

Household Water Security Using Choice Experiment: A Systematic Literature Review

Ahmad Hakimi Abd Halim, Zuraini Anang*, Mahirah Kamaludin, Roseliza Mat Alipiah,
Noorhaslinda Kulub Abd Rashid, Jumadil Saputra

Faculty of Business, Economic and Social Development (FBESD), University Malaysia Terengganu (UMT), Malaysia

Received April 20, 2024; Revised August 30, 2024; Accepted September 13, 2024

Cite This Paper in the Following Citation Styles

(a): [1] Ahmad Hakimi Abd Halim, Zuraini Anang, Mahirah Kamaludin, Roseliza Mat Alipiah, Noorhaslinda Kulub Abd Rashid, Jumadil Saputra, "Household Water Security Using Choice Experiment: A Systematic Literature Review," *Environment and Ecology Research*, Vol. 12, No. 5, pp. 467 - 479, 2024. DOI: 10.13189/eer.2024.120501.

(b): Ahmad Hakimi Abd Halim, Zuraini Anang, Mahirah Kamaludin, Roseliza Mat Alipiah, Noorhaslinda Kulub Abd Rashid, Jumadil Saputra (2024). *Household Water Security Using Choice Experiment: A Systematic Literature Review*. *Environment and Ecology Research*, 12(5), 467 - 479. DOI: 10.13189/eer.2024.120501.

Copyright©2024 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract Water security, a pivotal element of sustainable development, faces escalating challenges globally due to population growth, urbanization, and climate change impacts. This study focuses on household water security, emphasizing the scarcity of research using choice experiments, a valuable tool for understanding individual preferences. The macro-level examination underscores the need for holistic approaches to addressing water scarcity, emphasizing the urgency of sustainable resource management. Focusing on households, inadequate infrastructure, contamination, and unreliable water sources pose challenges worldwide. The research identifies a significant gap in choice experiment studies within household water security, particularly in regions with moderate water problems. The bias towards severe water challenges skews the understanding of preferences and decision-making factors. This study employed the ROSES protocol, emphasizing reporting standards for Systematic Evidence Syntheses in environmental management. The methodology entails delineating research inquiries, search methodologies, inclusion and exclusion criteria, quality evaluation, and data extraction, thus ensuring a thorough and comprehensive synthesis. Key findings indicate that households in the studied regions demonstrate high sensitivity to natural environmental changes, with water availability and quality alterations significantly impacting their livelihoods and socio-economic routines. Additionally, the area is highly vulnerable to impacts related to household water security, including issues such

as water scarcity and contamination. The effectiveness of adaptation strategies in reducing vulnerability and enhancing resilience in household water security remains to be seen, indicating a need for further research in this area. This review highlights the necessity of integrating choice experiments into household water security studies, especially in regions with moderate water issues. Bridging this gap contributes to a nuanced understanding of preferences, enabling evidence-based strategies for equitable and effective global water security interventions.

Keywords Water Security, Choice Experiment, Household Water Resource, Willingness to Pay

1. Introduction

Water security, a critical component of sustainable development, encompasses water resources' availability, access, quality, and sustainability. The global challenge of water security has garnered increasing attention due to growing populations, urbanization, and climate change impacts on water availability and distribution [1]. As societies grapple with these challenges, understanding the intricacies of water security at various levels, including the household level, becomes imperative for informed policymaking and sustainable water resource management [2].

At the macro level, water security addresses the overarching concern of ensuring an adequate and reliable water supply for diverse purposes, ranging from agriculture and industry to domestic use. The issue is multifaceted, involving quantity and quality considerations [3]. Water scarcity in certain regions, exacerbated by climate variability, population growth, and inefficient water use, underscores the urgency of adopting holistic and integrated approaches to managing water resources sustainably [4].

Focusing on the household level unveils a microcosm of water security challenges. Access to safe and reliable water within households is fundamental for meeting basic needs, ensuring health, and fostering socio-economic development. In many parts of the world, households grapple with issues such as inadequate water supply infrastructure, water contamination, and the unreliability of water sources. Understanding the dynamics of household water security is crucial for designing targeted interventions that address diverse households' specific needs and preferences.

Choice experiments, a method rooted in behavioral economics, have emerged as a powerful tool for investigating preferences and decision-making processes related to household water security. By presenting respondents with hypothetical scenarios featuring different attributes of water supply (such as source reliability, water quality, and cost), choice experiments enable the elicitation of stated preferences [5]. This approach provides a nuanced understanding of the trade-offs and individuals are willing to make in selecting water supply options, thereby informing policies and interventions that align more closely with community preferences [6].

The systematic literature review undertaken in this study aims to consolidate and analyze existing research on household water security, with a specific focus on studies utilizing choice experiments. This synthesis aims to contribute to the comprehension of the determinants that influence household water security decisions. It also intends to pinpoint any existing gaps in the literature, thereby providing guidance for future research directions and informing evidence-based strategies for improving water security at the household level.

1.1. Research Gap Existing Studies Related to Adaptation toward Household Water Security

The systematic literature review on household water security using choice experiments reveals a notable gap in research, primarily characterized by a limited number of studies employing the choice experiment methodology within the context of household water security. While the choice experiment approach has proven to be a valuable tool in understanding individual preferences and decision-making processes, its application in the specific domain of household water security needs to be explored. One significant gap is the need for more studies focusing on countries with moderate water problems. Existing literature

on water security tends to concentrate predominantly on regions facing acute and severe water challenges, often overlooking countries with moderate water issues. This bias can lead to a skewed understanding of the spectrum of challenges and potential solutions related to household water security. Moderate water problems, while not as acute as those in water-scarce regions, still pose substantial threats to households, and exploring the preferences and decision-making factors in such contexts is crucial for developing targeted and effective interventions.

Furthermore, the limited use of choice experiments in household water security is a noteworthy gap in the literature. The choice experiment methodology allows for a nuanced understanding of individuals' preferences by presenting them with alternative scenarios and eliciting their choices based on various attributes of water security. The underrepresentation of choice experiment studies in this field hinders the development of a comprehensive and nuanced understanding of how households prioritize different aspects of water security, such as water quality, reliability, and accessibility. To address this gap, future research should aim to incorporate choice experiments into the study of household water security, particularly in regions facing moderate water problems. By doing so, researchers can capture the nuanced preferences and trade-offs that households make in the context of water security, providing valuable insights for policymakers and practitioners. Expanding the geographical scope of studies to include countries with varying water challenges will contribute to a more comprehensive and globally relevant understanding of household water security issues and potential solutions. This inclusive approach is essential for developing strategies tailored to diverse households' needs and contexts, ultimately contributing to more effective and equitable water security interventions worldwide.

Consequently, this study aims to identify the dimensions of household water security, factors of household water security, determinants of household willingness to pay (WTP), type of choice set, and model employed for the water security study.

2. Materials and Methods

2.1. The Review Protocol – Reporting Standards for Systematic Evidence Syntheses (ROSES)

The present inquiry adhered to the Reporting Standards for Systematic Evidence Syntheses (ROSES) tailored explicitly for environmental management [7]. ROSES strives to encourage researchers to provide accurate and thorough information, promoting transparency and the ability to replicate results in systematic reviews. The justification for using the ROSES protocol in this study is multifaceted. Firstly, ROSES provides a structured framework that enhances the rigor and consistency of the

systematic review process. By adhering to these standards, the study ensures that the methodology is robust, reducing the risk of bias and increasing the reliability of the findings. Secondly, the environmental management context of this study aligns well with ROSES, specifically designed to address the complexities and interdisciplinary nature of ecological research. This alignment ensures that the review addresses relevant environmental management issues comprehensively.

The authors commenced their Systematic Literature Review by formulating relevant research questions as per the prescribed protocol. They established a systematic search strategy involving three crucial subprocesses: identification, screening (comprising inclusion and exclusion criteria), and eligibility assessment. Subsequently, the authors conducted a rigorous assessment of the quality of the selected articles, elucidating their strategy to ensure their suitability for the review. Finally, the study outlined the process of data abstraction for the review, as well as the subsequent analysis and validation of the abstracted data.

2.2. Formulation of Research Questions

The development of the research question in this study is guided by Patient, Intervention, Comparison, Outcome (PICO), a tool designed to assist authors in crafting suitable study questions for reviews. PICO revolves around three key elements: Population or Problem, Interest, and Context. In applying this framework, the author has identified three main components: water security (problem), willingness to pay (interest), and household (context). This structured approach has led to formulating the research question: "What is the willingness of households to pay for water security?"

2.3. Systematic Searching Strategies

The systematic search strategy involves three primary stages: identification, screening, eligibility, and data abstraction and discussion (see Fig. 1).

2.3.1. Identification

The identification process entails exploring synonyms, related terms, and variations of the primary study keywords: "water security," "dimension," and "household." The objective is to broaden search options in selected databases and uncover additional relevant articles. The selection of keywords aligns with the research question and follows Okoli's guidance [7]. Various sources, including online thesauri, prior studies' keywords, Scopus recommendations, and expert input, informed the identification process. The authors improved existing keywords and formulated a comprehensive search string by incorporating Boolean operators, phrase searching, truncation, wildcards, and field codes. This refined search strategy was applied to

Scopus and Web of Science, with details available in Table 1.

Scopus and Web of Science were selected as the primary databases for this systematic literature review due to their various advantages, encompassing advanced search capabilities, extensive coverage (indexing over 5,000 publishers), quality control measures, and a multidisciplinary focus, including studies related to environmental management [8, 9].

Additionally, Google Scholar was included as a supplementary database. Keyword combinations such as "water security," "water supply," "water services," and "household" were applied using phrase searching and Boolean operators (OR, AND) whenever appropriate. Incorporating Google Scholar aligns with Haddaway's recommendation [10], emphasizing its potential as a complementary database in the systematic review process [12].

Moreover, the selection of Google Scholar is justified by several advantages. Firstly, it generates a substantial number of results, as indicated by Gusenbauer [9], who reported 389 million documents available in this database. Orduna Malea [11, 12] similarly identified 165 million articles and journals in Google Scholar. In comparison to discovery tools [13], Google Scholar demonstrates a superior ability to retrieve established scholarly works from well-known publishers. A combined search across Scopus, Web of Science, and Google Scholar produced a total of 200 articles (refer to Fig. 1).

2.3.2. Screening

In this investigation, all 200 articles chosen underwent a screening process based on predefined criteria established following the research question, following the guidance of Kitchenham [14]. Recognizing the impracticality of reviewing every published article, Okoli [15] recommended setting a specific time frame. However, according to Kitchenham [14], limiting the publication timeline should only be considered when it is evident that pertinent studies were predominantly reported during a specific period. Following a database search, a notable surge in studies concerning water security was observed from 1999 onwards. Since the search was conducted in April 2023 and the year had yet to conclude, a timeline restriction of 2000 to 2022 was established as one of the inclusion criteria. Only articles containing empirical data and published in peer-reviewed journals were deemed suitable to uphold the review's rigor. Furthermore, for clarity, articles published in English were specifically chosen. As part of the study's objectives, articles from the Asia Pacific region were exclusively included (refer to Table 2). This screening process led to the exclusion of 71 articles that did not meet the inclusion criteria, and 18 duplicate articles were eliminated. Consequently, the remaining 111 articles formed the basis for the subsequent stages of the study.

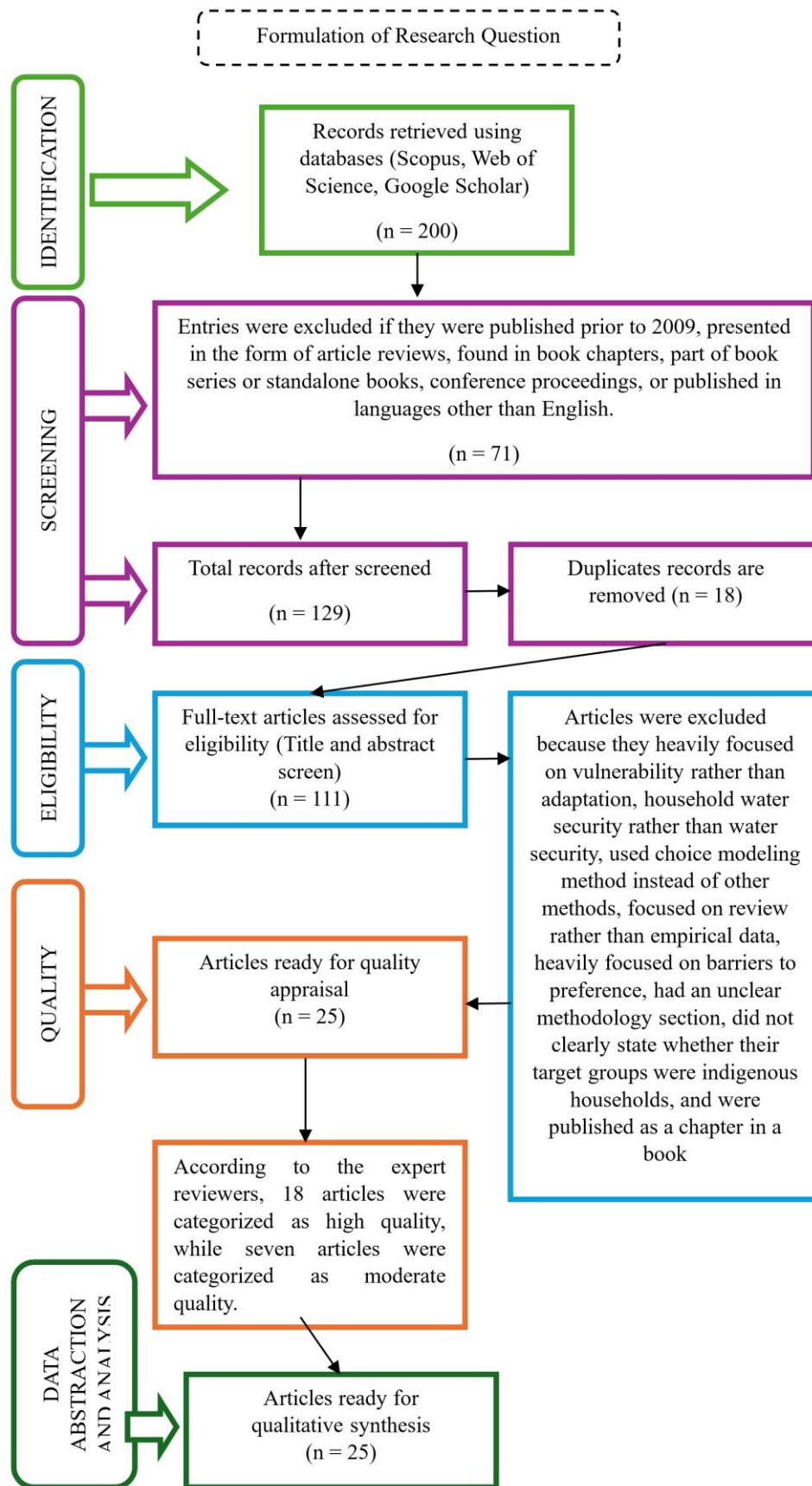


Figure 1. The Flow diagram (adapted from Shaffril, 2019) [19]

Table 1. The search string

Database	Search = (“household” AND “water security” AND (“choice modelling” OR “choice experiment”))
Scopus	TITLE-ABS-KEY ((“household” AND (“water security” OR “water supply” OR “water resources” OR “water safety” OR “aquatic security” OR “hydrosecurity” OR “water resource resilience” OR “hydrosafety” OR “water supply reliability” OR “water infrastructure security” OR “safe water access” OR “water stability” OR “water resilience” OR “water risk management” OR “water reliability”)) AND (“choice modelling” OR “choice experiment” OR “choice method” OR “CE” OR “preference modelling” OR “decision modelling” OR “attribute-based modelling” OR “conjoint experiment” OR “selection modelling”))
Web of Science	TS = ((“household” AND (“water security” OR “water supply” OR “water resources” OR “water safety” OR “aquatic security” OR “hydrosecurity” OR “water resource resilience” OR “hydrosafety” OR “water supply reliability” OR “water infrastructure security” OR “safe water access” OR “water stability” OR “water resilience” OR “water risk management” OR “water reliability”)) AND (“choice modelling” OR “choice experiment” OR “choice method” OR “CE” OR “preference modelling” OR “decision modelling” OR “attribute-based modelling” OR “conjoint experiment” OR “selection modelling”))

Table 2. The inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Timeline	2008 – 2023	<2008
Document Type	Article journal	Article review, book, conference proceeding
Language	English	Non-English
Focusing Group	Household	Besides the household

2.3.3. Eligibility

The third stage of the process, eligibility, entailed a manual review by the authors to confirm that the remaining articles, following the initial screening, adhered to the established criteria. In the course of this assessment, careful scrutiny was applied to the titles and abstracts of the articles. Subsequently, 86 articles were disregarded due to various reasons, including their focus on vulnerability rather than adaptation, concentration on the perception of water security analysis, encompassing household water security, the methodology utilized in water security research, the dimensions of household water security, the effects of climate changes on water security, consumer willingness to pay for water supply, and the correlation between consumer willingness to pay and economic factors as well as affordability. Additionally, articles published in the form of book chapters were excluded. Consequently, only 25 articles satisfied the eligibility criteria and were retained for further analysis.

2.3.4. Quality Appraisal

To uphold the content quality of the articles, the authors subjected the remaining papers to a quality assessment carried out by two experts. Following Petticrew and Roberts' guidance [16], these specialists categorized the articles into three quality levels: high, moderate, and low. Only articles falling into the high and moderate categories were considered for review. The primary focus of the experts was to evaluate the methodology employed in the articles to assign quality rankings. The inclusion of an article in the review was contingent upon mutual agreement by both authors regarding the article's quality, ensuring at

least a moderate level of quality. In cases where experts held differing views, they engaged in discussions to reconcile disparities before reaching a final decision on whether to include or exclude the articles. This meticulous evaluation process led to the classification of 18 articles as high quality and seven as moderate quality. Consequently, all remaining articles were considered eligible for inclusion in the review [12].

2.3.5. Data Abstraction and Analysis

The present study implemented an integrative review methodology, encompassing diverse research designs such as quantitative, qualitative, and mixed-method studies. Following the guidance of Whitemore and Knafel [17], a qualitative approach was employed to synthesize integrative data and facilitate iterative comparisons across primary data sources. A comprehensive examination of all 25 articles was conducted, with specific attention given to the abstracts, results, and discussion sections. Data abstraction was tailored to the research questions, involving the direct extraction of data addressing these questions, which was then organized into a tabulated format. Subsequently, a thematic analysis was conducted to discern overarching themes and sub-themes. This analysis encompassed the identification of patterns, clustering of related information, quantification of occurrences, and observation of similarities and relationships within the abstracted data, in accordance with the framework proposed by Braun and Clarke [18]. Thematic analysis was chosen for its suitability in synthesizing mixed research designs, aligning with the integrative approach in this study, as highlighted by Flemming [19] Described as a flexible and descriptive

method, thematic analysis is compatible with various data analysis techniques, as explained by Vaismoradi [20].

The initial step of the thematic analysis focused on theme generation, with the authors aiming to identify recurring patterns within the abstracted data from all the reviewed articles. Similar or related content was grouped, resulting in the formation of seven main groups. Following this, the authors revisited these seven groups and identified 22 sub-groups. The next step involved a meticulous review of the accuracy and utility of these themes. All main and sub-themes underwent reassessment during this process to ensure their effective data representation. As a result of this scrutiny, two sub-themes were excluded: one from the overarching theme of water security and another from the theme of household water security. Upon completing this process, the authors arrived at a final set of patterns comprising seven main themes and twenty sub-themes. The subsequent stage involved naming these themes for each group and their corresponding sub-groups. The authors initiated this naming process for the main groups before naming the sub-group themes as shown in Table 3 [12].

The collaborative effort to develop themes involved the corresponding authors and co-authors closely aligned with the study's findings. Throughout this phase of thematic development, the researchers engaged in discussions to address any inconsistencies, thoughts, puzzles, or ideas related to data interpretation. The deliberations continued until achieving unanimity on refining the developed themes and sub-themes. Subsequently, two panel experts, each proficient in qualitative techniques and community development studies, evaluated the developed themes and

sub-themes. Their mandate was to conduct an objective assessment of the seven themes and 20 sub-themes. Both experts concurred that the themes and sub-themes were pertinent and suitable in light of the review results.

3. Result

3.1. Background of the Selected Article

The review successfully identified and included a total of 25 articles. Following a thematic analysis, seven primary themes were established, which are as follows: "Choice Experiment (CE) Utilization in analyzing household water security, dimensions of household water security, factors affecting household water security, type of choice set and model used in the analysis. An in-depth analysis of these themes further revealed a total of 20 sub-themes. Among the 25 selected articles, six studies were carried out in Malaysia, and one study was conducted simultaneously in Vietnam, Chile, Greece, North America, Central America, Jordan, China, Spanish, Bangladesh, and France. Additionally, another study was conducted simultaneously, three in Australia, two in South Africa, and one in East Africa, considering their shared context as an analysis of household water security using choice modelling. Regarding the publication dates of the selected articles, one was published in 2008, one in 2009, two in 2011, one in 2013, one in 2014, three in 2015, one in 2016, three in 2018, two in 2019, one in 2020, one in 2021, one in 2022 and five articles were published in 2023 (Table 3).

Table 3. The themes and the sub-themes

Studies	Years	Region	CE in Household Water Security	Factor affecting household willingness to pay	Dimension of Household Water Security			Factors of Household Water Security			Type of Choice Set				Model Use		
					SP	CS	NT	NT	HM	TX	VS	TV	CL	ML	MLM	CVM	
1. P Kanyoka [28]	2008	South Africa	/	/	/	/	/	/	/			/				/	
2. Jill Windle [32]	2009	Australian	/	/	/	/	/	/				/	/				
3. P. Khanh Nam [4]	2006	Vietnam	/	/	/			/	/			/				/	
4. M. Rusli Yacob [32]	2011	Malaysia	/	/	/	/			/	/			/				
5. M. Rusli Yacob [31]	2013	Nigeria	/	/	/	/		/	/	/				/			
6. D.Latinopoulos [26]	2014	Greece	/	/	/	/	/	/				/	/				
7. Claudine Uwera [1]	2015	East Africa	/	/	/		/	/			/		/	/			
8. Vitor Dias [23]	2015	North America	/	/	/	/	/	/	/	/				/			
9. Rob Hope [33]	2015	East Africa	/	/	/			/			/		/	/			
10. Suleiman Alhaji Dauda [35]	2015	Nigeria	/	/	/			/	/	/				/			
11. Buhari Abdulkarim [2]	2016	Malaysia	/	/	/		/	/	/			/				/	
12. William F. Vasquez [29]	2018	Central America	/	/	/	/	/	/	/		/		/	/		/	
13. Christian Klassert [30]	2018	Jordan	/	/	/	/		/				/	/			/	
14. Mahirah Kamaludin [5]	2018	Malaysia	/	/	/			/				/	/	/			
15. Sorada Tapsuwan [27]	2018	Australia			/			/	/	/						/	
16. Nur Syuhada Che Ibrahim [6]	2019	Malaysia	/	/	/							/	/	/			
17. Imran Khan [3]	2019	China			/		/	/		/			/				
18. Nur Syuhada [36]	2020	Malaysia	/	/	/			/	/	/						/	
19. Gloria Amaris [21]	2021	Chile	/	/	/	/		/				/					
20. William F. Vasquez [37]	2022	Spanish	/	/	/		/	/	/	/						/	
21. Chandramalar Munusami [38]	2023	Malaysia	/	/	/		/	/	/	/							
22. Roy Brouwer [22]	2023	Bangladesh	/	/	/		/	/	/			/				/	
23. Ifedotun Victor Aina [34]	2023	South Africa	/	/	/			/				/				/	
24. Bethany Cooper [25]	2023	Australian	/	/	/			/				/				/	
25. Benedicte Rulleau [24]	2023	France	/	/	/	/		/				/	/	/			

Notes:

CE = Choice Experiment; SP = Supplier; CS = Consumer; NT = Natural; HM = Human; TX = Text; VS = Visual; TV = Text and Visual; CL = Conditional Logit Model; ML = Mixed Logit Model; MLM = Multinomial Logit model; CVM = Contingent Valuation Method

3.2. The Themes and the Sub-themes

3.2.1. Choice Experiment (CE) Using in Analysis Household Water Security

Choice modelling, specifically the Choice Experiment (CE), is a powerful technique used in economics, marketing, and social sciences to understand how individuals make decisions when faced with multiple alternatives or choices. It is a quantitative research method designed to elicit individuals' preferences and estimate the value they place on different attributes or characteristics of a product, service, or policy [21]. A choice Experiment is a specific type of choice modelling used to analyze and model these choices. The use of choice experiment in analyzing household water security is to set the most suitable value for clean water supply by studying the willingness to pay households for water. Apart from using choice experiments in analyzing households' willingness to pay for water, some other studies use choice modeling to measure farmers' willingness to pay for water [22].

3.2.2. Dimension of Household Water Security

The dimension of household water security refers to the various aspects and components considered when assessing the security of a household's water supply and its ability to meet its water-related needs. Household water security is a multifaceted concept that encompasses several dimensions. In this review, the study lists several dimensions of household water security which include the availability of water, and this dimension assesses whether a household has a reliable and consistent source of water, ensuring that an adequate quantity of water is accessible for daily needs [23]. Access to clean and safe water sources is a critical dimension. It evaluates whether households can easily reach and use these water sources without undue hardship or risk [24, 25]. Water quality is vital for household water security. It examines whether the water available to the household is safe, free from contaminants, and suitable for consumption and other uses. Next, as for the reliability of water, it considers the consistency and predictability of water supply, evaluating whether households can depend on a regular and uninterrupted water source [26].

Other than that, there is also a study that places affordability for water services as one of the main dimensions of household water security that needs to be highlighted; the economic aspect of household water security focuses on whether households can afford the cost of obtaining and using water without compromising their overall well-being. Sorada Tapsuwan [27] Sustainable water management practices are also crucial for long-term water security. This dimension assesses whether households use water resources in an environmentally responsible manner, minimizing waste and preserving resources for future generations [28]. D. Latinopoulos [26] also includes the storage and infrastructure that examines whether households have adequate storage facilities and infrastructure to manage and distribute water effectively

within the household [29].

The study by Christian Klassert [30] also considers cultural and social considerations as the dimensions of household water security. These dimensions consider cultural norms, social practices, and community dynamics that influence household water access and use. Health and hygiene are evaluating the impact of water on the health and hygiene of household members, including access to sanitation facilities, is another important dimension. M. Rusli Yacob [31] said that household water security also considers the ability of a household to withstand and recover from disruptions in water supply, such as during natural disasters or emergencies. The specific dimensions of household water security may vary depending on the context, region, and research focus. Assessing these dimensions helps policymakers, researchers, and organizations understand the challenges and strengths of household water security and develop strategies to improve access to safe and reliable water for all.

3.2.3. Factors of Household Willingness to Pay for Water Services

Factors influencing household willingness to pay for water services are diverse and multifaceted. While income, education, geography, and social and political factors are important, additional variables can also play a significant role in shaping households' willingness to pay for water services. Here's an expanded explanation of each factor and the inclusion of a few more relevant factors. The first is income; household income is a crucial determinant of willingness to pay. Higher-income households will be more willing to pay for better water services due to their greater financial capacity [32]. The second is education, which is awareness about clean water, particularly awareness and understanding of the importance of clean water and its impact on health, which can influence willingness to pay [3]. More educated households will be more willing to invest in clean water services.

The geographic location of a household can affect willingness to pay. Those living in urban areas with better infrastructure will be more willing to pay than those in remote or underserved rural areas [31]. Other than that, social and political factors can play a significant role. This includes trust in the government's ability to provide clean water, the presence of community organizations advocating for improved services, and cultural factors that influence communal decision-making [23]. Next, the perceived quality and reliability of water services are critical. Households will be more willing to pay if they believe the water provided is safe, consistent, and meets their needs. The size and composition of the household, including the number of family members, can impact willingness to pay. Larger households with more water needs may be more willing to invest in water services [5]. Furthermore, the age of the person responsible for the household also can influence willingness to pay. Older individuals may prioritize water quality and reliability due

to health concerns.

Awareness of water-related health risks can also impact willingness to pay. Households with a higher understanding of the link between water quality and health will be more willing to invest in better services. The availability of alternative water sources, such as wells or springs, can affect willingness to pay [2]. Households with limited access to alternatives will be more willing to pay for formal water services. Economic stability and job security can influence households' financial capacity and willingness to allocate funds to pay for water services. The perceived value of water services, including benefits like improved health, convenience, and time savings, can impact willingness to pay [33]. Cultural beliefs and practices related to water and hygiene can influence willingness to pay. Households will be inclined to pay based on cultural norms and values. Awareness of water scarcity issues, such as droughts or water shortages in the region, can affect willingness to invest in reliable water services.

It's essential to recognize that these factors can vary from one region or community to another. Effective policies and interventions to improve access to clean water services should consider the specific context and the interplay of these factors.

3.2.4. Type of Choice Set

Choice experiments are a powerful method used in social science research to understand individuals' preferences and choices regarding different product or service attributes. In household water security, the three types of choice sets: text, visual, and text with visual play crucial roles in eliciting and analyzing preferences.

Respondents are presented with descriptions or textual information about different attributes of household water security scenarios in text-based choice sets. These attributes may include water source reliability, water quality, accessibility, and cost. Respondents evaluate each scenario based on these attributes and express their preferences by choosing the option that aligns with them. Text-based choice sets are helpful when the attributes are more effectively conveyed through language, allowing respondents to consider and deliberate on each scenario carefully [16, 23, 25, 33, 34, 36].

Visual-based choice sets present respondents with graphical representations, charts, or images depicting different aspects of household water security scenarios. For example, a chart might show the reliability of various water sources over time, or images could represent water quality levels. Visual aids enhance respondent engagement and comprehension by providing a more intuitive and vivid representation of the attributes under consideration. Visual-based choice sets are particularly effective when the attributes are more easily grasped through images, and they can reduce cognitive burden by simplifying complex information [7, 31, 38].

Text with visual choice sets combines textual

descriptions and visual elements to comprehensively view household water security scenarios. This hybrid approach leverages the strengths of both methods, catering to different learning and decision-making styles. The textual component ensures detailed information, while the visual elements enhance clarity and facilitate quicker comprehension. This type of choice set is valuable when researchers seek a balance between providing detailed information and ensuring that respondents can quickly grasp and evaluate the scenarios presented [4, 22, 24, 25, 28, 32, 34].

In the context of household water security, these three choice sets provide researchers with the flexibility to tailor their experiments to the specific characteristics of the attributes being studied and the preferences of the target population. The choice between text, visual, or a combination of both depends on the research objectives, the complexity of the attributes, and the desired level of respondent engagement and understanding.

3.2.5. Model Use in Data Analysis

In household water security research employing choice experiments, various statistical models are utilized to analyze and interpret the data collected from respondents' choices. Each model has its strengths and applications, catering to different aspects of the decision-making process. The four key models commonly used in choice experiments are the Conditional Logit Model (CLM), Contingent Valuation Method (CVM), Mixed Logit Model (MLM), and Multinomial Logit Model.

The Conditional Logit Model is foundational and widely used in choice experiments. It assumes that the utility a respondent associates with a particular choice is a linear function of the attributes associated with that choice. CLM is particularly suitable when the choices are mutually exclusive, and respondents evaluate each alternative in isolation. This model is well-suited for scenarios where the independence of irrelevant alternatives assumption holds, meaning that the inclusion or exclusion of a third alternative does not affect the relative utilities of the remaining options [1, 23, 26, 31, 33].

The Contingent Valuation Method goes beyond mere choice analysis; it is primarily used for valuing non-market goods and services, such as environmental amenities or, in this case, household water security. CVM involves asking respondents to assign a monetary value to the attributes or changes in attributes presented in the choice experiment. While CVM provides a direct measure of an individual's willingness to pay for certain water security features, it requires careful consideration of hypothetical bias and other methodological challenges associated with monetary valuation [4, 28].

The Mixed Logit Model extends the CLM by allowing for the incorporation of random parameters, offering more flexibility in capturing heterogeneity in preferences among respondents. Unlike CLM, MLM recognizes that individuals may have varying tastes and that unobserved

factors can influence preferences. This model is valuable when there is a need to account for individual-specific heterogeneity, making it more realistic and accommodating a broader range of preference structures [5, 6, 27].

The Multinomial Logit Model is a generalization of the Conditional Logit Model and is suitable when choices involve selecting from more than two alternatives. It assumes that the errors are independent and identically distributed across choices. While it simplifies the estimation process, it may need to be more flexible in capturing certain complexities, such as the correlation of unobserved factors across alternatives. Nevertheless, the Multinomial Logit Model remains popular when the decision context involves selecting one option from a set of alternatives [2, 30].

In household water security, the appropriate model depends on the nature of the research questions, the structure of the choices being analyzed, and the desired level of detail in capturing respondent preferences. Researchers often consider the strengths and limitations of each model to ensure the robustness and validity of their findings in informing policies related to water resource management and household well-being.

3.2.6. Factors of Water Security

Household water security is a multifaceted concept influenced by various factors, broadly categorized into human and natural factors. Understanding these factors is crucial for developing effective strategies to ensure reliable, safe, and sustainable water access for households.

The integrity of water supply infrastructure is a critical human factor impacting household water security. Pipe bursts and leaks in the water distribution system can lead to water losses, reduce supply reliability, and challenge maintaining consistent water quality. Efficient management and timely maintenance of water supply infrastructure are essential to mitigate the risks associated with pipe bursts. Dependence on non-renewable water sources, such as underground aquifers, can contribute to long-term water security challenges. Over-extraction and depletion of these sources may lead to reduced water availability, affecting households that rely on them. Sustainable water management practices and promoting renewable sources are essential to enhance long-term household water security. The management practices of water suppliers play a crucial role in ensuring reliable and safe water access for households. Effective governance, transparent management practices, and proactive measures in response to challenges are essential for water supplier management. Collaboration between water utilities, regulatory bodies, and households is vital for fostering a resilient and secure water supply system [12, 22, 24, 25, 34, 36, 37, 38].

Climate change significantly affects water security, as shifts in precipitation patterns, heightened occurrences of extreme weather events, and increasing temperatures can influence the quantity and quality of available water

resources. To effectively address the challenges posed by climate change, it is imperative to adapt to these changes, implement efficient water usage practices, and establish resilient water supply systems. Moreover, it is crucial to recognize that flooding events can result in immediate and severe consequences for household water security. Contamination of water sources, damage to infrastructure, and disruptions in water supply can result from floods. Robust infrastructure design, early warning systems, and community preparedness are critical for minimizing the impact of floods on household water security [2, 30, 35, 37].

Understanding the interplay between human and natural factors is central to developing comprehensive strategies for household water security. A choice experiment within the context of this research can illuminate how households prioritize and make decisions regarding these factors, offering valuable insights for policymakers and water resource managers. By addressing both human and natural factors, holistic approaches can be formulated to enhance the resilience of household water security in the face of evolving challenges.

4. Discussion

This study proposes several recommendations for future scholars focusing on household water security. First and foremost, there is a need for more research on adaptation strategies related to water security among households. Household water security pertains to the access of households to a sufficient amount of safe drinking water to fulfill their fundamental requirements. It comprises a range of water-related factors that could jeopardize the well-being and survival of household members. The systematic literature review highlights the importance of conducting more studies on household water security among households. Future studies should specifically focus on the household water security practices and adaptation strategies these households employ.

Several reasons emphasize the significance of studies on household water security. Firstly, households in these areas demonstrate high sensitivity to changes in the natural environment, as alterations in water availability and quality can disrupt their livelihoods and socio-economic routines. Secondly, the region is highly vulnerable to impacts related to household water security, including issues such as water scarcity and contamination. Like the climate change context, previous studies in household water security lack clear explanations regarding the effectiveness of adaptation strategies in reducing vulnerability and enhancing resilience in small island households.

Drawing insights from the observed patterns in previous studies, this research aligns with the notion that existing studies need to provide a comprehensive understanding of the impacts of household water security adaptation strategies. Future scholars should address these gaps by investigating the positive and negative impacts of various

household water security adaptation approaches. For instance, an overreliance on technology-assisted solutions in water management may impose financial burdens on households. At the same time, excessive dependence on government support could result in passive responses to water security challenges. By incorporating both positive and negative aspects, future studies can offer a more nuanced and comprehensive understanding of household water security adaptation strategies, ultimately contributing to more effective and sustainable water resource management in rural areas households.

5. Conclusions

The study aims to systematically review water security analysis, with a specific focus on households, utilizing a choice modelling model. The research provides practical applications and significantly contributes to the existing knowledge base. The review offers valuable insights for stakeholders such as policymakers, the public, researchers, and environmentalists, enabling the derivation of short and long-term adaptation strategies for local households. The findings play a vital role in integrating local knowledge with scientific discoveries, thereby facilitating the development of water security policies. Furthermore, the study sheds light on the involvement of indigenous households in policy development. Additionally, the results serve as a guide for researchers, directing their attention to specific areas and content within water security studies that warrant further exploration in their research pursuits.

Acknowledgements

This research was supported by the Ministry of Higher Education (MOHE) through Fundamental Research Grant Scheme (FRGS/1/2022/SS06/UMT/02/8).

REFERENCES

- [1] Claudine Uwera, Individual status quo modelling for a rural water service in Rwanda: application of a choice experiment, *Environment and development economics*, vol. 21, no. 4, pp. 490-511, 2016. <https://doi.org/10.1017/S135770X15000364>
- [2] Buhari Abdulkarim, Mohd Rusli Yacob, Ahmad Makmom Abdullah, & Alias Radam, Households' preferences and willingness to pay for watershed services attributes in North Selangor peat swamp forest Malaysia, *Asian Journal of Economic Modelling*, vol. 5, no. 1, Pp 98-109 2017. <https://econpapers.repec.org/scripts/redirect.php?u=https%3A%2F%2Farchive.aessweb.com%2Findex.php%2F5009%2Farticle%2Fview%2F890%2F1342;h=repec:asi:ajemod:v:5:y:2017:i:1:p:98-109:id:890>
- [3] Imran Khan, & Minjuan Zhao, Water resource management and public preferences for water ecosystem services: A choice experiment approach for inland river basin management, *Science of The Total Environment*, vol. 646, pp. 821-831, 2019. <https://doi.org/10.1016/j.scitotenv.2018.07.339>
- [4] Pham Khanh Nam, & Tran Vo Hung Son, Household Demand for improved water services in Ho Chi Minh City: A comparison of contingent valuation and choice modeling estimates, *The International Development Research Centre*, vo. 1, 2005. <http://www.eepsea.org/pub/rr/11201072431NamRR3.pdf>
- [5] Mahirah Kamaludin, Azlina Abd. Aziz, Nur Syuhada Che Ibrahim, & Alias Radam, A survey on the willingness to pay for domestic water service attributes in Terengganu, Malaysia, *Journal of Sustainability Science and Management*, 133-144, 2018. <http://jssm.umt.edu.my/wp-content/uploads/sites/51/2018/07/bab-9.pdf>
- [6] Nur Syuhada Che Ibrahim, Mahirah Kamaludin, & Nur Fatihah Shaari, A discrete choice experiment in estimate public willingness to pay for attributes of water services in Terengganu, Malaysia, *Malaysia Economics Journal*, vol. 53, no. 1, pp. 213-226, 2019. <http://dx.doi.org/10.17576/JEM-2019-5302-16>.
- [7] Haddaway, N.R., Macura, B., Whaley, P., Reporting standards for Systematic Evidence Syntheses: pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps, *Environmental Evidence*, vol. 7, no. 7, 2018. <https://doi.org/10.1186/s13750-018-0121-7>.
- [8] Martin-Martin, A., Orduna-Malea, E., Thelwall, M., Delgado Lopez-Cozar, E., Google Scholar, Web of Science, and Scopus: a systematic comparison of citations in 252 subject categories, *Journal of informetrics*, vol. 12, no. 4, pp. 1160-1177, 2018. <https://doi.org/10.1016/j.joi.2018.09.002>
- [9] Gusenbauer, M., Haddaway, NR., Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources, *Research Synthesis Method*, vol. 11, no. 2, pp. 181-217, 2019. <https://doi.org/10.1002/jrsm.1378>.
- [10] Haddaway, N.R., Collins, A.M., Coughlin, D., Kirk, S., The role of Google scholar in evidence reviews and its applicability to grey literature searching, *PLoS One*, vol. 10, no. 9, 2015. <https://doi.org/10.1371/journal.pone.0138237>
- [11] Orduna-Malea, E., Ayllon, J.M., Martin-Martin, A., Delgado Lopez-Cozar, E., The lost academic home: institutional affiliation links in Google Scholar Citations, *Online Information Review*, vol. 41, no. 6, pp. 762-781, 2017. <https://doi.org/10.1108/OIR-10-2016-0302>
- [12] Hayrol Azril Mohamed Shaffril, Asnarulkhadi Abu Samah, Samsul Farid Samsuddin, & Zuraina Ali, "Mirror-mirror on the wall, what climate change adaptation strategies are practiced by the Asian's fisherman of all?" *Journal of Cleaner Production*, vol. 232, pp. 104-117, 2019. <https://doi.org/10.1016/j.jclepro.2019.05.262>
- [13] Loan, F., Sheikh, S., Is Google Scholar really scholarly? *Library Hi-Tech News*, vol. 35, no. 3, pp. 7-9, 2018. <https://doi.org/10.1108/LHTN-11-2017-0078>
- [14] Kitchenham, B.A., Charters, S.M., Kitchenham, B.A.,

- Charters, S.M., Guidelines for performing systematic literature reviews in software engineering, *Information and software technology*, vol. 51, no. 1, pp. 7-15, 2009. <https://doi.org/10.1016/j.infsof.2008.09.009>
- [15] Okoli, C., A guide to conducting a standalone systematic literature review, *Communications of the Association for Information Systems*, vol. 37, 2015. <https://hal.science/hal-01574600/>
- [16] Petticrew, M., & Roberts, H. *Systematic Reviews in the Social Sciences: A Practical Guide*. 2016 Oxford: Blackwell. <https://doi.org/10.1002/9780470754887>
- [17] Whitemore, R., Knafl, K., The integrative review: Updated methodology, *Journal of Advanced Nursing* Volume, vol. 52, no. 5, pp. 546-553, 2005. <https://doi.org/10.1111/j.1365-2648.2005.03621>
- [18] Braun, V., & Clarke, V., Using thematic analysis in psychology, *Qualitative Research in Psychology*, Vol. 3, No. 2, pp. 77-101, 2006. <https://doi.org/10.1191/1478088706qp0630a>
- [19] Flemming, K., Booth, A., Garside, R., Tunçalp, O., Noyes, J., Qualitative evidence synthesis for complex interventions and guideline development: clarification of the purpose, designs, and relevant methods, *BMJ Global Health*, vol. 4, no. 1, 2019. <https://doi.org/10.1136/bmjgh-2018-000882>
- [20] Vaismoradi, M., Turunen, H., Bondas, T., Content analysis and thematic analysis: implications for conducting a qualitative descriptive study, *Nursing & Health Sciences*, vol. 15, no. 3, pp. 398-405. <https://doi.org/10.1111/nhs.12048>
- [21] Gloria Amaris, Richard Dawson, Jorge Gironas, Stephane Hess, & Juan de Dios Ortúzar, From mathematical models to policy design: Predicting greywater reuse scheme effectiveness and water reclamation benefits based on individuals' preferences, vol. 74, 2021. <https://doi.org/10.1016/j.scs.2021.103132>
- [22] Roy Brouwer, Dilruba F. Sharmin, Susan Elliott, Jennifer Liu, & Mizan R. Khan, Costs and benefits of improving water and sanitation in slums and non-slum neighborhoods in Dhaka, a fast-growing mega-city, *Ecological economics*, vol. 207, 2023. <https://doi.org/10.1016/j.ecolecon.2023.107763>
- [23] Vitor Dias, & Ken Belcher, Value and provision of ecosystem services from prairie wetlands: A choice experiment approach, *Ecosystem Services*, vol. 15, pp. 35-44, 2015. <https://doi.org/10.1016/j.ecoser.2015.07.004>
- [24] Benedicte Rulleau, Household preferences for cyber-attack resilient water distribution networks: A latent class analysis of a discrete choice experiment in France, *Water resources and economics*, vol. 43, 2023. <https://doi.org/10.1016/j.wre.2023.100230>
- [25] Bethany Cooper, Lin Crase, & Michael Burton, Households' willingness to pay for water for the environment in an urban setting, *Journal of Environmental Management*, vol. 348, 2023. <https://doi.org/10.1016/j.jenvman.2023.119263>
- [26] Dionysis Latinopoulos, Using a choice experiment to estimate the social benefits from improved water supply services, *Journal of Integrative Environmental Sciences*, vol. 11, no. 3, pp. 187-204, 2014. <https://doi.org/10.1080/1943815X.2014.942746>
- [27] Sorada Tapsuwan, Stephen Cook, & Magnus Moglia, Willingness to Pay for Rainwater Tank Features: A Post-Drought Analysis of Sydney Water Users, *water*, vol. 10, no. 9, 2018. <https://doi.org/10.3390/w10091199>
- [28] P Kanyoka, S Farolfi, & S Morardet, Households' preferences and willingness to pay for multiple use water services in rural areas of South Africa: An analysis based on choice modelling, *water SA*, vol. 34, no. 6, 2008. <https://doi.org/10.4314/wsa.v34i6.183675>
- [29] William F. Vasquez, & Jessica Alicea-Planas, Unbundling household preferences for improved sanitation: A choice experiment from an urban settlement in Nicaragua, *Journal of Environmental Management*, vol. 218, pp. 477-485, 2018. <https://doi.org/10.1016/j.jenvman.2018.04.085>
- [30] Christian Klassert, Katja Sigel, Bernd Klauer, & Erik Gawel, Increasing block tariffs in an arid developing country: a discrete/continuous choice model of residential water demand in Jordan, *water*, vol. 10, no. 3, 2018. <https://doi.org/10.3390/w10030248>
- [31] Mohd Rusli Yacob, Suleiman Alhaji Dauda, Alias Radam, & Zaiton Samdin, Household's Willingness to Pay for Drinking Water Quality Service Improvement in Damaturu, Nigeria, *Current World Environment*, vol. 8, no. 3, pp. 381-389, 2013. <https://doi.org/10.12944/CWE.8.3.06>
- [32] Jill Windle, John Rolfe, & Roy Brouwer, Public values for improved water security for domestic and environmental use, *Research Agricultural & Applied Economics, Australasian Agricultural and Resource Economics Society (AARES) Conference (53rd)*, February 11-13, 2009, pp. 1-18. <https://doi.org/10.22004/ag.econ.47627>
- [33] Rob Hope, Is community water management the community's choice? Implications for water and development policy in Africa, *water policy*, vol. 17, no. 4, pp. 664-678, 2015. <https://doi.org/10.2166/wp.2014.170>
- [34] Ifedotun Victor Aina, Djiby Racine Thiam, & Ariel Dinar, Economics of household preferences for water-saving technologies in urban South Africa, *Journal of Environmental Management*, vol. 339, 2023. <https://doi.org/10.1016/j.jenvman.2023.117953>
- [35] Suleiman Alhaji Dauda, Mohd Rusli Yacob, & Alias Radam, Household's willingness to pay for heterogeneous attributes of drinking water quality and services improvement: an application of choice experiment, *Applied Water Science*, vol. 5, pp. 253-259, 2015. <https://doi.org/10.1007/s13201-014-0186-6>
- [36] Nur Syuhada, K. Mahirah, & M.A. Roseliza, Dealing with attributes in a discrete choice experiment on valuation of water services in East Peninsular Malaysia, *Utilities Policy*, vol. 64, 2020. <https://doi.org/10.1016/j.jup.2020.101037>
- [37] William F. Vasquez, Nejem Raheem, Diego Quiroga, & Valeria Ochoa-Herrera, Valuing improved water services and negative environmental externalities from seawater desalination technology: A choice experiment from the Galapagos, *Journal of Environmental Management*, vol. 304, 2022. <https://doi.org/10.1016/j.jenvman.2021.114204>

- [38] Chandramalar Munusami, Norzalina Zainudin, Santhi Govindan, & Hamidah Md Yusop, Discrete choice experiment: household willingness to pay for wastewater treatment improvements, *Malaysian Journal of Social Sciences and Humanities (MJSSH)*. Vol. 8, no. 3, 2023. <https://doi.org/10.47405/mjssh.v8i3.2205>