Development and validation of the Multidimensional Instrument for Social Perception of Water Scarcity (IMPSEH) in rural communities in northern Mexico

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Abstract
Water scarcity in northern Mexico transcends the physical availability of water, affecting public health and social cohesion. The aim of this research was to develop and validate the Multidimensional Instrument of Social Perception of Water Scarcity (IMPSEH, by its Spanish acronym) in rural communities of northern Mexico. Using a psychometric, quantitative, cross-sectional design, an initial 85-item version was constructed, comprising nine dimensions: sociodemographic characteristics, water supply and access, water quality, social perception, conservation practices, perceived environmental impact, impact on health and well-being, governance and participation, and water insecurity (HWISE-4). Content validity, assessed by eight expert judges using the relevance (iP) and clarity (iU) indices, showed high relevance (iP = 0.91) and clarity close to the acceptance threshold (iU = 0.79), resulting in an 84-item version. The instrument was administered through simple random sampling to 350 adults (aged 18 to 94) in the municipality of San Francisco de Conchos, Chihuahua. Reliability analysis yielded Cronbach's alpha values between 0.70 and 0.86. It is concluded that the IMPSEH provides evidence of content validity and acceptable-to-good internal consistency, and constitutes an original tool for diagnosing water-related problems and informing public policy grounded in the human right to water.

Keywords: Water scarcity, instrument validation, social perception, public health, rural communities.

1. Introduction

Access to safe and adequate drinking water services represents one of the fundamental pillars for poverty reduction and the promotion of public health at the global level. However, the World Health Organization (WHO, 2024) warns that more than 40% of the world's population resides in rural areas, where dependence on small supply systems increases vulnerability to water security deficiencies, leading to adverse social and economic consequences. In the context of Mexico, this problem acquires critical nuances, especially in the arid and semi-arid regions of the north of the country, where the natural availability of the resource is inversely proportional to population growth and economic demand (Jiménez-Cisneros et al., 2010).

The contemporary water crisis in northern Mexico is the result of a management model that has privileged agricultural use (a sector that consumes approximately 77% of national water resources) over sustainability and human well-being (Jiménez-Cisneros et al., 2010). This unequal distribution has generated a "social scarcity" that transcends the mere technical fact of the physical lack of water. Wheatley (2024) stresses that water scarcity acts as a catalyst for social conflicts, exacerbating community tensions and the perception of injustice when the population feels that access to the resource is limited by deficient distribution capacities or financial constraints. Likewise, Unfried et al. (2022) show that decreases in the local water mass triple the probability of social unrest, particularly in areas where there is no guaranteed access to groundwater or surface water.

Beyond its socio-political impact, water insecurity can affect mental health and human biology. Recent studies show that the inability to access enough water reliably causes chronic stress responses and cognitive distress (Rosinger & Young, 2020). This phenomenon presents itself differently in vulnerable groups; for example, Rhue et al. (2023) indicate that children in water-insecure areas face increased risks of malnutrition, dehydration, and psychological trauma, jeopardizing their physical and cognitive development. For women, who are often primarily responsible for managing water in rural households, this burden increases their vulnerability to disease and high psychosocial stress, due to water transport and ongoing concerns about family hygiene (Rosinger & Young, 2020; Soares & Hatch Kuri, 2023).

In northern Mexico, this problem reaches critical levels. An example of this is that 100% of the territory of the state of Chihuahua is in a drought condition, with 34.9% affected by extreme drought and 15.7% by exceptional drought (H. Congreso del Estado de Chihuahua, 2024). An emblematic case is the La Boquilla Dam, the largest in the state and the support of Irrigation District 005, one of the most important in the country, which as of April 24, 2025 was operating at a critical level of 14.7% of its capacity, data provided by the National Water Information System (SINA/CONAGUA, 2026), compromising the human supply, irrigated agriculture, fishing, tourism and hydroelectric generation on which the communities settled in their surroundings depend. The historic drought has reduced the yields of the countryside and the economy of families, causing the first social tensions over access to and distribution of water (Córdova, 2020). In the absence of instruments that capture how these populations perceive and respond to scarcity, the development of a measurement tool contextualized to this region is justified.

That said, there is still a notable lack of scientifically validated tools that allow capturing the social perception of water scarcity in all its multidimensionality. To fill this gap, the development of robust psychometric instruments is indispensable. As Boateng et al. (2018) point out, creating scales that assess the lived experience of water insecurity allows policymakers to identify and prioritize resources more effectively. In this sense, content validation through expert judgment is a critical phase to ensure that the items on a scale faithfully represent the conceptual cultural domain they intend to measure, minimizing semantic errors and ensuring the relevance of the tool (Pedrosa et al., 2014). The procedure proposed by Carrera et al. (2011) for the validation of instruments provides objectivity to the process by calculating two key statistical indicators: the univocity index (iU), which quantifies the degree of clarity and univocal understanding of each item, and the relevance index (iP), which assesses the relevance of the item with respect to the construct studied (De la Cruz and Gordillo, 2020; Mata De los Ríos & Parra Acosta, 2023).

Although there are internationally validated instruments to measure water insecurity at home, such as the HWISE (Household Water Insecurity Experiences) scales derived from the global consortium protocols (Pearson et al., 2025), their focus is on the experiences of access, use and availability of water at the domestic level during the last weeks. These scales, due to their vocation of cross-cultural comparability, were not designed to capture other dimensions that are central in contexts of water conflict such as that of northern Mexico: the perception of local environmental impact, resource conservation practices, the valuation of governance and citizen participation, and the perception of social conflict derived from a distribution of water considered inequitable. The IMPSEH seeks to fill this gap by integrating, in a single instrument, both an internationally comparable measure of water insecurity (short version HWISE-4) and the socio-environmental and governance dimensions of the regional rural context, thus offering a multidimensional reading that existing scales alone do not provide.

The scientific soundness of an instrument is complemented by the analysis of its internal consistency through Cronbach's alpha coefficient. This statistic is fundamental in psychometric validation, since it allows quantifying the homogeneity of the items; an adequate value (usually ≥ 0.70) ensures that the application of the instrument produces stable and reliable results (George & Mallery, 2003; Hernández-Sampieri & Mendoza Torres, 2018).

In this context, there is no tool that captures water scarcity in all its multidimensionality in rural communities in northern Mexico, emblematic areas of the country's water tensions in which agricultural, tourist, and domestic interests converge. In this absence, the general objective of the research was to develop and validate the IMPSEH, an instrument that integrates variables of social perception, public health, environmental impact, governance and experiences of water insecurity, in the areas surrounding the La Boquilla Dam, in the state of Chihuahua, Mexico. Specifically, the scope of this article is limited to the first two phases of the validation of the instrument: content validity, through expert judgment and the calculation of relevance and univocity indices, and reliability, through internal consistency analysis. The analysis of the data derived from its application, as well as the construct validity, will be addressed in subsequent works.

2. Methodology

2.1. Type of study

This research is quantitative, descriptive and cross-sectional, and was developed through a deductive procedure. This is a psychometric design study aimed at content validation and the analysis of the internal consistency of a newly created measurement instrument. This type of design is recognized in the methodological literature as the most appropriate to ensure that the items of an instrument faithfully represent the conceptual domain they intend to measure, so that the results can be generalized to the target population (Hernández-Sampieri & Mendoza Torres, 2018).

2.2. Context of the research

This study is developed within the framework of the problem of water scarcity that affects the communities surrounding the La Boquilla Dam, in the municipality of San Francisco de Conchos, Chihuahua, Mexico.

2.3. Geographical location

The study was carried out in the municipality of San Francisco de Conchos, in the south-central region of the state of Chihuahua, Mexico, where the La Boquilla Dam (also known as Lake Toronto) is located, between coordinates 27°32'14.67"–27°30'56.60" N and 105°23'21.01"–105°43'25.26" W, two hours from the state capital. The dam is part of the hydrological region of the Rio Grande, within the current of the Conchos River; its curtain has a length of 750 m and a height of 80 m and has a capacity of 2,894 hm3, and its water is mainly used for agricultural irrigation in District 005, in addition to human consumption, fishing, tourist activities and hydroelectric power generation (Puga, 2010; Rubio Arias et al., 2014). The main localities of the municipality are La Boquilla and San Francisco de Conchos (INEGI, 2020), to which are added neighboring communities such as El Molino and El Tigre.

2.4. Sample, type of sampling and representativeness

The reference population was 2,696 adult residents of the municipality of San Francisco de Conchos (INEGI, 2020). Simple random sampling was used. The sample size was calculated using the formula for finite populations (1):

$$n = N\cdot Z^2 \cdot p \cdot q / (N \cdot e^2 + Z^2 \cdot p \cdot q) \text{ .... (1)}$$

Where n is the sample size, N is the size of the population, Z is the value associated with the confidence level, p is the expected proportion, q = 1 − p and e is the estimation error. Under the assumption of maximum variance (p = q = 0.5), with a confidence level of 95% (Z = 1.96) and a margin of error of 5% (e = 0.05), the minimum size required to statistically represent the population (N = 2,696) was 337 surveys. Finally, 350 instruments were applied, a figure that exceeds the minimum calculated.

2.5. Inclusion and exclusion criteria
Men and women from 18 to 94 years of age, residents of the localities that make up the municipality of San Francisco de Conchos (Boquilla, El Tigre, San Francisco de Conchos, Amparaneño, Rancho Nuevo, Rancho Viejo, El Molino, Lote 4, Colina), who signed the informed consent form, were included. Children under 18 years of age, those over 94 years of age and migrants who were in the municipality for the planting season were excluded.

2.6. Development of the IMPSEH instrument
The process of building the instrument began with the operational definition of the subject of study, breaking it down into observable and measurable variables and ensuring the alignment of the items with these variables. Each item was formulated through clear questions, selecting the most appropriate type of scale for the construct to be measured. First, a sociodemographic data card was designed; The variables included age, gender, level of education, marital status, and place of residence, among others.

Initially, the instrument was built with nine sections: I. Sociodemographic data (nine items), II. Water supply and access (seven items), III. Water quality (five items), IV. Social perception of water scarcity (twenty-three items), V. Resource conservation practices (fourteen items), VI. Perceived environmental impact (thirteen items), VII. Impact on health and well-being (six items), VIII. Governance and Citizen Participation (four items) and IX. Water insecurity (four items), for a total of eighty-five. The types of questions used included: open and closed questions (dichotomous, polychotomous, and Likert-type scale), with nominal, ordinal, interval, and ratio measurement levels. Subsequently, each variable was operationalized, including its dimensions, indicators, and items.

Once the instrument was built, the sequence of the procedure was: 1) Content validation through expert judgment; 2) Preparation of the refined and final version; 3) Application to a sample made up of inhabitants of communities surrounding the La Boquilla Dam, in Mexico; 4) Reliability analysis (n = 350).

2.7. Review by expert judgment
The content validation of the instrument was carried out using the expert judgment method, a technique that guarantees that the items or constructs respond to the scientific rigor of the process (Pedrosa et al., 2014). The objective of this phase was to detect semantic or grammatical errors and evaluate the degree of comprehensibility of the items. The panel of experts was multidisciplinary; His areas of knowledge included territorial development, anthropology, energy, health, and water and sanitation. The group was made up of eight specialists: five with a doctorate, one with a master's degree and two with a bachelor's degree in engineering, all with professional and academic experience related to the thematic axes of the instrument. The number of experts consulted is considered sufficient, given that the methodological literature recommends between five and ten judges to guarantee representativeness and reduce the variability of individual judgment (Escobar-Pérez & Cuervo-Martínez, 2008).

The instrument was hosted in a Google Forms form. For each item, the experts evaluated two central criteria: univocity and relevance. Following the centesimal scale proposed by Carrera et al. (2011), the values assigned to each criterion were: optimal univocity = 3, high univocity = 2, low univocity = 1 and null univocity = 0. The same scale of values was applied to the relevance criterion (optimal relevance = 3, high relevance = 2, low relevance = 1, null relevance = 0). Recent studies in the Ibero-American context confirm the validity and solidity of this procedure for the validation of instruments in applied research in health and social sciences (De la Cruz & Gordillo, 2020; Mata De los Ríos & Parra Acosta, 2023).

2.7.1. Calculation of the IMPSEH univocity and relevance indices
The information issued by the judges was processed using the procedure defined by Carrera et al. (2011), which establishes the calculation of two indices: the univocity index (iU) and the relevance index (iP). Both make it possible to objectively determine whether an item should be retained in its original wording, modified or eliminated from the instrument. The univocity index is calculated from the following expression (2):

$$\frac{[(\Sigma nUO \cdot VUO) + (\Sigma nUE \cdot VUE) + (\Sigma nUB \cdot VUB) + (\Sigma nUN \cdot VUN)]}{(\Sigma nTU \cdot VMU)} = iU \ldots\ldots\ldots\ldots (2)$$

Where iU represents the item's univocity index; ΣnUO is the number of responses obtained at the optimal univocity level and VUO is its assigned value (3); ΣnUE is the number of responses at the high univocity level and VUE its value (2); ΣnUB corresponds to low-univocity responses with VUB value (1); ΣnUN is the number of responses at the level of null univocity with a value VUN (0); ΣnTU is the total number of responses obtained for the criterion of univocity; and VMU is the maximum value of the univocity scale (3).
Similarly, the index of relevance is obtained by the expression (3):

$$\frac{[(\Sigma nPO \cdot VPO) + (\Sigma nPE \cdot VPE) + (\Sigma nPB \cdot VPB) + (\Sigma nPN \cdot VPN)]}{(\Sigma nTP \cdot VMP)} = iP \ldots.. (3)$$

Where iP represents the item's relevance index; ΣnPO is the number of responses at the level of optimal relevance and VPO its value (3); ΣnPE corresponds to the level of high relevance with a VPE value (2); ΣnPB is the number of low-relevance responses with a BPV value (1); ΣnPN corresponds to null relevance with a value of NPV (0); ΣnTP is the total number of responses obtained for the relevance criterion; and PMV is the maximum value of the relevance scale

(3).

The values resulting from both formulas range from 0 to 1. Based on these, the decision criteria established by Carrera et al. (2011) were applied: items with an index greater than or equal to 0.80 were preserved in their original form; those with an index between 0.60 and 0.79 were subject to revision and modification in their wording or location within the instrument; and items with an index equal to or less than 0.59 were eliminated. These same cut-off criteria have been consistently used in instrument validation studies in health and education contexts in Mexico (Parra et al., 2019; Espinosa-Solís et al., 2021).

2.7.2. Adjustments and final version of the IMPSEH instrument
Based on the univocity and relevance indices calculated for each item, and taking into consideration the qualitative observations issued by the experts in the evaluation form, the instrument was refined. Items that obtained indices below 0.59 in either of the two criteria were eliminated; those with indexes in the range of 0.60 to 0.79 were modified in their wording according to the suggestions of the judges to improve the clarity and comprehension of the participants. The result of this process gave rise to the final version of the Multidimensional Instrument of Social Perception on Water Scarcity (IMPSEH), whose structure (variables, dimensions, indicators, and type of variable) is presented in Table 4.

In addition to the quantitative indices, the evaluation template included, for each item, an open field in which the judges recorded qualitative observations on its wording, clarity and relevance. These observations were collected in a structured way and, together with the index values, guided the debugging of the instrument. The items with relevance or univocity indices in the intermediate zone (0.60–0.79) that also received qualitative observations were reformulated by the research team, which wrote the new version. In cases of disagreement between judges regarding the conservation or elimination of a reagent, the final decision fell on the technical manager of the project, who resolved based on his expert judgment and the values of the relevance and univocity indexes. The version resulting from this reformulation was considered final and did not undergo a second formal round of evaluation by the panel of judges.

It is important to note that it was not possible to carry out a pilot test before applying the instrument in the final sample. As a result, the instrument was applied to the entire sample without a previous piloting phase. This situation is recognized as a limitation of the study, since the pilot test helps to improve validity, detect possible errors in the tool, application errors, comprehension problems in the specific context of the population, and establish the estimated response time (Hernández-Sampieri & Mendoza Torres, 2018).

2.8. Reliability analysis
To evaluate the internal consistency of the instrument, Cronbach's alpha coefficient was calculated, a statistic that involves items measured on Likert-type scales, treated as interval according to usual psychometric practice (George & Mallery, 2003). Consequently, the inclusion of each variable in the analysis depended on the nature of its items, and three situations were distinguished. First, the variables made up entirely of Likert-type scale items (Water Resource Conservation Practices and Water Insecurity), were analyzed with all their items. Second, in the variables that combine items of different nature (Social perception of water scarcity, Perceived environmental impact, and Governance and citizen participation), alpha was calculated only with the subset of Likert-type items, and nominal items (dichotomous and polycotomic) were excluded, as well as those with response formats that are not comparable with the rest of the scale (e.g., the introductory item of percentage ranges in Section VI). Finally, alpha was not calculated for variables whose items, due to their nominal nature or the heterogeneity of their response formats, do not make up a summative scale: Sociodemographic data, Water supply and access, Water quality, and Impact on health and well-being. Table 5 details, for each variable analyzed, the total number of items and the number of items effectively evaluated (k). This analysis was performed with data collected from a sample of n = 350 participants, using the Statistical Package for the Social Sciences (SPSS, version 22).

For the interpretation of the coefficients obtained, the criteria proposed by George and Mallery (2003) were adopted: values greater than or equal to 0.90 are considered excellent; between 0.80 and 0.89, good; between 0.70 and 0.79, acceptable; between 0.60 and 0.69, questionable but reportable with complementary justification; and less than 0.60, unacceptable. For dimensions whose items are nominal or polychotomous in nature, such as the sections on causal attribution or impact on health and well-being, Cronbach's alpha was not calculated since this statistic assumes an ordinal or interval scale.

2.9. Ethical considerations
This research work is derived from the research project entitled "Social perception on water scarcity, conservation practices and environmental impact in the surroundings of the La Boquilla Dam: Consequences for public health", with registration number UACH2025/PE/025 granted by the Secretariat of Research and Postgraduate Studies of the Autonomous University of Chihuahua and approved by the Bioethics Committee of the UACH registration number CB-UACH-2-2026.

The study was carried out in accordance with the ethical principles established in the Declaration of Helsinki for research with human beings, as well as with the provisions of the Regulations of the General Health Law on Research for Health of Mexico, and was considered a risk-free research, since it did not involve interventions or intentional modifications of physiological or psychological variables in the participants.
Both the experts who participated in the content validation panel and the members of the representative sample (n = 350) were clearly informed about the objectives, procedures, risks, and benefits of the study, and participated

voluntarily, after signing a letter of informed consent. His right to withdraw from the studio was guaranteed at all times without any repercussions.

The information collected was treated with strict confidentiality, safeguarding the anonymity of the participants by assigning numerical codes instead of personal data. The data obtained were used exclusively for academic and research purposes.

3. Results

3.1 Content validation by expert judgement

This section presents the results of the content validation of the Multidimensional Instrument for Social Perception of Water Scarcity (IMPSEH), developed to evaluate the perception of rural communities in northern Mexico.

3.1.1. Index of univocity and relevance

For Relevance, of the total of 85 items analyzed, 82.35 % of the items obtained an iP ≥ 0.80 (keep category), while the general average iP was 0.91 (Table 1). 16.47 % obtained values between 0.60 and 0.79 (Modify category) and 1.18 % obtained iP ≤ 0.59 (Delete category) (Table 1).

The general analysis of univocity showed that 41.18 % of the items were preserved in their original wording and section (Table 2). Only one item was eliminated, because it was duplicated in Section III (Water quality). In the initial version of the instrument, item CA19 posed the question "In your opinion, how much do you agree or disagree with the following sentence? The water service is of quality", while item CA21 asked a similar question: "The quality of the drinking water service you receive in your home is:". It was decided to keep item CA20, since it came from one of the bibliographic sources most suited to the context of the research; additionally, the relevance and univocity indices of item CA19 were less than 0.60, which confirmed the relevance of its elimination. As a result, the items in Section III were recoded: from the original five items (CA17 to CA21), four (CA17 to CA20) were changed (Table 4 and Figure 2).

On the other hand, the univocity analysis showed that more than half of the items (57.65%) obtained iU values in the range of 0.60 to 0.79, which indicated that they required a revision of their wording to achieve a clearer and more succinct formulation. Regarding the relevance analysis, 82.4% of the items were classified in the category "Keep the item". The marked difference between the two indices reveals that the judges considered the items highly relevant to the construct they measured, but considered that a significant number of them required adjustments in their wording and clarity to guarantee a univocal interpretation by the respondents.

3.1.2. Relevant aspects identified by section of the instrument

Table 3 shows the variables used for section I (Sociodemographic data), highlighting the variables adapted to the research context, for example, the names of the communities included in the study and the types of occupation related to the economic activities of the region.

Table 4 shows the operationalization of the variables of the final version of the instrument, and Figure 2 shows the hierarchical structure of the instrument (IMPSEH).

The sections with the highest univocity were I, II, IV and IX, with iU values of 0.89, 0.88, 0.87 and 0.91, respectively (Table 2). In contrast, sections VI (Perceived environmental impact, iU = 0.63) and VIII (Governance and citizen participation, iU = 0.67) registered the lowest univocity averages and, therefore, required modification; both visually approximate the lower threshold in Figure 1. In these two sections, the common pattern was the presence of grammatical errors and excessive length of the items.

The content validity analysis of the IMPSEH, through the judgment of eight experts, allowed us to conclude that the instrument has a high content relevance (iP = 0.91); that is, the items evaluate the constructs that were intended to be measured. The overall univocity (iU = 0.79) was very close to the threshold of 0.80, which indicated that some sections contained items that required wording adjustments to ensure their unambiguous understanding in the target population.

The revision of the wording focused primarily on Sections V, VI and VIII, which had the lowest univocity averages. After applying the recommended modifications, reassigning items between sections, and eliminating the duplicate item (CA19), the final version of the instrument was made up of eight main variables, 29 dimensions, 36 indicators, and 75 items, to which are added the nine items of sociodemographic data (Table 3), for a total of 84 items.
The reassignments between sections were carried out as follows.

The case of Section IV (Social perception of water scarcity): of its original 23 items, four were reassigned (PS30, PS32, PS33 and PS40) to Section VIII. and seven required drafting adjustments; despite this, its average univocity was high (iU = 0.87), which is explained by the high ratings given by the judges and by the lower magnitude of the wording changes.

Section V (Water Resource Conservation Practices) initially had 14 items (PC45 to PC58), of which four were also moved to Section VIII (Table 4).
As a result of these reassignments, Section VIII (Governance and citizen participation) was the one that was modified the most. In the original version it only had four items (GP78 to GP81); after receiving four items from Section IV

(PS30, PS32, PS33 and PS40) and four from Section V (PC45, PC56, PC57 and PC58), it became part of 12 items. When the section was moved, these eight items adopted the prefix corresponding to Governance (GP), and the reassignment displaced the general numbering of the instrument (Table 4). Of these 12 items, only the three measured by having a Likert-type scale were (GP72, GP73 and GP74) and were included in the internal consistency analysis (Table 5), since Cronbach's alpha coefficient requires variables of this nature.

3.2. Reliability Analysis

According to the criteria described in section 2.8, Cronbach's alpha was estimated for the five variables with Likert-type items, with the responses of the 350 participants; Sections I, II, III, and VII were not included in the analysis. Table 5 presents the results for the remaining dimensions, with the total number of items of each variable that were evaluated with alpha.

The coefficients ranged from 0.70 to 0.86, with 95% confidence intervals supporting an acceptable to good internal consistency in the dimensions assessed. The table also includes the means (M) and standard deviations (SD) of each scale. It is important to note that the scales have different metrics, the Likert dimensions range from 1 to 5, while HWISE-4 scores from 0 to 3, and that explains why its average of 2.30 is low along with the others.

Here's the professionally written paragraph:
In a first reliability analysis, Dimension 1 of Section IV obtained a Cronbach's alpha coefficient of 0.675, a value below the minimum acceptable threshold. The review of the items revealed that item PS23 presented an inverted response scale with respect to the rest of the items in the dimension, which negatively affected the internal consistency of the set. Consequently, it was decided to eliminate this item from the instrument. After this debugging, the reliability analysis was performed again with the remaining 10 items of the dimension, obtaining a Cronbach's alpha of 0.74, a value considered acceptable for research purposes. As a result of this adjustment process, the final version of the instrument was made up of a total of 83 items.

Table 4 shows the items used for each dimension with the respective code reassignment, after eliminating the PS23 item, the general coding of the instrument was again moved (Table 4).

On the other hand, given the extent of the research, the results of the application of the instrument are presented in an independent manuscript, currently in preparation.

4. Discussion

The structure of IMPSEH integrates physical, cognitive, and social variables, and is aligned with theoretical frameworks that transcend the traditionally technical view of water. Next, each dimension is discussed, articulating its conceptual foundation with the psychometric evidence obtained.

4.1. Discussion by dimensions

Supply and access (Section II) and water insecurity (Section IX). The instrument defines access not only by the presence of infrastructure, but also by perceived sufficiency, which agrees with Jiménez-Cisneros et al. (2010), who emphasize that access is the ability to satisfy basic needs. Both sections showed strong content validity in expert judgment (Section II: iP = 0.96, iU = 0.88; Section IX: iP = 0.93, iU = 0.91), and water insecurity showed good internal consistency ($\alpha = 0.83$). The integration of the HWISE-4 scale in Section IX makes it possible to measure water insecurity as a lived experience, i.e., the concern and lack of water for hygiene, which Young et al. (2019) and Pearson et al. (2025) validate as a global standard to capture the phenomenon beyond macroeconomic indicators.

Water quality (Section III). When evaluating organoleptic attributes (color, taste, smell), IMPSEH recognizes that citizen perception is inherently subjective. It was the dimension with the least relevance in the expert judgment (iP = 0.77, iU = 0.74), which reflected the need to specify some items. Ortega Márquez and Márquez Fernández (2017) reinforce the relevance of this dimension by pointing out that users judge potability based on their senses, which directly influences trust in the public service.

Social perception of water scarcity (Section IV). The instrument emphasizes the cognitive evaluation of the problem and the perception of social conflicts derived from the lack of the resource. This dimension had a high content validity (iP = 0.91, iU = 0.87) and an internal consistency that ranged from acceptable ($\alpha = 0.74$, for the perception of the problem and the conflict) to good ($\alpha = 0.86$, for the importance of water by sector). This approach is fundamental, according to Unfried et al. (2022) and Wheatley (2024), who demonstrate that scarcity acts as a catalyst for community tensions. In contrast, the model of Bustos Aguayo et al. (2022), which reported a general alpha of 0.80 for its scale, focuses on risk aversion (collaboration) and risk propensity (delegation to the State) as axes for negotiation, dimensions that are explored transversally in governance in the IMPSEH.

Water Resource Conservation Practices (Section V). The inclusion of saving and reuse behaviors is based on environmental psychology. The dimension showed adequate content validity (iP = 0.88, iU = 0.73) and acceptable internal consistency, although at the limit of the criterion ($\alpha = 0.70$), which indicates it as the dimension most likely to be strengthened in future versions. Corral-Verdugo et al. (2003) show that these practices are mediated by ecological beliefs (water is limited) versus utilitarian beliefs (water is a right to exploit): while the former inhibit consumption, the latter promote it.
Perceived environmental impact (Section VI). This dimension included reagents referring to the water bodies in the study area, as well as to flora, fauna and pollution. It was the dimension with the least univocity in the expert

judgment (iU = 0.63; iP = 0.96), which led to a reformulation of its items before application; after this, it reached a good internal consistency (α = 0.82). This result is consistent with what was reported by Benez et al. (2010), who documented that riparian communities build their assessment of the state of water based on direct observation of the deterioration of their environment, changes in water bodies, vegetation and fauna rather than on technical indicators. The relevance of including this dimension lies in the fact that the perception of local environmental damage is a component that instruments focused on the domestic experience of water insecurity, such as the HWISE scale, do not capture.

Impact on health and well-being (Section VII). Evaluating physical symptoms and emotions (stress, anguish) was a methodological success in the construction of the IMPSEH; in fact, this dimension obtained the greatest relevance of the instrument (iP = 0.97, iU = 0.78). Rosinger and Young (2020) indicate that water insecurity can affect human biology through psychosocial stress and generate differentiated risks in vulnerable groups (children and the elderly), as broken down by the IMPSEH.

Governance and citizen participation (Section VIII). This section measures institutional trust and willingness to participate. It presented a low univocity in the expert judgment (iU = 0.67; iP = 0.96), so it was necessary to reformulate the items before their application. In the reliability analysis, only the 3 items (out of 12) measured on an interval scale were included, a methodologically correct procedure given that Cronbach's alpha assumes variables of this nature; the value obtained (α = 0.72) for items GP72, GP73 and GP74, supports the consistency of the perception of institutional trust in the municipality of San Francisco de Conchos. Mussetta (2009) and Soares and Hatch Kuri (2023) agree that effective governance requires that social participation transcend consultative to become collective action and accountability monitoring.

4.2. Limitations of the study

The present study recognizes some limitations that should be considered when interpreting its results. First, the validation process did not include a pilot test prior to the final application of the instrument. This decision was conditioned by administrative restrictions inherent to the financing of the project, which established an execution period of six weeks for the delivery of results, which limited the possibility of incorporating an intermediate phase of piloting. However, the methodological literature recognizes that the pilot test, although a recommended practice, is not an essential requirement when the content validation was rigorously carried out and the final sample is large enough to provide stable psychometric estimates (Boateng et al., 2018; DeVellis & Thorpe, 2022). In this study, both conditions were met: content validation was performed by a panel of eight multidisciplinary expert judges using the procedure of Carrera et al. (2011), and the sample size obtained (n = 350) far exceeded the minimum criteria recommended for internal consistency analysis and estimation of Cronbach's alpha (Streiner et al., 2014).

On the other hand, the resolution of disagreements between judges depended on the judgment of the technical manager and a coefficient of agreement between judges was not calculated, which constitutes a limitation that future applications could be corrected by means of formal measures of inter-judge agreement.

Second, the sample was made up of residents of the communities surrounding the La Boquilla Dam in the municipality of San Francisco de Conchos, Chihuahua, which limits the generalization of the results to water contexts with different sociodemographic, geographical, and cultural characteristics. The IMPSEH instrument was designed and validated for this specific population, so its application in other contexts would require a process of adaptation and revalidation. Third, the validation process did not include the evaluation of construct validity through confirmatory factor analysis (CFA), which is the most rigorous standard for verifying the dimensional structure of the instrument (Muñiz et al., 2013). This stage is pending as part of the longitudinal validation process of the IMPSEH in subsequent studies.

4.3. Strengths of the study

Despite the limitations indicated, the present study presents several methodological strengths that support the quality and usefulness of the developed instrument. The IMPSEH is the first multidimensional instrument specifically designed to measure the social perception of water scarcity in rural communities in northern Mexico, integrating in a single tool a sociodemographic data card and eight variables, 29 dimensions, 36 indicators and 74 items. The variables are conceptually differentiated and range from access to water to water insecurity, which constitutes an original contribution to the field of environmental psychology and public health.

The content validation process was rigorous and systematic. The panel of eight expert judges, with training in complementary areas (territorial development, anthropology, energy, health, water and sanitation), guaranteed a multidisciplinary evaluation of the items, which resulted in an average relevance index (iP = 0.91), which indicates a high consensus on the relevance of the items with respect to the constructs they measure. This value exceeds the threshold of 0.80 recommended by Carrera et al. (2011) for item acceptance.

The reliability analysis was performed with a sample of n = 350 participants (calculated representative sample), which provides more stable and representative estimates of Cronbach's alpha than those that would be obtained with a small subsample typical of a conventional pilot test (usually between 30 and 50 cases). From this perspective, the direct application of the refined instrument to the final sample made it possible to obtain psychometric indicators based on the real variability of the target population, which strengthened the accuracy of the results (Boateng et al., 2018).
The integration of the HWISE-4 scale (Young et al., 2019; HWISE RCN, 2021) as a section on water insecurity provides international comparability to the instrument, given that this scale has been validated in 28 sites in 23 low-

and middle-income countries, which opens the possibility of comparing the results of the community studied with the global evidence on the phenomenon. Finally, the multidimensional nature of the instrument, which encompasses public health variables, perceived environmental impact, governance and citizen participation, water quality and social perception, will allow a comprehensive analysis of the water phenomenon and will offer a useful tool both for scientific research and for the design of public policies aimed at sustainable water management in rural communities.

5. Conclusion

The objective of this research was to develop and validate the Multidimensional Instrument of Social Perception on Water Scarcity (IMPSEH) for rural communities in northern Mexico. The psychometric results provide evidence of content validity, supported by favorable relevance and univocity indices in the judgment of experts and of acceptable to good internal consistency, which positions the IMPSEH as an original tool and, as far as is recorded, the first specifically designed to capture the complexity of the water phenomenon in the rural environment of the north of the country. It should be noted that the evidence reported here corresponds to the validity of content and reliability; Construct validity, through exploratory and confirmatory factor analysis, is pending for later stages.

The strength of the instrument lies in its multidimensional nature, which allows it to transcend the technical vision of scarcity and integrate variables of public health, environmental impact, governance and experiences of water insecurity. As has been documented, the water problem is a systemic phenomenon in which factors such as over-concession for agricultural use, deficiencies in public policies and growing pollution of the resource converge. In this framework, the IMPSEH makes it possible to make visible dimensions that are usually ignored, such as the impact on mental health associated with chronic stress responses, anguish and worry that affect the biopsychosocial well-being of the inhabitants, especially in vulnerable groups such as children and the elderly, and also captures the perception of social conflict derived from a distribution of water that the population could consider inequitable.

The future directions of this work are focused on the analysis of the data obtained after the application of the instrument, which is the second central objective of the project. This analysis will allow characterizing the phenomenon of water scarcity in the study community and provide evidence to move from diagnosis to the proposal of public policy actions based on the local reality. The comprehensive description of the water problem in its different dimensions is an essential step to understand and address it. Thus, this work contributes to the field by offering a tool that can support interventions aimed not only at technical efficiency, but also at respecting the human right to water and improving the quality of life and dignity of the inhabitants of rural areas of Mexico.

Conflict of interest

The authors declare that they have no conflict of interest.

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Figure 1. Average iU and iP indices by section of the IMPSEH instrument.

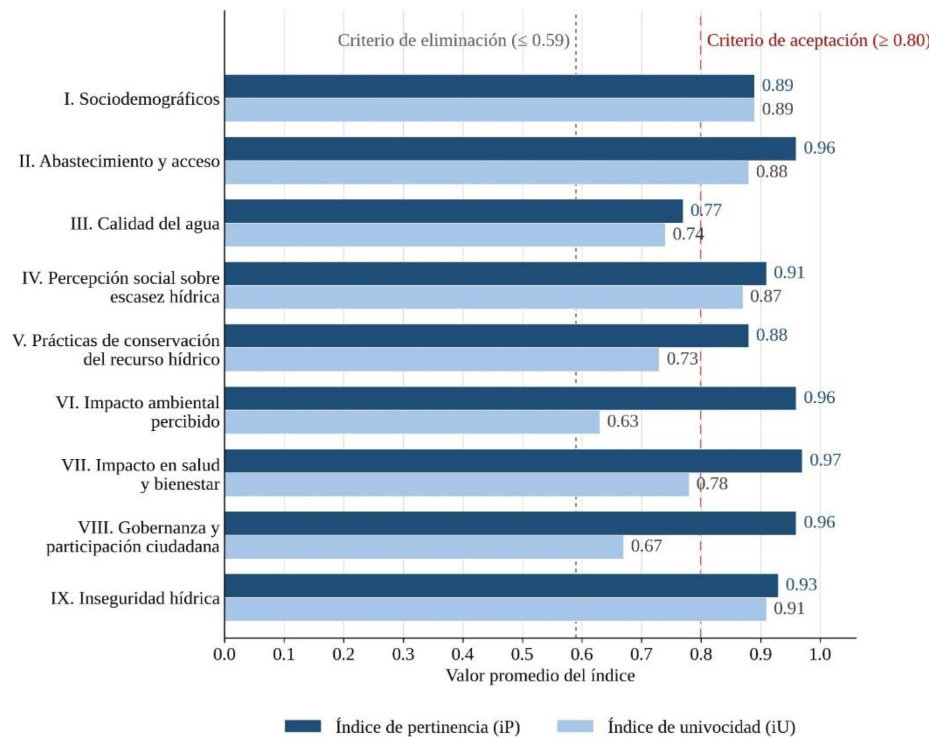

Figure 2. Hierarchical structure of the Multidimensional Instrument of Social Perception on Water Scarcity (IMPSEH).

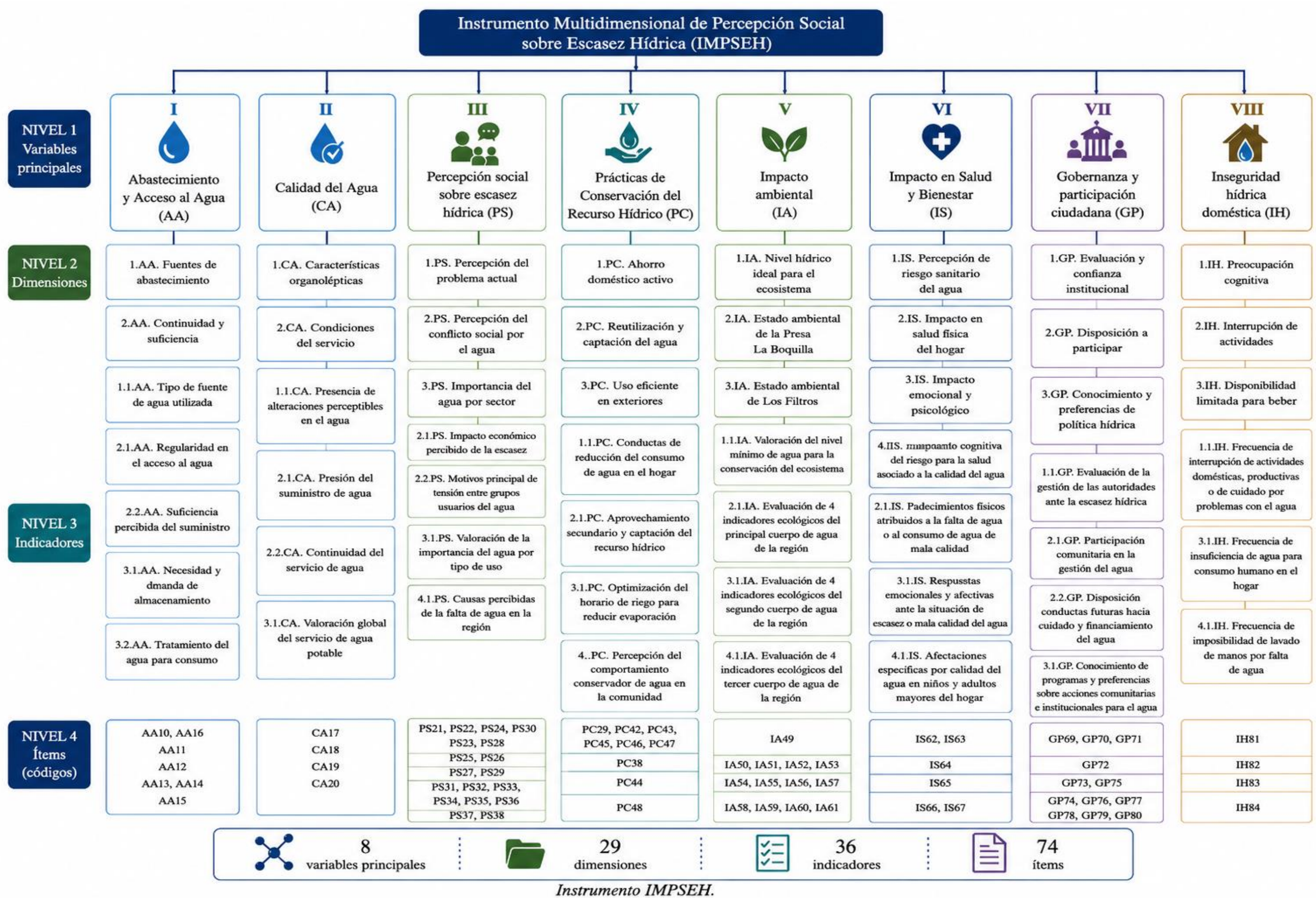

Table 1. Summary of the results of the Relevance analysis by section of the IMPSEH instrument.

Section	k	Store	Modify or move sections	Delete	Average iP	iP standard deviation	Minimum iP	Maximum iP
I. Sociodemographic	9	7 (77.8 %)	2 (22.22 %)	None	0.89	0.15	0.63	1.00
II. Supply and access	7	5 (71.43 %)	2 (28.57 %)	None	0.96	0.05	0.88	1.00
III. Water quality	5	4 (80 %)	None	1 (20 %)	0.77	0.34	0.21	0.96
IV. Social perception of water scarcity	23	17 (73.91 %)	6 (26.09 %)	None	0.91	0.14	0.67	1.00
V. Water Resource Conservation Practices	14	10 (71.43 %)	4 (28.57 %)	None	0.88	0.15	0.67	1.00
VI. Perceived environmental impact	13	13 (100 %)	None	None	0.96	0.05	0.88	1.00
VII. Impact on health and well-being	6	6 (100 %)	None	None	0.97	0.04	0.92	1.00
VIII. Governance and Citizen Participation	4	4 (100 %)	None	None	0.96	0.05	0.92	1.00
IX. Water insecurity	4	4 (100%)	None	None	0.93	0.02	0.92	0.96
Overall average*	85	70 (82.35 %)	14 (16.47 %)	1 (1.18 %)	0.91			

Note: Authors. k = number of items; avg. iP = average of the relevance index; Carrera et al. (2011) criteria: accepted item: $0.8 \leq iP \leq 1$; item to be modified or change section: $0.6 \leq iP \leq 0.79$; item to be eliminated: $iP \leq 0.59$. *The Overall Average row reports statistics calculated on the 85 items.

Table 2. Summary of the results of the univocity analysis by section of the IMPSEH instrument.

Section	k	Store	Modify or move sections	Delete	iU Prom.	iU standard deviation	iU Minimum	iU Max
I. Sociodemographic	9	7 (77.78%)	2 (22.22 %)	None	0.89	0.12	0.71	1.00
II. Supply and access	7	5 (71.43 %)	2 (28.57 %)	None	0.88	0.12	0.71	1.00
III. Water quality	5	2 (40 %)	2 (40 %)	1 (20 %)	0.74	0.27	0.33	1.00

IV. Social perception of water scarcity	23	12 (52.17 %)	11 (47.83 %)	None	0.87	0.15	0.63	1.00
V. Water Resource Conservation Practices	14	3 (21.43 %)	11 (78.57 %)	None	0.73	0.14	0.63	1.00
VI. Perceived environmental impact	13	None	13 (100 %)	None	0.63	0	0.63	0.63
VII. Impact on health and well-being	6	2 (33.33 %)	4 (66.67 %)	None	0.78	0.17	0.67	1.00
VIII. Governance and citizen participation	4	None	4 (100 %)	None	0.67	0	0.67	0.67
IX. Water insecurity	4	4 (100%)	None	None	0.91	0.06	0.88	1.00
Overall average*	85	35 (41.18 %)	49 (57.65 %)	1 (1.18 %)	0.79			

Note: Authors. k = number of items; avg. iU = Average of the univocity index; Carrera et al. (2011) criteria: item accepted: $0.8 \leq iU \leq 1$; item to be modified or change section: $0.6 \leq iU \leq 0.79$; item to be eliminated: $iU \leq 0.59$. *The Overall Average row reports statistics calculated on the 85 items.

Table 3. Description of the sociodemographic variables of the IMPSEH instrument.

Variable Number	Sociodemographic variable	Nature of the variable	Response categories		Measurement Level
DS1	**Geographical location**	Territorial context variable	Open registration of the community/colony where the instrument is applied		Nominal
DS2	**Age**	Demographic characterization variable	20 to 34 years old 35 to 49 years old 50 to 64 years old	65 to 79 years old 80 to 94 years old	Ordinal (age ranges)
DS3	**Gender**	Sociodemographic characterization variable	Male Female	Other I prefer not to specify	Nominal
DS4	**Locality where you live**	Territorial assignment variable	Mouthpiece The Tiger San Francisco de Conchos (head) Amparaneño Rancho Nuevo	Rancho Viejo The Mill Lot 4 Choline	Nominal polychotomous
DS5	**Type of residence**	Territorial link variable	Permanent Tourist Floating population (seasonal workers)	Business visit / rest at home Other	Nominal polychotomous
DS6	**Level of schooling**	Educational capital variable	No studies Primary Secondary	High School University or higher technician Postgraduate Other	Ordinal
DS7	**Monthly household income**	Socioeconomic level variable	Less than $5,000 $5,001 – $10,000 $10,001 – $20,000	$20,001 – $35,000 Over $35,000 I prefer not to answer / Other	Ordinal
DS8	**Marital status**	Sociodemographic characterization variable	Married Divorced Single	Widow(er) Free union Other	Nominal polychotomous
DS9	**Main occupation**	Economic activity variable	Agriculture Livestock Trade Tourism / Fishing	Student Housework Retired/Pensioner Public employee Other	Nominal polychotomous

Note: Sociodemographic variables are not included in the calculation of Cronbach's alpha or in the reliability analysis of the instrument. Its function is descriptive and stratification: they allow the sample to be characterized and the responses of sections II to IX to be compared between groups (by age, gender, locality, occupation, schooling and income).

Table 4. Operationalization of the variables of the Multidimensional Instrument of Social Perception on Water Scarcity (IMPSEH). Final version.

Variable	Conceptual definition	Operational definition	Dimensions	Indicators	Items	Variable Type
Water Supply and Access	Households' ability to obtain water in sufficient quantity, quality, and continuity to cover their basic needs, considering the sources of supply, regularity of service, storage, and treatment for consumption (Jiménez-Cisneros et al., 2010).	It is measured by 7 closed-response items that assess: The type of main water source. The frequency and hours of access to the service. The perception of sufficiency on a 5-point Likert scale. The need and method of storage. The treatment applied to drinking water.	1.AA. Sources of supply	1.1.AA. Type of water source used	AA10 and AA16	Nominal polychotomous
			2.AA. Continuity and sufficiency	2.1.AA. Regularity of access to water	AA11	Ordinal
				2.2.AA. Perceived Sufficiency of Supply	AA12	Ordinal
			3.AA. Storage and treatment	3.1.AA. Need and method of storage	AA13 AA14	Nominal dichotomous/polychotomous
				3.2.AA. Drinking water treatment	AA15	Nominal polychotomous
Quality of the Water	Physical, organoleptic and service characteristics determining the suitability of the water for human consumption and domestic use, including perceptible attributes (color, taste, odour, residues), pressure conditions, continuity of supply and user satisfaction (WHO, 2024; Ortega Márquez and Márquez Fernández, 2017).	It is measured by 4 response items Closed Evaluating: Presence of negative organoleptic attributes: colour, taste, smell or sand residues in the water. Perception of the level of water pressure in the home on a 5-point rating scale. Degree of agreement with the continuity of the service on a 5-point Likert scale. Overall rating of the drinking water service on a 5-point rating scale.	1.CA. Organoleptic characteristics	1.1.CA. Presence of perceptible alterations in the water	CA17	Nominal polychotomous
			2.CA. Terms of Service	2.1.CA. Water supply pressure	CA18	Ordinal
				2.2.CA. Continuity of water service	CA19	Ordinal
			3.CA. Service satisfaction	3.1.CA. Overall assessment of the drinking water service	CA20	Ordinal
Social perception of water scarcity	It is defined as the collective way in which Communities interpret the availability, quality, and management of water, integrating fundamental components: beliefs and values about water, knowledge about water problems, attitudes towards its conservation, behaviors in its use, and impact of socioeconomic and geographical factors (Benez et al., 2010). Unfried et al. (2022) y Wheatley (2024) They point out that the perception of water scarcity includes the cognitive evaluation of the current problem, the attribution of causes, the valuation of water uses and the perception of social conflicts derived from competition for the resource.	It is measured by 19 items organized in 4 dimensions: Perception of the current problem: Likert 1-5 agree/disagree scale. Importance of water by sector: importance scale 1-5. Perception of social conflict: items Likert y nominal. Causal attribution: multiple choice nominal (up to 3 options).	1.PS. Perception of the current problem	1.1.PS. Perception of the severity and availability of water	PS21, PS22, PS24, PS30	Ordinal
				1.2.PS. Perception of future water risk	PS23, PS28	Ordinal
			2.PS. Perception of social conflict over water	2.1.PS. Perceived economic impact of scarcity	PS25, PS26	Ordinal
				2.2.PS. Main reason for tension between water user groups	PS27, PS29	Nominal polychotomous
			3.PS. Importance of water by sector	3.1.PS. Assessment of the importance of water by type of use	PS31, PS32, PS33, PS34, PS35, PS36	Ordinal
			4.PS. Causal attribution of water scarcity	4.1.PS. Perceived causes of water scarcity in the region	PS37, PS38	Nominal polychotomous
Conservation	Water conservation practices are	It is measured by 10 items with a five-	1.PC. Active	1.1.PC. Behaviors to reduce	PC39, PC42, PC43,	Ordinal

Practices of the appeal water	conscious, habitual, and targeted behaviors that people engage in on a daily basis to reduce water use, reuse water, and avoid waste, driven by economic, environmental, and social norms (Corral-Verdugo et al., 2003). In addition, pro-environmental behaviors aimed at the water conservation are linked to prosocial behaviors, since by caring for the environment individuals they take care of collective well-being (Purnama et al., 2025).	point frequency scale. Active domestic savings: direct behaviors of reducing consumption in daily household activities. Reuse and catchment: behaviors of secondary use of water resources. Efficient outdoor use: practice of optimizing irrigation according to schedule. Perceived social norm: perception of conservation behavior in the community.	household savings	water consumption in the home	PC45, PC46, PC47	
			2.PC. Water reuse and harvesting	2.1.PC. Secondary use and abstraction of water resources	PC38	Ordinal
			3.PC. Efficient outdoor use	3.1.PC. Optimizing the irrigation schedule to reduce evaporation	PC44	Ordinal
			4.PC. Social norm of perceived conservation	4.1.PC. Perception of water conserving behavior in the community	PC48	Ordinal
Impact Environmental	Perceived environmental impact is defined as the subjective assessment made by individuals and communities on the state of deterioration or conservation of their environment based on observable indicators such as water quality, water coverage, vegetation, the presence of fauna and the accumulation of solid waste, the interpretation of which is mediated by the worldview, direct experience with The ecosystem and the conditions local socioeconomic (Benez et al., 2010). Hernández Solórzano et al. (2020), They point out that the environmental perception of pollution in bodies of water integrates visual and sensory dimensions: water cleanliness, state of riparian vegetation, abundance of aquatic and terrestrial fauna, and presence of solid waste on the banks.	It is measured by 13 items organized in 4 dimensions: Ideal water level: scale of percentage ranges of 5 categories (introductory item). Environmental status of the La Boquilla Dam: 4 ecological indicators with a rating scale of 1 to 5. Environmental status of Los Filtros: the same 4 indicators applied to the second body of water. Environmental status of Lake Colina: the same 4 indicators applied to the third body of water.	1.IA. Ideal water level for the ecosystem	1.1.IA. Assessment of the minimum water level for the conservation of the ecosystem	IA49	Ordinal
			2.IA. Environmental status of the La Boquilla Dam	2.1.IA. Evaluation of 4 ecological indicators of the main body of water in the region	IA50, IA51, IA52, IA53	Ordinal
			3. IA. Environmental status of Los Filtros	3.1.IA. Evaluation of 4 ecological indicators of the second body of water in the region	IA54, IA55, IA56, IA57	Ordinal
			4.IA. Environmental status of Lake Hill	4.1.IA. Evaluation of 4 ecological indicators of the third body of water in the region	IA58, IA59, IA60, IA61	Ordinal
Impact on Health and Wellbeing	The impact on health and well-being derived from water quality and insecurity includes both the physical consequences, such as gastrointestinal, dermatological, renal diseases and fatigue due to carrying water. Emotional and psychological consequences (stress, anxiety, despair and resignation) that households experience chronic exposure to poor quality or scarcity water of the resource (Rosinger & Young, 2020). This impact is differential by vulnerable groups: children and the elderly have increased susceptibility to infectious diseases, hygiene and effects on psychosocial well-being related to access to water (Rhue et al., 2023).	It is measured by 6 items with three types of scale: • Perception of health risk: scale Likert agree/disagree 1-5. • Impact on the physical health of the household: nominal polychotomous with specific symptoms. • Emotional and psychological impact: nominal polychotomous with feelings. • Differential impact on vulnerable groups: nominal polychotomous.	1.IS. Perception of water health risk	1.1.IS. Cognitive assessment of the health risk associated with water quality	IS62 and IS63	Ordinal
			2. IS. Impact on the physical health of the household	2.1.IS. Physical ailments attributed to lack of water or poor water consumption	IS64	Nominal polychotomous
			3. IS. Emotional and psychological impact	3.1.IS. Emotional and affective responses to the situation of water scarcity or poor quality	IS65	Nominal polychotomous
			4.IS. Differential impact on vulnerable groups	4.1.IS. Specific effects on water quality in children and older adults in the household	IS66 and IS67	Nominal polychotomous

Governance and citizen participation	Water governance is defined as the decision-making process and collective management of water that involves governments, communities and citizens in the formulation of of rules, policies and actions for the fair, sustainable and transparent management of water resources, articulating institutional trust, citizen participation and the willingness to contribute financially to its conservation (Mussetta, 2009). From a community perspective, social participation in water management transcends the technical and administrative aspects to include symbolic and collective action dimensions: meeting attendance, participation in conservation activities, demand for accountability, and willingness to learn new ways of caring for water (Soares & Hatch Kuri, 2023).	It is measured using 12 items organized into 3 dimensions and 2 types of scale: •Institutional evaluation and trust: Likert scale of agreement/disagreement 1–5 and scale of amount of information 1–5. Willingness to participate: frequency, willingness, and probability scales 1–5. Knowledge and preferences of water policy: nominal variables (dichotomous and polychotomous).	1.GP. Evaluation and institutional trust	1.1.GP. Evaluation of the authorities' management of water scarcity	GP72, GP73, GP74	Ordinal
				1.2.GP. Institutional trust and transparency in water management	GP68	Ordinal
			2.GP. Willingness to participate	2.1.GP. Community participation in water management	GP70, GP71, GP76	Ordinal
				2.2.GP. Future behavioral disposition toward water care and financing	GP75, GP78	Ordinal
			3.GP. Water policy knowledge and preferences	3.1.GP. Knowledge of programs and preferences on community and institutional actions for water	GP69, GP77, GP79	Nominal Polychotomics
Domestic water insecurity	Water insecurity in the household is the inability to reliably access enough water in quantity, quality, and continuity for basic needs, affecting thoughts, behaviors, and hygienic practices (Young et al., 2019). The HWISE-4 scale is the validated abbreviated version of the Household Water InSecurity Experiences (HWISE) Scale, developed to measure water insecurity in an equivalent way in diverse cultural and ecological contexts (HWISE RCN, 2021).	Measured with the abbreviated version HWISE-4 (4 items from 0 to 3 points depending on frequency in the last 4 weeks (range 0–12). Cut-off point ≥ 4 = household with water insecurity).	1.IH. Cognitive preoccupation	1.1.IH. Frequency of concern about lack of water in the home	IH80	Ordinal
			2.IH. Business interruption	2.1.IH. Frequency of interruption of domestic, productive or care activities due to water problems	IH81	Ordinal
			3. IH. Limited drinking availability	3.1.IH. Frequency of insufficient water for human consumption in the household	IH82	Ordinal
			4.IH. Hygienic limitation	4.1.IH. Frequency of inability to wash hands due to lack of water	IH83	Ordinal

Note: Prepared by the author based on the literature review and the theoretical framework of the study. The final instrument was made up of eight main variables, 29 dimensions, 36 indicators and 74 items.

Reliability analysis of the Multidimensional Instrument of Social Perception on Water Scarcity (IMPSEH).

Variable	**Dimensions**	**Items**	***k***	***M***	**OF**	**a**	**95% CI**	**Interpretation**
IV. Social perception	Perception of the current problem; Perception of social conflict over water	18	10	4.08	0.44	0.74	[0.67, 0.76]	Acceptable
	Importance of water by sector		6	4.60	0.62	0.86	[0.84, 0.88]	Good
V. Water Resource Conservation Practices	Active household savings; reuse and capture; efficient outdoor use; Social norm of perceived conservation	10	10	3.75	0.74	0.70	[0.65, 0.75]	Acceptable
VI. Perceived	Environmental status of the La Boquilla Dam,	13	12	3.38	0.36	0.82	[0.79, 0.85]	Good

environmental impact	Los Filtros and Lake Colina							
VIII. Governance and citizen participation	Evaluation and institutional trust	12	3	2.96	1.42	0.72	[0.67, 0.77]	Acceptable
IX. Water Insecurity (HWISE-4)	Cognitive preoccupation; interruption of activities; limited drinking availability; Hygienic limitation	4	4	2.30	1.29	0.83	[0.80, 0.86]	Good

Note: n = 350. α = Cronbach's alpha; 95% CI = 95% confidence interval calculated by the method of Feldt et al. (1987); k = items evaluated; M = mean; SD = standard deviation. Prepared by the author based on the data obtained from the application of the instrument.