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Validation Model of Water Crisis Management Policy in Iran

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The present study is applied in nature and employs a quantitative, descriptive cross-sectional survey method for data collection. The statistical population comprises all experts and active managers associated with the water industry (national water resources management). According to the latest human resources statistics in national water resources management, the population includes 20,000 technical, engineering, and managerial personnel across the country. The sample size for this study was calculated using the Morgan table, resulting in a sample of 391 respondents. The research instrument consists of a 47-item questionnaire developed by Mahdavi Far et al. (2024). The reliability of the research instrument was assessed using Cronbach's alpha, yielding a value of 0.724. The findings from the study indicate that the highest path coefficient pertains to the relationship between strategies and outcomes, with a path coefficient of 0.947. The second highest is the relationship between causal conditions and the core category, with a path coefficient of 0.923. The relationship between contextual conditions and strategies follows, with a path coefficient of 0.879. The fourth highest path coefficient is between intervening conditions and strategies at 0.851, and finally, the core category and strategies have a path coefficient of 0.844. The results of the research demonstrate that causal conditions have a significant positive effect on the core phenomenon ($\beta = 0.923$, $t = 49.568$, $p < 0.0001$). Therefore, an increase in causal conditions leads to an increase in the core phenomenon. Additionally, contextual factors significantly and positively affect strategies ($\beta = 0.879$, $t = 47.632$, $p < 0.001$), suggesting that an increase in contextual factors leads to an enhancement in strategies. Intervening conditions also have a significant positive effect on strategies ($\beta = 0.851$, $t = 41.937$, $p < 0.001$), indicating that these conditions contribute to the reduction in strategies. Furthermore, the core phenomenon significantly and positively influences strategies ($\beta = 0.844$, $t = 45.177$, $p < 0.001$), suggesting that an increase in the core phenomenon enhances strategies. Finally, strategies significantly and positively affect outcomes or results ($\beta = 0.947$, $t = 53.941$, $p < 0.001$), indicating that an increase in strategies leads to improved outcomes or results.

Keywords: *model, crisis, policy-making, framework, water crisis.*

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1. Introduction

Water management in Iran is a matter of both technical and economic decision-making. The technical aspects, such as the relationship between water, soil, and plant, and the economic aspects, such as the cost-benefit analysis of water projects, are deeply intertwined. However, it is the economic considerations that often drive the decision-making process in water management (Al Yasin, 2007; Bagheri & et al., 2023; Damavandi et al., 2023; Riyahi Pour et al., 2020). As long as the benefits of a project outweigh its costs, particularly in social terms, the project is likely to be implemented. This approach, however, has led to significant challenges, particularly when the knowledge driving these decisions is based on imported models that may not be well-calibrated to local conditions. For instance, while irrigation models are calibrated to the specific conditions of soil and climate, no social models for water management have been adequately localized in Iran (Eslami & Rahimi, 2019).

The current water crisis in Iran is the result of a confluence of factors across different levels and domains. Understanding these factors is crucial for developing effective management strategies. The first level involves the most apparent causes, such as the excessive consumption of water resources over the past 70 years (Fattahi, 2018). This has been exacerbated by policies that have simplified the perception of the crisis, leading policymakers to believe that technological solutions alone could bridge the gap between water consumption and available resources. This reductionist approach has not only failed to mitigate the crisis but has also deepened it by increasing water consumption, thereby accelerating the country's trajectory towards water bankruptcy (Eslami & Rahimi, 2019).

Moving beyond the first level of causes requires examining deeper, systemic issues that have contributed to the water crisis. One such issue is the inability of Iranian society to manage the impacts of both internal and external disruptive factors, as well as to regulate the behaviors of individual and collective actors in a manner that ensures the sustainability of water resources (Eslami & Rahimi, 2019). This raises a critical question: why has Iran been unable to manage its water resources effectively despite the awareness of the impending crisis? Evidence suggests that this inability is not due to a lack of awareness. Historical documents, parliamentary debates, and expert reports from the past several decades indicate that there has been a relatively consistent awareness of the water crisis in Iran. Yet, this awareness has not translated into effective action, partly due to a disconnect between policy knowledge and implementation (Saeedi & Sadeghi Deh Cheshmeh, 2023).

At a deeper level, the current crisis has been exacerbated by several key factors, including the overemphasis on dam construction, the neglect of agricultural efficiency, inappropriate water pricing mechanisms across different sectors, and the lack of attention to local conditions and complexities (Saeedi & Sadeghi Deh Cheshmeh, 2023). The Iranian governance system has often issued broad, one-size-fits-all directives for water management across the country, ignoring the significant social, economic, and environmental differences between regions. Such an approach can have stabilizing effects in some areas while leading to destabilization in others. Furthermore, the focus on food security, without considering agricultural efficiency and regional capabilities, has compounded the crisis. Other contributing factors include the normalization of illegal groundwater extraction due to weak legal and judicial systems, and the prioritization of resource augmentation over the optimal use of existing resources, which has led to continued water shortages despite increases in water availability in some regions (Eslami & Rahimi, 2019).

The fourth level of analysis delves into the structural weaknesses in the selection mechanisms for key actors in water governance, such as senior government officials and parliamentarians. The efficiency of a governance system is closely linked to its ability to select capable key actors. However, both before and after the Islamic Revolution, the mechanisms for selecting these actors in Iran have not been highly effective, leading to the appointment of less competent individuals in key positions. This has resulted in poor decision-making that has significantly impacted the country's water resources over the past few decades (Eslami & Rahimi, 2019).

Given the complexity of the water crisis in Iran, a coordinated policy response is required to address the issues of water supply, distribution, and consumption. The High Water Council, a powerful body established in 2000, plays a central role in coordinating national water policies to ensure good governance and sustainable

development by 2026. The council, which includes key ministers and experts, is responsible for monitoring water policies, coordinating these policies, and ensuring their effective implementation. The council's ultimate goal is to facilitate institutional collaboration and align policies to achieve an ideal state of water supply, distribution, and consumption (Eslami & Rahimi, 2019).

Numerous studies have been conducted on water-related policy-making, highlighting various aspects of the crisis and suggesting potential solutions. For example, a study by Bagheri et al. (2023) identified and ranked the factors contributing to the water crisis in Isfahan province, using the Analytic Hierarchy Process (AHP) to categorize these factors into political, human, agricultural, industrial-service, and climatic dimensions (Bagheri & et al., 2023). Similarly, Saeeidi and Sadeghi (2023) analyzed the security implications of the water crisis in Chaharmahal and Bakhtiari province, proposing scenarios for future governance based on ideal conditions for addressing these security challenges (Saeedi & Sadeghi Deh Cheshmeh, 2023).

Moreover, international perspectives provide valuable insights into water crisis management. For instance, Ray Biswas et al. (2023) evaluated the effectiveness of water demand management during a water crisis in an Australian border city (Ray Biswas et al., 2023), while Khan and Charles (2023) analyzed policy processes following major water contamination events, emphasizing the need for new approaches to policy-making in response to emerging health threats from water pollution (Khan & Charles, 2023).

In light of these challenges and the extensive body of research on water crisis management, this study aims to develop a validation model for water crisis management policy in Iran. The model seeks to integrate the diverse factors contributing to the crisis, from technical and economic considerations to social and governance issues. By doing so, it aims to provide a comprehensive framework for policymakers to address the water crisis effectively, ensuring the sustainable management of water resources in Iran.

2. Methods and Materials

2.1. Study Design

This study adopts a quantitative descriptive cross-sectional survey design, chosen for its effectiveness in capturing and describing the characteristics of a large population at a specific point in time. The research is both applied in its objectives and descriptive in its approach, aiming to uncover the nature of the current conditions, explore the relationships between various variables, and provide a detailed description of the status of water crisis management in Iran. The cross-sectional design is particularly suited to this study as it allows for data collection from a broad sample of experts and managers involved in water resources management across the country, offering a comprehensive snapshot of the prevailing practices and perspectives within this critical sector.

2.2. Population and Sample

The target population for this study includes all experts and active managers associated with the water industry in Iran, particularly those involved in the national water resources management sector. According to the latest statistics, this population comprises approximately 20,000 individuals, encompassing technical, engineering, and managerial personnel distributed across various regions of the country. To determine an appropriate sample size, the Morgan sample size determination table was utilized, resulting in a sample size of 391 participants. This sample size was deemed sufficient to ensure the reliability and validity of the study's findings. A stratified random sampling method was employed to select the sample, ensuring that it was representative of the various sectors and regions involved in water management in Iran.

2.3. Data Collection Instrument

Data for this study were collected using a researcher-developed questionnaire designed to capture the key dimensions of water crisis management policy in Iran. The questionnaire was developed (Mahdavi Far et al., 2024) following a comprehensive review of relevant literature and consultations with field experts. It comprises 47 items, each addressing different aspects of water crisis management, including causal conditions, contextual factors, intervening conditions, strategies, and outcomes. The questionnaire was structured into several sections, each focusing on a different dimension of the water crisis management model. The items were formulated to be clear and concise, utilizing a Likert scale

format ranging from 1 (strongly disagree) to 5 (strongly agree) to measure respondents' perceptions and attitudes towards each dimension. This approach allowed for the quantification of qualitative data, facilitating a more robust analysis.

2.4. Validity and Reliability

To ensure the validity of the questionnaire, both content and construct validity were evaluated. Content validity was established through expert consultations, ensuring that the questionnaire comprehensively covered all relevant aspects of the water crisis management model. Construct validity was assessed through factor analysis, which confirmed that the items in the questionnaire effectively measured the intended constructs. The reliability of the questionnaire was tested using Cronbach's alpha, a widely accepted measure of internal consistency. The overall Cronbach's alpha for the questionnaire was calculated to be 0.724, indicating a satisfactory level of reliability. Additionally, Cronbach's alpha was calculated for each of the subscales within the questionnaire, confirming the reliability of each dimension of the model. Specifically, the reliability coefficients were 0.788 for causal conditions, 0.805 for contextual factors, 0.796 for intervening conditions, 0.796 for strategies, and 0.788 for outcomes. These results suggest that the questionnaire is a reliable tool for measuring the critical dimensions of water crisis management in Iran.

2.5. Data Collection Procedure

The data collection process spanned several weeks. The questionnaire was distributed to the selected sample of experts and managers through both email and in-person visits, depending on the accessibility of the participants. Prior to distributing the questionnaire, participants were informed about the purpose of the study and their consent was obtained. They were assured that their participation was voluntary and that they could withdraw at any time without any consequences. Confidentiality and anonymity were emphasized to encourage honest and accurate responses. To maximize the response rate, follow-up reminders were sent to participants who had not responded within two weeks of receiving the questionnaire. The data collection process was closely monitored to ensure that the required sample size was achieved.

2.6. Data Analysis

The collected data were analyzed using structural equation modeling (SEM), which is appropriate for testing complex models involving multiple variables and their interrelationships. SEM was utilized to assess the relationships between the different dimensions of the water crisis management model, including causal conditions, contextual factors, intervening conditions, strategies, and outcomes. The analysis was conducted in two main stages. First, the measurement model was tested to confirm the validity and reliability of the constructs. This involved assessing the factor loadings of the items as well as the fit indices of the model. In the second stage, the structural model was tested to evaluate the hypothesized relationships between the constructs. Fit indices such as the Chi-square (χ^2) test, Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA) were used to assess the model fit. A model was considered to have a good fit if the CFI was greater than 0.90 and the RMSEA was less than 0.08.

3. Findings and Results

The findings of this study provide significant insights into the critical dimensions of water crisis management policy in Iran. The analysis focused on five primary constructs: causal conditions, contextual factors, intervening conditions, strategies, and outcomes. The relationships between these constructs were evaluated using structural equation modeling (SEM), with particular attention to the strength and significance of the path coefficients.

Table 1 presents the statistical results of all components categorized by dimensions, including path coefficients, t-values, and significance levels for each component.

Table 1

Summary of Path Coefficients (Factor Loadings) for Each Dimension

Dimension	Component	Path Coefficient (β)	t-value	Significance (p-value)
Causal Conditions	Clear Mission and Vision	0.889	11.59	< 0.001
	Organizational Structure	0.814	10.23	< 0.001
	Water Policy Laws and Regulations	0.793	9.718	< 0.001
Core Phenomenon	Creation of Need	0.649	7.08	< 0.001
	Participation Engagement	0.719	8.19	< 0.001
	Policy Development	0.687	7.54	< 0.001
Contextual Factors	Enhancement of Water Consumption Culture	0.856	11.59	< 0.001
	Establishment of Water Management Policy Thinking	0.908	12.43	< 0.001
Intervening Conditions	Financial Resources Provision	0.769	8.54	< 0.001
	Development of Technological Infrastructure	0.822	9.17	< 0.001
Strategies	National Water Policy Leadership	0.889	10.05	< 0.001
	Meritocracy	0.773	7.324	< 0.001
	Stakeholder Capacity Building	0.796	8.937	< 0.001
Outcomes	Quality Enhancement of Water Crisis Management	0.759	9.171	< 0.001
	Professional Development Activities	0.711	8.355	< 0.001
	Establishment of Continuous Monitoring System	0.817	9.549	< 0.001

The analysis revealed that within the dimension of causal conditions, the component "Clear Mission and Vision" had a path coefficient of 0.889 with a t-value of 11.59, and "Organizational Structure" had a path coefficient of 0.814 with a t-value of 10.23, both statistically significant with p-values less than 0.001. The "Water Policy Laws and Regulations" component had a path coefficient of 0.793 and a t-value of 9.718, also significant at $p < 0.001$.

Within the core phenomenon, the "Creation of Need" component showed a path coefficient of 0.649 with a t-value of 7.08, while "Participation Engagement" exhibited a path coefficient of 0.719 with a t-value of 8.19, both highly significant ($p < 0.001$). The "Policy Development" component had a path coefficient of 0.687 and a t-value of 7.54, also significant at $p < 0.001$.

For contextual factors, the component "Enhancement of Water Consumption Culture" showed a strong path coefficient of 0.856 with a t-value of 11.59, while "Establishment of Water Management Policy Thinking" exhibited an even higher path coefficient of 0.908 with a t-value of 12.43, both highly significant ($p < 0.001$).

Within the dimension of intervening conditions, "Financial Resources Provision" had a path coefficient of 0.769 with a t-value of 8.54, and "Development of Technological Infrastructure" had a path coefficient of 0.822 with a t-value of 9.17, both significant at $p < 0.001$.

The strategies dimension highlighted the importance of "National Water Policy Leadership," with a path coefficient of 0.889 and a t-value of 10.05. "Meritocracy" and "Stakeholder Capacity Building" had path coefficients of 0.773 and 0.796, with t-values of 7.324 and 8.937, respectively, all of which were statistically significant at $p < 0.001$.

Lastly, in the outcomes dimension, the "Quality Enhancement of Water Crisis Management" component had a path coefficient of 0.759 and a t-value of 9.171, while "Professional Development Activities" and "Establishment of Continuous Monitoring System" had path coefficients of 0.711 and 0.817, with t-values of 8.355 and 9.549, respectively, all significant at $p < 0.001$.

Following the detailed breakdown of components, Table 2 summarizes the key relationships between the major dimensions in the model.

Table 2

Path Analysis Results

Relationship	Path Coefficient (β)	t-value	Significance (p-value)
Causal Conditions → Core Phenomenon	0.923	49.568	< 0.001
Contextual Factors → Strategies	0.879	47.632	< 0.001
Intervening Conditions → Strategies	0.851	41.937	< 0.001
Core Phenomenon → Strategies	0.844	45.177	< 0.001
Strategies → Outcomes	0.947	53.941	< 0.001

The relationship between strategies and outcomes was the strongest, with a path coefficient of 0.947, indicating that the effectiveness of strategies directly influences the outcomes of water crisis management efforts. The second most substantial relationship was found between causal conditions and the core category, with a path coefficient of 0.923, suggesting that foundational factors driving the water crisis significantly impact the overall phenomenon of water crisis management in Iran. The relationship between contextual factors and strategies was also strong, with a path coefficient of 0.879, underscoring the importance of the environment in shaping strategic responses to the crisis. Additionally, the relationship between intervening conditions and strategies had a path coefficient of 0.851, indicating that these factors play a crucial role in either facilitating or hindering the implementation of effective strategies. Lastly, the core phenomenon's impact on strategies was confirmed with a path coefficient of 0.844, suggesting that as the core issues related to the water crisis intensify, the strategies must be adjusted accordingly to address these challenges.

The hypothesis testing results further support the findings from the path analysis. Causal conditions were found to have a significant positive effect on the core phenomenon, with a path coefficient of 0.923 ($t = 49.568$, $p < 0.001$). This confirms that an increase in the underlying factors contributing to the water crisis leads to a corresponding increase in the severity of the core phenomenon. Similarly, contextual factors were shown to have a positive and significant impact on strategies, with a path coefficient of 0.879 ($t = 47.632$, $p < 0.001$). This implies that improvements in the surrounding conditions, such as infrastructure and governance, can enhance the effectiveness of the strategies employed in water crisis management.

The analysis also demonstrated that intervening conditions, while generally positive, had a nuanced effect on strategies ($\beta = 0.851$, $t = 41.937$, $p < 0.001$). These conditions can either support or undermine strategic efforts depending on how they are managed. The core phenomenon's direct influence on strategies was also confirmed ($\beta = 0.844$, $t = 45.177$, $p < 0.001$), further underscoring the need for strategies to be closely aligned with the central issues of the crisis. Finally, the most significant finding was the positive effect of strategies on outcomes ($\beta = 0.947$, $t = 53.941$, $p < 0.001$). This demonstrates that well-formulated and effectively implemented strategies are essential for achieving successful outcomes in water crisis management.

Table 3 presents the reliability and validity of the constructs, with Cronbach's alpha, Composite Reliability (CR), and Average Variance Extracted (AVE) values provided for each dimension.

Table 3

Validity and Reliability Results

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Causal Conditions	0.788	0.844	0.549
Contextual Factors	0.805	0.877	0.598
Intervening Conditions	0.796	0.849	0.631
Strategies	0.796	0.836	0.706
Outcomes	0.788	0.799	0.592

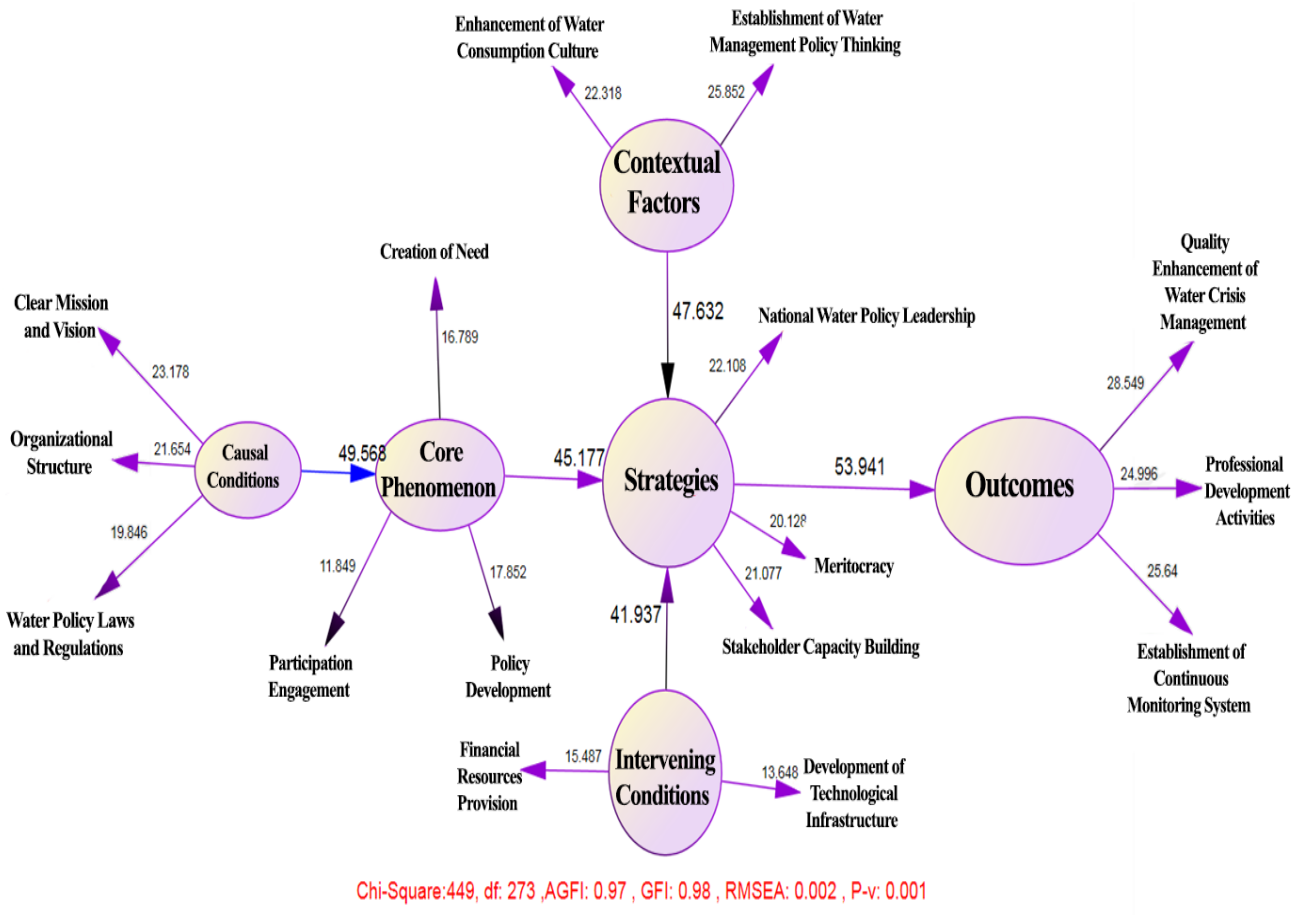
The constructs demonstrated good internal consistency and reliability, with Cronbach's alpha values exceeding 0.7 and CR values also above 0.7, confirming the reliability of the constructs. The AVE values were above 0.5, indicating good convergent validity. Specifically, the results for causal conditions were 0.844 (CR) and 0.549 (AVE), for contextual factors 0.877 (CR) and 0.598 (AVE), for intervening conditions 0.849 (CR) and 0.631 (AVE), for strategies 0.836 (CR) and 0.706 (AVE), and for outcomes 0.799 (CR) and 0.592 (AVE).

The overall model fit was evaluated using several indices, including the Chi-square (χ^2) test, Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Goodness of Fit (GOF). The model exhibited a good fit, with a Chi-square of 325.48, a CFI of 0.93, an RMSEA of 0.056, and a GOF of 0.781. These indices confirm that the proposed model accurately represents the relationships among the constructs and provides a reliable framework for understanding water crisis management in Iran.

In summary, the results of this study highlight the complex interplay between various factors in managing water crises. Causal conditions and contextual factors significantly influence the strategies developed to address the crisis, and these strategies, in turn, have a direct and profound impact on the outcomes. The findings emphasize the importance of a holistic approach to water crisis management, where both the foundational causes and the surrounding environment are considered in the formulation of effective strategies. The study's model provides a robust framework for policymakers and practitioners to enhance water crisis management efforts in Iran, ultimately leading to more sustainable and effective outcomes.

Figure 1

Model with T-Values



4. Discussion and Conclusion

The findings of this study offer critical insights into the complexities of water crisis management in Iran, highlighting the significant interrelationships between causal conditions, contextual factors, intervening conditions, strategies, and outcomes. These relationships underscore the multifaceted nature of the water crisis in Iran, where technical, environmental, and socio-political factors are deeply intertwined. The strong impact of causal conditions on the core phenomenon of the water crisis (β = 0.923) indicates that fundamental issues, such as unsustainable water usage practices and inadequate policy frameworks, are key drivers of the crisis. This aligns with previous research emphasizing the importance of addressing root causes in environmental management (Eslami & Rahimi, 2019; Fattahi, 2018).

The substantial influence of contextual factors on strategies (β = 0.879) further highlights the importance of the broader environmental, infrastructural, and governance contexts in shaping effective water management strategies. This finding suggests that improving the surrounding conditions—such as enhancing infrastructure, governance practices, and public awareness—can significantly bolster the effectiveness of crisis management strategies. This is consistent with the literature, which suggests that robust environmental and governance frameworks are essential for sustainable water management (Bagheri & et al., 2023; Saeedi & Sadeghi Deh Cheshmeh, 2023).

Intervening conditions, while generally positive, presented a nuanced effect on strategies (β = 0.851), indicating that these factors can both support and complicate the implementation of effective strategies. This complexity reflects the challenges inherent in managing a crisis where multiple, often conflicting, variables must be balanced. For instance, while financial resources and technological infrastructure are crucial for implementing strategies, they may also introduce challenges related to resource allocation and technological integration. This finding suggests that policymakers must carefully manage these intervening factors to optimize their impact on crisis management strategies.

The direct influence of the core phenomenon on strategies (β = 0.844) underscores the need for strategies to be closely aligned with the central issues of the water crisis. This alignment is critical for ensuring that strategies are both relevant and effective in addressing the most pressing aspects of the crisis. The strong relationship between strategies and outcomes (β = 0.947) reinforces the idea that well-formulated and effectively implemented strategies are essential for achieving successful outcomes in water crisis management. This finding echoes the broader consensus in the literature that strategic planning and implementation are crucial for effective environmental management (Khan & Charles, 2023; Ray Biswas et al., 2023).

The model's overall good fit, as indicated by the Chi-square, CFI, RMSEA, and GOF indices, confirms that the proposed framework is a robust tool for understanding and managing the water crisis in Iran. The reliability and validity results further support the robustness of the model, suggesting that the constructs used in this study accurately represent the key dimensions of water crisis management.

One of the most significant implications of these findings is the need for a holistic and integrated approach to water crisis management in Iran. This approach must address the root causes of the crisis while simultaneously improving the broader environmental and governance contexts. Moreover, the complexity of the intervening conditions requires careful management to ensure that resources and technologies are effectively utilized. The strong link between strategies and outcomes also highlights the importance of strategic planning and execution in achieving successful crisis management outcomes.

This study provides a comprehensive analysis of the key factors influencing water crisis management in Iran, offering a detailed understanding of how causal conditions, contextual factors, intervening conditions, strategies, and outcomes interact to shape the effectiveness of crisis management efforts. The findings emphasize the importance of addressing the root causes of the crisis, improving the broader environmental and governance contexts, and carefully managing intervening factors to optimize the implementation of strategies.

The proposed model offers a robust framework for policymakers and practitioners to enhance their efforts in managing the water crisis in Iran. By focusing on the

interrelationships between the various dimensions of the crisis, the model provides a holistic approach that can guide the development and implementation of more effective water management strategies.

In practical terms, the study suggests that policymakers should prioritize addressing the underlying causes of the water crisis, such as unsustainable water usage and inadequate policies, while also enhancing the broader contextual factors that support effective crisis management. Additionally, careful attention should be given to managing the complexities introduced by intervening conditions, such as financial resources and technological infrastructure, to ensure that these factors contribute positively to crisis management efforts.

The strong link between strategies and outcomes further underscores the need for well-planned and executed strategies that are closely aligned with the central issues of the water crisis. Such strategies are essential for achieving successful outcomes and ensuring the long-term sustainability of water resources in Iran.

Future research could build on this study by exploring the specific mechanisms through which contextual and intervening factors influence water crisis management strategies, as well as by examining the applicability of the proposed model in other regions facing similar water management challenges. By expanding the scope of research in this area, scholars and practitioners can continue to improve their understanding of how to effectively manage water crises in increasingly complex and resource-constrained environments.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

Not applicable.

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