International Journal of Sustainable Development and Planning
Vol. 21, No. 6, June, 2026, pp. 2783-2794
Journal homepage: http://iieta.org/journals/ijsdp

Towards Sustainable Water Consumption: Developing and Validating a Proposed Behavioral Measurement Instrument in the Context of Malaysia

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https://doi.org/10.18280/ijsdp.210633

Received: 19 January 2026
Revised: 2 June 2026
Accepted: 9 June 2026
Available online: 30 June 2026

Keywords:
content validity, instrument development, perceived service quality, price sensitivity, satisfaction, sustainable water consumption, sustainability

ABSTRACT

This study outlines the development of an instrument and the assessment of its preliminary content validity, designed to provide initial evidence that its items measure water consumption behavior in the context of Malaysia. The instrument integrates insights from the Stimulus-Organism-Response (S-O-R) framework and the SERVPERF model, with price sensitivity as a moderating variable, comprising a total of 36 initial items. This study provides critical insights into how perceptions may influence sustainable actions across four distinct domains: perceived service quality, satisfaction, price sensitivity, and sustainable water consumption behavior. Content validity was assessed through consensus from 10 experts selected based on predefined criteria and quantified using three key indices: the Content Validity Index (CVI), Content Validity Ratio (CVR), and modified Kappa (K). Experts rated 32 of the 36 items as excellent (I-CVI ≥ 0.78, CVR > 0, $K > 0.74$). The average scale (S-CVI/Ave) for all items was 0.92, the average CVR was 0.67, and the average K value was 0.91. One item that did not meet the CVR threshold was retained and revised following expert recommendations. Additionally, one item emphasizing the importance of environmental stewardship was added. The final scale comprises 34 items. Future recommendations include conducting comprehensive statistical analysis to ensure reliability and construct validity, as well as empirical validation to confirm that this instrument could effectively translate perceptions into actionable progress in water policy roadmaps.

1. INTRODUCTION

The fundamentals of ethical, methodologically sound, and transparent research depend on its capacity to accurately describe and appropriately measure the phenomena it aims to explore. This capacity is fundamentally represented by an instrument comprising domains that may be adopted, adapted, or newly developed, all anchored in the concept of validity [1, 2]. Validity, in turn, is a critical factor in the selection and application of an instrument both in practice and research. It can be defined as "the degree to which evidence and theory support the interpretation of test scores entailed by the proposed use of tests" or the extent to which the instrument measures what it intends to measure [3-5]. Comprehending the concept of validity enables researchers to appreciate its complexity and its critical role in upholding research integrity [1]. However, validity is not one-dimensional and cannot be assessed in isolation or through a single method. In this context, the study underwent an expert pretest, which provided an initial validity check on the appropriateness of the measure by evaluating whether it appears to assess what it is intended to, based on subjective judgment. Consequently, the quantification of content validity, as the next layer of the research validation process, ensures that the instrument is both conceptually sound and operationally captures all relevant domains, producing findings that genuinely reflect the phenomena under study, as judged by experts [1, 3, 6, 7].

The instrument was designed to assess water consumption behavior in Malaysia, particularly within the context of water demand management. This area has become a crucial policy strategy for addressing issues related to water stress and environmental sustainability [8]. In fact, the Organization for Economic Cooperation and Development (OECD) projected in 2012 that water demand would increase by more than 50% between 2000 and 2050, driven by economic industrialization and development, as well as a parallel increase in population, which would elevate domestic consumption by 130% [9]. A key issue is striking a balance between the accessibility and

affordability of water, recognized as a basic human right, while aligning economic benefits with long-term sustainability goals [10]. The economic aspect of water, as both a commodity and a public good, inevitably comes into play to facilitate a more effective allocation of water resources. Achieving sustainable development indeed requires the efficient use of resources, along with the advancement of technologies and practices that are both environmentally sustainable and economically viable [11].

The increasing gap between water supply and demand in recent years underscores the growing severity of water stress. None of the targets under Sustainable Development Goal (SDG) 6, specifically Target 6.1, which aims to "achieve universal and equitable access to safe and affordable drinking water for all" by 2030, are on track to be achieved [12]. In 2015, when the SDGs were introduced, approximately 70% of the global population had safe drinking water, and this figure has gradually increased recently [13] (see Figure 1). However, if progress continues at this slow pace, we will not achieve the target of universal and equitable access to safe and affordable drinking water by 2030 [13]. Water stress is also affecting several developing countries, endangering their survival and economies [10]. In this regard, the crisis is caused by two main challenges: in certain nations, the primary issue is economic scarcity, where water is costly for potable purposes, while in other countries, the major barrier is the limited availability of water resources [14].

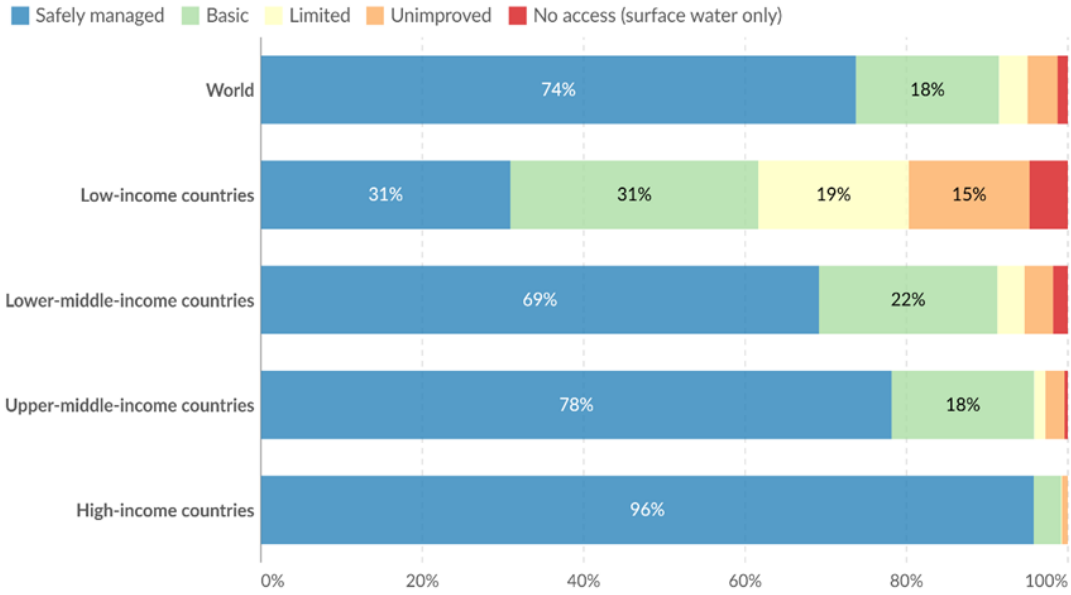

Figure 1. Share of the population using five different levels of drinking water services in 2024 [13]

Malaysia, as a water-rich country, has raw water extraction totaling 17,299 million liters per day, with sources primarily from surface water, constituting 80.2% from rivers and 17.5% from dams, while groundwater accounts for 2.3% [15]. Most Malaysians have access to basic amenities and facilities for clean and safe water, with piped water availability in households reaching almost universal coverage at 97% in both urban and rural areas as of 2023 [15]. Despite living in a water-rich country, consumers lack strong internalized norms for conservation [16]. The average daily water consumption is 225 liters per capita per day (LCD), exceeding the United Nations' recommended limit of 165 LCD [15]. Furthermore, the water tariffs for domestic water in Malaysia are highly subsidized, making it affordable for the average household [17]. Although these subsidized tariffs enable consumers to access services at a minimal expense, they inadvertently cultivate the perception that water is abundant and of little worth. As a result, consumers view water as "cheap" relative to its true cost of sustainable service provision, diminishing their initiatives to conserve [18]. Conversely, water operators face financial constraints that impede their capacity to update deteriorating water pipelines, leading to excessive amounts of non-revenue water; thus, water operators compromise on maintenance due to financial constraints [19]. Undeniably, the discrepancy between price sensitivity and available funding is a significant obstacle, as low tariff revenues deprive water operators of necessary resources, resulting in service failures.

To effectively manage water demand, consumers need to transform their water usage habits to be more environmentally friendly [20]. In this context, managing household water consumption emerges as a critical strategy for easing the burdens of water stress and alleviating growing pressure on the environment [21]. However, a persistent challenge undermines this effort: the "behavioral gap" where high awareness of water issues often fails to translate into consistent sustainable consumption actions [22]. Addressing this issue requires a strategic shift from supply-side solutions to demand-side governance, prioritizing long-term sustainability through consumer engagement and equitable policy design. A key question arises: What undermines consumers' motivation to conserve water? A critical concern is how perceived service quality fails to enhance consumer satisfaction and cooperation with sustainability initiatives. This behavioral gap suggests that current messaging does not effectively translate consumers' perceptions into actions. Therefore, this study aims to fill this gap by proposing a conceptual model that explores the intricate interplay between perceived service quality and satisfaction and the moderating factor of price sensitivity in shaping sustainable water consumption behavior, particularly within the underexplored context of developing nations like Malaysia.

This study presents a novel conceptual framework that integrates perceived service quality, assessed using the SERVPERF scale, as an antecedent to satisfaction, which is

hypothesized to subsequently influence sustainable water consumption behavior in a proposed framework. It also explores price sensitivity as a moderator. Effective water tariffs can increase consumer awareness, enabling individuals to recognize their consumption patterns and adjust their usage based on cost signals, where higher prices typically lead to reduced consumption and promote water resource sustainability [23]. Although SERVPERF was originally developed for commercial marketing [24], this study highlights its strategic applicability to the public water utility sector, providing a robust metric for assessing how performance perceptions impact consumer behavior. To guide this investigation, the study employs the Stimulus-Organism-Response (S-O-R) framework [25], which provides a useful theoretical lens for hypothesizing environmental behavior [26]. This theoretical application offers a structured method for analyzing how external stimuli influence internal states, ultimately driving behavioral responses, with price sensitivity serving as a significant boundary condition.

The relevance of this study lies in its provision of essential knowledge for advancing environmental management by moving beyond mere awareness campaigns to tackle the complex factors that influence consumer behavior. Additionally, the conceptual model developed in this study links service marketing theory with environmental psychology, offering significant transferability. This enhances its relevance to a broader audience and makes it applicable to other public goods and sustainable consumption behaviors beyond the immediate focus of this study. Furthermore, the proposed instrument, following future full-scale validation to establish its reliability and construct validity, could form a crucial foundation for developing effective policies for water demand management. The conceptual model proposes a direct correlation between the behavioral gap that contributes to per capita consumption and its tangible environmental consequences, a relationship that warrants empirical testing in future research. Consequently, if this proposed model is supported by subsequent empirical research, policymakers could use such an instrument to create targeted interventions, provide incentives, and enforce regulations that promote water conservation at the household level.

2. THEORETICAL BACKGROUND

Developing a content-valid instrument of an abstract theoretical concept is not as straightforward as it may seem and can be a complex process [27]. The theoretical framework outlines the underlying theory and model that guide the study, clarifying the theoretical assumptions and principles that inform the research. Meanwhile, the conceptual model illustrates the relationships among key concepts derived from or guided by the theoretical framework, serving as a blueprint for how these concepts are expected to interact [1]. Including irrelevant items or omitting important ones during the development of the domain can jeopardize its internal consistency and interfere with the relationships and correlations between the items within the domain [3].

Validity does not assess theories directly but rather evaluates how well questions represent those theories. In this context, an initial framework for evaluating sustainable water consumption behavior was developed through a literature review and theoretical analysis. To investigate the effects of perceived service quality and satisfaction, along with the moderating role of price sensitivity, this study develops a conceptual model by integrating the S-O-R framework [25] and the SERVPERF model [24]. The S-O-R framework posits that external environmental Stimulus (S) influences an individual's internal cognitive and affective states, which constitute the Organism (O), ultimately triggering a behavioral Response (R) (see Figure 2).

While the original theory emphasized a direct S-R link, connecting them without considering the internal cognitive and emotional processes that mediate this relationship [28], subsequent work by the study [29] expanded the framework by incorporating the organism as a component that includes cognition and physiology [30]. Many researchers notably utilize the expanded S-O-R framework as the foundational theory to align with their specific study contexts. This framework integrates diverse factors into conceptual models to evaluate consumers' perceptions and behavioral intentions within a cohesive structure, effectively explaining consumer behavior [31, 32]. Its flexibility allows for the incorporation of various variables [30].

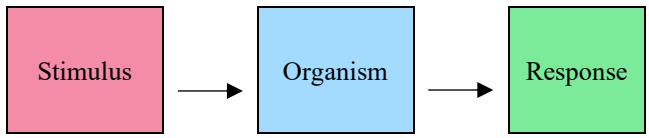

Figure 2. The expanded S-O-R framework [25]

This study introduces a novel conceptual integration by systematically incorporating the established SERVPERF model to operationalize *Stimulus* as a multi-dimensional, performance-based measure of service quality. It extends the S-O-R framework by embedding price sensitivity as a moderator within the *Organism* stage in relation to the *Response* of water consumption behavior. This dual integration is distinctive: SERVPERF provides a precise, marketing-validated gauge of the external stimulus specific to utility services, whereas the incorporation of price sensitivity acknowledges that translating satisfaction into sustainable behavior depends on consumers' economic perceptions. This enhanced model presents a more comprehensive framework for understanding the cognitive, effective, and economic determinants of sustainable water consumption behaviors. In this context, the domains are mapped onto the S-O-R framework as follows:

***Stimulus*: Perceived Service Quality.** This study positions perceived service quality as the external stimulus, representing the objective characteristics of water supply services as experienced by consumers. To operationalize this stimulus, we employ the SERVPERF model, which measures the extent to which consumers evaluate service quality through performance-based perceptions across five dimensions: tangibles, reliability, responsiveness, assurance, and empathy [24]. Although SERVPERF originated in commercial marketing, its application here is justified, as public utilities provide a "service" to "consumers," and its performance-based nature offers a precise measure of the external stimulus influencing internal states [33, 34]. Furthermore, SERVPERF's performance-based perceptions align with the nature of public utilities, where expectations are often complex or inconsistent.

***Organism*: Satisfaction (with Price Sensitivity as a Moderator).** The organism component represents the internal psychological processes activated by the service quality

stimulus. The primary internal state examined is consumer satisfaction, conceptualized as the affective evaluation reflecting how content customers are with the services provided and their perceived value [35]. Furthermore, this study incorporates price sensitivity as a moderator of the organism stage. It is conceptualized as the extent to which the internal state of satisfaction translates into behavioral responses to changes in prices for water supply services [36]. For instance, a highly price-sensitive individual may respond differently to water consumption behavior than a less sensitive one, positioning price sensitivity as a critical boundary condition within the cognitive-affective system of the organism that influences the response.

***Response*: Sustainable Water Consumption Behavior.** The final component is the behavioral response, which is the outcome of the internal processes. This response reflects the desire to enter or leave a particular environment, represented by approach or avoidance behavior [26]. Researchers typically analyze the response as the final output or dependent variable from various perspectives, depending on their specific research objectives [30]. In this model, the response represents the manifestation of sustainable water consumption behavior, operationalized as the adoption of practices that promote responsible water use [37]. This phenomenon encompasses both overt actions and consumer behavior related to efficient water use and resource conservation, constituting a behavioral approach [26] that this study aims to operationalize and validate through expert judgment for future empirical testing. The conceptual research framework presented in Figure 3 is proposed based on theoretical grounding and expert validation.

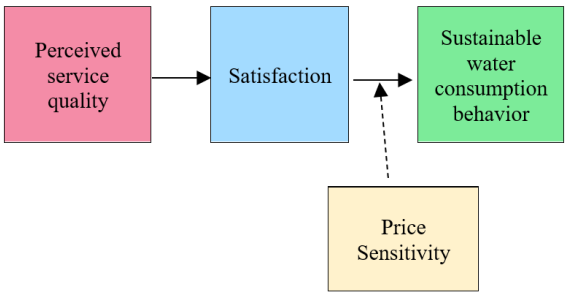

Figure 3. Conceptual research framework

3. METHODOLOGY

When a new instrument is designed, measuring and reporting its content validity is fundamentally important [38]. Content validity is a prerequisite for other types of validity and should be prioritized in the earliest phase of instrument development [7, 39]. If an instrument lacks content validity, establishing its reliability becomes impossible. Therefore, allocating more resources to a content validity study at the outset can reduce the need for resources in future reviews of the instrument during the psychometric process [40-42]. Consequently, this study utilized a practical methodology for instrument development and content validity evaluation, drawing from Almanasreh et al. [3]. The content validation process also included a pretest, as suggested by Lim [1]. This involved getting feedback from experts within pertinent academic disciplines and subsequently implementing modifications informed by the feedback received. Thus, the instrument development and content validation process in this study consists of four stages: the development stage, the judgment and quantification stage, the pretest stage, and the content validation quantification stage, as illustrated in Figure 4.

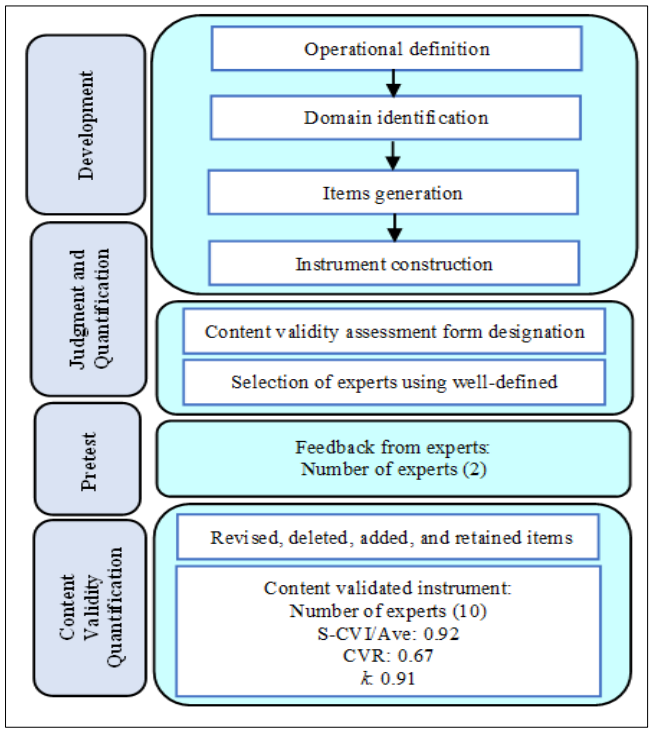

Figure 4. The flow diagram illustrates the process of instrument development and content validation for this study

Table 1. Domains, sources and number of items

Domains	Sources	No. of Items
Perceived service quality	[24]	22
Satisfaction	[43, 44]	5
Price sensitivity	[45, 46]	5
Sustainable water consumption behavior	[47]	4
Total		**36**

3.1 Development stage

Following an extensive literature review of the theoretical background, a conceptual research framework was developed utilizing the S-O-R framework and the SERVPERF model. The operational definitions of the domains were clearly defined to avoid incongruity [3, 27], as discussed in Section 2. Subsequently, the instrument was developed through determining the domains, item generations, and instrument construction [3, 40, 42]. A total of 36 items were generated by adapting items from previous studies, which collectively formed the instrument for this study (see Table 1).

3.2 Judgment and quantification stage

This stage involves the designation of the content validity assessment form and the invitation to a group of experts to evaluate how effectively the operationalization of the items captures the domains and how well they have been incorporated into the instrument. Additionally, experts assess the extent to which the instrument is designed to measure the

specific concept of interest [1, 3, 40]. The content validity assessment form was created to gather responses from experts regarding the adequacy of the items' operationalization in capturing the construct. Consequently, selected experts with the necessary expertise, experience, and exposure the study [1] in the water sector were invited to participate in the assessment.

There is no consensus on the number of experts required to review the instrument. Lynn [39] suggested a minimum of three experts, while Muhamad Jamil et al. [48] recommended at least five to ensure that the consensus reflects the experts' professional knowledge and understanding rather than mere coincidence. However, Yusoff [49] asserted that the number of experts for content validation should be at least six but should not exceed 10. In this study, the selection of experts adhered to the principle of representativeness, including policymakers, regulators, academics, and industry representatives for a comprehensive assessment of the instrument. The experts selected to review the instrument were chosen based on well-defined criteria adapted from guidelines established by the study of Grant and Davis [50], along with quantitative scoring adaptations from previous studies [51-53]. The criteria for participation included a solid educational background with at least a bachelor's degree (Q1), a relevant professional background (Q2), a minimum of five years of practical experience in the water sector (Q3), and familiarity with the concepts evaluated in this study (Q4). These criteria ensured that all participants possessed substantial experience and insight, making them suitable for accurate judgments.

Table 2. Experts' profile criteria

Categories	No. of Experts
Q1: Educational attainment	
PhD	5
Master's degree	3
Bachelor's degree	2
Q2: Professional background	
Secretary General/Chairman/CEO	2
Manager/Academician	7
Professional in operational position	1
Q3: Experience	
More than 10 years	9
6 to 10 years	1
Less than 5 years	0
Q4: Familiarity with the concept evaluated in this study	
High	2
Medium	8
Low	0

The content validity assessment form was emailed to 15 experts, accompanied by a cover letter and a comparison between the original and adapted items for this study. The cover letter outlined the study's purpose, provided a brief description of the domains and research conceptual framework, and explained the content validity assessment form the study of Rubio et al. [41]. After two weeks, the primary author sent a reminder to all the experts. Five experts agreed to complete the form in person, while five provided feedback via email. After six weeks, feedback from 10 experts with diverse backgrounds was gathered (see Table 2).

The overall authority of the experts was evaluated by quantifying the combined influence of their experience and insight in the water sector through the calculation of an Expert Authority Coefficient (Cr) according to the Delphi method. The equation utilized for this assessment is represented as $Cr = (Ca + Cs) / 2$, wherein Ca denotes the Expert Judgment Basis Coefficient and Cs signifies the Expert Familiarity Score [53]. The Ca encompasses three distinct criteria, each classified into three tiers: high, medium, and low, with coefficients of 0.4, 0.3, 0.2 (Q1), 0.2, 0.1, 0.1 (Q2), and 0.4, 0.3, 0.2 (Q3). Cs represents Q4, rated over three tiers: high (1.0), medium (0.7), and low (0.5). Consequently, Cr serves as an indicator of the degree of expert authority, which is denoted by the mean of Ca and Cs. Prediction accuracy increases with the level of Cr; a Cr of ≥ 0.70 is considered acceptable [53].

3.3 Pretest stage

Lim [1] explained that achieving content validity typically involves a pretest, during which a cyclical process of critique and refinement occurs, guided by feedback from a panel of experts. These experts, selected from relevant academic and professional fields, possess the necessary expertise to evaluate the instrument's alignment with the domains. While he suggests that starting with a minimum of two experts is advisable, he notes that the ideal number may vary depending on the complexity of the domains and the scope of the study. For this study, two experts with academic backgrounds in quantitative research methodology were selected. Their feedback led to revisions of the instrument, specifically in terms of wording clarity and adjustments to the response.

3.4 Content validation quantification stage

There is no uniform approach for examining the content validity of an instrument, nor is there a single statistical method [3]. In this study, the instrument was quantitatively assessed using the content validity index (CVI) to measure the relevance of each item (the level of importance of the item [6, 54, 55], the content validity ratio (CVR) to evaluate the essentiality of each item (how necessary the item is) [56], and modified Kappa (K) to determine the level of agreement among experts. Microsoft Excel was utilized for data entry and tabulation of measurements related to relevance, essentiality, and expert agreement. After analyzing the quantitative data, the experts' comments and suggestions were considered to decide whether to retain, revise, delete or add new items to the instrument.

3.4.1 Content Validity Index

The CVI is a widely used method for assessing the relevance of items on the instrument [7]. Following recommendations from the study of Polit et al. [54] that reference the method outlined by the study of Waltz and Bausell [55], a 4-point Likert scale was utilized to rate the relevance of each item (1 = Not Relevant, 2 = Somewhat Relevant, 3 = Quite Relevant, and 4 = Highly Relevant). The CVI was measured at both the item level (I-CVI) and the scale level (S-CVI). Before calculating the CVI, relevance ratings were recorded as 1 (for ratings of 3 or 4) or 0 (for ratings of 1 or 2). The I-CVI was determined by dividing the number of experts who rated an item as 3 or 4 by the total number of experts [39]. With 10 experts participating in this study, the acceptable cut-off score for the I-CVI value is 0.78, indicating that items rated above this threshold are considered relevant [39, 54]. Items with an I-CVI value lower than 0.78 but above 0.70 require revisions, while items with an I-CVI value below

0.70 are eliminated [39].

$$I\text{-}CVI = \frac{number\ of\ experts\ agree\ on\ items\ rated\ as\ 3\ or\ 4}{total\ number\ of\ experts} \quad (1)$$

Meanwhile, the S-CVI indicates the overall CVI of the instrument. The literature presents varying acceptable standards for the S-CVI; generally, the minimum acceptable range is between 0.8 and 0.9 [3, 6, 48]. The average S-CVI (S-CVI/Ave) in this study was computed by dividing the sum of the I-CVIs by the total number of items [3].

$$S\text{-}CVI/Ave = \frac{\sum(I\text{-}CVIs)}{total\ number\ of\ items} \quad (2)$$

3.4.2 Content Validity Ratio

The CVR measures the essentiality of each item, as established by the study of Lawshe [56]. According to Lawshe [56], a minimum CVR of 0.62 is typically required for 10 experts to establish statistical significance. Experts evaluate each item by utilizing a 3-point scale: 1 = not essential, 2 = useful but not essential, and 3 = essential. Ratings of 1 and 2 signify content that is deemed "not essential," whereas a rating of 3 denotes content that is considered "essential" [48, 57]. The CVR is computed by subtracting half the total number of experts from the count of experts who have rated an item as "essential," followed by dividing this result by half the total number of experts. CVR values range from 1 (indicating perfect agreement) to -1 (indicating perfect disagreement), with a value above 0 signifying more than half of the experts agree on the item's essentiality. However, given the preliminary nature of this instrument development and to ensure comprehensive domain coverage, this study adopted a relaxed threshold of CVR > 0 as a baseline for item retention or revision, provided that the item also achieved excellent relevancy (I-CVI $\geq$ 0.78), and excellent agreement (K > 0.74), as recommended by research [54]. Items falling below CVR 0.62 but above 0 were not automatically retained but were strictly revised based on qualitative expert feedback.

$$CVR = \frac{n_e - (N/2)}{N/2} \quad (3)$$

3.4.3 Modified Kappa

Polit et al. [54] have developed a modified Kappa (K) to overcome a major weakness of the I-CVI. It is derived by translating the I-CVI into a Kappa statistic to measure the level of agreement among experts while accounting for chance. The evaluation criteria for the K value are established as fair (0.40 - 0.59), good (0.60 - 0.74) and excellent (> 0.74). After calculating the value of I-CVI for all the items, K can be computed by applying the value of probability of chance agreement and I-CVI through the equation:

$$K = \frac{I\text{-}CVI - P_c}{1 - P_c} \quad (4)$$

4. RESULTS AND DISCUSSION

The experts participating in this study demonstrated strong authority, with the highest Cr of 1.0, the lowest of 0.7, and an average of 0.8. In terms of item quantification, the experts rated 32 out of 36 initial items as having excellent content validity (32 items: I-CVI $\geq$ 0.78, CVR > 0, K > 0.74). Three items (T3, A4, E2) failed to meet the minimum threshold and were deleted. The average scale (S-CVI/Ave) for all items was 0.92, the average CVR was 0.67, and the average K was 0.91. Based on the expert's qualitative comments, 13 of the accepted items underwent minor wording modifications to improve clarity or change reverse-coded items into a positive tone. One item (SWCB4) that did not meet the ideal CVR threshold was retained but heavily revised, following specific expert recommendations. Additionally, one item emphasizing the importance of environmental stewardship was added to the sustainable water consumption behavior domain. This new item was developed through discussions among the primary author and co-authors until consensus was reached. Consequently, the final scale comprises 34 items, as shown in Table 3 (see Tables A1 and A2).

Table 3. The summary of initial, revised, deleted, added, and final items for the evaluated domains

Domains	No. of Initial Items	No. of Items Revised	No. of Items Deleted	No. of Items Added	No. of Final Items
Perceived service quality	22	9	3	0	19
Satisfaction	5	1	0	0	5
Price sensitivity	5	1	0	0	5
Sustainable water consumption behavior	4	2	0	1	5
Total	**36**	**13**	**3**	**1**	**34**

Nauges and Whittington [58] emphasized that proper pricing by aligning tariff structures with the full economic and environmental costs of water services can enable water utilities to generate sufficient revenue for maintenance and infrastructure improvements. This alignment also allows for the implementation of innovative technologies that enhance overall service efficiency, potentially incentivizing sustainable water consumption behavior.

Previous studies highlight the broader role of water tariffs in recognizing the economic and environmental value of water [59-61], which can address environmental externalities by incorporating the costs associated with water use and conservation. However, Massarutto [62] cautioned that the incorporation of an externality cost without a clear and transparent remediation mechanism poses the risk of creating a regressive tax system and reducing the initiative to a mere exercise in revenue generation, thus undermining the purpose of internalization. The assessment of externalities is undeniably challenging due to the scarcity of data and the complex measurement methodologies. Furthermore, water tariff determination is influenced by a combination of operational factors, economic regulations, public policies, utility ownership, and political considerations, all of which vary significantly across regions, system types, and institutional histories [63]. This study proposes and provides preliminary content validity evidence for a new scale of measurement items designed to assess initiatives promoting sustainable water consumption behavior in the context of water pricing to address challenges in Malaysia. If supported by future full-scale validation, these items could be valuable

for studies that require a proposed means of assessing consumer behavior when raw data are not available. With the support of a group of experts, measurement items relevant to the domains of sustainable water consumption were identified as content valid.

The proposed instrument could enable the identification of specific perceptions of service quality and value that may most effectively drive or hinder sustainable water consumption behavior. Moreover, this study aligns with the Water Sector Transformation 2040 (Air 2040) initiative launched by the Malaysian Government in 2024. This national roadmap of the water sector addresses critical challenges such as unsustainable consumption, high non-revenue water, and financially strained operators by advocating progressive tariff structures that reflect the true economic value of water, promoting significant investments in infrastructure upgrades, and encouraging a culture of conservation [64]. By transitioning to a demand-management paradigm, the conceptual framework proposed in this study could inform targeted, evidence-based interventions that align consumer behavior with economic and sustainability goals. Ultimately, when supported by empirical validation, this approach may contribute to a more resilient and efficient water sector, aligning water consumption with global sustainability benchmarks and enhancing resilience against climate change and water stress [9, 65].

The findings provide initial evidence of content validity and propose a link through the novel conceptual integration of SERVPERF within the S-O-R framework. By employing the SERVPERF model to define the stimulus, we moved beyond abstract perceptions to capture how specific, measurable dimensions of service performance may impact behavior. Furthermore, based on experts' feedback, price sensitivity was identified as a conceptually relevant moderating factor within the organism stage. This suggests that the relationship between satisfaction and sustainable behavioral response may not be universal; rather, it could be critically influenced by individual economic considerations. This integration offers a potentially compelling explanatory perspective suggesting that water conservation behavior arises not solely from service evaluation or attitude, but rather from a complex interaction between detailed service performance assessments and personal economic thresholds. Consequently, future research and utility management strategies should account for both service experience and price sensitivity when seeking to effectively promote sustainable water consumption.

However, this study has several limitations. The primary limitation is that it only provides evidence for content validity, defined as expert judgment regarding whether the items adequately represent the conceptual domain of sustainable water consumption behavior. This study does not establish other essential psychometric properties, including pilot testing to assess item comprehension, readability, or response patterns; reliability assessment for internal consistency; or factor analyses to examine the underlying dimensional structure of the instrument. Incorporating these additional measures in future research could provide a more comprehensive understanding of the instrument's psychometric properties. Consequently, this study cannot establish causal relationships between perceived service quality, satisfaction, price sensitivity, and sustainable water consumption behavior, as we did not empirically test the proposed instrument with a sample of respondents, which is beyond the scope of this study. Additionally, we also did not assess predictive criterion validity or linked instrument scores to metered water use. Therefore, the proposed instrument should be viewed as a preliminary tool for hypothesis generation rather than an operational measure. Future research must administer the scale to target respondents to test its reliability, factor structure, criterion validity, and association with actual water consumption behavior.

5. CONCLUSIONS

This study proposes a preliminarily developed instrument to assess the content relevance of items related to the interplay between service performance, satisfaction, and price sensitivity in shaping sustainable water consumption behavior. It emphasizes that effective demand management may need to consider the nuanced interactions between concrete service evaluations and economic perceptions. This concept is presented in the conceptual framework, which suggests potential applicability to water governance in Malaysia and similar contexts within developing countries. By documenting this process, the study enables readers to systematically understand and replicate the content validation procedure.

While further empirical validation is needed, this instrument, after future full-scale validation, could serve as a tool for policymakers and utilities seeking to design equitable, efficient, and conservation-oriented pricing strategies. Ultimately, its future application could help translate national roadmaps, such as Air 2040, into tangible progress and promote a financially sustainable water sector that is resilient and aligned with broader environmental goals. However, given this study's limitation to content validity, future research must assess its reliability, factor structure, criterion validity, and association with actual water use across diverse populations. Additionally, validation across various populations and settings is necessary to enhance the instrument's generalizability, reliability, and validity, thereby supporting resilient and conservation-oriented water pricing.

DATA AVAILABILITY STATEMENT

The data used in this study are derived from publicly available secondary sources, including government reports, policy documents, and literature for item generation. Additionally, primary quantitative ratings and qualitative comments were collected from a panel of 10 experts for content validity assessment. To protect confidentiality, the raw individual expert ratings and written comments are not shared, as the experts were assured anonymity. Aggregated item-level statistics (I-CVI, CVR, *K*) and the scale item wording matrix are provided in the Appendix.

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NOMENCLATURE

n_e	number of experts indicating a measurement item is essential
N	total number of experts that answered that item
Pc	the probability of chance agreement

APPENDIX

Table A1. The I-CVI, S-CVI/Ave, CVR, *K*, comments, and decision regarding the instrument's items

Items	No. of Panel Agree on Relevancy	I-CVI	CVR	*K*	Comments	Decision
T1	9	0.90	1	0.90		Retained
T2	9	0.90	1	0.90		Retained
T3	5	0.50	-0.2	0.34	I-CVI, CVR, and *K* do not meet the minimum threshold.	Deleted
T4	10	1.00	1	1.00		Retained
R1	10	1.00	1	1.00		Retained
R2	10	1.00	1	1.00		Retained
R3	10	1.00	1	1.00		Retained
R4	10	1.00	0.8	1.00		Retained
R5	10	1.00	1	1.00		Retained
RN1	8	0.80	0.6	0.79	4/10 panels recommended revising the item to a positive tone.	Revised
RN2	10	1.00	0.8	1.00	4/10 panels recommended revising the item to a positive tone.	Revised
RN3	9	0.90	0.8	0.90	4/10 panels recommended revising the item to a positive tone.	Revised
RN4	8	0.80	0.4	0.79	4/10 panels recommended revising the item to a positive tone.	Revised
A1	9	0.90	0.4	0.90		Retained
A2	9	0.90	0.4	0.90		Retained
A3	9	0.90	0.6	0.90	1/10 panel commented that "polite" alone does not fully convey assurance. Therefore, the item is revised to enhance precision for the respondents.	Revised
A4	7	0.60	-0.2	0.50	I-CVI, CVR, and *K* do not meet the minimum threshold.	Deleted
E1	8	0.80	0.2	0.79	4/10 panels recommended revising the item to a positive tone.	Revised
E2	6	0.60	-0.2	0.50	I-CVI, CVR, and *K* do not meet the minimum threshold.	Deleted
E3	9	0.90	0.2	0.90	4/10 panels recommended revising the item to a positive tone.	Revised
E4	9	0.90	0.6	0.90	4/10 panels recommended revising the item to a positive tone.	Revised
E5	9	0.90	0.2	0.90	4/10 panels recommended revising the item to a positive tone.	Revised
S1	10	1.00	1	1.00		Retained
S2	10	1.00	1	1.00		Retained
S3	10	1.00	1	1.00	2/10 panels recommended revising the item to enhance precision for the respondents.	Revised
S4	10	1.00	1	1.00		Retained
S5	10	1.00	0.8	1.00		Retained
PS1	10	1.00	1	1.00		Retained
PS2	10	1.00	1	1.00		Retained
PS3	10	1.00	0.6	1.00	1/10 panel recommended revising the item to enhance precision for the respondents.	Revised
PS4	10	1.00	1	1.00		Retained
PS5	10	1.00	1	1.00		Retained
SWCB1	10	1.00	1	1.00		Retained
SWCB2	10	1.00	0.6	1.00	1/10 panel recommended revising the item to enhance precision for the respondents.	Revised
SWCB3	10	1.00	0.8	1.00		Retained
SWCB4	8	0.80	0	0.79	2/10 panels commented that this item is repetitive to SWCB2. The item does not meet the minimum CVR threshold for retention, but it is revised and retained as I-CVI and *K* exceed the minimum threshold.	Revised
Sum		33.00	24.20	32.60		
Average		**0.92**	**0.67**	**0.91**		

Table A2. Scale item wording matrix

No.	Original Scale Items	Items Proposed for This Study	Final Retained Items
		Construct 1: Perceived Service Quality	
1.	XYZ has up-to-date equipment.	T1: The water operator uses advanced technology for water supply, for example smart pressure sensors and smart water meters.	T1: The water operator uses advanced technology for water supply, for example smart pressure sensors and smart water meters.
2.	XYZ's physical facilities are visually appealing.	T2: The infrastructure of the water distribution system is well maintained to ensure continuous water supply.	T2: The infrastructure of the water distribution system is well maintained to ensure continuous water supply.
3.	XYZ's employees are well dressed and appear neat.	T3: The employees are well dressed.	[redacted]
4.	The appearance of the physical facilities of XYZ is in keeping with the type of service provided.	T4: The water operator supplies clean and safe drinking water, for example odorless.	T4 (reindex as T3 of the final scale): The water operator supplies clean and safe drinking water, for example odorless.
5.	When XYZ promises to do something by a certain time, it does so.	R1: The water operator is fulfilling its promises of providing a consistent water supply to consumers.	R1: The water operator is fulfilling its promises of providing a consistent water supply to consumers.
6.	When you have problems, XYZ is sympathetic and reassuring.	R2: The water operator immediately resolves issues, such as replacing broken meters.	R2: The water operator immediately resolves issues, such as replacing broken meters.
7.	XYZ is dependable.	R3: The water operator meets the service standards in delivering water supply to consumers.	R3: The water operator meets the service standards in delivering water supply to consumers.
8.	XYZ provides its services at the time it promises to do so.	R4: The water operator is committed to immediately restoring services in the event of a water supply interruption.	R4: The water operator is committed to immediately restoring services in the event of a water supply interruption.
9.	XYZ keeps its records accurately.	R5: The water operator ensures accurate water billing based on water consumption.	R5: The water operator ensures accurate water billing based on water consumption.
10.	XYZ does not tell its customers exactly when services will be performed.	RN1: The water operator does not tell its consumers exactly when the services will be performed.	RN1: The online platform is convenient for consumers to lodge reports about service interruptions.
11.	You do not receive prompt service from XYZ employees.	RN2: I do not receive prompt services from the employees.	RN2: The employees deliver services punctually.
12.	Employees of XYZ are not always willing to help customers.	RN3: The employees are not always willing to help consumers.	RN3: The employees are genuinely concerned about consumers' issues.
13.	Employees of XYZ are too busy to respond to customer requests promptly.	RN4: Complaints from consumers are not handled quickly.	RN4: Complaints from consumers are handled quickly.
14.	You can trust employees of XYZ.	A1: I can trust the water operator's employees.	A1: I can trust the water operator's employees.
15.	You can feel safe in your transactions with XYZ 's employees.	A2: I can feel safe in my transactions with the employees.	A2: I can feel safe in my transactions with the employees.
16.	Employees of XYZ are polite.	A3: The employees are polite.	A3: The employees are competent in providing services to consumers.
17.	Employees get adequate support from XYZ to do their jobs well.	A4: The employees get adequate support to do their jobs well.	[redacted]
18.	XYZ does not give you individual attention.	E1: The employees do not give individual attention to consumers.	E1: The employees give individual attention to consumers.
19.	Employees of XYZ do not give you personal attention.	E2: The employees do not give personal attention.	[redacted]
20.	Employees of XYZ do not know what your needs are.	E3: The employees do not know consumers' needs.	E3 (reindex as E2 of the final scale): The employees know consumers' needs.
21.	XYZ does not have your best interests at heart.	E4: The employees do not have consumers' best interest at heart.	E4 (reindex as E3 of the final scale): The employees are compassionate when dealing with consumers.
22.	XYZ does not have operating hours convenient to all their customers.	E5: The operating hours are not convenient for all their consumers.	E5 (reindex as E4 of the final scale): The operating hours are convenient for all consumers.
		Construct 2: Satisfaction	
23.	I am satisfied with the water supply services.	S1: I am satisfied with the quality of the water supply services.	S1: I am satisfied with the quality of the water supply services.
24.	I am satisfied with the value for money of water supply services.	S2: I am satisfied with the value for money of water supply services.	S2: I am satisfied with the value for money of water supply services.
25.	Overall, I am satisfied with the facilities, equipment, and infrastructure of the water supply services.	S3: I am satisfied with the facilities, equipment, and infrastructure of the water supply services.	S3: I am satisfied with the facilities and infrastructure of the water supply system.
26.	Overall, I am satisfied with the management and employees of	S4: I am satisfied with the water operator's management and employees.	S4: I am satisfied with the water operator's management and employees.

	SATU/SAJSB.		
27.	Overall, the water supply services meet my expectations.	S5: Overall, the water supply services meet my expectations.	S5: Overall, the water supply services meet my expectations.
		Construct 3: Price Sensitivity	
28.	Even if the price of water is high, excellent service quality would make me feel the cost is justified.	PS1: Even if the price of water is high, excellent service quality would make me feel that the price is justified.	PS1: Even if the price of water is high, excellent service quality would make me feel that the price is justified.
29.	I would be more satisfied with water supply services if price increases were tied to measurable improvements in service quality.	PS2: I would be more satisfied with water supply services if price increases were tied to measurable improvements in the services.	PS2: I would be more satisfied with water supply services if price increases were tied to measurable improvements in the services.
30.	I am not willing to pay higher water price if the supply services are always disrupted.	PS3: I am not willing to pay higher water price if the supply services are always disrupted.	PS3: I am not willing to pay a higher price for water if the supply is frequently disrupted.
31.	I am willing to pay more if the quality of water supply is excellent.	PS4: I am willing to pay a higher price for the excellent water supply quality.	PS4: I am willing to pay a higher price for the excellent water supply quality.
32.	In general, the price of water supply services is important to me.	PS5: In general, the price of water supply services is important to me.	PS5: In general, the price of water supply services is important to me.
		Construct 4: Sustainable Water Consumption Behavior	
33.	Whenever possible, I take measures to save water.	SWCB1: I try to use water efficiently at home whenever possible.	SWCB1: I try to use water efficiently at home whenever possible.
34.	I purposefully select products that let me save water.	SWCB2: I purposefully select products that let me conserve water.	SWCB2: I use water-efficient appliances to save water.
35.	I try to limit my use of water when performing household tasks.	SWCB3: I try to limit my water use when performing household tasks; for example, turning off the tap while applying dish soap during dishwashing.	SWCB3: I try to limit my water use when performing household tasks; for example, turning off the tap while applying dish soap during dishes washing.
36.	I purposefully purchase products that allow me to save water.	SWCB4: I purposefully purchase products that allow me to conserve water.	SWCB4: I collect rainwater for non-drinking purposes; for example, for watering plants.
37.	[redacted]		SWCB5: I report pipe leaks as soon as I notice them.