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Article

Validity and Reliability Analysis of the Household Water Insecurity Experiences Scale: The Case of Argentina

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Abstract: Objective. Evaluate the validity and reliability of the Household Water Insecurity Experiences Scale (HWISE) as a tool to assess the experiences of households and the Argentine population regarding insecurity in access to water. Material and methods. The scale was administered as part of the Argentine Social Debt Survey (EDSA), on a probabilistic sample of 5,799 households. Results. The HWISE scale proved to be reliable globally and in each of its items (Cronbach's Alpha of 0.95 at a total level and greater than 0.94 in each of the items), and criterion validity in terms of correlation with a broad set of indicators of social deprivations, sanitary infrastructure, food insecurity, and psychological health. Finally, the scale showed internal consistency, with a total Omega coefficient value of 0.96, suggesting that all scale indicators refer to the same concept of deprivation in water access. Conclusions. The HWISE scale applied to the case of Argentina is deemed appropriate for estimating household water insecurity

Keywords: reliability; scales; sustainable development goals; validity; water insecurity

1. Introduction

Several international instruments have recognized the human right to water [1–3]. The UN Committee on Economic, Social and Cultural Rights established that water has to be considered a social, cultural and economic good. On 28 July 2010, the United Nations General Assembly passed the resolution 64/292, called The Human Right to Water and Sanitation, recognizing that drinking water and sanitation are essential for the full development of life and all human rights [4]. In 2015, that entity established the Sustainable Development Goals (SDGs) of the 2030 Agenda, which sets as a goal to "Ensure access to water and sanitation for all" [5]. At present, the World Economic Forum states that humanity is facing a global crisis regarding water supply [6].

Water insecurity is defined as the inability to access and benefit from adequate, reliable and safe water for one's well-being and healthy life [7]. The interest on the impacts of unreliable water supplies has increased [8], and some studies have already started to realize the multiple implications of the lack or poor condition of water on the health and well-being of populations and households [9–15].

Within this framework, the HWISE Scale arises, which offers the possibility to evaluate and quantify people's experiences in their households regarding water access and use. It has been validated in several countries, both high- and low-income ones [9] which makes it a comparative measurement for different communities, regions or countries, as well as for overtime comparisons. In April 2023, a Pan-American meeting about the measurement of water insecurity was convened with the participation of experts from more than 30 institutions in nine countries and from the United Nations too. In this meeting, it was recognized the importance of promoting the use of valid and

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reliable measurements that support sustainable progress towards the full realization of the human right to water [16].

In Argentina, the official tools available for the measurement of this phenomenon focus solely on water access and availability in terms of infrastructure. With the aim of improving water security information, understood as the ability to access sufficient adequate quality water for human consumption, in 2023 the HWISE Scale was integrated into the Argentine Social Debt Survey (EDSA) of the Pontifical Catholic University of Argentina (UCA). This study has as its general objective to determine the validity and reliability of the HWISE Scale as an instrument for evaluating the experiences of Argentine households regarding insecurity.

2. Materials and Methods

2.1. Source of Information

In the present work, the microdata of EDSA, a multipurpose survey which has periodically provided since 2004 a broad set of development indicators, were used. For this study, a multistage probability sample of 5,799 households was used, with a first stage of clustering and a second of stratification. This sample represents the universe integrated by private households living in Argentine urban centers with more than 80 thousand inhabitants. The estimated margin of error is +/- 1.3%, with an estimated population proportion of 50% and a confidence level of 95%. Figure 1 shows the operational definitions of the main variables analyzed in this study.

Table 1. Operational definition of the analyzed variables.

Variable	Operational definition	Variable values
Poverty [17]	Percentage of households whose income does not allow them to acquire the value of the Total Basic Basket (CBT), and/or does not allow them to acquire the value of the Basic Food Basket (CBA)	0. Not poor 1. Poor not indigent 2. Homeless
Food Insecurity [17]	Percentage of households that reported reducing food portions and/or experiencing hunger due to economic	Moderate Deficit: Households in which it is expressed to have reduced the portion of food in the last 12 months. Severe Deficit: Households in which it is expressed that they have felt hungry in the last 12 months.

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	hardship during the past 12 months.	Safety: Households in which it is not reported that they have reduced the portion of food in the last 12 months.
Socioeconomic level in quartiles [18]	Percentage of households that are located in four levels of belonging based on a factorial index that takes into account the educational capital of the head of household, access to durable household goods and the residential condition of the housing, this index being re-coded into socioeconomic strata according to quartiles of the distribution.	1. Very low (1st quartile) 2. Low (2nd quartile) 3. Middle (3rd quartile) 4. Medium-high (top 25%)
Urban agglomerates [18]	Percentage of households residing in four large regions of urban agglomerations taken in the sample according to their spatial distribution, geopolitical importance	1. Autonomous City of Buenos Aires 2. Buenos Aires Metropolitan Area 3. Other Metropolitan Areas 4. Urban rest of the interior

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	and degree of socioeconomic consolidation.	
Neighborhood Type [17]	Percentage of households residing in three different forms of urbanization with varying degrees of formality in terms of planning, regulation and public investment in urban assets and with a heterogeneous presence of different socioeconomic levels.	1. Emergency Village/Settlement 2. Social housing / Monoblocs 3. With an urban layout
Deficit of connection to the sewer network [17]	Percentage of households living in homes without connection to the sewer network.	0. No deficit 1. Deficit
Perception of lack of water in the home [17]	Percentage of households in which the respondent reports that the neighborhood has the problem of lack of water.	0. No deficit 1. Deficit
Psychological distress [19]	Percentage of households in which the respondent	1.High 2. Moderate 3. Low

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	reports having symptoms of anxiety and depression integrated into a score that indicates moderate or high risk of psychological distress on the KPDS-10 scale (score ranging from 10 to 50 points, and the distribution is categorized into tertiles).	

2.2. Evaluation of Water in Insecurity

The HWISE Scale was applied to a household member aged 18 years or older randomly selected. Language was adapted based on the scale incorporated in the 2021 National Survey on Health and Nutrition (ENSANUT) in Mexico [20]. The questions included were the following:

In the last 4 weeks, how often have you or someone from your household…

1. How frequently did you or anyone in your household worry you would not have enough water for all of your household needs?
2. How frequently has your main water source been interrupted or limited (e.g. Water pressure, less water than expected, river dried up)?
3. How frequently have problems with water meant that clothes could not be washed?
4. How frequently have you or anyone in your household had to change schedules or plans due to problems with your water situation? (activities that may have been interrupted include caring for others, doing household chores, agricultural work, income-generating activities, sleeping, etc.)
5. How frequently have you or anyone in your household had to change what was being eaten because there were problems with water (e.g., for washing foods, cooking, etc.)?
6. How frequently have you or anyone in your household had to go without washing hands after dirty activities (e.g., defecating or changing diapers, cleaning animal dung) because of problems with water?
7. How frequently have you or anyone in your household had to go without washing their body because of problems with water (e.g., not enough water, dirty, unsafe)?
8. How frequently has there not been as much water to drink as you would like for you or anyone in your household?
9. How frequently did you or anyone in your household feel angry about your water situation?
10. How frequently have you or anyone in your household gone to sleep thirsty because there wasn't any water to drink?
11. How frequently has there been no useable or drinkable water whatsoever in your household?

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12. How frequently have problems with water caused you or anyone in your household to feel ashamed/excluded/stigmatized?

The response options for each of the items are presented on an ordinal scale, and out of them, a score is calculated by adding the responses of each item in terms of frequency, following the methodology of Young et al. (2019). Four categories were used: Never (0), Rarely (1-2 times), Sometimes (3-10 times) and Often (11 or more times), which were scored 0, 1, 2 and 3, respectively. If the respondent of the household chooses the option "Do not know/No answer" in any of the questions, the household is excluded from the sample. The same criterion is followed in the case of missing values. As a result, 115 observations were excluded, which represent 2.6% of the original sample. In Figure 2 and 3, descriptive statistics measures of the excluded observations are shown. Although there are statistically significant differences between the household characteristics of the included and the excluded observations, they did not significantly affect the representativity of the results exposed in the following section.

Following the methodology, it is considered that households with a score equal to or greater than 12 experience water insecurity.

Table 2. Water insecurity indicator according to associated characteristics.

	%	IC95%	
OVERALL AVERAGE	6,5%	5,6%	7,5%
SEX OF HEAD OF HOUSEHOLD			
Female	6,8%	5,5%	8,3%
Male	6,3%	5,2%	7,6%
AGE OF THE HEAD OF HOUSEHOLD			
18 to 29 years old	5,4%	3,6%	7,8%
30-49	7,2%	5,8%	9,0%
More than 50 years	6,1%	4,9%	7,5%
CONNECTION TO THE SEWER NETWORK			
No access	10,8%	8,7%	13,4%
With access	4,9%	4,1%	5,9%
PRESENCE OF CHILDREN AND ADOLESCENTS IN THE HOM E			
With children	8,6%	7,2%	10,3%
Without children	4,3%	3,4%	5,4%
SOCIO-ECONOMIC LEVEL			
Very low	12,8%	10,4%	15,6%
Low	7,0%	5,4%	9,1%
Middle	3,4%	2,4%	4,8%
Medium High	2,4%	1,5%	3,8%
POVERTY AND INDIGENCE BY INCOME			
Indigent	14,0%	9,6%	20,0%
Poor no indigent	10,1%	8,1%	12,6%
No poor	4,1%	3,3%	5,0%
URBAN REGIONS			
Autonomous City of Buenos Aires	1,7%	0,6%	4,3%
Buenos Aires Metropolitan Area	8,0%	6,4%	9,9%
Other Metropolitan Areas	7,1%	6,0%	8,4%

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Urban rest of the interior	6,0%	4,7%	7,7%
TYPE OF NEIGHBORHOOD			
Emergency Village/Settlement	12,6%	7,9%	19,3%
Social housing / Monoblocs	23,2%	14,0%	36,0%
With an urban layout	5,9%	5,0%	6,8%

Source: Authors' elaboration based on the Argentina Social Debt Survey - Agenda for Equity Series (2017-2023), Argentina Social Debt Observatory, UCA.

Table 3. Water insecurity indicator according to food insecurity and psychological distress.

	%	IC95%	
OVERALL AVERAGE	6,5%	5,6%	7,5%
FOOD INSECURITY			
Severe	23,1%	17,8%	29,3%
Moderate	12,5%	9,1%	16,9%
Safety	3,8%	3,1%	4,6%
PSYCHOLOGICAL DISTRESS			
Hight	10,5%	8,5%	12,9%
Moderate	5,2%	4,1%	6,7%
Low	4,3%	3,1%	5,8%

Source: Authors' elaboration based on the Argentina Social Debt Survey - Agenda for Equity Series (2017-2023), Argentina Social Debt Observatory, UCA.

2.3. Validity and Reliability Measurements

To evaluate the reliability of the HWISE and its robustness as an instrument in the case of Argentina, validity and reliability tests were conducted. The validity of the instrument was verified by demonstrating that the indicators of the water insecurity scale are valid measurements related to lack of in water access and use. For this, the relationships of the HWISE with other variables that have previously proven to be related to water insecurity were tested. The following variables were selected: connection to sewer networks, lack of water in the neighborhood, total and severe food insecurity in the household [21], and the respondent's psychological distress.

2.4. Data Analysis

Logistic regression models were applied which regress these dichotomous variables on the individual indicators of the water module, the water insecurity indicator, and the HWISE. Furthermore, control variables related to the household socio-economic and demographic characteristics, such as the logarithm of per capita family income, the number of household members, the gender of the head of household, and the urban agglomeration where the household is at, were included [22].

For the reliability analysis the Classical Test Theory (CTT) was used, that included Cronbach's alpha, Revelle's beta, Guttman's lambda, and Omega [23]. A Cronbach's alpha coefficient equal to or greater than 0.7 was considered as acceptable [24]. A threshold value of 0.5 was used for Beta, and a threshold of 0.7 for Guttman's lambdas and Omega.

Finally, a hierarchical cluster analysis was conducted as a variable clustering technique. The hierarchical cluster analysis is employed to examine how items relate to each other based on their proximity [25].

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3. Results

In the second semester of 2023, based on the application of the HWISE scale, it was estimated that 6.5% of the urban Argentine households suffered from water insecurity. A higher water insecurity prevalence was found in the least socioeconomically advantaged households. On this matter, it was observed that water insecurity affected 14% of people in extreme poverty, and in the lowest social stratum (25% lower), it affected 12.8%. Simultaneously, it affected the residents from Buenos Aires Conurbation (Conurbano Bonaerense) and other large metropolitan areas from the Argentine provinces more than the citizens from City of Buenos Aires (CABA) and other small metropolises from the provinces. It is worth acknowledging that it rose above average in informal housings (shanty towns and settlements) and in social housing neighborhoods and monoblocks (public housing projects). Moreover, a significant difference in households with children and adolescents was registered. This difference remained significant even after controlling it by urban agglomeration, social stratum, and type of neighborhood (Figure 2).

This study also explored the relationship between water insecurity and two health indicators: psychological distress and severe food insecurity (Figure 3). It was found that households where the respondent has a “high” psychological distress present 10.5% of water insecurity, and that in households with severe food insecurity, the percentage is 23.1%.

Regarding the 12 items of the HWISE Scale, it was observed that the item that referred to experiences of interruptions in water supply (20%) was the most common, followed by those related to feeling worry about not having enough water (17.7%) and problems with washing clothes (14.6%) (Figure 4).

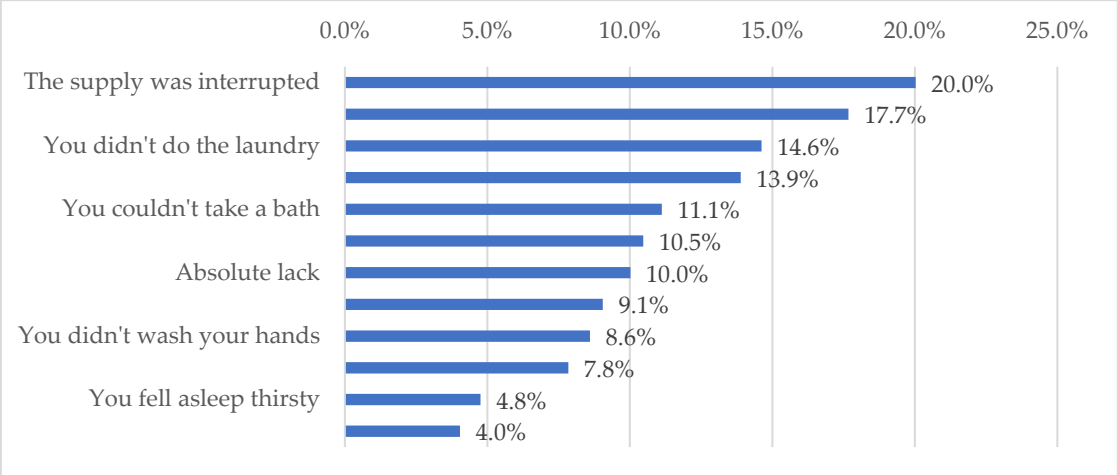

Figure 4. Distribution of responses to HWISE Scale items: Have experienced at least one occasion water deprivation or problem. Source: Authors' elaboration based on the Argentina Social Debt Survey - Agenda for Equity Series (2017-2023), Argentina Social Debt Observatory, UCA.

Figure 5 contains the results of the Maximum Likelihood estimation from the proposed logistic model. As it was expected, income poverty and extreme poverty maintained a positive and statistically significant relationship with water insecurity ($p<0.001$). In addition, having children and adolescents in the household increases the probability of experiencing water insecurity ($p<0.10$). Also, in low-socioeconomic neighborhoods the probability of having water insecurity increased ($p<0.05$). On the other hand, lack of connection to sewer networks had a significant and positive relationship with water insecurity ($p<0.05$). Finally, the validity was evaluated through logistic regressions, where lack of severe connection, lack of water in the neighborhood, total and severe water insecurity, and the respondent's psychological distress were statistically correlated with all the items included in the HWISE scale. Validity tests were successful, as all coefficients were significant in at least 10%. Moreover, reliability was verified through Cronbach's alpha, Revelle's beta, Guttman's lambda, and

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Omega statistics. The Alpha was satisfying and as can be observed in Figure 7, if any of the indicators are removed, the Alpha does not increase. In relation to Guttman's lambdas, and the Beta and Omega statistics, all of them exceed the suggested threshold of 0.8 (Figure 6).

Table 5. Logistic regression model of household water insecurity.

	IH
Female Head of Household	0.127
	(0.156)
Age of the head of household	0.005
	(0.005)
It has no sewers	0.360**
	(0.181)
Presence of children (0 to 17 years) in the home	0.324*
	(0.180)
POVERTY SITUATION (BASE=Not Poor)	
Poor no indigent	0.621***
	(0.184)
Indigent	0.914***
	(0.264)
URBAN AGLOM (BASE=CABA)	
Greater Buenos Aires	1.222**
	(0.546)
Other large metropolitan areas	1.188**
	(0.531)
Rest of urban areas	1.103**
	(0.544)
TYPE OF NEIGHBORHOOD (BASE=With urban layout)	
Social housing / Monoblocks	1.515***
	(0.310)
Emergency village / Settlement	0.669**
	(0.291)
Constant	-4.798***
	(0.613)
Pseudo-R2	0.0714
Remarks	5,684

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' elaboration based on the Argentina Social Debt Survey - Agenda for Equity Series (2017-2023), Argentina Social Debt Observatory, UCA.

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Table 6. Reliability coefficients.

	Cronbach's Alpha if the item is deleted
Total Alpha (without the deletion of any items)	**0,95**
The supply was interrupted	0,94
You worried	0,94
You didn't do the laundry	0,94
You got upset	0,94
You couldn't take a bath	0,94
You had to change plans	0,94
Absolute lack	0,94
You had to change the food	0,94
You didn't wash your hands	0,94
Not enough water to drink	0,94
You fell asleep thirsty	0,95
You felt ashamed	0,95
Beta Coefficient	**0,81**
Lambda 2	**0,95**
Lambda 3 = Alpha	**0,95**
Lambda 4	**0,97**
Omega_t	**0,96**

Source: Authors' elaboration based on the Argentina Social Debt Survey - Agenda for Equity Series (2017-2023), Argentina Social Debt Observatory, UCA.

4. Discussion

It has been shown that the HWISE is an important instrument to estimate and describe household water insecurity at a population level and has been tested in few Latin-American countries [26], and to address the social gaps that condition and restrict children's opportunities for a better development [27]. For instance, in the study by Shamah Levy et al. [20] the application of the HWISE Scale was studied at a national level in Mexico, among other countries of the region [21,28]. The results of this study show that the HWISE scale can also be used as an estimate of water insecurity experiences in the case of Argentina, where it was previously qualitatively validated in terms of comprehension, acceptance, and relevance [29], and in this article, quantitatively.

A significant association between higher scores of water insecurity measured with the HWISE and different variables of interest included in the analysis, such as monetary poverty, number of children in household, and socio-residential space, among others, was observed, matching with the findings of previous research. Thus, HWISE is deemed as a valid tool in terms of its measuring water insecurity and its association with other situations of deprivation and social vulnerability [26,30–32]. Similarly, water insecurity was evaluated in Bolivia and was related to infant feeding [26]. In the study by Young et al. [26] the association between water insecurity and food insecurity was studied using representative samples of 25 low-income and middle-income countries, including Brazil, Guatemala, and Honduras. The correlation between household water insecurity and the water insecurity has been previously reported [8,34,35]. Also, we found a relationship between water insecurity and psychological distress. This has been previously reported, which allows us to build confidence regarding its consequences are not only physical [37] but also psychological

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[8,11,35,36,38]. This finding supports the theory about water insecurity is determined by multiple dimensions which may operate differently across populations in space and time [39].

Firstly, the high response rate to the scale (97.4%) stands out, similar to that achieved in the Mexican case [20], indicating that the scale's questions were understood by the urban Argentine population, confirming the results obtained in qualitative approaches [29].

According to Cronbach's alpha coefficient, the scale demonstrates very good internal consistency. This result is consistent with the validation of the scale in Mexico [20] and with the validation of a household water insecurity measure for low- and middle-income countries [13].

The study presents a limitation: the information was gathered during the winter season in Argentina and the scale questions refer to a recall period of 4 weeks, which could have influenced the prevalence of water insecurity. As the country undergoes extremely different weather conditions depending on the season, and summer usually presents higher water access problems, it may be more adequate to evaluate household water insecurity using a recall period of more than 4 weeks. Given the climate difference between seasons, the measurement of water insecurity at household level can be affected by climate changes, as shown in Mexico [20].

However, an important strength of our study is that includes a large sample of individuals, that allows comparisons between sociodemographic groups. In addition, other variables were measured that not online allowed to evaluate the criterion validity of the scale in Argentina, but it also provides new evidence to monitor and to evaluate water insecurity in the region and worldwide.

The access to safe water has been monitored for a long time using well-established metrics to evaluate water resources and their accessibility [22]. Nevertheless, it is well understood that these old metrics are inaccurate and that they contribute to the underestimation of water insecurity [34,40].

The evidence presented contributes to the validity of measuring water insecurity using the HWISE scale. The case of Argentina also provides evidence within Latin America on the importance of the HWISE scale as a key instrument for estimating water insecurity, its causes, and consequences, considering social and geographical inequalities and its evolution over time.

The validation process of a scale is long and complex. Given the nature of the scale, it is essential to ensure its validity in different contexts, and in this regard, this article represents an applied contribution to the case of Argentina. Contexts are highly diverse, even within a single country, so each contribution that demonstrates the scale’s validity is a step toward its global use.

Additionally, the correlations of the scale with poverty, food insecurity, habitat deprivations, and even indicators of psychological distress confirm the relevance of studying deprivations in access to water as a vital resource (and right) for human development and well-being.

Water insecurity affects the overall health of the population and, therefore, has consequences for the fulfillment of basic rights to subsistence and life, as well as the potential for human and social development in the country.

5. Conclusions

Access to safe water has historically been monitored through established metrics designed to assess water resources and their availability. However, it is widely acknowledged that these traditional metrics are often inaccurate and may underestimate the extent of water insecurity. In this context, the validation of the Household Water Insecurity Experiences Scale (HWISE) in Argentina represents a significant advancement in measuring this phenomenon, as it enables a more precise assessment of the deprivations associated with water access and use in households.

The findings of this study confirm the reliability and validity of the HWISE scale in the Argentine context, demonstrating its capacity to reflect social and geographical inequalities in water access. Furthermore, its significant correlation with indicators of social deprivation, food insecurity, sanitary infrastructure, and psychological distress reinforces its utility as a comprehensive tool for understanding the multiple dimensions of water insecurity and its impact on population well-being.

From a methodological perspective, this study constitutes a rigorous validation exercise that not only establishes the scale’s reliability in Argentina but also reinforces its applicability in countries

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with similar characteristics. The validation of measurement instruments is a fundamental step in social research and in the generation of reliable scientific evidence, as it ensures that the indicators employed accurately reflect the phenomenon they are intended to measure. In this regard, the analysis of internal consistency, criterion validity evaluation, and comparison with other social vulnerability factors consolidate HWISE as a robust and replicable instrument for future research and applications in the region.

In particular, the validation of this scale in Argentina is of special relevance due to the country's geographical and socioeconomic heterogeneity. The unequal distribution of water resources, deficient infrastructure in certain areas, and extreme climatic conditions result in substantial disparities in water access across regions and socioeconomic groups. The adoption of a locally validated instrument facilitates a precise identification of these disparities and enables the implementation of more effective and context-specific public policies.

From a public policy perspective, the findings of this study support the need for the Argentine government to incorporate the HWISE scale into its official household surveys as a fundamental input for diagnosing and managing water access policies. Having robust and comparable data will enhance the design and implementation of strategies aimed at reducing water insecurity and its effects on the population's quality of life.

Finally, this study reaffirms that measuring water insecurity is not merely a technical or statistical issue but also a moral imperative and a global commitment. Ensuring equitable and safe access to water is a fundamental human right and a key requirement for sustainable development. In this regard, advancing the accurate measurement of water insecurity through tools such as the HWISE scale is an essential step toward achieving the Sustainable Development Goals (SDGs) and building more just and resilient societies

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Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three letter acronym
LD	Linear dichroism

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