

# “Economic valuation of air quality improvement using contingent valuation: Evidence from San Juan de Lurigancho, Lima, Peru”

|         |                                                                                                    |
|---------|----------------------------------------------------------------------------------------------------|
| AUTHORS | Carlos Minaya     |
|         |                   |
|         | Milagros Estrada  |
|         |                   |
|         | Carolay Vasquez   |
|         |                   |
|         | Duber Chinguel    |
|         |                   |
|         | Karla Vega        |
|         |                   |

|              |                                                                                                                                                                                                                                                                                                                                                          |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARTICLE INFO | Carlos Minaya, Milagros Estrada, Carolay Vasquez, Duber Chinguel and Karla Vega (2026). Economic valuation of air quality improvement using contingent valuation: Evidence from San Juan de Lurigancho, Lima, Peru. <i>Environmental Economics</i> , 17(4), 1-19. doi: <a href="https://doi.org/10.21511/ee.17(4).2026.01">10.21511/ee.17(4).2026.01</a> |
| DOI          | <a href="http://dx.doi.org/10.21511/ee.17(4).2026.01">http://dx.doi.org/10.21511/ee.17(4).2026.01</a>                                                                                                                                                                                                                                                    |
| RELEASED ON  | Wednesday, 07 October 2026                                                                                                                                                                                                                                                                                                                               |
| RECEIVED ON  | Monday, 16 February 2026                                                                                                                                                                                                                                                                                                                                 |
| ACCEPTED ON  | Friday, 24 July 2026                                                                                                                                                                                                                                                                                                                                     |
| LICENSE      | <br>This work is licensed under a <a href="https://creativecommons.org/licenses/by/4.0/">Creative Commons Attribution 4.0 International License</a>                                                                                                                   |
| JOURNAL      | "Environmental Economics"                                                                                                                                                                                                                                                                                                                                |
| ISSN PRINT   | 1998-6041                                                                                                                                                                                                                                                                                                                                                |
| ISSN ONLINE  | 1998-605X                                                                                                                                                                                                                                                                                                                                                |
| PUBLISHER    | LLC “Consulting Publishing Company “Business Perspectives”                                                                                                                                                                                                                                                                                               |
| FOUNDER      | LLC “Consulting Publishing Company “Business Perspectives”                                                                                                                                                                                                                                                                                               |

|                                                                                     |                                                                                     |                                                                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  |  |  |
| NUMBER OF REFERENCES                                                                | NUMBER OF FIGURES                                                                   | NUMBER OF TABLES                                                                      |
| 64                                                                                  | 4                                                                                   | 9                                                                                     |

© The author(s) 2026. This publication is an open access article.



## BUSINESS PERSPECTIVES



LLC "CPC "Business Perspectives"  
Hryhorii Skovoroda lane, 10,  
Sumy, 40022, Ukraine  
[www.businessperspectives.org](http://www.businessperspectives.org)

Type of the article: Research Article

Received on: 16<sup>th</sup> of February, 2026

Accepted on: 24<sup>th</sup> of July, 2026

Published on: 7<sup>th</sup> of October, 2026

© Carlos Minaya, Milagros Estrada,  
Carolay Vasquez, Duber Chinguel,  
Karla Vega, 2026

Carlos Minaya, Ph.D. in Economics  
of Natural Resources and Sustainable  
Development, Professor, Faculty of  
Economics and Planning, Universidad  
Nacional Agraria La Molina [National  
Agrarian University La Molina], Peru.

Milagros Estrada, Master in Public  
Management, Graduate School,  
Universidad San Ignacio de Loyola  
[National Agrarian University La  
Molina], Peru.

Carolay Vasquez, Master of Science  
in Agricultural Economics, Professor,  
Faculty of Economics and Planning,  
Universidad Nacional Agraria La  
Molina [National Agrarian University  
La Molina], Peru. (Corresponding  
author)

Duber Chinguel, Master of Science  
in Environmental Sciences, Graduate  
School, Universidad Nacional Agraria  
La Molina [National Agrarian  
University La Molina], Peru.

Karla Vega, Master of Public Policy,  
Faculty of Economics and Planning,  
Universidad Nacional Agraria La  
Molina [National Agrarian University  
La Molina], Peru.



This is an Open Access article,  
distributed under the terms of the  
[Creative Commons Attribution 4.0  
International license](https://creativecommons.org/licenses/by/4.0/), which permits  
unrestricted re-use, distribution, and  
reproduction in any medium, provided  
the original work is properly cited.

**Conflict of interest statement:**

Author(s) reported no conflict of interest

Carlos Minaya (Peru), Milagros Estrada (Peru), Carolay Vasquez (Peru),  
Duber Chinguel (Peru), Karla Vega (Peru)

# ECONOMIC VALUATION OF AIR QUALITY IMPROVEMENT USING CONTINGENT VALUATION: EVIDENCE FROM SAN JUAN DE LURIGANCHO, LIMA, PERU

## Abstract

Air pollution causes an alarming number of deaths worldwide. Metropolitan Lima is one of the megacities with the worst air quality in the world; San Juan de Lurigancho, one of the most polluted districts in Peru, recorded an annual average concentration of 41.2  $\mu\text{g}/\text{m}^3$  of PM<sub>2.5</sub> in 2023, which significantly exceeds the annual reference limit of 15  $\mu\text{g}/\text{m}^3$  established by the World Health Organization. Therefore, this study aimed to estimate the economic benefit of improving air quality in San Juan de Lurigancho using the contingent valuation method in both simple and double dichotomous formats. A total of 400 face-to-face interviews were conducted to assess households' willingness to pay for this environmental improvement, based on a price vector of 4, 6, 8, and 10 PEN as a monthly contribution over one year. The results indicate that 60% of respondents are willing to make a financial contribution. The average willingness to pay values, taking into account the variables household income and age of the head of household – the only statistically significant variables in the econometric models – are 8.77 PEN/month and 7.99 PEN/month, for the simple dichotomous and double dichotomous formats, respectively. Using this latter estimate, the associated social benefit amounts to 28,994,112 PEN/year (approximately 8,076,354 USD/year), which provides a useful benchmark for evaluating public policies aimed at mitigating air pollution in large urban centers.

## Keywords

air pollution, particulate matter, economic benefit,  
contingent valuation, double dichotomous, Peru

## JEL Classification

Q50, Q51, Q53

## INTRODUCTION

Air quality has deteriorated steadily in recent decades, mainly due to consumption and production activities linked to modern economic systems, making it one of the most pressing environmental challenges, particularly in developing countries (WHO, 2021; World Bank, 2020). The World Health Organization estimated that about 95% of the global population lives in areas where annual average pollutant concentrations exceed its recommended guidelines, clearly reflecting the scale of the problem (WHO, 2021). Accordingly, air pollution is recognized as one of the leading environmental risks to public health worldwide (Landrigan et al., 2018).

Its effects on human health are well documented. Exposure to pollutants, most notably particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>), is linked to severe systemic pathologies because they can penetrate deep into the respiratory and cardiovascular systems (Samara & Voutsas, 2005; WHO, 2021). According to the WHO, air pollution-related deaths are primarily attributed to ischemic heart disease and stroke (37%), fol-

lowed by acute respiratory infections (23%), chronic obstructive pulmonary disease (18%), and respiratory tract cancer (11%).

In Peru, rapid and poorly planned urbanization has heightened air pollution in major cities, with significant consequences for public health and overall well-being (Bustíos et al., 2013). Metropolitan Lima stands out as one of the megacities with the highest concentrations of PM<sub>2.5</sub> in the region (IQAir, 2023). Within this urban sprawl, the district of San Juan de Lurigancho represents a critical case study. As one of the most densely populated areas, it suffers from chronic exposure to vehicle emissions, industrial activity, and dust resuspension. These levels consistently surpass both national and international air quality standards (Campos Díaz et al., 2024; SENAMHI, 2023), posing a direct threat to the well-being of its inhabitants.

Despite the evident physical risks, there is a persistent gap in understanding the economic value that citizens place on air quality improvements in high-risk districts. This gap is particularly critical in San Juan de Lurigancho, identified as Peru's most polluted district, with particulate matter levels far exceeding international standards. Addressing this knowledge gap is essential to design effective public policies and provide economic evidence to support investments that improve urban air quality.

## 1. LITERATURE REVIEW

Air pollution has become one of the most critical environmental challenges worldwide due to its adverse effects on ecosystems, human health, and economic well-being. Among the various pollutants, particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) has been the focus of particular attention due to its widespread presence in urban environments and its serious consequences for public health. Particulate matter consists of a heterogeneous mixture of solid and liquid particles suspended in the atmosphere, including dust, soot, smoke, and residues generated by combustion processes (Bayat et al., 2019; Arriazu-Ramos et al., 2025). The size of these particles largely determines their impact on human health. PM<sub>10</sub> particles can penetrate deep into the respiratory tract, while PM<sub>2.5</sub> particles are small enough to enter the bloodstream and affect multiple organs, increasing the risk of respiratory and cardiovascular diseases (Burnett et al., 2018; Vásquez-Apestegui et al., 2021; Hamanaka & Mutlu, 2025).

The sources of particulate matter are diverse and closely linked to urbanization and economic activity. PM<sub>10</sub> emissions are typically associated with industrial production, construction activities, dust resuspension caused by traffic, and wind erosion, while PM<sub>2.5</sub> emissions are primarily generated through fuel combustion in vehicles, industrial facilities, residential heating, power generation,

and agricultural activities (Tao et al., 2017; Fussell et al., 2022; Yang et al., 2025). In rapidly growing metropolitan areas, the transportation sector has become one of the main contributors to air pollution. In the Lima metropolitan area, vehicle emissions account for more than half of total air pollution, a situation exacerbated by traffic congestion, an aging vehicle fleet, and weak enforcement of environmental regulations (SENAMHI, 2023; Fonseca et al., 2022). Consequently, air pollution imposes a massive economic burden on societies through increased healthcare expenditures, productivity losses, and reductions in quality of life (WHO, 2021; Landrigan et al., 2018; Institute for Health Metrics and Evaluation, 2016).

Several studies have attempted to quantify these economic impacts. Bherwani et al. (2020) estimated that air pollution causes annual economic losses exceeding \$167 million in Delhi, \$134 million in Wuhan, \$108 million in Paris, and \$76 million in London. Similarly, Bayat et al. (2019) concluded that reducing PM<sub>2.5</sub> concentrations in Tehran would generate annual benefits exceeding \$2.8 billion, largely due to reduced premature mortality. In Peru, Silva Vivanco et al. (2021) estimated that vehicle pollution caused economic losses equivalent to between 0.21% and 0.29% of national GDP between 2010 and 2019. These findings demonstrate that air pollution is not only an environmental and health problem but also an economic challenge that warrants public intervention.

From an economic perspective, air quality is considered a public good whose deterioration generates negative externalities that affect health, productivity, and social well-being (Tietenberg & Lewis, 2018). Since clean air lacks a market price, economists have developed non-market valuation techniques to estimate the benefits associated with environmental improvements. Among these approaches, the contingent valuation (CV) method has become one of the most widely used tools for estimating the economic value of non-market environmental goods, due to its broad applicability and operational flexibility (Chu et al., 2020; Brander & Koetse, 2011). It is helpful when market data are not available, allowing researchers to conduct both *ex ante* and *ex post* evaluations of environmental policies and programs (Carson, 2012; Mitchell & Carson, 2013). The method creates a hypothetical market through structured questionnaires in which respondents express their willingness to pay for improvements in environmental quality, making it suitable for valuing public goods such as air quality and ecosystem services (Carson & Hanemann, 2006; Haab et al., 2020; Chu et al., 2020).

Among elicitation formats, the dichotomous choice approach has become standard because it closely resembles actual market decisions while reducing strategic bias compared with open-ended valuation questions (Hanemann, 1984). In particular, the double-bounded dichotomous choice format has been widely adopted as one of the most frequently used approaches in contingent valuation studies. Under this format, respondents first indicate whether they are willing to pay an initial bid, followed by a second question offering a higher or lower bid depending on their initial response. This sequential design provides more information about respondents' preferences than the single-bounded format, leading to greater statistical efficiency, narrower confidence intervals, and more precise willingness-to-pay estimates, even with relatively smaller sample sizes (Haab & McConnell, 2002; Aikoh et al., 2020; Chatterjee, 2022).

Building on these methodological advantages, a growing body of empirical studies has applied the CV method to estimate the economic value of environmental improvements in various contexts.

Empirical findings from developed countries show that citizens are consistently willing to contribute financially to improving environmental quality. Carlsson and Johansson-Stenman (2000), for example, observed a willingness to pay for better air quality in Sweden, highlighting the importance of environmental quality in determining social well-being. Similarly, Moon et al. (2021) found significant economic values associated with the reduction of multiple pollutants, confirming that households perceive cleaner air as a desirable public good. These studies suggest that people recognize both the health and well-being benefits associated with reducing pollution and are willing to support environmental programs through financial contributions.

Air quality has also been assessed in highly polluted urban environments. Filippini and Martínez-Cruz (2016) estimated an aggregate willingness to pay of approximately \$34.4 million per year for cleaner air in Mexico City, demonstrating that environmental improvements can generate social benefits that exceed the costs of investments in pollution control. Similarly, Evans et al. (2021) found that programs that reduce diesel emissions in Mexico City generate benefits that exceed implementation costs by approximately \$92 million per year. In Hanoi, Nguyen et al. (2021) reported that improvements in air quality could compensate for a substantial portion of the costs associated with urban environmental policies. Taken together, these studies indicate that investments in air pollution mitigation typically yield positive net social returns.

Evidence from developing countries supports similar conclusions, although socioeconomic conditions often play a more significant role in determining environmental preferences. Diallo and Seck (2023) found that residents of Dakar (Senegal) were willing to pay for improvements in air quality. In Thailand, Srisawasdi et al. (2021) documented significant support for pollution reduction measures in communities affected by coal-related emissions. Similarly, Li et al. (2024) demonstrated that environmental awareness significantly influences the willingness to support pollution control programs in Pakistan. Rafique et al. (2022) further demonstrated that people who perceive a closer link between pollution, health, and personal well-

being tend to show a greater willingness to pay for environmental improvements. These studies suggest that environmental valuation is influenced not only by economic factors but also by perceptions of environmental risks and expected benefits.

A vast body of literature has also analyzed the factors that determine willingness to pay for environmental improvements. Here, income consistently emerges as one of the most significant indicators. Households with higher incomes tend to express a greater willingness to pay, as they face fewer budget constraints and can allocate more resources to environmental quality (Zhang et al., 2021; Tavárez et al., 2024). Similar results have been obtained in various studies related to biodiversity conservation, ecosystem services, and pollution control programs (Ibrahim et al., 2025; Drupp et al., 2025; Ouyang et al., 2024). Consequently, willingness to pay is often interpreted as increasing with people's ability to finance environmental improvements.

Conversely, age is often associated with a lower willingness to pay. Xu et al. (2022) and Mamboleo and Adem (2022) found that older respondents tend to assign lower monetary values to environmental improvements. This relationship can be explained by differences in time preferences, expected future benefits, risk perception, and trust in public policies. Younger people tend to anticipate longer-term benefits from environmental improvements and, therefore, show greater support for environmental investments. These findings highlight the importance of incorporating socioeconomic heterogeneity into environmental valuation models.

Despite the general use of contingent valuation methods, methodological debates persist. One of the most debated issues concerns the treatment of rejection and negative responses. Jin et al. (2006) argued that respondents who reject all proposed payment scenarios do not necessarily assign a zero value to the environmental good. Instead, such responses may reflect disagreement with the payment mechanism, distrust of institutions, or objections to the hypothetical market framework. Similarly, Tudela-Mamani and Leos-Rodríguez (2018) emphasized that including these responses can influence willingness-to-pay distributions and, potentially, bias aggregate estimates.

Consequently, some researchers recommend comparing complete and filtered samples to assess the robustness of the estimated economic values.

Although previous studies have provided considerable evidence on the health effects of air pollution, the economic benefits of environmental improvements, and the determinants of willingness to pay, several gaps remain. First, most empirical studies have focused on national, regional, or metropolitan scales, while data on highly polluted neighborhoods in large cities remain limited. Second, relatively few studies have analyzed willingness to pay for air quality improvements in densely populated urban neighborhoods in Latin America that suffer from chronic exposure to particulate matter. Third, although the double-bound dichotomous choice approach is widely applied in contingent valuation studies, few studies have explicitly evaluated the effect of excluding negative responses in willingness-to-pay estimates. Addressing these gaps is particularly important in San Juan de Lurigancho, Peru's most polluted district, where no previous study has estimated the economic value of air quality improvements despite the district's severe pollution levels and high population density.

Therefore, the aim of this study is to estimate the economic benefit associated with improved air quality in the district of San Juan de Lurigancho, using the contingent valuation method in both single-bound and double-bound dichotomous choice formats. In addition, the study aims to identify the socioeconomic determinants of willingness to pay and to assess the effect of excluding negative responses on the estimated economic value of environmental improvements. Based on the theoretical and empirical evidence reviewed above, the following hypotheses are proposed:

- H1: *The average willingness to pay estimated using the simple dichotomous model is significantly higher than the estimate derived from the double-bounded dichotomous model.*
- H2: *Household income and the age of the respondent are the primary socioeconomic determinants influencing the probability of being willing to pay for air quality improvements in a developing megacity.*

*H3: The average willingness to pay estimated using the double-bounded model increases significantly when negative responses are excluded from the analysis.*

## 2. METHOD

To achieve the study's aim, a quantitative approach was employed to estimate the economic benefits of air quality improvements through the willingness to pay construct. This study uses the contingent valuation (CV) method, a non-market valuation technique based on stated preferences, to simulate a hypothetical market for environmental quality (Hanemann, 1984).

### 2.1. Double dichotomous contingent valuation method

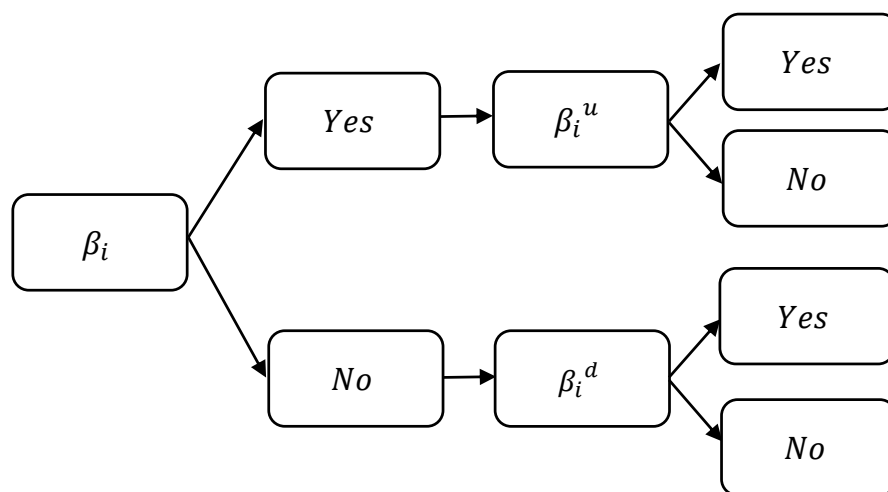
The CV method is widely used in environmental economics to estimate the economic value of goods and services that lack explicit markets, such as the benefits of improved air quality (Hanemann, 1984; Srisawasdi et al., 2021). It relies on a questionnaire designed to elicit individuals' willingness to pay for environmental improvements within a hypothetical market scenario. Respondents answer questions that simulate an exchange between the environmental good – in this case, improved air quality – and a monetary contribution (Diallo & Seck, 2023; Inostroza et al., 2020).

In the simple dichotomous (referendum) format, individuals are asked whether they are willing to pay a specified amount for the proposed improvement, choosing either *yes* or *no* (Villagrán et al., 2025). This study, however, applies the double dichotomous format, which incorporates two sequential questions to produce more accurate and reliable willingness to pay estimates (Haab et al., 2020).

Originally proposed by Hanemann et al. (1991), the double dichotomous approach improves upon the simple format by addressing limitations in estimation accuracy. The respondent first answers a closed yes/no question regarding willingness to pay a given amount. This initial price plan BID ( $\beta_i$ ) is then followed by a second dichotomous question whose amount depends on the first response: a higher BID ( $\beta_i^u$ ) if the answer was affirmative, or a lower BID ( $\beta_i^d$ ) if negative. This structure makes the second offer endogenous to the respondent's initial choice, while the first remains exogenous (Torres-Ramírez et al., 2023; Tudela-Mamani & Leos-Rodríguez, 2018).

A key advantage of this format is that it yields two observations per respondent, increasing the information available and improving the statistical efficiency of the econometric models used to estimate willingness to pay. As such, the double dichotomous method reduces estimation bias and enhances the reliability of results, addressing concerns with the simple referendum format such as

Source: Torres-Ramírez et al. (2023) and Tudela-Mamani and Leos-Rodríguez (2018).



**Figure 1.** Method of application of the double dichotomous choice

limited information and high variance (Cahui-Cahui et al., 2019). Figure 1 illustrates the application of this choice mechanism.

Following Hanemann et al. (1991) and Haab and McConell (2002), the probability responses for the dichotomous model can be expressed as follows:

$$Prob(yes, yes) = 1 - F(\beta'x_i^u), \quad (1)$$

$$Prob(yes, no) = F(\beta'x_i^u) - F(\beta'x_i), \quad (2)$$

$$Prob(no, yes) = F(\beta'x_i) - F(\beta'x_i^d), \quad (3)$$

$$Prob(no, no) = F(\beta'x_i^d), \quad (4)$$

where  $F(\cdot)$  represents the logistic cumulative distribution function;  $\beta$  is the vector of parameters to be estimated;  $x_i$  is the vector of explanatory variables for individual  $i$ , which includes the proposed payment amount and socioeconomic characteristics;  $x_i^u$  and  $x_i^d$  correspond to the vectors of variables when the upper BID and the lower BID are offered, respectively.

The econometric estimation problem is solved using the maximum likelihood method with the joint density function given by:

$$L = \prod_{i=1}^n \left( 1 - F(\beta'x_i^u) \right)^{d_i^{yy}} \left( F(\beta'x_i^u) - F(\beta'x_i) \right)^{d_i^{yn}} \left( F(\beta'x_i) - F(\beta'x_i^d) \right)^{d_i^{ny}} \left( F(\beta'x_i^d) \right)^{d_i^{nn}}, \quad (5)$$

where  $d_i^{yy}$ ,  $d_i^{yn}$ ,  $d_i^{ny}$ ,  $d_i^{nn}$  are binary variables derived from the responses: yes-yes, yes-no, no-yes, and no-no, respectively. When the respondent's answer falls into one of these categories, the variables take the value 1; otherwise, the value is 0. Subsequently, regression analysis is performed using a logit or probit model (see Appendix A), given that the dependent variable is discrete. In this study, the logit model was used.

## 2.2. Data sources and sampling

San Juan de Lurigancho is the district most affected by air pollution in Latin America (Vásquez-

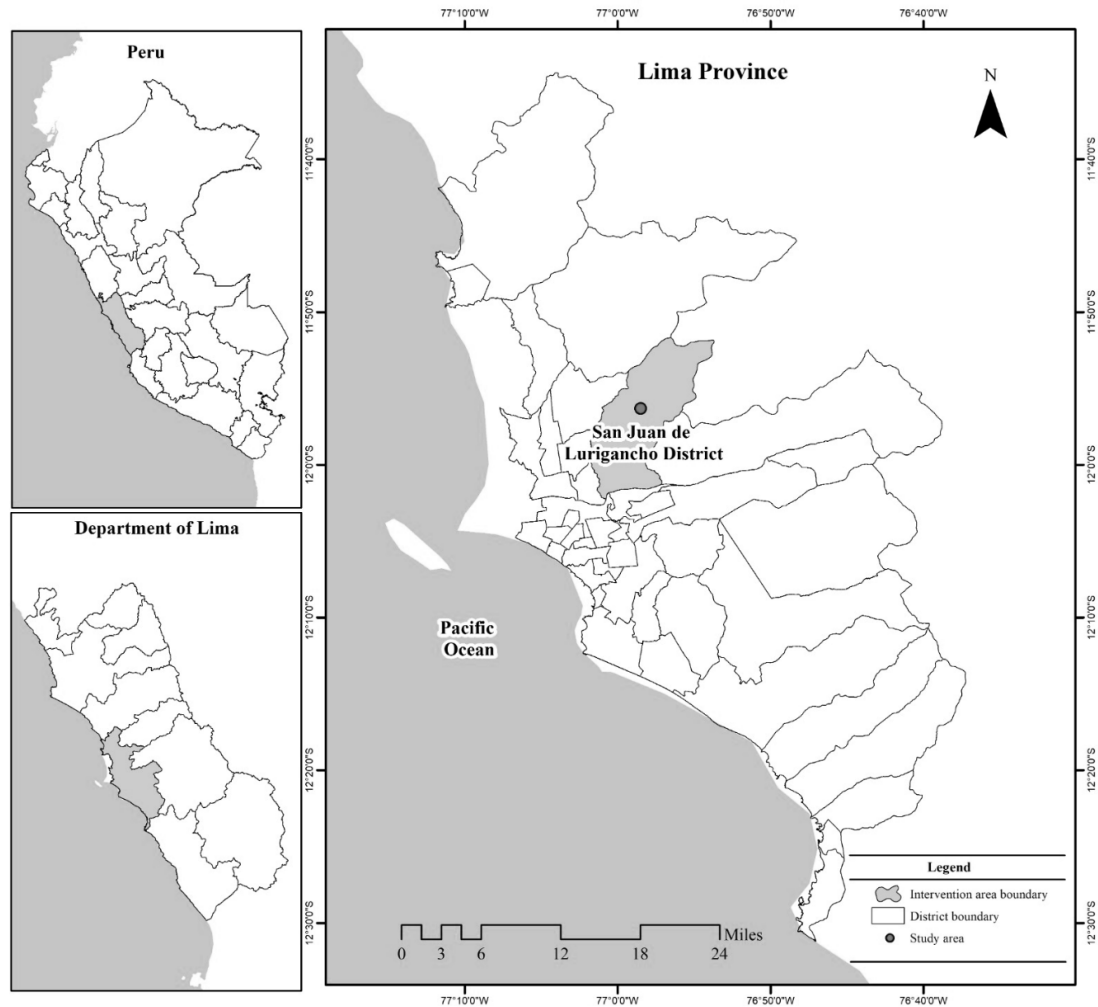
Apestegui et al., 2021). The city experiences high emissions of pollutants such as PM<sub>2.5</sub>, NO<sub>2</sub>, and O<sub>3</sub>, largely driven by traffic congestion, industrial activity, and commercial operations. This persistent pollution places Lima among the cities with the highest concentrations of fine particulate matter worldwide, particularly in the districts of San Juan de Lurigancho, Ate, and Santa Anita, which report some of the highest PM<sub>2.5</sub> levels in South America (IQAir, 2023).

The case of San Juan de Lurigancho is especially critical. Although the WHO recommends that particulate matter not exceed 15 µg/m<sup>3</sup> (WHO, 2021), ATU (2023) reported that concentrations here reached 41.2 µg/m<sup>3</sup>, making it the most polluted district in Peru. It is also the country's most populous district, with more than 1.2M residents (CPI, 2025), and one of the most densely settled, marked by rapid and uneven urban expansion and persistent deficits in territorial planning (Contreras et al., 2024; Vásquez-Apestegui et al., 2021). Figure 2 shows the location of San Juan de Lurigancho within Metropolitan Lima, Peru, highlighting the geographic context of the study area.

The data were collected through a structured primary survey administered to heads of households in San Juan de Lurigancho district who served as the primary economic decision-makers within their households and were therefore best positioned to declare preferences and payment decisions for environmental public goods (Carson & Hanemann, 2006; Li & Hu, 2018).

A probabilistic, multistage, and stratified sampling design was applied, with proportional allocation to the population size of the district's urban sectors. This approach ensured spatial and sociodemographic representativeness while minimizing biases linked to geographic clustering or respondent self-selection (Ann-Chyi & Sheau-Ting, 2024).

According to the Peruvian Research and Polling Institute (CPI, 2025), San Juan de Lurigancho has 302,400 households, representing 10.8% of all households in Lima. To determine the optimal sample size, the equation for proportions in finite populations was used:



**Figure 2.** Location map of San Juan Lurigancho in Metropolitan Lima

$$N = \frac{Z^2 pq}{e^2}, \quad (6)$$

where  $p$  is the proportion of households expected to support financing mitigation actions for emissions affecting air quality. Here,  $p = 0.5$  is adopted as it maximizes variance in the absence of prior information.  $q$  is set equal to  $(1-p)$  or 0.5 again.  $Z$  represents the 95% confidence level (quantile = 1.96), and  $e$  denotes the margin of error = 0.05.

Substituting these values, the calculated sample was 385, rounded to 400 respondents for the final analysis.

### 2.3. Survey structure and variables

The survey instrument contained four sections: (i) Awareness of general environmental problems in

San Juan de Lurigancho; (ii) Current air quality conditions, associated problems, and consequences; (iii) Application of the CV method in a double dichotomous format; and (iv) Socioeconomic information. The first section also gathered information on perceived causes of environmental problems and mitigation measures undertaken by public or private entities.

In the second section, notable consequences of poor air quality included:

- Increases in respiratory diseases, strokes, and lung cancer, and
- The economic cost of air pollution in Lima from PMs associated with vehicle fleets  $\approx 0.25$  Gross Domestic Product (GDP) (Silva Vivanco et al., 2021).

The third section introduced a hypothetical market framed around a local sustainability program funded directly by district households. It presented the following statement: “The implementation of this program would be the responsibility of the Municipality of San Juan de Lurigancho, through an agreement with the National Agrarian University of La Molina (UNALM). Therefore, society is being asked to support the financing of this program through a binding monthly monetary contribution (for a period of one year), which would be paid through their electricity bill”.

Appendix B provides details on the variables collected in the fourth section.

## 2.4. Data processing and statistical analysis

The econometric estimation and data visualization were performed using Stata 18.0. To test  $H3$ , we conducted a robustness check by comparing willingness-to-pay estimates from the full sample with a filtered distribution that excludes negative responses. The statistical significance of the differences between these two groups was evaluated using a  $t$ -test for independent samples (or a mean comparison test). This procedure allowed us to determine whether excluding negative responses leads to a statistically significant shift in the estimated economic benefit.

## 2.5. Ethics policies in human research

Ethical integrity was maintained throughout the research process. Informed consent was obtained from all participants prior to the interview. Respondents were briefed on the study’s objectives, the voluntary nature of their participation, and the fact that no sensitive personal identification (such as names or ID numbers) would be recorded. To ensure anonymity and impartiality, data were coded and stored in an encrypted database accessible only to the research team. The research protocol adhered to the ethical guidelines of the UNALM, ensuring the protection of participants’ rights and the confidential use of the collected data for strictly academic purposes.

# 3. RESULTS

## 3.1. Descriptive results

Trained university students and graduates administered the surveys between October and December 2024 (see Appendix B). Respondents were approached in public locations (e.g., parks, shopping centers, and recreation areas) across different urban zones of the district. Weekend administration was chosen to accommodate the work and leisure schedules typical of the San Juan de Lurigancho population.

According to respondents’ statements, 85% reported being aware of environmental problems in the district (P1: *Do you have knowledge about environmental problems occurring in San Juan de Lurigancho?*). However, because this variable is dichotomous – allowing only *yes* or *no* responses – this figure cannot be interpreted as evidence of comprehensive knowledge.

When including affirmative responses to P3 (*Do you have knowledge of any measures implemented to address these problems?*), which asks about awareness of measures implemented to address identified problems, the percentage drops to 29%.

This interpretation is reinforced by the quality of responses to follow-up questions. Question 2 asked respondents to list up to three environmental problems and identify their main causes, while Question 4 required them to specify the corresponding mitigation measures. After reviewing these detailed responses, only 22% of participants demonstrated substantive knowledge of environmental issues in San Juan de Lurigancho beyond the binary declaration in Q1. Table 1 presents descriptive statistics from the survey results.

Table 1 indicates that 63.25% of respondents were females, with an average age of 41. Regarding marital status, 36.5% identified as single, while 63.5% reported being married.<sup>1</sup> Income distribution shows that 11.25% of re-

<sup>1</sup> In this study, this civil status also implies cohabitation. The option for this category of marital status was: married/cohabiting. Therefore, both categories were considered equivalent.

**Table 1.** Main descriptive survey data statistics

| Variable       | Obs | Mean      | Std. dev. | Min   | Max    |
|----------------|-----|-----------|-----------|-------|--------|
| N              | 400 | 200.5     | 115.614   | 1     | 400    |
| P1             | 400 | 0.85      | 0.358     | 0     | 1      |
| P3             | 355 | 0.327     | 0.470     | 0     | 1      |
| P5             | 399 | 0.221     | 0.415     | 0     | 1      |
| BID            | 400 | 7         | 2.239     | 4     | 10     |
| BIDu           | 400 | 14        | 4.478     | 8     | 20     |
| BIDd           | 400 | 3.503     | 1.119     | 2     | 5      |
| No-No (NN)     | 400 | 0.22      | 0.415     | 0     | 1      |
| No-Yes (NY)    | 400 | 0.183     | 0.387     | 0     | 1      |
| Yes-No (YN)    | 400 | 0.418     | 0.494     | 0     | 1      |
| Yes-Yes (YY)   | 400 | 0.18      | 0.385     | 0     | 1      |
| Sex            | 400 | 0.368     | 0.483     | 0     | 1      |
| Age            | 400 | 40.845    | 13.038    | 18    | 78     |
| Income         | 395 | 3.643     | 2.320     | 0     | 10     |
| Income2*       | 395 | 3,043.623 | 2,063.662 | 1,025 | 11,275 |
| Education      | 398 | 2.512     | 0.622     | 1     | 3      |
| Marital status | 381 | 0.635     | 0.482     | 0     | 1      |

Note: \*Values for this variable were estimated based on the original polytomous variable (ranges).

spondents earned more than 5K PEN, whereas 7.25% earned the minimum wage (1,025 PEN).<sup>2</sup>

Table 2 shows that the *BID* values consisted of 4, 6, 8, and 10 PEN, each assigned proportionally so that every amount was presented exactly 100 times. Regarding the relationship between the initial price plan and the willingness to pay, 7.5% of respondents (30 individuals) issued protest responses – rejecting both the initial and reduced initial price plan amounts and citing reasons such as disagreement with the proposed

contribution or the belief that government or private entities should finance the mitigation program.

An inverse relationship between the initial price plan and willingness to pay is observed, as NN responses increase with higher initial price plan amounts. A similar pattern appears for YN and NY responses. This behavior mirrors a standard demand relationship in private goods markets, where higher prices reduce the likelihood of acceptance.

**Table 2.** Relationship between initial price plan and willingness to pay in simple and double dichotomous formats

| Items      | BID (PEN) |          |          |          | Total      |
|------------|-----------|----------|----------|----------|------------|
|            | 4         | 6        | 8        | 10       |            |
| YY         | 19        | 29       | 13       | 11       | 72         |
| YN         | 54        | 42       | 41       | 30       | 167        |
| Total Yes* | 73 (73%)  | 71 (71%) | 54 (54%) | 41 (41%) | 239 (60%)  |
| NY         | 12        | 11       | 24       | 26       | 73         |
| NN         | 15        | 18       | 22       | 33       | 88         |
| Total No   | 27 (27%)  | 29 (26%) | 46 (46%) | 59 (59%) | 161 (40%)  |
| Total      | 100       | 100      | 100      | 100      | 400 (100%) |

Note\*: This total number of responses (60%) corresponds to the simple dichotomous format. However, if we consider responses from the double dichotomous format, only 35.3% show an affirmative stance regarding their willingness to pay (YY and NY).

2 The minimum wage in Peru, also known as the Minimum Living Wage (RMV), is 1,130 PEN per month as of January 1, 2025, according to Supreme Decree No. 006-2024-TR.

### 3.2. Estimation of the logit regression and average willingness to pay based on simple and double dichotomous formats

Logit regressions were estimated with and without socioeconomic variables, the first examining only the relationship between willingness to pay and initial price plan under the simple dichotomous format. Table 3 presents the results of this baseline model.

A second logit regression incorporated the socioeconomic variables collected through the survey. Table 4 shows that age and income2 significantly affect the probability that willingness to pay is greater than zero. Age was statistically significant at the 1% level, while income2 is significant at 2%.

Because the logit model estimates marginal effects through the odds ratio, the coefficients themselves are not directly interpretable beyond their signs. Income exhibits a positive marginal effect, whereas both BID and age show negative

effects. Thus, a decrease in the age variable – a continuous measure – is associated with a higher probability of choosing an alternative other than the status quo ( $WTP = 0$ ). The pseudo  $R^2$  of 0.077, although modest, is typical of discrete choice models and aligns with values commonly reported in similar applications (Minaya et al., 2026).

Finally, average willingness to pay values were calculated based on the logistic regression results for both the simple and double dichotomous formats (Table 5). In both cases, adding the socioeconomic variables age and income<sup>2</sup> causes the average willingness to pay values to decline slightly. Because these values are derived from a representative sample of the San Juan de Lurigancho district, they can be extrapolated to the broader study population. The estimated willingness to pay values are monthly values over a one-year horizon. Using these averages, the annual economic benefit of improved air quality in San Juan de Lurigancho is estimated at 28,994,112 PEN/year (8,076,354 USD/year), reflecting gains that encompass health, productivity, and overall urban quality of life.

**Table 3.** Logit regression between willingness to pay and initial price plan under the simple dichotomous format

| Logistic regression |             |           |       |       | Number of obs =      | 400    |
|---------------------|-------------|-----------|-------|-------|----------------------|--------|
| AIC                 | 516.12566   |           |       |       | LR chi2(1) =         | 27.08  |
| BIC                 | 524.10859   |           |       |       | Prob > chi2 =        | 0      |
| Log likelihood =    | -256.06283  |           |       |       | Pseudo R2 =          | 0.050  |
| Items               | Coefficient | Std. err. | z     | P>z   | [95% conf. interval] |        |
| BID                 | -0.245      | 0.048     | -5.05 | 0.000 | -0.4893077           | -0.149 |
| _cons               | 2.137       | 0.366     | 5.83  | 0.000 | 1.419                | 2.854  |

**Table 4.** Logit regression estimation with socioeconomic variables

| Logistic regression |             |           |       |       | Number of obs =      | 375    |
|---------------------|-------------|-----------|-------|-------|----------------------|--------|
| AIC                 | 483.29848   |           |       |       | LR chi2(7) =         | 39.04  |
| BIC                 | 514.71389   |           |       |       | Prob > chi2 =        | 0      |
| Log likelihood =    | -233.64924  |           |       |       | Pseudo R2 =          | 0.0771 |
| Items               | Coefficient | Std. err. | z     | P > z | [95% conf. interval] |        |
| BID                 | -0.233      | 0.051     | -4.58 | 0.000 | -0.333               | -0.133 |
| Sex                 | -0.047      | 0.238     | -0.2  | 0.845 | -0.512               | 0.419  |
| Marital_status      | -0.068      | 0.234     | -0.29 | 0.772 | -0.527               | 0.392  |
| Age                 | -0.027      | 0.009     | -2.71 | 0.007 | -0.047               | -0.008 |
| Education           |             |           |       |       |                      |        |
| 2                   | -0.488      | 0.492     | -0.99 | 0.321 | -1.452               | 0.475  |
| 3                   | -0.462      | 0.505     | -0.91 | 0.36  | -1.453               | 0.528  |
| Income2             | 0.0002      | 0.000     | 2.43  | 0.015 | 0.000                | 0.000  |
| Cons                | 3.179       | 0.825     | 3.85  | 0.000 | 1.563                | 4.796  |

**Table 5.** Average willingness to pay derived from simple and double dichotomous formats

| WTP   | Coeff | Std. err. | Z     | P>z   | [95 % conf. interval] |
|-------|-------|-----------|-------|-------|-----------------------|
| WTP1  | 8.734 | 0.533     | 16.39 | 0.000 | 7.689 9.778           |
| WTP1* | 8.768 | 0.527     | 16.65 | 0.000 | 7.736 9.801           |
| WTP2  | 7.985 | 0.355     | 22.51 | 0.000 | 7.289 8.681           |
| WTP2* | 7.992 | 0.351     | 22.78 | 0.000 | 7.304 8.679           |

Note\*: In both willingness to pay estimates (1 and 2, corresponding to single and double cases, respectively), only the socio-economic variables of age and income2 were significant. WTP = willingness to pay.

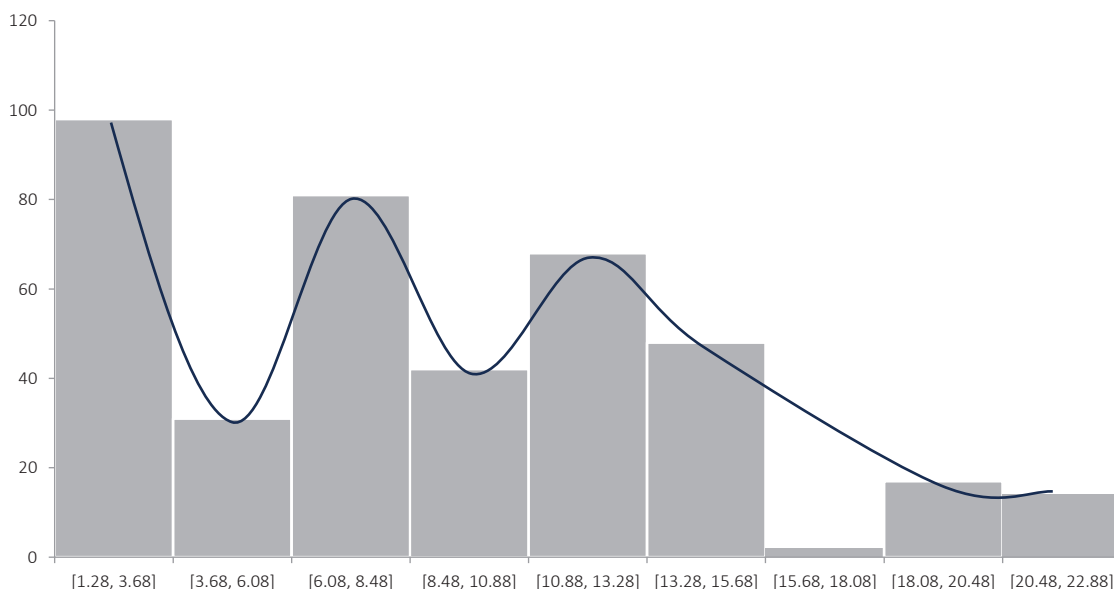
### 3.3. Estimation of willingness to pay with and without the exclusion of negative responses, based on the application of the double dichotomous format

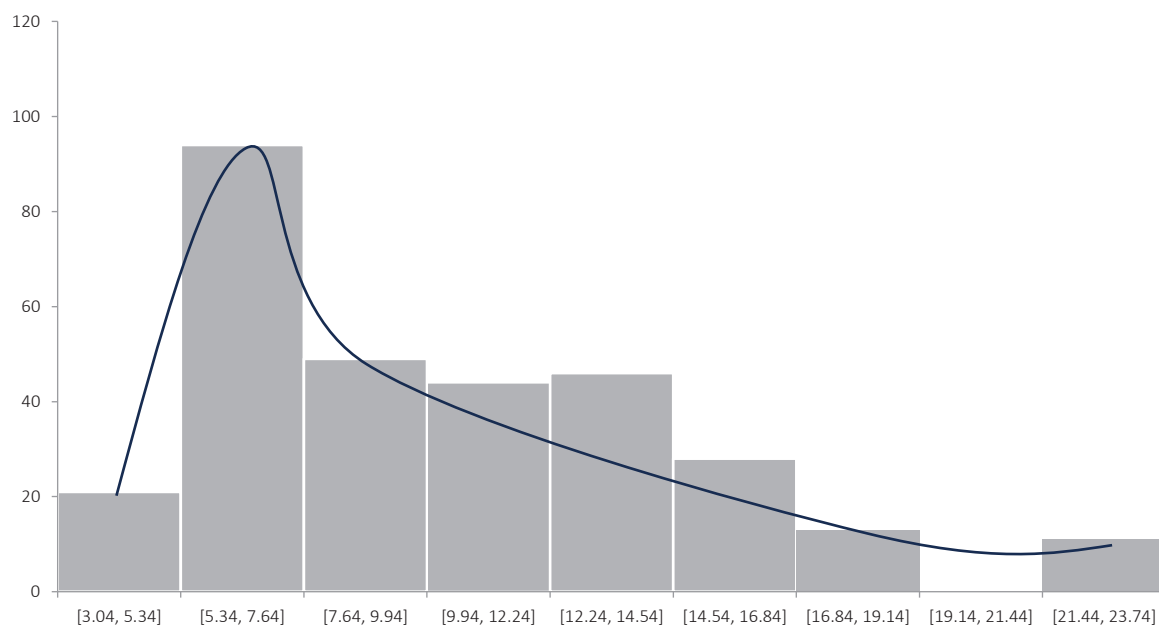
Based on the estimation of the simple dichotomous format, individualized willingness to pay values were obtained for each respondent. These values reflect both the observed response pattern – YY, YN, NY, or NN – and the significant socio-economic variables included in the model: age and income.

However, in line with methodological recommendations from Jin et al. (2006) and Tudela-Mamani and Leos-Rodríguez (2018), the estimation of average willingness to pay value must account for the influence of negative responses on the overall distribution. NN responses may indicate rejection of the hypothetical scenario, distrust of the

survey instrument, or reluctance to participate rather than a true valuation of the environmental service. Consequently, Jin et al. (2006) and Tudela-Mamani and Leos-Rodríguez (2018) recommend complementing the analysis with an alternative willingness to pay distribution that excludes such responses.

Figures 3 and 4 illustrate the estimated individual willingness to pay under the double dichotomous model, first using all responses (Figure 3) and then excluding NN cases (Figure 4). The full-sample histogram displays a more dispersed and asymmetric distribution with a concentration of low values. In contrast, the filtered histogram is more compact and less skewed, reflecting patterns commonly reported in contingent valuation studies (Tudela-Mamani & Leos-Rodríguez, 2018). These differences support the value of analyzing both distributions, as excluding negative responses produces a more stable and representative pattern of willingness to pay.

**Figure 3.** Willingness to pay histogram – Double dichotomous including all responses



**Figure 4.** Willingness to pay histogram – Double dichotomous excluding negative responses

To test whether the mean willingness to pay differs significantly between the complete and filtered samples, a *t*-test was conducted. Table 6 presents the results.

**Table 6.** Results of *t*-test

| Group                    | Obs | Mean   | SD    | <i>p</i> -value |
|--------------------------|-----|--------|-------|-----------------|
| Mean WTP – Full base     | 400 | 7.992  | 0.351 | 0.000***        |
| Mean WTP – Filtered base | 312 | 10.305 | 0.308 |                 |

Note: \*\*\*  $p < 0.01$ , statistically significant at 1%. WTP = willingness to pay.

The complete database yielded an average willingness to pay of 7.99 PEN/month, whereas the filtered database produced a substantially higher estimate of 10.31 PEN/month. The difference of 2.32 PEN/month is statistically significant at the 1% level ( $p < 0.01$ ). This finding confirms that removing negative responses not only alters the distributional shape observed in the histograms but also materially affects the estimated average willingness to pay.

These results support the hypotheses proposed in this study. Hypothesis H1 is confirmed in the expected direction, as the average willingness to pay is higher in the simple dichotomous format than in the double-bound format. Hypothesis H2 is confirmed, as income and age are the only so-

cioeconomic variables that significantly influence willingness to pay. Finally, Hypothesis H3 is confirmed, as the exclusion of negative responses significantly increases the estimated average willingness to pay ( $p < 0.01$ ).

## 4. DISCUSSION

The results show that residents of San Juan de Lurigancho assign a positive and significant economic value to improving air quality, demonstrating a genuine willingness to contribute financially to reducing particulate matter (PM10 and PM2.5). This valuation reflects a medium-to-high level of environmental awareness and a perception of clean air as an essential public good whose provision requires coordinated action between the state and citizens (Rafique et al., 2022).

A comparison with previous studies reveals broad consistency in both the magnitude of estimates and the economic valuation of air quality improvements. For example, Suarez et al. (2021) reported a willingness to pay of 4.1 USD/month in Colombia – though accompanied by 42% negative responses – for preserving the air purification function through conservation of urban green spaces. Likewise, Bayat et al. (2019) estimated that reducing PM2.5 in Tehran would generate annual

social benefits exceeding 2.8B USD, largely due to reductions in premature mortality (7,146 avoided deaths per year).

Regarding socioeconomic variables, households with higher income show greater willingness to contribute to environmental programs, consistent with findings by Tavárez et al. (2024) and Zhang et al. (2021), who emphasized the role of disposable income in shaping the valuation of public goods. Conversely, the negative effect of age suggests that older individuals tend to assign a lower economic value to improvements in air quality, potentially due to differing spending priorities, shorter time horizons for capturing future benefits, or varying levels of confidence in public policy effectiveness (Xu et al., 2022; Mamboleo & Adem, 2022).

Overall, the findings indicate that the study population recognizes the seriousness of local air pollution and assigns a specific economic value to shifting away from the status quo in favor of cleaner, healthier air. This supports the design and evaluation of public policies aimed at emissions mitigation and integrated air quality management. In this regard, the analysis of aggregate social benefits provides a framework for assessing the economic implications of environmental interventions.

The estimated annual social benefit of more than 28M PEN (8M USD) for San Juan de Lurigancho aligns with empirical evidence showing that aggregated individual benefits from environmental improvements can yield substantial social returns that justify mitigation efforts (Zhang et al., 2019; Giannakis et al., 2019). For instance, Evans et al. (2021) found that interventions targeting diesel

emissions in Mexico City generate benefits that exceed implementation costs by approximately 92M USD per year. Similarly, Nguyen et al. (2021) estimated that improvements in air quality in Hanoi could offset between 13% and 84% of the annual costs of urban environmental policies. Filippini and Martínez-Cruz (2016) also reported that in the Mexico City Metropolitan Area, an aggregate willingness to pay of roughly 34.4M USD per year surpasses the 30M USD required for investments in clean transportation, underscoring the social benefits of such interventions.

From a methodological perspective, comparing the full sample with the sample that excludes negative responses (NN) provides additional insight into the estimation of willingness to pay. As expected, excluding respondents who rejected both offers resulted in higher estimates of willingness to pay. This finding is consistent with previous contingent valuation studies suggesting that some negative responses may reflect protest behavior rather than genuinely zero valuations (Jin et al., 2006). However, these adjusted estimates should be interpreted with caution. Since all negative responses were excluded, the filtered sample might also omit respondents whose willingness to pay is truly zero, which could result in an upward bias in the estimated economic benefits. Therefore, the comparison between the full and filtered samples should be interpreted as a robustness analysis rather than evidence that the filtered estimates represent the true economic value of improved air quality. This emphasizes the need to differentiate, in contingent valuation studies, between responses driven by protest and genuine zero willingness to pay responses.

---

## CONCLUSION

The aim of this study was to estimate the economic benefit of improving air quality in a densely populated urban areas such as San Juan de Lurigancho district, Lima, Peru, using the contingent valuation method in both simple and double dichotomous formats.

The results indicate that households assign a positive economic value to improvements in air quality, with an estimated annual social benefit of 28,994,112 PEN/year (8,076,354 USD/year), reflecting the economic value that households assign to improvements in air quality and the associated gains in social welfare.

The findings also show that willingness to pay is significantly influenced by socioeconomic characteristics. In particular, income exhibits a positive effect, while age shows a negative relationship with the

probability of contributing to environmental improvements. These results are consistent with previous empirical evidence and highlight the importance of considering differences across population groups in the design of environmental policies.

From a methodological perspective, the analysis demonstrates that the exclusion of negative responses (NN) responses in the double-bounded dichotomous choice format results in higher willingness-to-pay estimates. In particular, when the 88 negative responses recorded at two stages are excluded, the average value increases to 10.31 PEN/month, compared to the estimate obtained from the full sample. However, these estimates should be interpreted with caution, as negative responses may include both protest responses and individuals with a genuinely zero willingness to pay. Consequently, the comparison between the complete and filtered samples should be viewed as a robustness analysis illustrating how the treatment of negative responses can influence estimates of willingness to pay. Future contingent valuation studies would benefit from incorporating follow-up questions that differentiate protest responses from those with a genuinely zero willingness to pay, improving the accuracy of welfare estimates.

In terms of policy implications, the estimated economic benefits provide a useful benchmark for evaluating air pollution mitigation strategies in highly polluted urban areas. Strengthening environmental education – particularly among older populations – and promoting coordinated actions between local governments, environmental agencies, and the transport sector are essential to improve air quality and enhance social welfare.

Future research could expand this analysis in several directions. First, the application of alternative valuation methods, such as choice experiments, would allow for robustness checks and methodological comparisons. Second, conducting comparative assessments across districts or cities would improve external validity and provide a broader understanding of the dynamics of urban air pollution. Finally, future research could integrate environmental and epidemiological data to link willingness to pay with quantifiable health outcomes, thereby strengthening the policy relevance of economic valuation studies.

## AUTHOR CONTRIBUTIONS

Conceptualization: Carlos Minaya, Milagros Estrada, Duber Chinguel.

Data curation: Milagros Estrada, Karla Vega.

Formal analysis: Carolay Vasquez.

Funding acquisition: Carlos Minaya, Milagros Estrada.

Investigation: Carlos Minaya, Carolay Vasquez, Karla Vega.

Methodology: Carolay Vasquez.

Project administration: Carlos Minaya, Duber Chinguel.

Resources: Milagros Estrada.

Software: Carolay Vasquez.

Supervision: Carlos Minaya, Milagros Estrada.

Validation: Karla Vega.

Visualization: Duber Chinguel, Karla Vega.

Writing – original draft: Carlos Minaya, Carolay Vasquez, Duber Chinguel, Karla Vega.

Writing – review & editing: Milagros Estrada, Carolay Vasquez.

## REFERENCES

1. Aikoh, T., Shoji, Y., Tsuge, T., Shibasaki, S., & Yamamoto, K. (2020). Application of the double-bounded dichotomous choice model to the estimation of crowding acceptability in natural recreation areas. *Journal of Outdoor Recreation and Tourism*, 32, Article 100195. <https://doi.org/10.1016/j.jort.2018.10.006>
2. Ann-Chyi, T., & Sheau-Ting, L. (2024). Methodological influences on ecosystem valuation: A systematic review of contingent valuation studies. *Journal of Environmental Economics and Policy*, 13(4), 449-467. <https://doi.org/10.1080/21606544.2024.2305964>
3. Arriazu-Ramos, A., Santamaría, J. M., Monge-Barrio, A., Bes-Rastrollo, M., Gutiérrez Gabriel, S., Benito Frías, N., & Sánchez-Ostiz, A. (2025). Health impacts of urban environmental parameters: A review of air pollution, heat, noise, green spaces and mobility. *Sustainability*, 17(10), Article 4336. <https://doi.org/10.3390/su17104336>
4. Autoridad de Transporte Urbano (ATU). (2023). *Calidad Ambiental. Red de monitoreo de Calidad Ambiental del Aire y Ruido para Lima y Callao. Boletín n°1- jun. 2023 [Environmental Quality. Air Quality and Noise Monitoring Network for Lima and Callao. Bulletin No. 1—June 2023]*. (In Spanish). Retrieved from <https://heyzine.com/flip-book/59b8530bda.html#page/6>
5. Bayat, R., Ashrafi, K., Motlagh, M. S., Hassanvand, M. S., & Daroudi, R. (2019). *Estimation of Tehran's particulate matter 2.5 micrometers or less in diameter (PM<sub>2.5</sub>) health effects, using BenMAP-CE*. CABI Database. Retrieved from <https://www.cabidigitallibrary.org/doi/full/10.5555/20219928518>
6. Bayat, R., Ashrafi, K., Motlagh, M. S., Hassanvand, M. S., Daroudi, R., Fink, G., & Kunzli, N. (2019). Health impact and related cost of ambient air pollution in Tehran. *Environmental Research*, 176, Article 108547. <https://doi.org/10.1016/j.envres.2019.108547>
7. Bherwani, H., Nair, M., Musugu, K., Gautam, S., Gupta, A., Kapley, A., & Kumar, R. (2020). Valuation of air pollution externalities: Comparative assessment of economic damage and emission reduction under COVID-19 lockdown. *Air Quality, Atmosphere & Health*, 13(6), 683-694. <https://doi.org/10.1007/s11869-020-00845-3>
8. Brander, L. M., & Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management*, 92(10), 2763-2773. <https://doi.org/10.1016/j.jenvman.2011.06.019>
9. Burnett, R., Chen, H., Szyszko-wicz, M., Fann, N., Hubbell, B., Pope, C. A., III, Apte, J. S., Brauer, M., Cohen, A., Weichenthal, S., Coggins, J., Di, Q., Brunekreef, B., Frostad, J., Lim, S. S., Kan, H., Walker, K. D., Thurston, G. D., Hayes, R. B., ... Spadaro, J. V. (2018). Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. *Proceedings of the National Academy of Sciences of the United States of America*, 115(38), 9592-9597. <https://doi.org/10.1073/pnas.1803222115>
10. Bustíos, C., Martina, M., & Arroyo, R. (2013). Deterioro de la calidad ambiental y la salud en el Perú actual [Deterioration of Environmental Quality and Health in Peru Today]. *Revista Peruana de Epidemiología*, 17(1), 1-9. (In Spanish). Retrieved from <https://www.redalyc.org/articulo.oa?id=203128542001>
11. Cahui-Cahui, E., Tudela-Mamani, J. W., & Huamaní-Peralta, A. (2019). Determinantes socio-económicos en la estimación de la disponibilidad a pagar del proyecto de agua potable y saneamiento en el centro poblado de Paxa, distrito de Tiquillaca – Puno 2017 [Socioeconomic Determinants in Estimating Willingness to Pay for the Drinking Water and Sanitation Project in the Town of Paxa, Tiquillaca District, Puno, 2017]. *Comuni@cción: Revista de Investigación en Comunicación y Desarrollo*, 10(1), 81-91. (In Spanish). <https://doi.org/10.33595/2226-1478.10.1.332>
12. Campos Díaz, A. H., Muñoz Vilela, A. J., Alvarez-Tolentino, D., Huamán De La Cruz, A., Unchupaico Payano, I., Camargo Caysahuana, A., Mariños Alfaro, J., & Unchupaico Fermin, J. (2024). A spatio-temporal behavior of PM<sub>2.5</sub> and PM<sub>10</sub> on changes of their concentration levels in the metropolitan area of Lima. *International Journal of Sustainable Development and Planning*, 19(10), 4083-4092. <https://doi.org/10.18280/ijssdp.191036>
13. Carlsson, F., & Johansson-Stenman, O. (2000). Willingness to pay for improved air quality in Sweden. *Applied Economics*, 32(6), 661-669. <https://doi.org/10.1080/000368400322273>
14. Carson, R. T. (2012). Contingent valuation: A practical alternative when prices aren't available. *Journal of Economic Perspectives*, 26(4), 27-42. <http://dx.doi.org/10.1257/jep.26.4.27>
15. Carson, R., & Hanemann, M. (2006). Contingent valuation. In *Handbook of Environmental Economics* (Vol. 2, pp. 821-936). Elsevier. Retrieved from <https://EconPapers.repec.org/RePEc:eee:envchp:2-17>
16. Chatterjee, N. (2022). Households' willingness to pay for improved water supply system in the dry-land areas of West Bengal – An estimation using double-bounded dichotomous-choice model. *Economic Affairs*, 67(5), 787-795. Retrieved from <https://ndpublisher.in/admin/issues/EAv67n51.pdf>
17. Chu, X., Zhan, J., Wang, C., Hameeda, S., & Wang, X. (2020). Households' willingness to accept improved ecosystem services and influencing factors: application of contingent valuation method in Bashang Plateau, Hebei Province, China. *Journal of Environmental Management*, 255, Article 109925. <https://doi.org/10.1016/j.jenvman.2019.109925>

18. Compañía Peruana de Estudios de Mercados y Opinión Pública (CPI). (2025). *Proyecciones poblacionales 2025. Edición N° 002, marzo 2025 [Population Projections for 2025. Issue No. 002, March 2025]*. Retrieved from [https://cpi.pe/images/upload/paginaweb/archivo/23/CPI%20-%20Market%20Report%20-%20Proyecciones%20Poblacionales%202025%20\(2\).pdf](https://cpi.pe/images/upload/paginaweb/archivo/23/CPI%20-%20Market%20Report%20-%20Proyecciones%20Poblacionales%202025%20(2).pdf)
19. Contreras, C., Aguilar, D., & Lázaro, J. (2024). Impacto del transporte masivo en la informalidad de vivienda: El caso de la Línea 1 del Metro de Lima [The Impact of Mass Transit on Informal Housing: The Case of Line 1 of the Lima Metro]. *Argumentos*, 5(1), 5-34. (In Spanish). <https://doi.org/10.46476/ra.v5i1.183>
20. Diallo, S. M., & Seck, A. (2023). Air pollution in urban Africa: Understanding attitudes and economic valuation in the case of Dakar, Senegal. *Sustainability*, 15(2), Article 1494. <https://doi.org/10.3390/su15021494>
21. Drupp, M. A., Turk, Z. M., Groom, B., & Heckenhahn, J. (2025). Global evidence on the income elasticity of willingness to pay, relative price changes and public natural capital values. *Environmental and Resource Economics*, 88(12), 3765-3804. <https://doi.org/10.1007/s10640-025-01042-5>
22. Evans, J. S., Rojas-Bracho, L., Hammitt, J. K., & Dockery, D. W. (2021). Mortality benefits and control costs of improving air quality in Mexico City: The case of heavy duty diesel vehicles. *Risk Analysis*, 41(4), 661-677. <https://doi.org/10.1111/risa.13655>
23. Filippini, M., & Martínez-Cruz, A. L. (2016). Impact of environmental and social attitudes, and family concerns on willingness to pay for improved air quality: A contingent valuation application in Mexico City. *Latin American Economic Review*, 25(1), Article 7. <https://doi.org/10.1007/s40503-016-0037-y>
24. Fonseca, J. P. S., Bravo, L. C. S., Leonor, R. C. V., Salazar, A. D. L. Á. C. S., Fonseca, J. P. S., Bravo, L. C. S., Leonor, R. C. V., & Salazar, A. D. L. Á. C. S. (2022). Congestión vehicular y contaminación ambiental en Lima Metropolitana [Traffic Congestion and Environmental Pollution in Metropolitan Lima]. *Revista Lasallista de Investigación*, 19(1), 152-164. (In Spanish). <https://doi.org/10.22507/rli.v19n1a9>
25. Fussell, J. C., Franklin, M., Green, D. C., Gustafsson, M., Harrison, R. M., Hicks, W., Kelly, F. J., Kishta, F., Miller, M. R., Mudway, I. S., Oroumijeh, F., Selley, L., Wang, M., & Zhu, Y. (2022). A review of road traffic-derived non-exhaust particles: Emissions, physico-chemical characteristics, health risks, and mitigation measures. *Environmental Science & Technology*, 56(11), 6813-6835. <https://doi.org/10.1021/acs.est.2c01072>
26. Giannakis, E., Kushta, J., Bruggeman, A., & Lelieveld, J. (2019). Costs and benefits of agricultural ammonia emission abatement options for compliance with European air quality regulations. *Environmental Sciences Europe*, 31(1), Article 93. <https://doi.org/10.1186/s12302-019-0275-0>
27. Haab, T. C., & McConnell, K. E. (2002). *Valuing environmental and natural resources: The econometrics of non-market valuation*. Edward Elgar Publishing. <https://doi.org/10.4337/9781843765431>
28. Haab, T., Lewis, L. Y., & Whitehead, J. (2020). State of the art of contingent valuation. In T. Haab, L. Y. Lewis, & J. Whitehead (Eds.), *Oxford Research Encyclopedia of Environmental Science*. New York: Oxford University Press. <https://doi.org/10.1093/acrefore/9780199389414.013.450>
29. Hamanaka, R. B., & Mutlu, G. M. (2025). Particulate matter air pollution: Effects on the respiratory system. *The Journal of Clinical Investigation*, 135(17). <https://doi.org/10.1172/JCI194312>
30. Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics*, 73(4), 1255-1263. <https://doi.org/10.2307/1242453>
31. Hanemann, W. M. (1984). Welfare evaluation in contingent valuation experiments with discrete response. *American Journal of Agricultural Economics*, 66, 332-341. <https://doi.org/10.2307/1240800>
32. Ibrahim, M. S. N., Johari, S., Asim, M. I. S. A., Mohammad, S. K. W., Afandi, S. H. M., & Hassan, S. (2025). An economic assessment on public well-being for biodiversity conservation in Gunung Mulu National Park, Sarawak, Malaysia. *Environment, Development and Sustainability*, 27(6), 14497-14521. <https://doi.org/10.1007/s10668-024-04533-5>
33. Inostroza, M. M., Saavedra, L., Poblete, V., & Bahamondez, A. (2020). A behavior model of willingness to pay for air improvement projects. *Revista Interamericana de Ambiente y Turismo*, 16(1), 88-96. <https://doi.org/10.4067/s0718-235x2020000100088>
34. Institute for Health Metrics and Evaluation. (2016). *The cost of air pollution: Strengthening the economic case for action*. World Bank. Retrieved from <https://hdl.handle.net/10986/25013>
35. IQAir. (2023). *World air quality report 2023*. IQAir. Retrieved from <https://www.iqair.com/newsroom/waqr-2023-pr>
36. Jin, J., Wang, Z., & Ran, S. (2006). Comparison of contingent valuation and choice experiment in solid waste management programs in Macao. *Ecological Economics*, 57(3), 430-441. <https://doi.org/10.1016/j.ecolecon.2005.04.020>
37. Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N. N., Baldé, A. B., Bertolli, R., Bose-O'Reilly, S., Boufford, J. I., Breyse, P. N., Chiles, T., Mahidol, C., Coll-Seck, A. M., Cropper, M. L., Fobil, J., Fuster, V., Greenstone, M., Haines, A., ... Zhong, M. (2018). The Lancet commission on pollution and health. *The Lancet*, 391(10119), 462-512. [https://doi.org/10.1016/S0140-6736\(17\)32345-0](https://doi.org/10.1016/S0140-6736(17)32345-0)
38. Li, F., Ahmad, R., Abbas, M., & Irfan, M. (2024). Public awareness and willingness to pay for

- eliminating atmosphere pollution in Pakistan: A case study. *Environment, Development and Sustainability*, 26(4), 9895-9922. <https://doi.org/10.1007/s10668-023-03125-z>
39. Li, Z., & Hu, B. (2018). Perceived health risk, environmental knowledge, and contingent valuation for improving air quality: New evidence from the Jinchuan mining area in China. *Economics & Human Biology*, 31, 54-68. <https://doi.org/10.1016/j.ehb.2018.07.007>
  40. Mamboleo, M., & Adem, A. (2022). Estimating willingness to pay for the conservation of wetland ecosystems, Lake Victoria as a case study. *Knowledge & Management of Aquatic Ecosystems*, 423, 22. <https://doi.org/10.1051/kmae/2022020>
  41. Minaya Gutierrez, C. A., Vásquez Quispe, C.Z., & Chinguel Laban, D.O. (2026). Social preferences and choice experiments in biodiversity conservation in Manu National Park, Peru. *Revista Portuguesa de Estudos Regionais*, 73, 65-80. <https://doi.org/10.59072/rper.vi73.765>
  42. Mitchell, R. C., & Carson, R. T. (2013). *Using surveys to value public goods: The contingent valuation method*. Rff Press.
  43. Moon, H., Yoo, S.-H., & Huh, S.-Y. (2021). Monetary valuation of air quality improvement with the stated preference technique: A multi-pollutant perspective. *Science of The Total Environment*, 793, Article 148604. <https://doi.org/10.1016/j.scitotenv.2021.148604>
  44. Nguyen, T. C., Le, H. T., Nguyen, H. D., Le, T. H., & Nguyen, H. Q. (2021). Estimating economic benefits associated with air quality improvements in Hanoi City: An application of a choice experiment. *Economic Analysis and Policy*, 71, 420-433. <https://doi.org/10.1016/j.eap.2021.06.009>
  45. Ouyang, Z., Sun, D., & Liu, G. (2024). Residents' willingness to pay for water pollution treatment and its influencing factors: A case study of Taihu Lake Basin. *Environmental Management*, 74(3), 490-504. <https://doi.org/10.1007/s00267-024-01968-4>
  46. Rafique, M. Z., Sun, J., Larik, A. R., & Li, Y. (2022). Assessment of willingness to pay for pollution prevention, health and happiness: A case study of Punjab, Pakistan. *Frontiers in Public Health*, 10, Article 825387. <https://doi.org/10.3389/fpubh.2022.825387>
  47. Samara, C., & Voutsas, D. (2005). Size distribution of airborne particulate matter and associated heavy metals in the roadside environment. *Chemosphere*, 59(8), 1197-1206. <https://doi.org/10.1016/j.chemosphere.2004.11.061>
  48. Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI). (2023). *Inventario de emisiones atmosféricas en Lima y Callao [Inventory of Air Emissions in Lima and Callao]*. SENAMHI. (In Spanish). Retrieved from [https://www.senamhi.gob.pe/?p=calidad\\_del\\_aire-estadistica](https://www.senamhi.gob.pe/?p=calidad_del_aire-estadistica)
  49. Silva Vivanco, C., Mogollon Ñañez, R. J., Diaz, S. E., & Chumpitaz Añi, V. C. M. (2021). Costo de la contaminación del aire por material particulado generado por el transporte vehicular en Lima Metropolitana [Cost of Air Pollution from Particulate Matter Generated by Vehicle Traffic in Metropolitan Lima]. *Natura@economía*, 6(2), 144-166. (In Spanish). <https://doi.org/10.21704/ne.v6i2.1944>
  50. Srisawasdi, W., Tsusaka, T. W., Winijkul, E., & Sasaki, N. (2021). Valuation of local demand for improved air quality: The case of the Mae Moh Coal Mine Site in Thailand. *Atmosphere*, 12(9), Article 1132. <https://doi.org/10.3390/atmos12091132>
  51. Suarez, A., Ruiz-Agudelo, C., Castro-Escobar, E., Flórez-Yepes, G. Y., & Vargas-Marín, L. A. (2021). On the mismatches between the monetary and social values of air purification in the Colombian Andean region: A case study. *Forests*, 12(9), Article 1274. <https://doi.org/10.3390/f12091274>
  52. Tao, J., Zhang, L., Cao, J., Zhong, L., Chen, D., Yang, Y., Chen, D., Chen, L., Zhang, Z., Wu, Y., Xia, Y., Ye, S., & Zhang, R. (2017). Source apportionment of PM2.5 at urban and suburban areas of the Pearl River Delta region, South China: With emphasis on ship emissions. *Science of the Total Environment*, 574, 1559-1570. <https://doi.org/10.1016/j.scitotenv.2016.08.175>
  53. Tavárez, H., Abelleira, O., & Elbakidze, L. (2024). Environmental awareness and willingness to pay for biodiversity improvement in Puerto Rico. *Journal of Environmental Studies and Sciences*, 14(1), 154-166. <https://doi.org/10.1007/s13412-023-00869-y>
  54. Tietenberg, T., & Lewis, L. (2018). *Environmental and natural resource economics* (11<sup>th</sup> ed.). Routledge. <https://doi.org/10.4324/9781315208343>
  55. Torres-Ramírez, R., Martínez Damián, M. Ángel, Valdivia Alcalá, R., González Juárez, A., & Sandoval Romero, F. (2023). Cerro de Amalucan: Disponibilidad a pagar (DAP) de una tarifa por el método de valoración contingente-doble límite [Cerro de Amalucan: Willingness to Pay (WTP) for a Fee Using the Contingent-Double-Limit Valuation Method]. *Ad-Gnosis*, 12(12), 1-12. (In Spanish). <https://doi.org/10.21803/adgnosis.12.12.615>
  56. Tudela-Mamani, J. W., & Leos-Rodríguez, J. A. (2018). Estimation of economic benefits due to improvements in basic sanitation services through choice experiments. *Revista Chapingo Serie Ciencias Forestales y del Ambiente*, 24(2), 237-250. <https://doi.org/10.5154/rchscfa.2017.05.037>
  57. Vásquez-Apestegui, B. V., Parras-Garrido, E., Tapia, V., Paz-Aparicio, V. M., Rojas, J. P., Sánchez-Ccoyllo, O. R., & Gonzales, G. F. (2021). Association between air pollution in Lima and the high incidence of COVID-19: Findings from a post hoc analysis. *Environmental Research*, 196, Article 110903. <https://doi.org/10.21203/rs.3.rs-39404/v2>
  58. Villagrán, X., Vásquez, W.F., & Leiva, B. (2025). Tourist preferences for cleaner mobility: A contingent

- valuation of electric rickshaws in Guatemala. *International Journal of Sustainable Transportation*, 19(5), 419-430. <https://doi.org/10.1080/15568318.2025.2499037>.
59. World Bank. (2020). *Pollution management and environmental health: 2020 annual report*. World Bank Group. Retrieved from <https://documents1.worldbank.org/curated/en/876611640299872666/pdf/Pollution-Management-and-Environmental-Health-Annual-Report-2020.pdf>
60. World Health Organization (WHO). (2021). *WHO global air quality guidelines: Particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization. Retrieved from <https://www.who.int/publications/item/9789240034228>
61. Xu, L., Xu, W., Jiang, C., Dai, H., Sun, Q., Cheng, K., Lee, C. H., Zong, C., & Ma, J. (2022). Evaluating communities' willingness to participate in ecosystem conservation in southeast Tibetan nature reserves, China. *Land*, 11(2), Article 207. <https://doi.org/10.3390/land11020207>
62. Yang, Y., Zhang, Y., Zhang, Y., Guo, D., & Xu, H. (2025). Comprehensive assessment of the environmental impacts of China's new energy industry policy from life cycle perspective. *Environmental Impact Assessment Review*, 104, Article 107916. <https://doi.org/10.1016/j.eiar.2025.107916>
63. Zhang, J., Jiang, H., Zhang, W., Ma, G., Wang, Y., Lu, Y., Hu, X., Zhou, J., Peng, F., Bi, J., & Wang, J. (2019). Cost-benefit analysis of China's action plan for air pollution prevention and control. *Frontiers of Engineering Management*, 6(4), 524-537. <https://doi.org/10.1007/s42524-019-0074-8>
64. Zhang, Y., Wang, H., & Duan, W. (2021). Household willingness to pay for forest ecological restoration in giant panda habitats: A discrete choice experiment. *Forests*, 12(12), Article 1735. <https://doi.org/10.3390/f12121735>

## APPENDIX A

**Table A1.** Probit regression estimate without socioeconomic variables

| Probit regression |             |           |       |     | Number of obs =      | 400   |
|-------------------|-------------|-----------|-------|-----|----------------------|-------|
| AIC               | 516.23977   |           |       |     | LR chi2(1) =         | 26.97 |
| BIC               | 524.2227    |           |       |     | Prob > chi2 =        | 0     |
| Log likelihood =  | -256.11989  |           |       |     | Pseudo R2 = 0.0500   | 0.05  |
| Items             | Coefficient | Std. err. | z     | P>z | [95% conf. interval] |       |
| BID               | -0.1500298  | 0.0292698 | -5.13 | 0   | -0.3000597           |       |
| _cons             | 1.310382    | 0.2184922 | 6     | 0   | .8,821,452 1.738619  |       |

**Table A2.** Probit regression estimate with socioeconomic variables

| Probit regression |             | Value     |       |       | Number of obs =      | 375        |
|-------------------|-------------|-----------|-------|-------|----------------------|------------|
| AIC               | 483.54873   |           |       |       | LR chi2(7) =         | 38.79      |
| BIC               | 514.96414   |           |       |       | Prob > chi2 =        | 0          |
| Log likelihood =  | -233.77437  |           |       |       | Pseudo R2 =          | 0.0766     |
| Items             | Coefficient | Std. err. | z     | P>z   | [95% conf. interval] |            |
| BID               | -0.1412611  | 0.0305    | -4.63 | 0     | -0.201101            | -0.0814213 |
| Sex               | -0.0376557  | 0.1446    | -0.26 | 0.795 | -0.3211356           | 0.2458241  |
| Marital_status    | -0.0360282  | 0.1431    | -0.25 | 0.801 | -0.316441            | 0.2443847  |
| Age               | -0.0161957  | 0.006     | -2.68 | 0.007 | -0.0280403           | -0.0043511 |
| Level_education   |             |           |       |       |                      |            |
| 2                 | -0.2865096  | 0.3029    | -0.95 | 0.344 | -0.8802414           | 0.3072221  |
| 3                 | -0.2710164  | 0.3112    | -0.87 | 0.384 | -0.8808772           | 0.3388445  |
| Income2           | 0.0000938   | 4E-05     | 2.49  | 0.013 | 0.0000199            | 0.0001677  |
| Cons              | 1.911705    | 0.4919    | 3.89  | 0     | 0.9475132            | 2.875896   |

## APPENDIX B

**Table B1.** Part 4 of the survey: Socioeconomic variables

| Items                                                                                                    | Choose or write your answer                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gender                                                                                                   | <input type="checkbox"/> Male<br><input type="checkbox"/> Female                                                                                                                                                                                                                                                                                                                                                                                       |
| Indicate your age                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Marital status                                                                                           | <input type="checkbox"/> Single<br><input type="checkbox"/> Married/Cohabiting<br><input type="checkbox"/> Divorced<br><input type="checkbox"/> Widowed                                                                                                                                                                                                                                                                                                |
| Level of education                                                                                       | <input type="checkbox"/> No education<br><input type="checkbox"/> Basic education<br><input type="checkbox"/> Higher education                                                                                                                                                                                                                                                                                                                         |
| How many people live in your household?                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| How many children under the age of 18 live in your household?                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Which range is closest to your household's monthly income? Please count all sources of household income. | <input type="checkbox"/> 0 – 1025<br><input type="checkbox"/> 1026 – 1500<br><input type="checkbox"/> 1501 – 2000<br><input type="checkbox"/> 2001 – 2500<br><input type="checkbox"/> 2501 – 3000<br><input type="checkbox"/> 3001 – 4000<br><input type="checkbox"/> 4001 – 5000<br><input type="checkbox"/> 5001 – 7000<br><input type="checkbox"/> 7001 – 9000<br><input type="checkbox"/> 9001 – 10000<br><input type="checkbox"/> More than 10000 |