, it was found that they are highly correlated, as shown in the following table.

From the table above, it can be said that in education, there is more probability of saying yes, as well as the contribution itself. Environmental perception has a negative relationship with respect to age; the older the person is, we consider that he/she is not interested in the environmental part.

Furthermore, based on the previously conducted analyses, we have obtained the marginal effects, which represent the partial derivatives of the probabilities in relation to the set of characteristics. These have been computed using the means of the variables in Xs. It is important to note that all available observations were utilized in this process.

According to the table above, it can be said that the price to pay and age have a significance at P < 0.05. and the model is: Y = -0.609 - 0.006xhypotheticalP. to pay + 0.079xIncome + 0.181xEducation + 0.064xEnvironmental perception - 0.081xGender - 0.064xHousehold size - 0.004xAge.

Table 2. Correlation matrix for variables

Variables	Hypothetical P. to pay	Probability YES	Gender	Household size	Age	Education	Income	Environmental Perception
Hypothetical P. to pay	1	0,1196	0,1250	-0,0799	-0,0970	0,3000	0,2345	0,2052
Probability YES	0,1196	1	0,0031	-0,1899	-0,1345	0,2755	0,2362	0,0980
Gender	0,1250	0,0031	1	-0.0794	0,0535	0,1993	0,0658	0,0624
Household size	-0,0799	-0,1899	-0.0794	1	0,2302	-0,08661	0,0399	-0,1882
Age	-0,0970	-0.1345	0,0535	0,2302	1	-0.2929	-0,0453	-0,0674
Education	0,3000	0,2755	0,1993	-0,0866	-0,2929	1	0,1853	0,1419
Income	0,2345	0,2362	0,0658	0,0399	-0,0453	0,1853	1	-0,0314
Environmental Perception	0,2052	0,0980	0,0624	-0,1882	-0,0674	0,1419	-0,0314	1

Table 3. Marginal effects

Variable	Observations
Constant	-0,60875
Hypothetical P. to pay	-0,00620
Income	0,07890
Education	0,18108
Environmental perception	0,06435
Gender	-0,08095
Household size	-0,06445
Age	-0,00362

3.1. Statistical Analysis of the Model

3.1.1. Individual Significance (Relevance)

The estimation of (Z-Statistic: b/St.Er.) is observed to be good individual significance for the following variables: education level, family income and household size, of the estimated variables.

3.1.2. Joint Significance (Dependence)

For the model or the ensemble, the significance is very high because the p-value of the likelihood ratio statistic is very small. In effect, one has:

$$RV = 2[\ell_{NR} - \ell_N] = 2[-244{,}8023 + 278{,}8823] = 68{,}160$$

$$X^2_{q,a=5\%} = X^2_{q,a=5\%} = 14{,}067$$

$$RV > X^2_{q,a=5\%}$$

Ho is rejected; it is concluded that there is joint dependence and all variables together are statistically significant (at a 5% significance level) in the model.

3.1.3. Model fit (Pseudo R-squared or McFadden's R-squared)

With respect to the Pseudo *R-squared*, we have a value of 0.3809 (not too close to unity); the value found reflects that there is a good fit in the model since this value is between the interval of 0.20 - 0.40; the range of values is equivalent to a conventional R^2 between 0.70 - 0.90. The calculation of the *Pseudo R-squared* is as follows:

$$pseudoR^2 = 1 - \frac{\ell_{NR}}{\ell_N} = 1 - \frac{-244{,}8023}{-278{,}8823} = 0{,}12220209$$

The prediction value, represented by the percentage, of the econometric output can be constructed in the following table of correct predictions:

Table 4. Frequencies of actual and predicted outcomes

Actual	0	1	Total
0	59	93	152
1	24	253	277
Total	**83**	**346**	**429**

$$PPC = \frac{(59 + 253)}{429} * 100 = 72{,}72727\%$$

The model adequately predicts 72.727% of the observations.

According to the table above, it can be said that family income, education and family size have a significance at P < 0.05. and the model would be: Y = - 2.538 + 0.342xIncome + 0.793xEducation + 0.245xEnvironmental perception - 0.363xGender - 0.285xHousehold size - 0.01xAge - 0.03xHypothetical P. to pay.

The estimation obtained using Maximum Likelihood lacks interpretation in terms of probability, and the model is due to the fact that they are not linear in the parameters. However, the interpretation of the relationship of the dependent and independent variables is:

The income variable (ING), the variable under study, gave a positive response, indicating that the higher the income level of the head of family or household surveyed, the greater the probability of obtaining a positive response.

Table 5. Final logit model of prediction

Variable	Coefficient	Standard Error	b/St.Er.	P||Z>z]	Mean of X
Constant	-2,53755	1,00768	-2,51800	0,01180	-
Income	0,34218	0,08329	4,10800	0,00000	4,63170
Education	0,79284	0,18783	4,22100	0,00000	3,63636
Environmental Perception	0,24516	0,28928	0,84800	0,39670	0,82051
Gender	-0.36309	0,22988	-1,58000	0,11420	0,44289
Household size	-0,28507	0,07985	-3,57000	0,00040	4,07459
Age	-0,00997	0,10292	-0,09700	0,92280	3,15618
Hypothetical P. to pay	-0,02954	0,06601	-0,44800	0,65440	3,35012

Table 6. Willingness to pay

Variable	Mean	Standard Deviation	Minimum	Maximum	Cases
DAPR	1,93706	0,56414	0,05619	2,91318	429

The variable Education Level (EDU), this variable varies, depending on the level or degree of education achieved, increases the probability of responding positively to the question of willingness to pay for the recovery, conservation and improvement of the drinking water service and the decontamination of the inner bay of Lake Titicaca; This corroborates what was expected a priori, that is, the more educated the heads of household are, the more aware they are of the environmental problems and the degree of deterioration of the inner bay of Lake Titicaca.

Therefore, they are willing to sacrifice part of their income for a program of recovery, conservation of the ecosystem and improving the quality of drinking water service for human consumption.

The variable of Household Size (TAH) gave us, as a response to the research, a positive value. This variable is directly related to the education variable; the more educated the population, the greater the predisposition to contribute to the development of the program to improve the drinking water system in the city of Puno, the probability of obtaining a positive response from the respondent, because the health of his family is affected, considering that he wants the welfare of his family, from all the respondents of the city of Puno.

The welfare measure used to aggregate benefits of the mean willingness to pay of the restricted model, which was S/. 4.50 soles; what was found by Sucasaca (2014) to perform the valuation of water at the level of the city of Juliaca is an amount of S/. 12.29 soles, also found another lower value of S/. 4.03 soles of the valuation of water for human consumption in the city of Juliaca made Coaquira (2017) take into account what was suggested by Tudela (2021), who proposes the linear aggregation of the WTP of the beneficiaries of a policy as a way to find the aggregate benefits, we proceeded to estimate this measure.

The willingness to pay by the heads of the family of each surveyed household who live and reside in the city of Puno is S/. 1.90 soles monthly and in addition to their water bill, which they would be willing to pay for the improvement of drinking water service and the decontamination and conservation of the inner bay of Lake Titicaca, which could allow some conservation activity at the level decontamination of the inner bay of Lake Titicaca.

The authors Anteneh et al. [29], Malinauskaite et al. [33], Islam et al. [43], Temkin et al. [44], and Wang and He [45], conducted similar studies using the contingent valuation in all cases there was a willingness to pay, for which a survey of the heads of the family was conducted as in our case. However, local studies determined as follows the contingent valuation method Achulli (2016), where he determined the willingness to pay S/. 5.65 soles per month and S/. 17.49 to improve the quality of drinking water service, these studies do not reflect whether EMSAPUNO would like to apply that amount.

According to Tudela (2021), where he refers that eutrophication occurs due to poor wastewater treatment processes and direct discharge into Lake Titicaca; Cayo (2014), who studied the quality of service on Taquile Island, concluded that they are willing to pay an additional S/. 14.00 soles additional to all services rendered by those who provide tourist services, including drinking water service; Tudela and Leos (2017) where determined a willingness to pay S/ 4.38 soles per head of household, where families closer to the inner bay of Lake Titicaca, are more willing to pay compared to those who are farther away to the inner bay of Lake Titicaca.

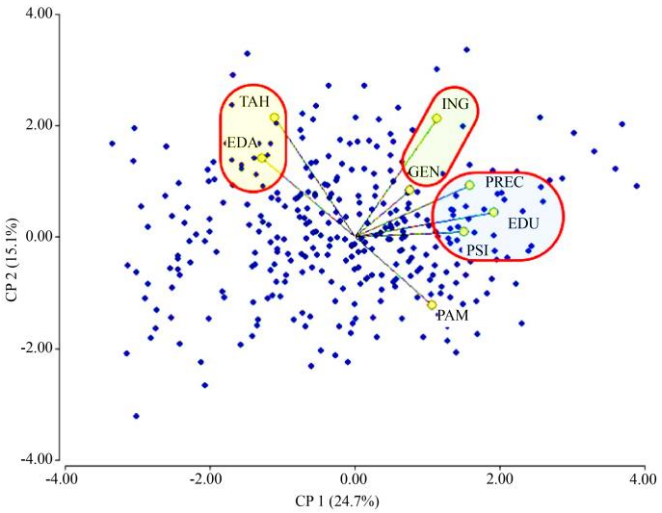

Fig 3. Principal component analysis

According to the aforementioned studies, the willingness to pay differs greatly. For our research, the willingness to pay is S/. 1.94 soles, which we consider reflects the reality of what each head of the family is willing to pay, given that the new rate increase according to the average family consumption for monthly payment is 3.04%, meaning from S/. 1.50 to 2.00 soles; the aforementioned values are close or have a relationship to the rate increase of an average family in the city of Puno.

The variables with the greatest impact are income, education, environmental perception, and family size, which have a positive sign. The variables that have the greatest impact are the level of education, the higher the academic degree achieved, the greater the willingness to contribute to improving the drinking water service, and the willingness to contribute to the decontamination and conservation of the inner bay of Lake Titicaca.

According to the previous figure, it can be said that the monthly salary income and the level of education attained are determining factors in having an environmental perception, having a greater concept of collaboration or willingness to pay monthly in addition to their drinking water bill at the end of the month, for the improvement of the drinking water service and the decontamination and conservation of the inner bay of Lake Titicaca. Variables such as household size (family members) and age have a negative effect: the larger the number of family members, the less willingness to pay, and the older the family members, the less willingness to contribute to the improvement of the drinking water service and the decontamination and conservation of the inner bay of Lake Titicaca.

The authors Tudela and Leos [18], Achulli [23], and Cayo [40] coincide with respect to the variables that influence the willingness to pay, which determine income level, education level and household size, associated in all cases with the perception of poor environmental management, and recommend the implementation of public policies for the good management of the environment in return for ecosystem services.

4. Conclusion

The determination of the willingness to pay for drinking water for domestic use in the city of Puno is feasible with a willingness to pay an additional S/. 1.90 soles monthly in water bills, with an average of 0.60 cents per month per head of family.

The estimate of the willingness to pay using the contingent valuation method has arrived at the following model: Y = - 2.538 + 0.342xIncome + 0.793xEducation + 0.245xEnvironmental perception - 0.363xGender - 0.285xHousehold size - 0.01xAge - 0.03xHypothetical willingness to pay..., where the most significant variables are the degree of education, income and environmental perception, which would be the population most willing to cooperate for the recovery and conservation of the inner bay of Lake Titicaca.

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