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A Study on the Driving Mechanisms of Water Supply and Demand Perception in the Digital Age

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Abstract: - This study investigates the drivers of water supply and demand perception in the digital age, focusing on the impact of various factors including climate change awareness, socio-economic impact perception, environmental policy awareness, and water resource protection consciousness. Through questionnaire surveys conducted in Chengdu City and data analysis using the Partial Least Squares Structural Equation Modeling (PLS-SEM), this study reveals how the aforementioned factors collectively influence the perception of water supply and demand. The findings indicate that a profound understanding of climate change and socio-economic activities, along with a high awareness of environmental policies, can significantly enhance the public's consciousness towards water resource protection, thereby affecting the accurate perception of water supply and demand conditions. This study not only offers a new perspective in the field of water resource management but also provides a theoretical basis and data support for formulating effective water resource protection strategies, emphasizing the critical role of intelligent water resource management in addressing climate change and promoting sustainable development. The limitations of the study include the restricted sample size and scope, which may affect the generalizability of the results. Future research is recommended to consider more variables, such as regional cultural and economic differences, and to conduct validations across a broader area and population.

Keywords: Digital Age, Water Resource Supply and Demand Perception, Driving Mechanisms, PLS-SEM, Water Resource Conservation, Climate Change.

I. Introduction

As global climate change intensifies and population growth escalates, the balance of water resource supply and demand is increasingly becoming a global focal point [1]. Water, being fundamental for life and development, its judicious use and protection pose a significant challenge for contemporary society. According to the Global Water Resources Report (2020), approximately 2 billion people live in areas of severe water scarcity, a number expected to continue rising in the coming decades. In this context, understanding and revealing the driving mechanisms of water resource supply and demand perception is crucial for formulating effective water resource management policies and promoting sustainable utilization. The perception of water supply and demand is closely linked to changes in the natural environment and is deeply influenced by socio-economic factors. For instance, the accelerating pace of economic development and urbanization increases the demand for water resources, while climate change-induced extreme weather events like droughts and floods exacerbate the instability of water supply. This imbalance leads to the intensification of water crises, drawing widespread attention to the perception of water supply and demand [2].

However, current research on the perception of water resource supply and demand often focuses on single natural or socio-economic factors, with few studies adopting a comprehensive approach to explore the multiple factors and their interactions. Additionally, existing studies have limitations in theory and methodology. For example, many studies use traditional statistical methods such as regression analysis, which have limited effectiveness and accuracy in dealing with complex data. Therefore, this study employs the PLS-SEM method, an advanced statistical technique suitable for complex data analysis, to effectively reveal complex relationships between variables.

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In the process of exploring the driving mechanisms behind the perception of water supply and demand, this study has come to a profound realization that the understanding and methodologies of water resource management are undergoing fundamental changes with the development of big data, Internet of Things (IoT) technologies, as well as the application of artificial intelligence and mathematical numerical analysis methods. In particular, big data provides us with unprecedented capabilities to analyze patterns and trends in water resource usage, while IoT technology enables real-time monitoring of water supply and demand. Moreover, simulation technologies and intelligent tools allow for the modeling of the impacts of various management strategies on the balance of water supply and demand, providing a scientific basis for formulating more effective water resource protection measures [3]. Therefore, this study is committed to integrating these advanced technologies to construct a diversified analytical framework, aimed at gaining a more comprehensive understanding and revealing the complex mechanisms of water supply and demand perception, thereby contributing new ideas and strategies for the sustainable management of global water resources.

The aim of this study is to explore and analyze the key factors affecting water resource supply and demand perception and their interactions using the PLS-SEM method, providing theoretical foundations and decision support for water resource management. The study first defines the concept of water resource supply and demand perception and constructs a theoretical framework with multiple key indicators based on literature review and theoretical analysis. These indicators include climate change awareness, perception of socio-economic impacts, understanding of environmental policies, and water resource conservation awareness. Through in-depth analysis and testing of these indicators, the study aims to reveal their impact and mechanisms on water resource supply and demand perception. As water resource issues become increasingly prominent, understanding and revealing the driving mechanisms of water resource supply and demand perception is vital for the enduring stewardship of worldwide water assets. Thus, this research not only provides a new theoretical perspective and methodological tools for academic research in the water resource field but also offers a scientific basis for government agencies, environmental protection organizations, and water resource managers to formulate effective management strategies. By comprehensively understanding the multiple factors affecting water resource supply and demand perception, we can more effectively address the global water crisis and achieve sustainable utilization and management of water resources.

In summary, based on the PLS-SEM method, this study aims to explore the multiple factors and their interactions affecting water resource supply and demand perception. It focuses not only on individual natural or socio-economic factors but also attempts to reveal how these factors collectively impact water resource supply and demand perception from a more comprehensive perspective. Through in-depth analysis of the key factors, this study hopes to provide new theoretical and practical guidance for the effective management and sustainable utilization of water resources.

II. Hypothesis Development

A deep understanding of climate change can heighten individual attention to environmental issues, particularly the scarcity of water resources, thereby stimulating their awareness and behavior towards water conservation. Specifically, when individuals have a comprehensive understanding of climate change and its potential threats to water resources, they tend to pay more attention to the sustainable use and protection of water resources. This awareness is not just limited to understanding the scientific principles of climate change, but also includes a profound perception of the consequences, such as water scarcity, deterioration in water quality, and ecosystem damage [4]. Moreover, as climate change awareness increases, individuals may be more inclined to support and participate in water conservation policies and actions, like water-saving measures, equitable distribution of water resources, and water pollution control. This behavioral change reflects a cognitive shift from personal to collective interests, where individuals start to view water conservation as a crucial part of addressing climate change, thus feeling a stronger sense of responsibility and urgency to protect water resources. Therefore, the positive correlation between awareness of climate change and water conservation awareness is not only at the knowledge level but also extends to actions and strategies, demonstrating how cognitive changes can translate into practical environmental protection actions. This transformation is theoretically aligned with the principles of cognitive psychology and behavioral economics, where changes in information and knowledge can promote changes in attitudes and behaviors. In summary, there is a significant positive correlation between climate change awareness and water conservation awareness, playing a key role in addressing global water resource issues and promoting sustainable development strategies. Building on this, the article posits Hypothesis H1:

Hypothesis H1: Climate change awareness has a significant positive impact on water conservation awareness.

As individuals deepen their understanding of climate change, they are more likely to comprehend and support environmental policies addressing climate change. This awareness typically includes understanding the scientific basis of climate change, its impacts on nature and human societies, and various strategies and policy measures to counteract climate change. In-depth climate change awareness not only prompts individuals to recognize the importance of formulating and implementing environmental policies but also makes them more concerned about the specific content and effectiveness of these policies [5]. Moreover, this awareness might further influence individual behavior and attitudes, encouraging them to support and engage in environmental protection activities at personal and societal levels. Therefore, the positive link between climate change awareness and environmental policy awareness is not just a knowledge-based connection but largely reflects a shift from understanding to action, which is crucial for promoting effective implementation of environmental policies and raising public awareness of environmental issues. Building on this, the article posits Hypothesis H2:

Hypothesis H2: Climate change awareness has a significant positive impact on environmental policy awareness.

Understanding the potential impacts of climate change on water resources, such as water scarcity or flooding caused by extreme weather events, can enhance individual awareness and concern for the balance of water supply and demand. This consciousness encompasses both a comprehension of climate change's scientific principles and a recognition of the particular effects climate change could exert on water resources' availability, quality, and distribution. As awareness of climate change and its impact on water resources increases, individuals are likely to recognize the importance of water resource management and take corresponding actions to address potential water issues. This may manifest as support for water-saving measures, approval of sustainable water management policies, and changes in personal water use behavior. Therefore, increased awareness of climate change may lead to strengthened perception of water supply and demand, enhancing effective management and protection of water resources [6]. Building on this, the article posits Hypothesis H3:

Hypothesis H3: Awareness of climate change significantly enhances the understanding of water supply and demand conditions.

The impact of environmental policy awareness on water conservation awareness is expected to be positive. When individuals have a deeper understanding of environmental policies, they tend to have a higher awareness of water resource protection [7]. This awareness includes understanding policy goals, strategies, and effectiveness, especially those policies that directly or indirectly affect water resources. For instance, knowing that certain environmental policies aim to reduce industrial pollution, protect aquatic ecosystems, or improve water efficiency may enhance individual awareness of the importance of water conservation. Moreover, awareness of environmental policies may also strengthen the motivation for individuals to practice water conservation measures in their daily lives, such as saving water and supporting community activities related to water conservation. Therefore, the positive link between environmental policy awareness and water conservation awareness is not just a knowledge-based connection but could also transform into specific protective actions. Building on this, the article posits Hypothesis H1:

Hypothesis H4: Environmental policy awareness has a significant positive impact on water conservation awareness.

The impact of socio-economic impact perception on environmental policy awareness is likely to be positive [8]. This relationship stems from a deep perception of changes in the socio-economic environment, such as economic growth, industrialization, and population increase, which can deepen an individual's understanding of the importance of environmental policies. Once individuals recognize the pressures and impacts of socio-economic development on natural resources and the environment, they may be more inclined to understand and support the necessity of implementing environmental policies. For example, when people become aware of the impacts of overdevelopment, population density, or economic activities on water resources and air quality, they may more readily agree with and understand why environmental policies for water conservation and air purification are necessary. Additionally, socio-economic impact perception might also prompt individuals to pay more attention to the actual effects and sustainability of environmental policies and how these policies help mitigate or adapt to environmental challenges brought about by socio-economic changes. Therefore, the positive link between socio-economic impact perception and environmental policy awareness is not just a more comprehensive understanding of environmental issues but could lead to greater attention and support for the formulation and implementation of environmental policies. Building on this, the article posits Hypothesis H5:

Hypothesis H5: Socio-economic impact perception has a significant positive impact on environmental policy awareness.

The impact of socio-economic impact perception on water supply and demand perception is expected to be positive. When individuals have a deeper understanding of socio-economic factors [9], such as population growth, urbanization, industrial development, and agricultural demands, they are likely to pay more attention to the balance of water supply and demand. This perception includes an understanding of how socio-economic activities affect the use, demand, and distribution of water resources. For instance, awareness of the increased water demand and distribution pressures caused by rapid urbanization might make individuals more aware of the importance of water resource management and conservation. Additionally, the recognition of the heavy water resource demands in agriculture and industry may prompt individuals to understand the necessity of implementing water-saving and sustainable water management measures in these areas. Therefore, the positive link between socio-economic impact perception and water supply and demand perception not only reflects an understanding of the current state of water resources but could also promote support for future water resource strategies and policies. This link emphasizes the interdependence between socio-economic activities and water resources and the importance of understanding this relationship for effective water resource management. Building on this, the article posits Hypothesis H6:

Hypothesis H6: Socio-economic impact perception has a significant positive impact on water supply and demand perception.

The impact of socio-economic impact perception on water conservation awareness is expected to be positive. An individual’s awareness of socio-economic factors like population growth, economic development, urbanization, and their impact on water resources might enhance their awareness of water conservation. This perception may include an understanding of how economic activities increase water pollution and water resource consumption, as well as an understanding of the impacts of population growth and urban expansion on water resource scarcity and sustainability. Recognizing these socio-economic factors as potential threats to water resources, individuals may place greater emphasis on water conservation, taking measures to reduce negative impacts on water resources, such as supporting water-saving measures, improving water resource utilization efficiency, and advocating sustainable water resource management policies [10].Therefore, the positive link between socio-economic impact perception and water conservation awareness is not just a more comprehensive understanding of water resource challenges but may also motivate individuals and society to take proactive actions for the protection and sustainable utilization of water resources. Building on this, the article posits Hypothesis H7:

Hypothesis H7: Socio-economic impact perception has a significant positive impact on water conservation awareness.

The impact of water conservation awareness on water supply and demand perception is expected to be positive. When individuals have a higher awareness of water resource protection, they are likely to have a deeper understanding and concern for the state of water supply and demand. This awareness may include an understanding of the importance of water conservation and the need for sustainable management of water resources. Individuals with a higher water conservation awareness may be more sensitive to issues of water supply limitations and demand growth, such as being more concerned and understanding the impacts of drought, water pollution, or other factors affecting water resource availability on water supply and demand balance [11]. Additionally, high water conservation awareness may prompt individuals to pay more attention to and support effective management and protection strategies for water resources, including water-saving measures and equitable water resource distribution, thereby deepening their understanding of water supply and demand conditions. Therefore, the positive link between water conservation awareness and water supply and demand perception reflects a transformation from environmental conservation awareness to specific resource management understanding, emphasizing the role of conservation awareness in promoting an understanding of the current state and challenges of water supply and demand. Building on this, the article posits Hypothesis H1:

Hypothesis H8: Water conservation awareness has a significant positive impact on water supply and demand perception.

Socio-economic impact perception, including awareness of factors such as economic growth, population change, and industrial development, may influence how individuals understand and respond to climate change and its impact on water resources. In this hypothesis, socio-economic impact perception is seen as a key moderating variable that may strengthen or weaken the impact of climate change awareness on water conservation awareness. Specifically, if individuals have a deep understanding of socio-economic impacts, they might be more aware of the specific impacts of climate change on water resources, thereby enhancing the positive impact of climate change awareness on water conservation awareness. For example, when a person understands the pressures on water resources due to economic activities and population growth, they may place more emphasis on the additional water resource challenges brought by climate change, thus paying more attention to water conservation. Conversely, if the perception of socio-economic impacts is weak, the impact of climate change awareness on water conservation awareness might be diminished, as individuals may not fully understand the compounded effects of climate change and growing socio-economic demands on water resources [12]. Building on this, the article posits Hypothesis H9:

Hypothesis H9: Socio-economic impact perception significantly moderates the relationship between climate change awareness and water conservation awareness.

Environmental policy awareness, as a moderating variable, can significantly affect the relationship between socio-economic impact perception and water supply and demand perception. This hypothesis is based on recognizing the important role of environmental policies in understanding and addressing the impacts of socio-economic development on water supply and demand. In this framework, environmental policy awareness is considered a key factor that may change how socio-economic impact perception affects water supply and demand perception. Specifically, if individuals have a deep understanding of environmental policies, they may more effectively understand the impacts of socio-economic development on water resources and be more capable of identifying and supporting policies and practices that mitigate these impacts. For example, when people understand water-saving policies, water resource management strategies, and pollution control measures, they may have a clearer understanding of the impacts of population growth and economic activities on the balance of water supply and demand and support these policies to improve the water supply and demand conditions. Conversely, if the understanding of environmental policies is insufficient, the impact of socio-economic impact perception on water supply and demand perception may be less apparent or underestimated. In this case, even if people are aware of the impacts of socio-economic activities on water resources, they may not be clear on how to address these challenges through policies and management measures [13]. Building on this, the article posits Hypothesis H10:

Hypothesis H10: Environmental policy awareness significantly moderates the relationship between socio-economic impact perception and water supply and demand perception.

Through the proposed hypotheses, this paper establishes the conceptual model as shown in Figure 1.

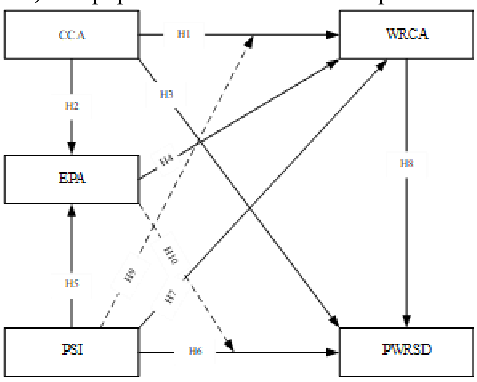

Figure 1: Conceptual Model

Climate Change Awareness (CCA). This indicator measures an individual's understanding of the scientific principles of climate change, awareness of the specific impacts that climate change may have on local water resources and the environment, and the perception of potential risks and consequences brought about by climate change. It reflects an individual's level of knowledge on climate change issues and their sensitivity to potential future changes [14].

Socio-Economic Impact Perception (PSI). This indicator reflects an individual's intuitive perception of how population growth, industrial activities, urbanization, and other economic activities impact water resources. It involves an understanding of socio-economic dynamics and their impact on the sustainability of water resources, including the demand and quality of water resources [15].

Environmental Policy Awareness (EPA). This indicator covers an individual's knowledge level about current water resource and environmental policies, as well as their assessment of the effectiveness of these policies' implementation. It also includes individuals' willingness and motivation to participate in the policy-making and implementation process, reflecting public engagement and investment in the policy-making process [16].

Water Resource Conservation Awareness (WRCA). This indicator measures an individual's recognition of the importance of water resource conservation, their perceived personal responsibility in water conservation, and the role they believe the community should play in water resource conservation. Additionally, it includes the frequency and extent to which individuals engage in sustainable water resource management behaviors in their daily lives.

Perception of Water Resources Supply and Demand (PWRSD). This indicator describes an individual's perception of the stability and sufficiency of water resource supply, awareness of the growth in water resource demand, the current state of supply and demand balance, and the evaluation of water resource utilization and distribution efficiency. It reflects the public's direct perception of the state of water resources and their assessment of the effectiveness of water resource management [17].

III. METHODOLOGY

This study adopted a quantitative research method to thoroughly analyze and verify the relationships between climate change awareness, socio-economic impact perception, environmental policy awareness, water resource conservation awareness, and perception of water resources supply and demand. To construct the theoretical framework for these variables, the study first reviewed relevant literature to identify potential influencing factors and hypothesized pathways of interaction. Subsequently, an extensive survey was conducted in Chengdu, China, to collect empirical data.

During the data analysis stage, the research utilized Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM stands as a robust multivariate statistical technique, especially adept at investigating and confirming intricate connections among variables, without strict constraints on data distribution. Due to its flexibility in handling complex models and theoretical constructs, PLS-SEM has been widely applied in various fields, including environmental science, social science, and behavioral science [18-20]. Given these attributes, choosing PLS-SEM as the analysis tool for this study was not only suitable for the research needs but also aligned with current research method trends. Through this methodological design, the study aims to accurately assess and interpret the multiple factors influencing water resource conservation awareness, providing a scientific basis for policy formulation.

A. Survey Area

Chengdu, serving as the capital city of Sichuan Province, serves not only as the administrative center of the province but also as a key economic and cultural hub in the southwest region of China. According to data from 2022, the permanent population of Chengdu is approximately 21.268 million, reflecting the rapid urban population growth characteristic of a developing city. The city is renowned for its unique hydrological features and abundant water resources, especially its historically significant irrigation system, which showcases a long tradition in water resource management and utilization. In response to various water resource challenges brought about by urbanization, the Chengdu municipal government has increased its investment in sustainable water resource management and water conservation in recent years, actively enhancing citizens' awareness of sustainable water utilization. Due to its significant achievements in water resource management and conservation, Chengdu provides valuable experience and models for effective water management. The choice of Chengdu as the research area for this study is based on its representativeness and exemplary role in addressing water resource challenges in the context of rapid urbanization. This study aims to delve into the practices of water resource management strategies in Chengdu, analyze citizens' awareness of water conservation, and how this awareness is influenced by factors such as climate change awareness, socio-economic impact perception, and environmental policy awareness. Through these analyses, the study expects to extract effective strategies and policy recommendations for sustainable water resource management in global cities, particularly insights into raising public awareness of water conservation and promoting protective actions. This will provide important strategic references and practical guidance for cities worldwide facing similar challenges.

B. Survey Design

In light of the aim to explore the attitudes and behaviors of residents in Chengdu regarding climate change awareness, socio-economic impact perception, environmental policy awareness, and water resource conservation awareness amid rapid urbanization and economic development, this study designed a detailed survey questionnaire. The questionnaire included several sections related to these themes, intending to comprehensively assess residents' views and reactions to these critical issues. In February 2023, a pilot survey was initially conducted in Chengdu to ensure the validity and reliability of the questionnaire. This pilot involved selecting representative areas of Chengdu and randomly choosing a certain number of residents for testing. These pilot areas were chosen due to their representativeness in urbanization and economic development, and their potential significant impact on water resource supply, demand, and conservation. Based on the feedback and suggestions from the pilot test, the questionnaire content was appropriately adjusted and refined. The formal survey targeted permanent residents living in Chengdu for over a year, as these individuals have a deeper understanding and experience of local water resource conditions, the impacts of climate change, and water-saving policies. The survey was conducted from April to August 2023. In total, nearly 300 questionnaires were collected, including both paper and electronic forms. After a thorough review and elimination of invalid questionnaires (such as those incompletely filled out or with unclear answers), approximately 280 valid questionnaires were obtained. This number exceeded the minimum sample size required for structural equation model analysis, ensuring the statistical validity and credibility of the study results. Through this survey, the study aims to gain a deeper understanding of the attitudes and behaviors of Chengdu residents towards water resource conservation in the face of climate change and socio-economic development challenges, providing a scientific basis for related policies.

C. Questionnaire Description

The questionnaire designed for this study is divided into two parts. The first part gathers basic information about the respondents, including gender, age, education level, and other demographic data. The second part consists of questions based on the various measurement indicators in the evaluation index system. All the questions are in the form of objective items, which saves time for the respondents. Additionally, all the items use a Likert 7-point scale for measurement. Table 1 in the study provides detailed information about each of these indicators.

Table 1: Description of Constructs and Measurement Items

No.	Primary Construct	Secondary Construct	Description of Indicator	Code
1	Climate Change Awareness	Understanding of Climate Change Science	Degree of understanding of the scientific principles of climate change.	CCA1
2		Awareness of Local Impacts of Climate Change	Awareness of the specific impacts of climate change on local water resources and environment.	CCA2
3		Perception of Climate Change Risks	Perception of the risks and consequences caused by climate change.	CCA3
4	Socio-Economic Impact Perception	Perception of Population Growth on Water Resources	Perception of the impact of population growth on local water resources.	PSI1
5		Assessment of Industrial Activities on Water Resources	Assessment of the impact of industrial development on water resource quality and sustainability.	PSI2
6		Perception of Urbanization Pressure on Water Resources	Perception of the pressure on water resource systems due to urban expansion and growth.	PSI3
7		Perception of Economic Activities and Water Resource Consumption	Perception of the impact of economic activities like agriculture, manufacturing on water resources.	PSI4
8	Environmental Policy Awareness	Knowledge Level of Environmental Policies	Understanding of current water resource and environmental policies.	EPA1
9		Assessment of Environmental Policy Effectiveness	Assessment of the effectiveness of environmental policies in improving water resource management.	EPA2
10		Perception of Environmental Policy Implementation	Perception of the actual implementation of environmental policies in practice.	EPA3
11		Willingness to Participate in Environmental Policy	Willingness and motivation to participate in the formulation and implementation of environmental policies.	EPA4
12	Water Resource Conservation Awareness	Importance of Water Resource Conservation	Recognition and importance of water resource conservation.	WRCA1
13		Awareness of Personal Responsibility in Protection	Recognition of personal responsibility in water resource conservation.	WRCA2
14		Awareness of Community Responsibility in Protection	Perception of the community's responsibility and role in water resource conservation.	WRCA3
15		Participation in Sustainable Water Resource Management Behaviors	Frequency and extent of sustainable water resource management behaviors in daily life.	WRCA4
16	Perception of Water Resources Supply and Demand	Stability of Supply	Perception of the stability and sufficiency of water resource supply.	PWRSD1
17		Growth in Demand	Perception of the trend of growth in water resource demand.	PWRSD2
18		Balance of Supply and Demand	Perception of the current state of water resource supply and demand balance.	PWRSD3
19		Efficiency of Resource Utilization	Perception of water resource utilization and distribution efficiency.	PWRSD4

IV. RESULTS

A. Measurement Model Testing

Cronbach's Alpha is a measure of internal consistency for questionnaires or scales, with standard values typically considered acceptable if they are above 0.7 [21]. Composite Reliability (rho_a, rho_c) measures the internal consistency of survey data, where rho_a and rho_c represent two different methods of calculating composite reliability, and values above 0.7 are generally considered good. Average Variance Extracted (AVE) measures the convergent validity of survey data, which is the extent to which the indicators of a construct explain the concept, and the standard value is usually above 0.5 [22].

Table 2: Consistency Test Results

Construct	Cronbach Alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	AVE
CCA	0.897	0.899	0.936	0.83
EPA	0.829	0.834	0.887	0.662
PSI	0.845	0.862	0.896	0.685
PWRSD	0.904	0.907	0.933	0.778
WRCA	0.789	0.792	0.863	0.613

From Table 2, it is evident that a quantitative analysis of the driving mechanisms for the perception of water resources supply and demand was conducted, employing statistical measures such as Cronbach's Alpha, Composite Reliability (rho_a, rho_c), and Average Variance Extracted (AVE). Cronbach's Alpha, used for measuring the internal consistency of the questionnaire, showed that all constructs had values higher than 0.7, indicating good reliability of the questionnaire. Composite Reliability (rho_a, rho_c) further confirmed this, with all constructs exceeding the 0.7 standard. AVE, as an indicator of construct convergent validity, indicates good validity when values are above 0.5. In this study, the AVE values reached or exceeded the 0.5 standard. Overall, these statistical results suggest that the scales used in the study demonstrate good internal consistency and convergent validity, providing a reliable data foundation for subsequent analysis.

Table 3: Heterotrait-Monotrait Ratio (HTMT)-Matrix

Construct	CCA	EPA	PSI	PWRSD	WRCA
CCA					
EPA	0.39				
PSI	0.247	0.298			
PWRSD	0.567	0.42	0.442		
WRCA	0.513	0.573	0.38	0.547	

Table 3 presents an analysis of the Heterotrait-Monotrait Ratio (HTMT) matrix. HTMT is an index used to assess the discriminant validity between constructs. Lower HTMT values indicate good discriminant validity among constructs. From Table 3, it is observed that the HTMT values between CCA and other constructs such as EPA, PSI, PWRSD, and WRCA are 0.39, 0.247, 0.567, and 0.513, respectively. This indicates that CCA is well-differentiated statistically from these constructs. The HTMT values between EPA and other constructs (PSI, PWRSD, and WRCA) are 0.298, 0.42, and 0.573, respectively, showing that EPA also has good discriminant validity with these constructs. The HTMT values between PSI and PWRSD and WRCA are 0.442 and 0.38, respectively, suggesting that PSI is also effectively differentiated. The HTMT value between PWRSD and WRCA is 0.547, indicating acceptable discriminant validity between them. Overall, the HTMT matrix demonstrates good discriminant validity among the constructs, supporting the validity of the scales used in the study.

Table 4: Results of Discriminant Validity Testing (Fornell-Larker)

Construct	CCA	EPA	PSI	PWRSD	WRCA
CCA	0.911				
EPA	0.34	0.813			
PSI	0.217	0.254	0.828		
PWRSD	0.511	0.362	0.388	0.882	
WRCA	0.433	0.465	0.313	0.464	0.783

According to the Fornell-Larker criterion, which is used to assess the discriminant validity between constructs, Table 4 shows the squared correlation coefficients between different constructs and their respective AVE values. The AVE values for CCA, EPA, PSI, PWRSD, and WRCA are 0.911, 0.813, 0.828, 0.882, and 0.783, respectively. Comparing these AVE values with the squared correlation coefficients among the constructs (shown in the lower triangular part of the table), it can be observed that the AVE values for all constructs are higher than their squared correlation coefficients with other constructs. This indicates that each construct has good discriminant validity in relation to the others, meeting the Fornell-Larker criterion and thus confirming the good discriminant validity of the scale.

B. Structural Model Testing

In this study, the coefficient of determination (R^2) is used to measure the explanatory power of exogenous variables on endogenous variables. The R^2 values for Environmental Policy Awareness (EPA), Perception of Water Resources Supply and Demand (PWRSD), and Water Resource Conservation Awareness (WRCA) are 0.194, 0.400, and 0.328, respectively. This means that the relevant exogenous variables can explain 19.4% of Environmental Policy Awareness, 40.0% of the Perception of Water Resources Supply and Demand, and 32.8%

of Water Resource Conservation Awareness. Additionally, the cross-validated redundancy (Q^2) values are 0.094, 0.288, and 0.176, respectively, all greater than 0, indicating that these variables have strong predictive relevance for the corresponding endogenous variables.

C. Analysis of Test Results

Figure 2 presents the graphical validation results based on PLS-SEM, and Table 5 contains the specific validation data.

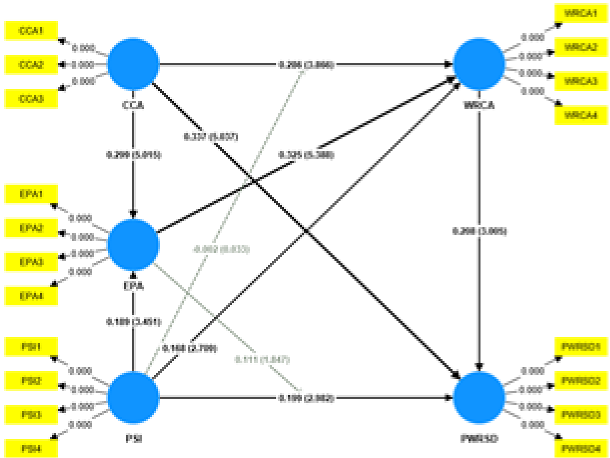

Figure 2: Based on PLS-SEM Simulation Results

Table 5: Path Analysis Results

Hypothesis	Path	Coefficient	STDEV	T value	p value
H2	CCA →EPA	0.299* * *	0.06	5.015	0
H3	CCA→PWRSD	0.337* * *	0.067	5.037	0
H1	CCA→WRCA	0.286* * *	0.074	3.866	0
H4	EPA→WRCA	0.325* * *	0.06	5.388	0
H5	PSI→EPA	0.189* *	0.055	3.451	0.001
H6	PSI→PWRSD	0.199* *	0.067	2.982	0.003
H7	PSI→WRCA	0.168* *	0.062	2.709	0.007
H8	WRCA→PWRSD	0.208* *	0.069	3.005	0.003
H10	EPA x PSI→PWRSD	0.111	0.06	1.847	0.065
H9	PSI x CCA→WRCA	-0.002	0.067	0.033	0.974

From Table 5, it is evident that in the path analysis of Hypothesis 1 (H1), Climate Change Awareness (CCA) showed a significant positive relationship with Water Resource Conservation Awareness (WRCA) (coefficient 0.286, T>1.96). This result suggests that a deeper understanding of climate change significantly enhances awareness of water resource conservation. The likely reason is a more comprehensive understanding of the scientific principles of climate change and its potential risks enhances individuals' awareness of water scarcity and the importance of conservation. As understanding of the impacts of climate change deepens, individuals are more likely to realize the importance of protecting water resources to mitigate climate change, thus fostering a stronger sense of awareness and responsibility for water conservation. This cognitive improvement may further translate into actual water conservation behaviors, such as supporting water-saving measures and participating in sustainable water resource management activities.

In the path analysis of Hypothesis 2 (H2), Climate Change Awareness (CCA) also shows a significant positive relationship with Environmental Policy Awareness (EPA) (coefficient 0.299, T>1.96). This finding indicates that as individuals gain a deeper understanding of climate change, their awareness of environmental policies correspondingly increases. This may be due to an enhanced recognition of the consequences of climate change, which strengthens their understanding of the importance of environmental policies. Specifically, a profound understanding of the impacts of climate change may encourage individuals to value the role of environmental policies in addressing these challenges, leading to higher attention and support for relevant policies. This transformation from cognition to action might strengthen individual support for environmental protection measures, reflecting how increased knowledge can influence changes in attitudes and behaviors.

In the path analysis of Hypothesis 3 (H3), Climate Change Awareness (CCA) demonstrates a significant positive relationship with Perception of Water Resources Supply and Demand (PWRSD) (coefficient 0.337, T>1.96). This suggests that a deeper understanding of climate change significantly enhances individuals' perception of water resource supply and demand. The reason might be that increased awareness of climate change and its potential impacts on water resources heightens sensitivity to the balance of water supply and demand. This awareness could stimulate individuals' attention to water resource management and conservation, leading to more accurate perceptions and assessments of water resource supply and demand conditions.

In the path analysis of Hypothesis 4 (H4), Environmental Policy Awareness (EPA) shows a significant positive relationship with Water Resource Conservation Awareness (WRCA) (coefficient 0.325, T>1.96). This indicates that a deeper understanding of environmental policies plays a significant role in enhancing individuals' emphasis on water resource conservation. When individuals have a better understanding of the objectives, strategies, and effectiveness of environmental policies, they are more likely to recognize the importance of water conservation and take corresponding actions. This understanding might encourage them to practice water-saving and water conservation measures in daily life, thus enhancing water resource conservation awareness.

In the path analysis of Hypothesis 5 (H5), Socio-Economic Impact Perception (PSI) shows a significant positive relationship with Environmental Policy Awareness (EPA) (coefficient 0.189, T>1.96). This indicates that a deep understanding of socio-economic factors such as population growth, industrial activities, urbanization, and their impact on water resources can enhance awareness of environmental policies. This understanding might stem from individuals' observation and comprehension of the interplay between socio-economic activities and the environment, particularly how these activities affect the quality and sustainability of water resources. A clear awareness of the environmental impacts of these economic activities might inspire support for the implementation of effective environmental policies, thus strengthening environmental protection consciousness. This phenomenon may reflect a comprehensive understanding of environmental issues and the importance attached to the effectiveness of environmental policies, showing a shift in attitude from understanding socio-economic development to taking environmental protection actions.

In the path analysis of Hypothesis 6 (H6), Socio-Economic Impact Perception (PSI) demonstrates a significant positive relationship with Perception of Water Resources Supply and Demand (PWRSD) (coefficient 0.199, T>1.96). This suggests that individuals' understanding of socio-economic factors like population growth, industrial activities, and urbanization significantly enhances their perception of water resource supply and demand balance. This might be because a deeper understanding of these socio-economic activities and their impact on water resource use leads individuals to pay more attention to water resource management and conservation, resulting in a more accurate understanding and assessment of water resource supply and demand conditions.

In the path analysis of Hypothesis 7 (H7), Socio-Economic Impact Perception (PSI) also shows a significant positive relationship with Water Resource Conservation Awareness (WRCA) (coefficient 0.168, T>1.96). This implies that individuals' understanding of socio-economic factors such as population growth, industrialization, and urbanization enhances their awareness of water resource conservation. This might be because a deeper understanding of socio-economic impacts makes individuals more aware of the significance of water resources and the challenges confronting them, thus strengthening their sense of responsibility and urgency for water conservation.

In the path analysis of Hypothesis 8 (H8), Water Resource Conservation Awareness (WRCA) exhibits a significant positive relationship with Perception of Water Resources Supply and Demand (PWRSD) (coefficient 0.208, T>1.96). This means that the higher the individuals' emphasis on water resource conservation, the more sensitive their perception of water resource supply and demand conditions. This could be because an increased awareness of the importance of water conservation heightens individuals' attention to water resource supply stability, demand growth, and the balance of supply and demand. This relationship reflects how individuals translate their awareness of water resource conservation into a deeper understanding and concern for the actual water resource situation.

In the path analysis of Hypothesis 9 (H9), the interaction effect between Socio-Economic Impact Perception (PSI) and Climate Change Awareness (CCA) on Water Resource Conservation Awareness (WRCA) is not significant (coefficient -0.002, T value 0.033, p value 0.974). Additionally, the moderation graph (Figure 3) shows that as Climate Change Awareness (CCA) increases, Water Resource Conservation Awareness (WRCA) also improves, and this improvement is more pronounced when Socio-Economic Impact Perception (PSI) is higher. Different colors in the graph represent different levels of PSI. Although the graph shows a trend of PSI level influencing the relationship between CCA and WRCA, the lack of statistical significance in the interaction effect indicates that the relationship between CCA and WRCA varies at different PSI levels but does not reach a statistically significant difference. This might mean that PSI's role in enhancing the impact of CCA on WRCA is not as strong as expected. This implies that although Climate Change Awareness and Socio-Economic Impact Perception each have a significant impact on Water Resource Conservation Awareness, their interaction does not significantly enhance water resource conservation awareness. The possible reason is that the mechanisms by which

Climate Change Awareness and Socio-Economic Impact Perception influence Water Resource Conservation Awareness may be independent of each other, or there might be other unconsidered variables or factors interfering with their relationship.

In the path analysis of Hypothesis 10 (H10), the interaction effect between Environmental Policy Awareness (EPA) and Socio-Economic Impact Perception (PSI) on Perception of Water Resources Supply and Demand (PWRSD) is not significant (coefficient 0.111, T value 1.847, p value 0.065). From Figure 4, it can be seen that although there is an intersection between the lines, the data reveals that the moderating effect is not significant, indicating that in terms of Perception of Water Resources Supply and Demand, the interaction effect between Environmental Policy Awareness and Socio-Economic Impact Perception is not strong enough to be significant. The possible reason is that although Environmental Policy Awareness and Socio-Economic Impact Perception each impact Perception of Water Resources Supply and Demand, their interactive effect might be weak or overshadowed by other unconsidered factors.

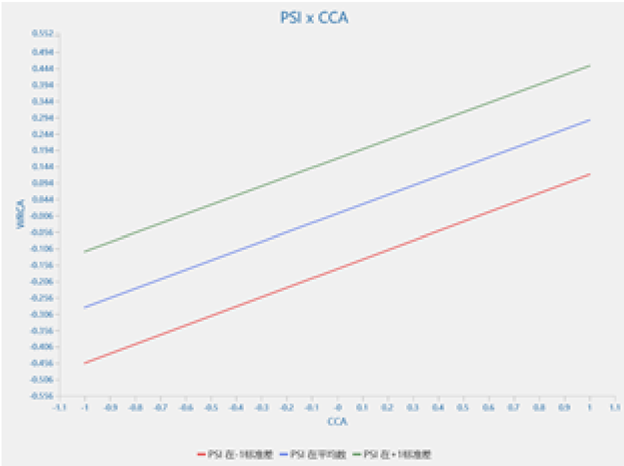

Figure 3: Analysis of the Moderating Effect of Socio-economic Impact Perception

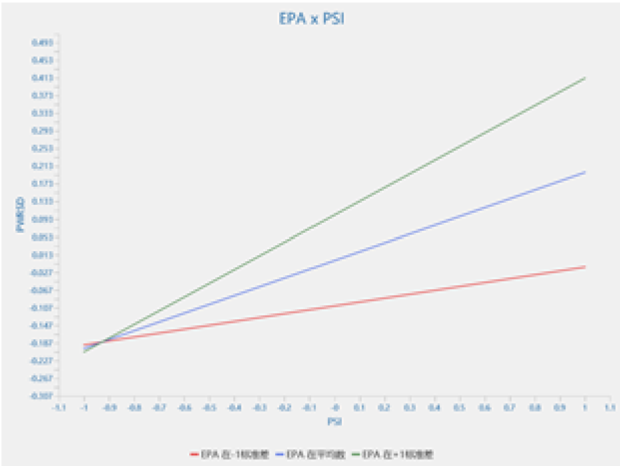

Figure 4: Analysis of the Moderating Effect of Environmental Policy Awareness

Table 6 presents the results of tests for each mediating effect.

Table 6: Path Analysis Results

Path	Coefficient	STDEV	T value	p value
PSI→EPA→WRCA	0.061* *	0.022	2.807	0.005
PSI→EPA→PWRSD	0.019	0.014	1.396	0.163
PSI→EPA→WRCA→PWRSD	0.013*	0.006	2.126	0.034
CCA→EPA→WRCA→PWRSD	0.02*	0.008	2.559	0.011
PSI →WRCA→PWRSD	0.035*	0.016	2.255	0.024
CCA→EPA→WRCA	0.097* * *	0.026	3.773	0
CCA→EPA→PWRSD	0.031	0.019	1.582	0.114
CCA→WRCA→PWRSD	0.06*	0.03	1.983	0.047
EPA→WRCA→PWRSD	0.068* *	0.023	2.937	0.003

Analysis from Table 6 reveals that the results of the mediation effect tests demonstrate the pathways through which Socio-Economic Impact Perception (PSI) and Climate Change Awareness (CCA) influence the Perception of Water Resources Supply and Demand (PWRSD) via Environmental Policy Awareness (EPA) and Water Resource Conservation Awareness (WRCA). The results show that PSI and CCA not only directly affect WRCA and PWRSD but also indirectly influence them through EPA, exhibiting a certain mediating effect. Particularly notable is the impact of CCA on WRCA through EPA (coefficient 0.097), indicating that a deeper understanding of climate change enhances water resource conservation awareness by increasing awareness of environmental policies, which in turn has an important indirect effect on the perception of water resources supply and demand.

V. POLICY IMPLICATIONS

Based on the conclusions of this study, policy implications should include the following aspects: Firstly, it is crucial to raise public awareness of the impacts of climate change, especially its effect on the balance of water resources supply and demand. Governments and environmental organizations should intensify educational and promotional activities to increase public awareness of water resource conservation. Secondly, the promotion and implementation of effective environmental policies to ensure the sustainability of water resource management, while enhancing public awareness and support for these policies, are essential. Additionally, the impact of socio-economic activities on water resources should be addressed through policies and management measures to mitigate these effects. Finally, policymakers should consider the roles of climate change awareness and socio-economic impact perception in water resource management to develop more effective water resource protection and management strategies.

This study, by thoroughly analyzing the impacts of Climate Change Awareness, Socio-Economic Impact Perception, and Environmental Policy Awareness on Water Resource Conservation Awareness and the Perception of Water Resources Supply and Demand, confirms the significant role of these factors in water resource management and conservation. The results emphasize the importance of public education and policy formulation in enhancing awareness of water resource conservation.

VI. CONCLUSION AND LIMITATIONS

This study confirms the significant role of Climate Change Awareness, Socio-Economic Impact Perception, and Environmental Policy Awareness in water resource management and conservation by analyzing their impacts on Water Resource Conservation Awareness and the Perception of Water Resources Supply and Demand. Especially with the assistance of big data analysis and Internet of Things (IoT) technology, we can monitor and predict the supply and demand conditions of water resources more accurately, providing strong technical support for formulating more efficient and sustainable water resource management policies. Furthermore, the application of artificial intelligence and automation technologies has further optimized the implementation efficiency of water resource protection measures, showcasing the tremendous potential of information technology in driving the modernization of water resource management. The results underscore the importance of public education and policy formulation in enhancing water resource conservation awareness. However, the study may not have covered all the factors influencing water resource conservation awareness. Future research could consider more variables, such as regional cultural and economic differences. Moreover, the limitations in sample size and scope might affect the generalizability of the study results, and future research should be validated in a broader range of areas and populations.

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