Developing a Policy Support System Model for Enhancing Rationality in Water Resource Management Using Structural Equation Modeling

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Abstract

The policy support system for enhancing rationality in water resource management is an analytical and decision-support tool that, using comprehensive physical, social, economic, and environmental data, assists managers and policymakers in making effective decisions based on facts and accurate information. The primary objective of this research is to design a policy support system to promote rationality in water resource management. A quantitative approach utilizing Structural Equation Modeling (SEM) was employed to design this system, with AMOS software used for analysis. Data collection was carried out using a questionnaire, whose validity was confirmed through construct validity and reliability measured by Cronbach's alpha coefficient at 0.87. The statistical population of this research consisted of managers and experts in the field of water management in Iran. The sample size was determined to be 256 individuals using the Morgan table. The quantitative data analysis led to the identification of 19 key components structured within the proposed model. These components include data collection and analysis, the use of geographic information systems, modeling and simulation, stakeholder analysis, decision support systems (DSS), legal and policy frameworks, performance evaluation and monitoring, training and capacity building, ensuring public participation and transparency, technology transfer and utilization, attention to climate change, inter-organizational alignment, continuous risk assessment and management, and integration with sustainable development, which can be employed in implementing the policy support system for enhancing rationality in water management.

Keywords: *Policy Support System, Rationality Enhancement, Water Management.*

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1. Introduction

Decision Support Systems (DSS) are recognized as powerful tools in business environments and various organizations for improving the quality of decision-making [1]. These systems integrate information technology and analytical methods to assist managers and decision-makers by providing accurate data, advanced analyses, and various simulations. DSS facilitates real-time data and information analysis, enabling the evaluation of different options and the selection of the most suitable solution [2].

The applications of DSS have expanded into various fields, including finance, healthcare, human resource management, and supply chain management. These systems can process complex and large datasets and utilize sophisticated analytical algorithms to clarify and reduce decision-making complexities [3]. For instance, in healthcare, DSS can assist physicians in selecting the best treatments by analyzing patient data and monitoring their health. In business, DSS can aid in market trend analysis, consumer behavior prediction, and strategic planning to improve organizational performance. Additionally, DSS reduces errors and increases efficiency within organizations. With the growing volume of data and the complexity of decision-making, the need for DSS is increasingly felt, as these systems facilitate complex processes and provide precise analyses, allowing decision-makers to make more informed decisions. Ultimately, with the rapid advancement of information technologies and the need for quick and effective decision-making, DSS plays a crucial role in optimizing and improving organizational processes [4-7].

Among these systems, the Policy Support System (PSS) serves as a tool to assist decision-makers and policymakers in formulating, evaluating, and implementing policies and strategies [8]. These systems use complex analytical models and simulations to examine and analyze the conditions and potential outcomes of different policies. PSS enables policymakers to more accurately evaluate the potential impacts of each decision and policy across various sectors, such as the economy, environment, and society, and to select the best options based on comprehensive information and data [9]. These systems provide efficient tools for modeling and analyzing multi-dimensional data, especially in areas like urban development, environmental protection, public health, and economic policy. For example, in environmental policies, a PSS can simulate the effects of pollution reduction policies, illuminating the long-term results for decision-makers [10]. In urban and regional planning, these systems assist managers and planners by offering analytical tools such as GIS maps and population forecasts, helping them make decisions that align with the future needs of society. One of the prominent features of PSS is its ability to present alternative scenarios and analyze their outcomes. This capability helps decision-makers consider not only the direct effects of a policy but also its indirect and secondary consequences. With the increasing complexity of information and the rapid pace of social and economic changes, PSS is crucial for effective and responsible decision-making and can increase transparency and trust in policy-making processes [11].

Developing a Policy Support System model for enhancing rationality in water resource management helps policymakers and managers make well-informed decisions when facing complex and multi-dimensional water challenges. Water resources are vital yet limited natural assets, and their management has become increasingly sensitive and complex due to rising demand and climate change [12]. A PSS can assist managers by modeling and simulating water resource conditions and the effects of different policies, allowing them to evaluate the impacts of their decisions before implementation and adopt the best strategies considering existing constraints [12].

These models assist in comprehensive and precise assessments of water-related issues by analyzing historical data, climate forecasts, and the future needs of various sectors, such as agriculture, industry, and urban consumption. Using simulation and scenario analysis techniques, a PSS can examine the potential consequences of each policy at local and regional levels and provide alternative solutions [13]. For instance, these systems can demonstrate to policymakers which policies will preserve groundwater resources or which measures will be most effective in reducing water consumption in agriculture. Consequently, water resource managers can make evidence-based, long-term decisions. By utilizing a PSS in water resource management, rationality and efficiency in decision-making can be improved. This approach not only reduces the risks of incorrect decisions but also enhances transparency and accountability in policy-making. Given the need for coordination among different sectors and the involvement of multiple stakeholders in water-related issues, PSS provides a platform for interaction and collaboration among various institutions, promoting an integrated and rational approach to water resource management. This study aims to present a PSS model to enhance rationality in water resource management using Structural Equation Modeling. Initially, the model's fit will be examined using structural modeling methods.

1. Methodology

This study examines the role of a Policy Support System in water resource management with a special emphasis on critical areas and the impacts of climate change. In recent years, climate change and the water scarcity crisis have highlighted the necessity of improving and developing analytical tools for sustainable water resource management. To achieve this goal, a quantitative research method using Structural Equation Modeling (SEM) was selected as the primary tool, enabling the analysis of complex relationships among the various research variables. Through this approach, the capability of the Policy Support System to coordinate and support decision-making by managers and policymakers regarding the allocation and utilization of water resources, especially in critical areas, was evaluated. The main objective of this study is to design a model for the Policy Support System that, by providing accurate and comprehensive information, enhances rationality and efficiency in water resource management decision-making.

Data collection was conducted using a questionnaire developed based on a comprehensive literature review and theoretical studies. This instrument consists of a series of questions addressing the indicators and various dimensions of the Policy Support System, gathering information on the implementation of policies, their impacts, and the degree of rationality in water resource management from the perspective of managers and experts in the water sector of Tehran Province. The statistical population of this research includes all managers and experts active in the water management sector of Tehran Province, totaling 850 individuals. Using the Morgan table, an appropriate sample size of 256 respondents was determined and randomly selected to represent the overall population.

The validity of the questionnaire was assessed to confirm the precision of the measurement tool through construct validity, demonstrating that the questions align with the research objectives. Additionally, the reliability of the instrument was calculated using Cronbach's alpha coefficient, which yielded a value of 0.87, indicating the consistency and stability of the responses over time and supporting the high reliability of the questionnaire in collecting valid data.

Using Structural Equation Modeling, the relationships and impacts of different variables within the Policy Support System on water resource management were examined and analyzed. The results of this research are expected to identify the strengths and weaknesses in the policy-making process for water resource management, providing a proposed model that offers a framework for enhancing rationality in this area. Ultimately, with the use of this system, decision-makers can adopt optimal policies and strategies for managing water resources in the face of environmental and climate changes, which will not only contribute to resource conservation but also ensure sustainability and responsiveness to future needs.

To address the research questions, Structural Equation Modeling was employed, conducted using AMOS software.

2. Findings

According to the data, the highest mean is related to the indicator of the legal and policy framework, while the lowest mean is observed in the modeling and simulation section. In terms of skewness and kurtosis, all the indicators examined are assessed to be at a normal level (Table 1).

Table 1. Description of Research Variables

Variable Name	Mean	Standard Deviation	Variance	Kurtosis	Skewness
Data Collection and Analysis	3.8	1.435	0.723	-0.12	0.05
Use of Geographic Information Systems	4.0	1.589	0.785	-0.18	-0.03
Modeling and Simulation	3.6	1.320	0.682	-0.10	0.04
Stakeholder Analysis	3.9	1.280	0.582	-0.08	0.02
Decision Support Tools (DSS)	3.7	1.450	0.752	-0.15	0.01

Legal and Policy Frameworks	4.1	1.380	0.612	-0.20	-0.04
Performance Evaluation and Monitoring	3.5	1.470	0.720	-0.17	0.03
Training and Capacity Building	3.4	1.300	0.590	-0.11	0.06
Ensuring Public Participation and Transparency	3.8	1.400	0.700	-0.14	-0.02
Technology Transfer and Innovation	3.9	1.510	0.761	-0.19	0.00
Attention to Climate Change	3.7	1.320	0.582	-0.13	0.02
Inter-organizational Alignment	4.0	1.480	0.700	-0.12	-0.01
Continuous Risk Assessment and Management	3.6	1.350	0.640	-0.16	0.04
Integration with Sustainable Development	3.8	1.360	0.700	-0.11	0.01

The normality of the research indicators was analyzed using the Kolmogorov-Smirnov (K-S) test in SPSS software. The results are presented in Table 2.

Table 2. Normality Analysis of Research Indicators

Indicator Name	Test Statistic	Significance Level	Normal/Non-Normal
Data Collection and Analysis	0.192	0.11	Normal
Use of Geographic Information Systems	0.205	0.15	Normal
Modeling and Simulation	0.187	0.09	Normal
Stakeholder Analysis	0.223	0.12	Normal
Decision Support Tools (DSS)	0.195	0.18	Normal
Legal and Policy Frameworks	0.201	0.07	Normal
Performance Evaluation and Monitoring	0.250	0.22	Normal
Training and Capacity Building	0.212	0.10	Normal
Ensuring Public Participation and Transparency	0.199	0.14	Normal
Technology Transfer and Innovation	0.204	0.20	Normal
Attention to Climate Change	0.185	0.25	Normal
Inter-organizational Alignment	0.235	0.35	Normal
Continuous Risk Assessment and Management	0.221	0.16	Normal
Integration with Sustainable Development	0.208	0.30	Normal

As shown in Table 2, since the significance levels of the variables are greater than 0.05 and the test statistics are less than 1.96, it can be concluded that all research variables are normally distributed.

The overall measurement model of the components of the rational Policy Support System in water management is shown in Figure 1.

In Figure 1 and Table 3, it is observed that the factor loadings associated with all categories are greater than 0.50, and the p-values for all categories are less than 0.05. Therefore, it is concluded that all categories related to the model design and the obtained results have a significant and meaningful impact on their measurement. Additionally, the figure shows that to improve the goodness-of-fit indices, the model has been modified, and correlations have been included between some categories. The goodness-of-fit indices reported in the figure include a chi-square to degrees of freedom ratio of 2.52 and an RMSEA of 0.065, both of which are below 5 and 0.10, respectively. The CFI, GFI, and TLI values are 0.99, 0.99, and 0.97, respectively, all exceeding 0.90, and the AGFI value of 0.92 is greater than 0.80 and within the acceptable range. Therefore, the model demonstrates good fit with the data collected from the research sample, and all the goodness-of-fit indices are within the acceptable range. The final measurement model and the results derived from it are accepted.

Table 3. Overall Measurement Model

RMSEA	TLI	CFI	AGFI	GFI	chi-square/df
0.065	0.974	0.987	0.925	0.990	2.52

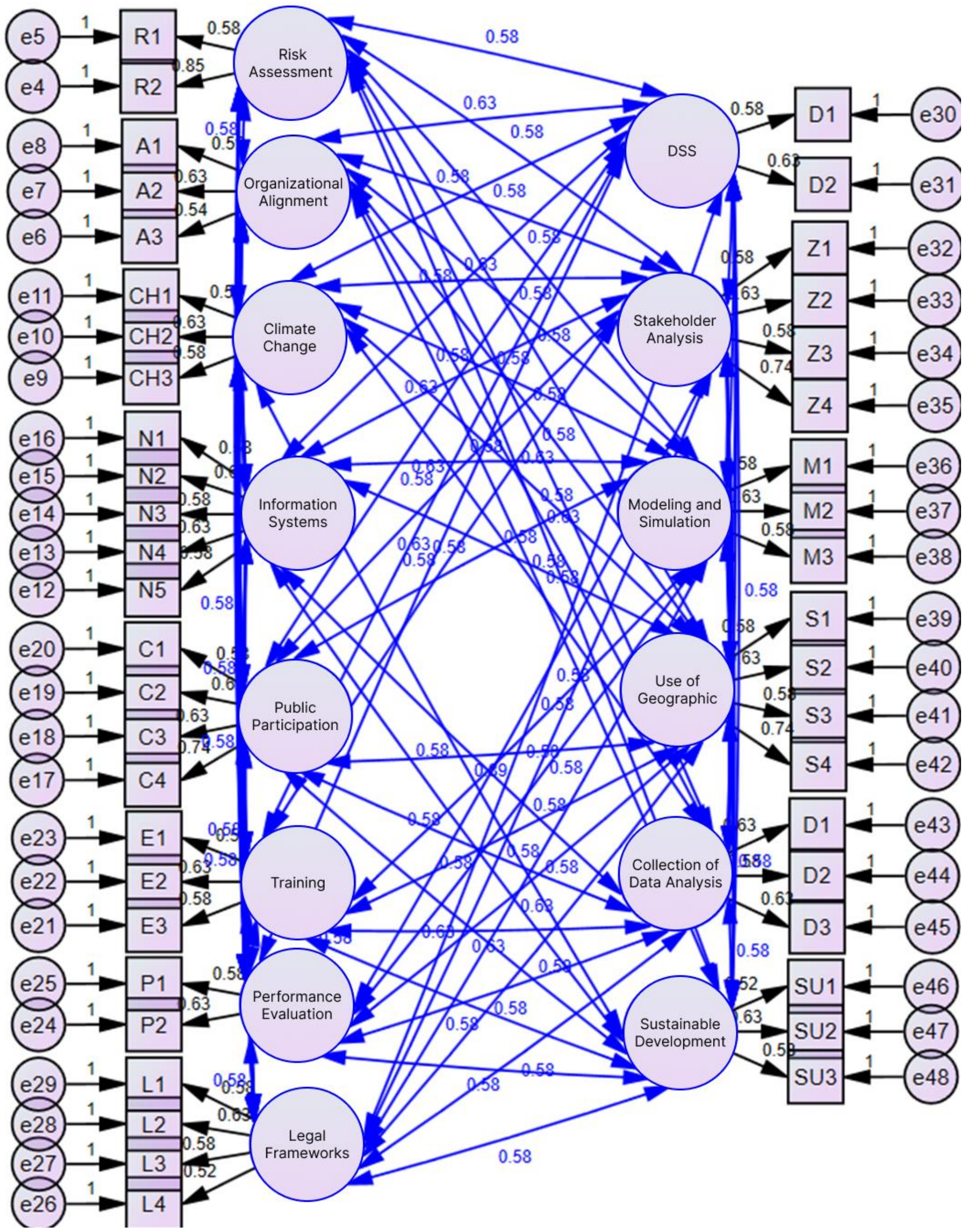

Figure 1. Overall Measurement Model

Consequently, the model fit is confirmed. Finally, based on the findings, the final conceptual model of this study is presented in Figure 2.

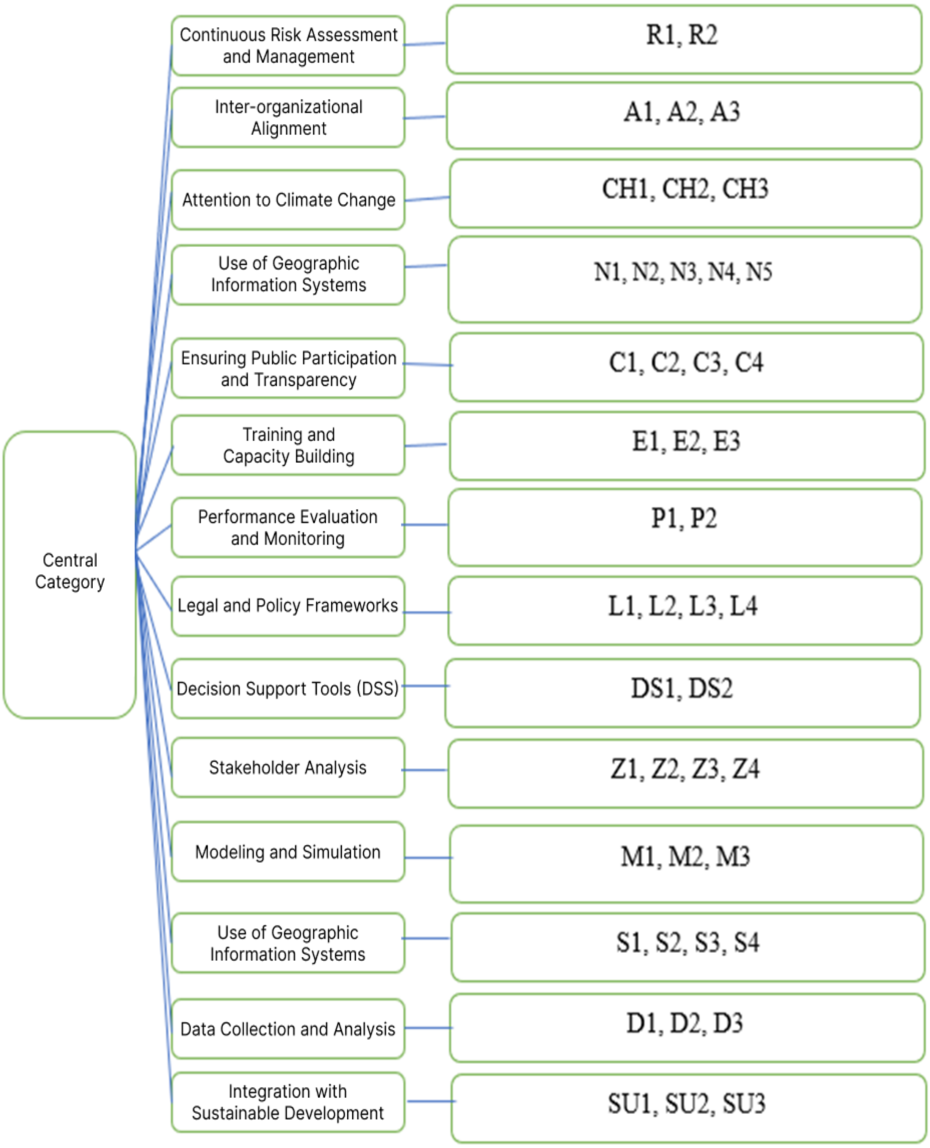

Figure 2. Policy Support System Model for Enhancing Rationality in Water Resource Management

3. Discussion and Conclusion

This study focused on designing a Policy Support System (PSS) to enhance rationality in water resource management. Using a quantitative approach and Structural Equation Modeling, the main and subsidiary components of this system were identified and analyzed. The results from data collected through questionnaires administered to managers and experts in the field of water resource management in Iran indicate the existence of a comprehensive and multidimensional framework for improving water resource management. The identification of 19 main components—including data collection and analysis, use of geographic information systems (GIS), modeling and simulation, stakeholder analysis, decision support tools (DSS), legal and policy frameworks, performance evaluation and monitoring, training and capacity building, ensuring public participation and transparency, technology transfer and innovation, attention to climate change, inter-organizational alignment, continuous risk assessment and management, and integration with sustainable development—demonstrates that an effective PSS must comprehensively and coherently include these elements.

A key point of this study is the emphasis on the importance of using GIS and advanced modeling for accurate water resource mapping and identifying critical areas. These tools enable managers to make decisions based on accurate and up-to-date data. Furthermore, stakeholder analysis plays a crucial role in identifying the needs and expectations of various groups involved in water resource management, which can lead to the formulation of comprehensive and actionable policies. The legal and policy frameworks identified in this research highlight the need for robust laws and regulations aligned with national and international policies for water resource management. Continuous performance evaluation and risk management are also critical for mitigating the negative impacts of water crises. The emphasis on training and capacity building reflects the need to enhance the knowledge and skills of staff and stakeholders in using PSS tools.

Attention to climate change and integration with sustainable development goals are other significant elements of the PSS, emphasizing the need for a comprehensive and multidimensional approach to water resource management. Utilizing modern technologies such as artificial intelligence and big data analytics can improve the precision and efficiency of water resource management and facilitate knowledge transfer in this field. The findings of this study suggest that designing and implementing a comprehensive and multidimensional PSS can significantly enhance rationality in water resource management. This system, by providing necessary tools and frameworks for data collection and analysis, stakeholder identification and evaluation, decision support, and ensuring transparency and public participation, enables water resource managers to make better decisions and achieve sustainable water management.

Ultimately, this study can serve as a foundation for future research aimed at improving water resource management systems and developing effective policies in this area. Future research should evaluate and assess the practical implementation of this system in different environments and examine its impacts on improving water resource management to comprehensively assess its practical capabilities. Based on the results of this research, it is recommended that relevant institutions in the field of water resource management implement a comprehensive and multidimensional PSS that includes the collection and analysis of physical, social, and environmental data, extensive use of GIS, and the development of advanced forecasting and simulation models. It is also recommended to review and strengthen existing legal and policy frameworks to align them with national and international policies. Strengthening educational capacities and enhancing the skills of staff and stakeholders in using decision support tools are essential, and transparent processes for public participation should be established to ensure that decisions are made transparently and collaboratively. Additionally, the use of modern technologies such as artificial intelligence and big data analytics can increase the accuracy and efficiency of water resource management, and special attention should be given to climate change and integration with sustainable development goals. Finally, future research should focus on the practical evaluation and continuous improvement of this system in different environments, providing solutions for its ongoing enhancement to more effectively promote rationality in water resource management.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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