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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):

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

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):

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

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):

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

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 participatedvoluntarily, 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 and Figure 1). The 16.47 % obtained values between 0.60 and 0.79 (Modify category) and 1.18 % obtained iP ≤ 0.59 (Delete category).

The general analysis of univocity showed that 41.18 % of the items were preserved in their original wording and section (Table 2 and Figure 1). 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 3 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 4 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 3 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.

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

Section	k	Store	Modify or move sections	Item to be eliminated	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			

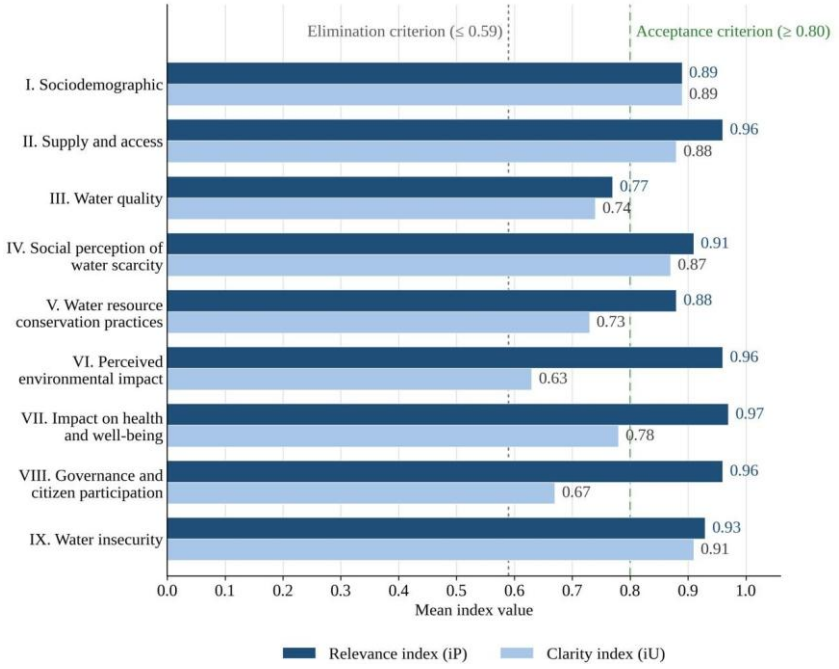
Note: Authors. k = number of items; avg. iP = average of the relevance index; Carrera et al. (2011) criteria: accepted item: $0.8 \leq iP \leq 1$; item to be modified or change section: $0.6 \leq iP \leq 0.79$; item to be eliminated: $iP \leq 0.59$. *The Overall Average row reports statistics calculated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

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



Section V (Water Resource Conservation Practices) initially had 14 items (PC45 to PC58), of which four were also moved to Section VIII (Table 3). 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.

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 3 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.

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.

Table 3. Operationalization of the Variables in the Multidimensional Instrument for the Social Perception of 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 and of adequate quality, with sufficient continuity to meet their basic needs, considering water sources, service regularity, storage, and treatment for drinking (Jiménez-Cisneros et al., 2010).	Measured using seven closed-ended items assessing: The primary water source. The frequency and duration of access to water services. Perceived sufficiency on a 5-point Likert scale. The need for and method of water storage. Treatment applied to drinking water.	1.AA. Water sources	1.1.AA. Type of water source used	AA10 and AA16	Polytomous nominal
			2.AA. Continuity and sufficiency	2.1.AA. Regularity of water access	AA11	Ordinal
				2.2.AA. Perceived sufficiency of the water supply	AA12	Ordinal
			3.AA. Water storage and treatment	3.1.AA. Need for and method of water storage	AA13 AA14	Dichotomous/polyto mous nominal
				3.2.AA. Drinking-water treatment	AA15	Polytomous nominal
Water Quality	Physical, organoleptic, and service-related characteristics that determine the suitability of water for human consumption and domestic use, including perceptible attributes (color, taste, odor, and residues), pressure, continuity of supply, and user satisfaction (WHO, 2024; Ortega Márquez & Márquez Fernández, 2017).	Measured using four closed-ended items assessing: The presence of undesirable organoleptic characteristics, such as color, taste, odor, or sand residues. Perceived household water pressure on a 5-point rating scale. Agreement with the continuity of 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	Polytomous nominal
			2.CA. Service conditions	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	The social perception of water scarcity is the collective way in which communities interpret water availability, quality, and management. It integrates beliefs and values concerning water, knowledge of water-related problems, conservation attitudes, water-use behaviors, and the influence of socioeconomic and	Measured using 18 items organized into four dimensions: Perception of the current problem: 5-point agreement Likert scale. Importance of water by sector: 5-point importance scale. Perception of social	1.PS. Perception of the current problem	1.1.PS. Perceived severity of scarcity and water availability	PS21, PS22, PS24, PS30	Ordinal
				1.2.PS. Perceived future water-related risk	PS23, PS28	Ordinal
			2.PS. Perception of social conflict over water	2.1.PS. Perceived economic impact of water scarcity	PS25, PS26	Ordinal
				2.2.PS. Primary reason for tension among water-user	PS27, PS29	Polytomous nominal

	geographic factors (Benez et al., 2010). Unfried et al. (2022) and Wheatley (2024) note that the perception of water scarcity includes cognitive appraisal of the current problem, attribution of causes, evaluation of water uses, and perception of social conflicts arising from competition for the resource.	conflict: Likert-type and nominal items. Causal attribution: nominal multiple-choice item (up to three options).		groups		
			3.PS. Importance of water by sector	3.1.PS. Assessment of water importance by type of use	PS31, PS32, PS33, PS34, PS35, PS36	Ordinal
			4.PS. Causal attribution of water scarcity	4.1.PS. Perceived causes of regional water scarcity	PS37, PS38	Polytomous nominal
Water Conservation Practices	Water conservation practices are conscious, habitual, and goal-directed behaviors that people engage in daily	Measured using 10 items on a 5-point frequency scale:	1.PC. Active household water conservation	1.1.PC. Behaviors that reduce household water consumption	PC39, PC42, PC43,	Ordinal

Table 3. Operationalization of the Variables in the Multidimensional Instrument for the Social Perception of Water Scarcity (IMPSEH): Final Version. Continued.

Variable	Conceptual definition	Operational definition	Dimensions	Indicators	Items	Variable type
Water Conservation Practices (continued)	to reduce water use, reuse water, and prevent waste, motivated by economic, environmental, and social norms (Corral-Verdugo et al., 2003). In addition, pro-environmental behaviors aimed at water conservation are linked to prosocial behaviors because, by caring for the environment, individuals contribute to collective well-being (Purnama et al., 2025).	Active household conservation: direct behaviors that reduce water use in daily household activities. Water reuse and harvesting: secondary use and collection of water resources. Efficient outdoor water use: optimization of irrigation schedules to reduce evaporation. Perceived conservation norm: perceived water-conservation behavior in the community.			PC45, PC46, PC47	
			2.PC. Water reuse and harvesting	2.1.PC. Secondary use and collection of water resources	PC40, PC41	Ordinal
			3.PC. Efficient outdoor use	3.1.PC. Optimization of irrigation schedules to reduce evaporation	PC44	Ordinal
			4.PC. Perceived social norm for water conservation	4.1.PC. Perceived water-conservation behavior in the community	PC48	Ordinal
Environmental Impact	Perceived environmental impact is defined as individuals' and communities' subjective assessment of environmental degradation or conservation, based on observable indicators such as water quality, surface-water extent, vegetation, fauna, and solid-waste accumulation. This assessment is shaped by worldview, direct experience with the ecosystem, and local socioeconomic conditions (Benez et al., 2010). Hernández Solórzano et al. (2020) note that perceptions of pollution in water bodies encompass visual and sensory dimensions: water cleanliness, condition of riparian vegetation, abundance of aquatic and terrestrial fauna, and presence of solid waste along the banks.	Measured using 13 items organized into four dimensions: Ideal water level: five-category percentage-range scale (introductory item). Environmental status of La Boquilla Dam: four ecological indicators rated on a 5-point scale. Environmental status of Los Filtros: the same four indicators applied to the second water body. Environmental status of Lake Colina: the same four indicators applied to the third water body.	1.IA. Ideal water level for the ecosystem	1.1.IA. Assessment of the minimum water level required for ecosystem conservation	IA49	Ordinal
			2.IA. Environmental status of La Boquilla Dam	2.1.IA. Assessment of four ecological indicators for the region's primary water body	IA50, IA51, IA52, IA53	Ordinal
			3.IA. Environmental status of Los Filtros	3.1.IA. Assessment of four ecological indicators for the region's second water body	IA54, IA55, IA56, IA57	Ordinal
			4.IA. Environmental status of Lake Colina	4.1.IA. Assessment of four ecological indicators for the region's third water body	IA58, IA59, IA60, IA61	Ordinal
Impact on Health and Well-being	The health and well-being impacts associated with water quality and insecurity include physical consequences, such as gastrointestinal, dermatological, and renal diseases and fatigue from carrying water, as well as	Measured using six items with three scale types: • Perceived health risk: 5-point agreement Likert scale. • Impact on household physical health: polytomous	1.IS. Perceived water-related health risk	1.1.IS. Cognitive appraisal of health risks associated with water quality	IS62 and IS63	Ordinal
			2.IS. Impact on household physical health	2.1.IS. Physical ailments attributed to water scarcity or consumption of poor-	IS64	Polytomous nominal

	emotional and psychological consequences (stress, anxiety, hopelessness, and resignation) experienced by households chronically exposed to poor-quality water or water scarcity (Rosinger & Young, 2020). These impacts vary across vulnerable groups: children and older adults are more susceptible to infectious diseases, hygiene-related problems, and adverse psychosocial effects associated with water access (Rhue et al., 2023).	nominal items addressing specific symptoms. • Emotional and psychological impact: polytomous nominal items addressing feelings. • Differential impact on vulnerable groups: polytomous nominal items.		quality water		
			3.IS. Emotional and psychological impact	3.1.IS. Emotional and affective responses to water scarcity or poor water quality	IS65	Polytomous nominal
			4.IS. Differential impact on vulnerable groups	4.1.IS. Specific effects of water quality on children and older adults in the household	IS66 and IS67	Polytomous nominal

Table 3. Operationalization of the Variables in the Multidimensional Instrument for the Social Perception of Water Scarcity (IMPSEH): Final Version. Continued.

Variable	Conceptual definition	Operational definition	Dimensions	Indicators	Items	Variable type
Water Governance and Citizen Participation	Water governance comprises decision-making and collective water-management processes involving governments, communities, and citizens in formulating rules, policies, and actions for equitable, sustainable, and transparent water-resource management, linking institutional trust, citizen participation, and willingness to contribute financially to water conservation (Mussetta, 2009). From a community perspective, participation in water management extends beyond technical and administrative aspects to include symbolic and collective-action dimensions: attendance at meetings, participation in conservation activities, demands for accountability, and willingness to learn new ways to conserve water (Soares & Hatch Kuri, 2023).	Measured using 12 items organized into three dimensions and two scale types: Institutional evaluation and trust: 5-point agreement Likert scale and 5-point information-quantity scale. Willingness to participate: 5-point frequency, willingness, and probability scales. Knowledge of and preferences regarding water policy: dichotomous and polytomous nominal variables.	1.GP. Evaluation and institutional trust	1.1.GP. Evaluation of 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 intention toward water conservation and financing	GP75, GP78	Ordinal
			3.GP. Knowledge of and preferences regarding water policy	3.1.GP. Knowledge of water programs and preferences regarding community and institutional water-management actions	GP69, GP77, GP79	Polytomous nominal
Household Water Insecurity	Household water insecurity is the inability to reliably access sufficient water of adequate quality and continuity for basic needs, affecting thoughts, behaviors, and hygiene practices (Young et al., 2019). The HWISE-4 is the validated abbreviated version of the Household Water InSecurity Experiences (HWISE) Scale, developed to measure water insecurity comparably across diverse cultural and ecological contexts (HWISE RCN, 2021).	Measured using the abbreviated HWISE-4 scale (four items scored from 0 to 3 according to frequency during the previous four weeks; total score range: 0-12; a cutoff score of 4 or higher indicates household water insecurity).	1.IH. Cognitive concern	1.1.IH. Frequency of concern about water scarcity in the household	IH80	Ordinal
			2.IH. Disruption of activities	2.1.IH. Frequency of disruption to household, productive, or caregiving activities due to water-related problems	IH81	Ordinal
			3.IH. Limited availability of drinkin	3.1.IH. Frequency of insufficient drinking water in the household	IH82	Ordinal

			g water			
			4.IH. Hygiene constraints	4.1.IH. Frequency of inability to wash hands due to water scarcity	IH83	Ordinal

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

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

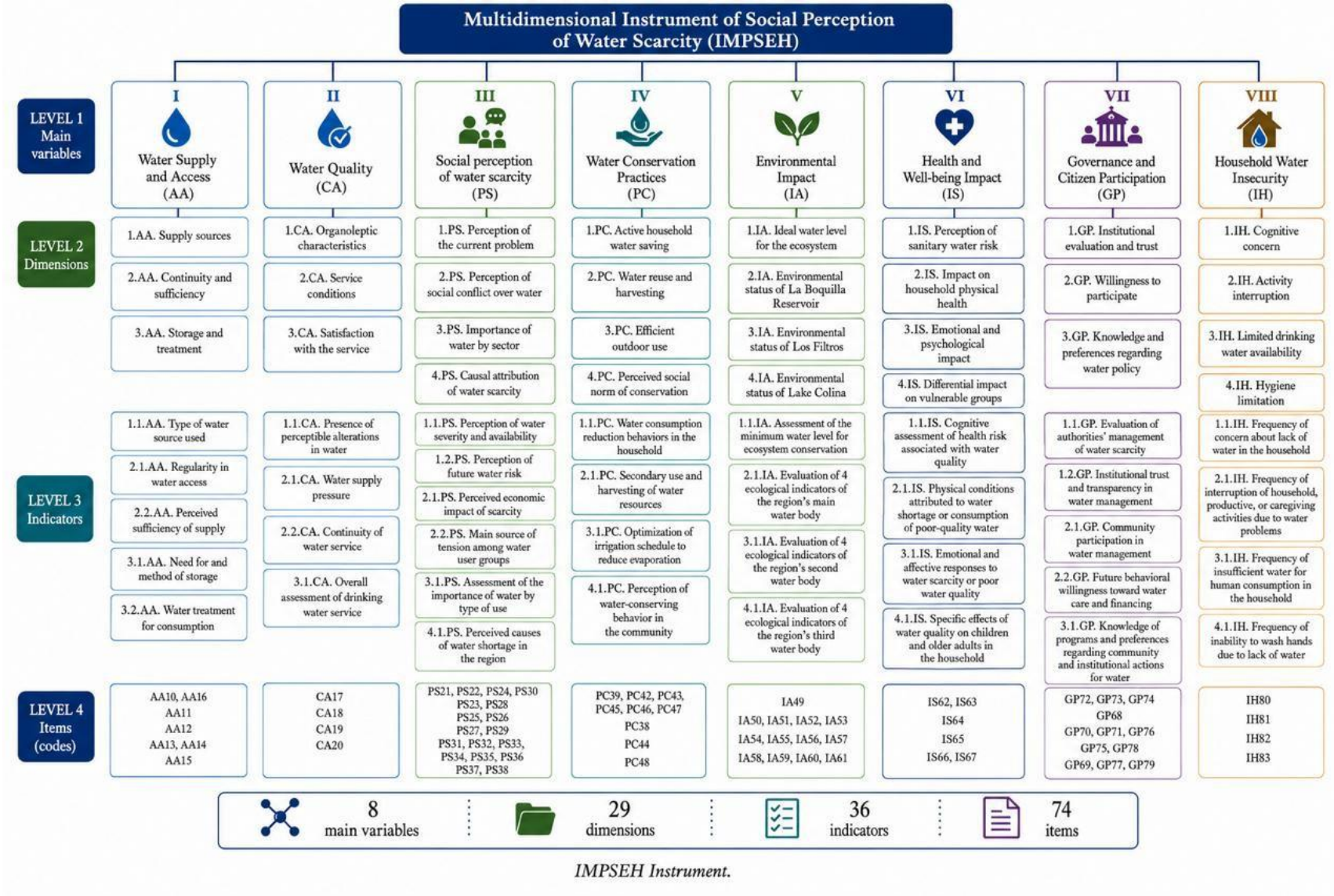


Table 4. Description of the sociodemographic variables of the IMPSEH instrument.

Variable code	Sociodemographic variable	Variable domain	Response options
DS1	**Geographic location**	Territorial context	Open-ended entry: community or neighborhood where the instrument is administered.
DS2	**Age**	Demographic profile	20-34 years; 35-49 years; 50-64 years; 65-79 years; 80-94 years.
DS3	**Gender**	Sociodemographic profile	Male; Female; Another gender identity; Prefer not to say.
DS4	**Locality of residence**	Territorial affiliation	La Boquilla; El Tigre; San Francisco de Conchos (municipal seat); Amparaneño; Rancho Nuevo; Rancho Viejo; El Molino; Lote 4; Colina.
DS5	**Residency status**	Residential status	Permanent resident; Tourist; Temporary resident (seasonal worker); Short-term visitor (business or leisure); Other.
DS6	**Educational attainment**	Educational profile	No formal education; Primary school; Secondary school; High school (upper secondary); University or higher technical education; Postgraduate education; Other.
DS7	**Monthly household income (MXN)**	Socioeconomic status	Less than $5,000; $5,001-$10,000; $10,001-$20,000; $20,001-$35,000; More than $35,000; Prefer not to answer; Other.
DS8	**Marital status**	Sociodemographic profile	Married; Divorced; Single; Widowed; Cohabiting (common-law union); Other.
DS9	**Primary occupation**	Economic activity	Agriculture; Livestock farming; Commerce; Tourism; Fishing; Student; Homemaker; Retired or pensioner; Public-sector employee; Other.

Note. MXN = Mexican pesos.

Table 5. Reliability Analysis of the Multidimensional Instrument for the Social Perception of Water Scarcity (IMPSEH).

Variable	Dimensions	Items	*k*	*M*	SD	α	95% CI	Interpretation
IV. Social Perception of Water Scarcity	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 Conservation Practices	Active household water conservation; water reuse and harvesting; efficient outdoor water use; perceived social norm for water conservation	10	10	3.75	0.74	0.70	[0.65, 0.75]	Acceptable
VI. Perceived Environmental Impact	Environmental status of La Boquilla Dam, Los Filtros, and Lake Colina	13	12	3.38	0.36	0.82	[0.79, 0.85]	Good
VIII. Water Governance and Citizen Participation	Institutional evaluation and trust	12	3	2.96	1.42	0.72	[0.67, 0.77]	Acceptable
IX. Household Water Insecurity (HWISE-4)	Cognitive concern; disruption of activities; limited availability of drinking water; hygiene constraints	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 using the method of Feldt et al. (1987); Items = total number of items; k = number of items included in the reliability estimate; M = mean; SD = standard deviation. Authors' calculations based on data obtained from administration of the instrument.

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

Water supply and access (Section II) and household water insecurity (Section IX). The IMPSEH conceptualizes water access not merely as the presence of infrastructure, but as households' capacity to obtain water in sufficient quantity and quality, with adequate continuity to meet basic needs. This conceptualization is consistent with Jiménez-Cisneros et al. (2010), who define access in terms of the effective satisfaction of basic water-related needs. Both sections demonstrated high content-validity coefficients in the expert evaluation (Section II: iP = 0.96, iU = 0.88; Section IX: iP = 0.93, iU = 0.91) (Table 1 and Table 2), and Section IX showed good internal consistency (α = 0.83) (Table 5). Incorporating the HWISE-4 allowed household water insecurity to be assessed as a lived experience, including worry about water availability and constraints on hygiene-related activities. This approach is consistent with Young et al. (2019) and Pearson et al. (2025), who support experience-based measurement as a means of capturing water insecurity beyond infrastructure coverage and macro-level socioeconomic indicators.

Water quality (Section III). By assessing organoleptic attributes such as color, taste, and odor, the IMPSEH acknowledges that perceived water quality is inherently subjective. This section yielded the lowest relevance and univocity coefficients in the expert evaluation (iP = 0.77, iU = 0.74) (Table 1 and Table 2), indicating that several items required more precise wording. Nevertheless, the construct remains substantively important. Ortega Márquez and Márquez Fernández (2017) emphasize that users often infer potability from sensory cues, and these judgments can directly shape trust in water services.

Social perception of water scarcity (Section IV). The instrument emphasizes cognitive appraisal of water scarcity and perceived social conflict arising from competition over limited water resources. This section demonstrated high content validity (iP = 0.91, iU = 0.87) (Table 1 and Table 2), Internal consistency ranged from acceptable for the combined perception-of-the-problem and social-conflict subscale (α = 0.74) to good for the perceived importance of water by sector (α = 0.86) (Table 5). This framing is consistent with Unfried et al. (2022) and Wheatley (2024), who describe water scarcity as a potential catalyst for community tensions. By comparison, Bustos Aguayo et al. (2022) reported an overall Cronbach's alpha of 0.80 for a model that conceptualizes negotiation through risk aversion, expressed as collaboration, and risk propensity, expressed as delegation to the state. In the IMPSEH, related processes are addressed across the domains of governance, institutional trust, and citizen participation.

Water conservation practices (Section V). The inclusion of water-saving and reuse behaviors is grounded in environmental psychology. This section showed adequate content-validity coefficients (iP = 0.88, iU = 0.73) and acceptable internal consistency (α = 0.70) (Table 5). Because this value lies at the conventional lower threshold of acceptability, the findings support the use of the subscale while also identifying it as a priority for further refinement in subsequent versions. Corral-Verdugo et al. (2003) suggest that conservation practices are shaped by ecological beliefs, such as recognizing water as a finite resource, and by utilitarian beliefs that may frame water as a resource available for unrestricted use. Whereas the former tend to inhibit consumption, the latter may encourage greater water use.

Perceived environmental impact (Section VI). This section included context-specific items concerning water bodies in the study area, as well as vegetation, fauna, and pollution. It obtained the lowest univocity coefficient in the expert evaluation while maintaining high relevance (iU = 0.63; iP = 0.96) (Table 1 and Table 2), suggesting that the content was pertinent but that some items were ambiguously worded. This finding prompted item reformulation before field administration. Following revision, the subscale demonstrated good internal consistency (α = 0.82) (Table 5). This result is consistent with the observations of Benez et al. (2010), who documented that riparian communities assess water conditions through direct observation of environmental deterioration, changes in water bodies, vegetation, and fauna, rather than solely through technical indicators. The inclusion of this section therefore extends household experience-based measures, such as the HWISE scale, by capturing perceptions of local ecological change and environmental damage.

Impact on health and well-being (Section VII). The inclusion of physical symptoms and emotional responses, including stress and distress, broadened the construct coverage of the IMPSEH and represented a methodological strength. This section achieved the highest relevance coefficient in the instrument (iP = 0.97, iU = 0.78) (Table 1 and Table 2). Rosinger and Young (2020) describe pathways through which water insecurity may affect human biology via psychosocial stress and may produce differential risks among vulnerable groups, particularly children and older adults. The IMPSEH operationalizes these pathways by distinguishing physical, emotional, and vulnerable-group impacts associated with water scarcity and poor water quality.

Water governance and citizen participation (Section VIII). This section assesses institutional trust, evaluations of public water management, and willingness to participate. Although it showed high relevance in the expert evaluation, its univocity coefficient was comparatively low (iP = 0.96, iU = 0.67) (Table 1 and Table 2), indicating that the content was important but that several items required clearer wording. The items were therefore reformulated before field administration. For the reliability analysis, only three of the 12 items were included because they used a common rating scale and were designed to measure the same subdimension. This restriction was methodologically appropriate because Cronbach's alpha is interpretable when items form a coherent multi-item scale and use comparable response metrics; heterogeneous nominal items should not be pooled into the same estimate. The resulting coefficient for items GP72, GP73, and GP74 (α = 0.72) indicated acceptable internal consistency for the institutional evaluation and trust subscale in the study sample. Mussetta (2009) and Soares and Hatch Kuri (2023) similarly argue that effective governance requires social participation to move beyond consultation toward collective action and mechanisms for accountability.

Taken together, these findings indicate that the IMPSEH integrates infrastructural, experiential, cognitive, behavioral, environmental, health-related, and governance dimensions of water scarcity. Sections with lower univocity coefficients were revised before field administration, and the subscales evaluated with Cronbach's alpha achieved acceptable to good internal consistency. These results support the preliminary psychometric adequacy of the instrument; however, they do not by themselves establish construct validity. Future research should examine factorial structure, test-retest reliability, and measurement invariance across communities and population groups.

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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