

Original Article

Assessing the components of water governance in Qom province within the framework of sustainable development

Avaliando os componentes da governança da água na província de Qom no âmbito do desenvolvimento sustentável

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Abstract

One of the most important issues and challenges for Iran, particularly in hot and arid regions such as Qom province, is the current water crisis. Research has shown that good governance is directly linked to sustainable rural development. Therefore, the present study aims to design a water governance model in rural communities of Qom province to achieve sustainable rural development. The research population comprised 163 water experts from the Agricultural Engineering Organization of Qom province and 130 experts from the Water Organization of Qom province. Based on Cochran's formula and considering the population size, a sample size of 170 individuals was calculated and selected using simple random sampling. A questionnaire was used as the main research tool for data collection, which had been validated and confirmed for its reliability. The collected data were analyzed using structural equation modeling (partial least squares method) and confirmatory factor analysis. According to the results, it was determined that in the research model for measuring sustainable development in Qom province, three factors, namely government effectiveness, participation, and technical factors, are recognized as components of sustainable development. Additionally, for measuring the factors influencing water governance, technical, economic, social, institutional, legal, and customary factors are recognized as identified factors. Previous studies have not considered the role of water governance in rural development. This study, however, has placed greater emphasis on the role of water governance in sustainable rural development through a review of various theories and perspectives on this matter.

Keywords: water governance, sustainable development, water crisis, water management, Qom Province.

Resumo

Uma das questões e desafios mais importantes para o Irã, particularmente em regiões quentes e áridas como a Província de Qom, é a atual crise hídrica. Pesquisas mostram que a boa governança está diretamente ligada ao desenvolvimento rural sustentável. Portanto, o presente estudo tem como objetivo elaborar um modelo de governança hídrica em comunidades rurais da Província de Qom para alcançar o desenvolvimento rural sustentável. A população da pesquisa foi composta por 163 especialistas em água da Organização de Engenharia Agrícola da Província de Qom e 130 especialistas da Organização de Água da Província de Qom. Com base na fórmula de Cochran e considerando o tamanho da população, um tamanho de amostra de 170 indivíduos foi calculado e selecionado usando amostragem aleatória simples. Um questionário foi usado como a principal ferramenta de pesquisa para coleta de dados, que foi validado e confirmado quanto à sua confiabilidade. Os dados coletados foram analisados usando modelagem de equações estruturais (método dos mínimos quadrados parciais) e análise fatorial confirmatória. De acordo com os resultados, foi determinado que no modelo de pesquisa para medir o desenvolvimento sustentável na província de Qom, três fatores, a saber, eficácia do governo, participação e fatores técnicos, são reconhecidos como componentes do desenvolvimento sustentável. Além disso, para medir os fatores que influenciam a governança da água, os fatores técnicos, econômicos, sociais, institucionais, legais e consuetudinários são reconhecidos como fatores identificados. Estudos anteriores não consideraram o papel da governança da água no desenvolvimento rural. Este estudo, no entanto, colocou maior ênfase no papel da governança da água no desenvolvimento rural sustentável através de uma revisão de várias teorias e perspectivas sobre esta matéria.

Palavras-chave: governança hídrica, desenvolvimento sustentável, crise hídrica, gestão hídrica, Província de Qom.

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1. Introduction

On a global scale, water-related environmental crises have become the main topics of national and international discussions. This is because, on the one hand, with the increasing population, the human water demand has risen, and on the other hand, climate change phenomena have led to reduced rainfall and drought in certain parts of the world. Additionally, the expansion of environmental pollution has resulted in a decrease in accessible water resources (Arabbpour, 2021). In Iran, one of the most important challenges and issues the country is currently facing is the water crisis, which some refer to as “water scarcity” (Fattahi 2018). Qom Province, with its hot and dry climate, has limited water resources. Despite the development of dams in the province, many of its rivers have completely dried up. The precipitation rate in Qom Province is lower than the national average, further highlighting the constraints on water resources (Iran Water News Network, 2017), emphasizing the significance of this research. Between the years of 1365 and 1396, Qom has witnessed an upward trend in the number of wells dug and exploitation of underground water resources

But despite Increasing the number of wells, the outflow volume of underground aquifers has not increased, and this means that the potential of aquifers is decreasing, the extraction of underground water happens more than they can and this is very worrying.

After the construction of dams, in addition to decreasing runoff inflow rivers of Qom province. Also has been created big problems in the field of underground water.

Although part of the reduction of water inflow to the 15 Khordad dam is related to Climatic issues most parts of it are due to the construction of upstream dams and indiscriminate harvesting.

If water resources are not managed, the future generation will face problems due to lack of water resources (Iran Water News Network, 2017).

Despite the consensus on the existence of a water crisis at the international and national levels in Iran, there is no consensus on its causes. Generally, opinions in this regard can be categorized into three main groups: 1. The first group, which includes the majority of the general public, attributes the crisis to the excessive extraction and utilization of water due to the use of advanced technologies. 2. The second group blames poor governance and mismanagement of water and soil resources. 3. The third group, including many environmental philosophers, considers the crisis to be a result of consumerist and unsustainable lifestyles (Balali et al., 2010 cited in Asgari Bazaye, 2016). Therefore, many experts in this field have always emphasized the role of governance in water crises and their management. The United Nations World Water Development Report states that the “[...] water crisis in the world is a problem of water governance primarily caused by poor water management practices” (United Nations, 2003).

Water governance, as a normative concept for improving water resource management at the global level, has been promoted with a focus on increasing stakeholder engagement, flexibility, and less hierarchical forms of interaction between government and society (Groenfeldt

and Schmidt, 2013; Pahl-Wostl, 2017). This concept, which can be traced back to the early 1980s (Yousefian et al., 2021), reflects perspectives that highlight the separation between the act of governance and the actor of governance, placing governance beyond the scope of the state (and even government) (Omranian Khorasani, 2014). Governance is considered a prerequisite for improving water management (Pahl-Wostl, 2009). Although water governance emerged in the scientific literature as an evolving approach to natural resource management, there is a clear distinction between governance and water management, as stated by Pahl-Wostl (2009). In governance, water management is described as activities for analyzing, monitoring, and implementing developed measures to sustainably manage resources under favorable conditions. Water governance, on the other hand, is described as a social function that regulates the development and management of water resources and services, guiding them toward desirable outcomes and away from undesirable ones (Pahl-Wostl, 2009).

Good governance is directly related to sustainable development. According to many experts, water governance differs from water management due to its supra-governmental nature. In general, governance encompasses the macro and strategic aspects, while management involves the infrastructural aspects (Dehghani et al., 2019). Furthermore, water sector policymaking refers to any policymaking action related to the extraction, supply, treatment, transfer, collection, distribution, and consumption of water (Pilip-Florea, 2012). Water governance refers to the political, economic, social, and administrative framework that determines who has access to water, where, when, and under what conditions, who benefits from its use, and how the costs of water-related services are distributed (Parra-Armenta and Salazar Adams, 2017). Therefore, it has been argued that a paradigm shift is needed from technocratic water management strategies towards regimes that understand the institutional complexities and human dimensions of water resources (Pahl-Wostl et al., 2010). In Iran, water governance, through the design, implementation, and operation of water resource development projects, has led to not only achieving balanced and sustainable rural and regional development goals but also creating disorder, various environmental, economic, and social crises, and exacerbating the development gap (Saidi, 2015). But in the end, the concept of water governance, despite numerous emphasis in different forums, is still vague; Because water faces a variety of functions and values, and different organizations and institutions have different attitudes towards it, in many cases, there are different institutions with different and conflicting interests about water (Teisman et al., 2013). However, through reviewing different definitions of water governance, it can be concluded that: 1) Governance is consistently considered a decision-making process. 2) Decision-making processes occur through institutions (including mechanisms, systems, and traditions). And 3) Decision-making processes involve multiple actors (Jiménez et al., 2020).

Over the past four decades, Researchers have paid increasing attention to sustainable development issues related to water issues, especially governance, management,

and technical Wang et al. (2020). Moving to economic growth without water demand growth a decomposition analysis of decoupling from economic growth and water use in 31 provinces of China. Good water governance is directly related to sustainable development. From the point of view of Jimenez et al., water governance is an important factor for proper and desirable progress toward achieving sustainable development goals (Jiménez et al., 2020).

Regarding the topic of this research, Babuna et al. (2023) concluded that water inequality, water security, and water governance are fundamental parameters that influence the sustainable use of water resources. Through policy formulation and decision-making, water governance determines both water security and water inequality. Ineffectively addressing water inequality poses a threat to water security, leading to poverty, exacerbating underdevelopment, increasing tensions in water consumption, and causing instability. With proper water governance, water inequality can be addressed by implementing approaches that promote equal allocation and sustainable use of water resources (Babuna et al., 2023).

With increasing attention to the concepts of sustainable development and the flexibility of management approaches, the administration of water resources and services has changed significantly over the past years.

Engineering and technology-oriented approaches are currently being scrutinized and more integrated approaches that emphasize good governance have emerged.

In Iran, waste and non-optimal use of water resources is visible. In the issues related to water, there is no strategic and long-term approach, and the plans and actions taken are scattered and short-term.

Also, mainly looking towards the government, and the capacities of the civil society and media sector besides the capacity of the public sector, it is not properly utilized (Saadat et al., 2023). There is no field of effective interaction and synergy between different beneficiaries, which shows that the development-oriented view on water governance is not considered. This issue clarifies the current research.

McIlwain et al. (2023) have titled their research "Power in Adaptive Water Governance: A Review" and highlighted that power dynamics have widely been recognized as key factors in the weak outcomes of environmental governance, particularly in the context of adaptive water governance. The processes of water governance are evolving with a greater emphasis on collaboration and learning. Understanding how power dynamics influence these processes in adaptive governance is crucial for improving governance outcomes. Power dynamics in the realm of adaptive water governance are complex and highly variable, and the theories of power that offer potential explanations for poor governance outcomes are also highly variable (McIlwain et al., 2023).

Whaley (2022) in his review titled "Water governance research in a messy world: a review" acknowledges that research on water governance is confronted with a turbulent world that is challenging to understand. Mainstream policy-oriented approaches tend to simplify and standardize this turbulence, obscuring complexity, power dynamics, and politics. Consequently, these approaches not only promise more than they can deliver but often reproduce unequal

and inequitable governance dynamics. A multitude of critical research efforts have attempted to address these limitations but have had limited impact (Whaley, 2022).

This review identifies this dilemma as its main concern. The article proposes three broad interdisciplinary approaches that seek to manage turbulence by bringing together scalar complexity, institutional diversity, and multiple meanings and performances. The article concludes by revisiting the problem mentioned above: the failure of vital water governance research to influence mainstream policies and practices (Whaley, 2022). Annala (2021) in her study titled "Co-producing drinking water in rural Ethiopia: governance by the name of community management" seeks to understand what kind of power relations are produced among participating actors through the discourse of community management. For governments and development practitioners, this study highlights how the language of community management can be used to (re)produce power structures, opening up spaces for discussion and dialogue.

Keller and Hartmann (2020), by examining the principles of water governance of the Organization for Economic Cooperation and Development (OECD) at the local level in water management in the Netherlands, demonstrated that utilizing these principles of water governance is suitable for water management at the local scale, and these principles can provide awareness to some stakeholders (governmental) in dealing with the water governance process. Furthermore, the evaluation results indicated that water governance in the Netherlands is in a favorable state (Keller and Hartmann, 2020). Jiménez et al. (2020) identified the key elements of water governance, including policy and strategy components, collaboration, financing, arrangement management, planning and preparedness, capacity development, laws and regulations, monitoring, evaluation, and learning. These identified components create an operational framework for assessing and working with water governance, encompassing water service delivery, water resource management, and transboundary waters. Kofi Akamani (2016) discusses adaptive water governance, which integrates human dimensions into water resource governance, particularly in the context of adaptive water governance - participatory, flexible, and learning-based institutions that connect governmental and non-governmental actors at various levels to manage ecosystem-based water and land resources. As an institutional mechanism for integrating human dimensions into water, adaptive water governance highlights four characteristics of adaptive management: (1) the reintegration of humans into nature, (2) the integration of diverse sources and types of knowledge, (3) the promotion of integrated and cohesive management objectives, and (4) the use of polycentric institutions and consultative-analytical processes. Through these mechanisms, adaptive governance can contribute to sustainability, good governance, conflict management, and social-ecological resilience in water resource systems (Akamani, 2016).

Yousefian et al. (2021) conducted a study on this subject in Iran by designing a comprehensive policy framework for water governance. They demonstrated that water governance policymaking in Iran faces multiple

challenges, and there is a need for strategies to reduce its adverse effects. Based on their findings, three categories of challenges were identified: governance gap, policy gap, and operational gap. Additionally, they identified 10 key strategies for water management, including resource management, participatory governance, water economy, enhancing the executive framework, macro-management, water demand management, water supply management, scientific capacity building, customer orientation, and cultural development (Yousefian et al., 2021). In their study, Pourkhesravani et al. (2020) investigated the factors influencing the inefficiency of water resource policies in Iran. They showed that over the past four decades, water resource policies in Iran have been formulated based on short-term and sectoral needs, primarily focusing on agricultural development. The main reason for the inefficiency of these policies can be attributed to the lack of a scientific governance approach in the water resource policy-making process. Similarly, Oskoochi and Asmaeili (2021) analyzed theories of governance and water resource management in Iran, with a focus on water, sustainability, and development. They highlighted the absence of a national and indigenous model for governance that aligns with social values and is compatible with Iran's cultural and historical conditions as one of the reasons for the failure in the development path.

Based on the literature and background, the conceptual model of the research has been depicted (Figure 1).

2. Methodology

The present research aims to design a water governance model in rural communities of Qom province to achieve sustainable rural development. This research is in the quantitative phase and falls under the classification of applied research based on its objectives. In terms of research approach (deductive - from general to specific), due to the impossibility of controlling variables, it is a non-experimental type of research. The statistical population of the study consists of water experts from the Agricultural

Engineering Organization of Qom province, with a total of 163 individuals (official statistics of the organization, 2022), and water experts from the Water Organization of Qom province, with a total of 130 individuals (official statistics of the organization, 2022). Based on Cochran's formula and considering the size of the statistical population, the sample size in this research was calculated to be 170 individuals. A simple random sampling method was used in this study. Additionally, a researcher-made questionnaire was used to collect data. The quantitative questionnaire consists of three sections: the first section includes the personal characteristics of respondents (age, gender, education level, occupation, work experience), the second section covers water governance items, and the third section includes items of factors affecting water governance. The questionnaire's questions are presented in a five-part Likert scale format.

The reliability of the structure was measured by two criteria 1) Cronbach's alpha coefficients 2) composite reliability Cronbach's alpha coefficient is a classic test for reliability analysis.

This test provides an estimate for reliability based on the internal correlation of indicators, And the suitable value for it is greater than 0.7.

To calculate reliability, there is another criterion, which brings advantages over the traditional method of calculating it by Cronbach's alpha and it is called composite reliability (CR).

The superiority of composite reliability over Cronbach's alpha is that the reliability of structures is not calculated in absolute terms, but according to the correlation of their structures with each other.

Also, for its calculation, indicators with higher factor load are more important. As a result, both criteria are used to better measure reliability.

For composite reliability, a value above 0.7 is suitable. construct validity, is measured by two criteria 1) Convergent Validity and 2) discriminant validity

Data analysis has been analyzed using SmartPLS v3 software and structural equation method with a partial least squares approach.

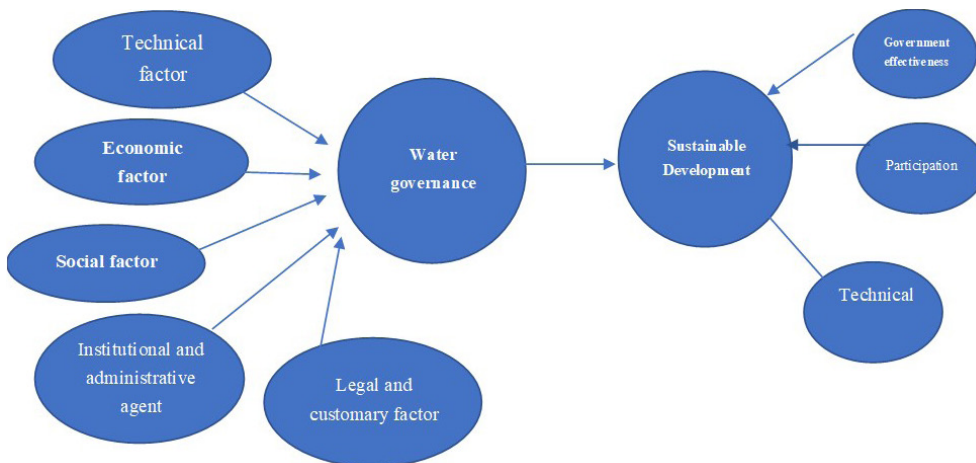


Figure 1. Conceptual Model of the Research Methodology.

3. Results

The results of this study in the demographic sections are presented in Table 1. According to the results in the studied sample, there were 12 individuals under the age of 30, 66 individuals aged 30 to 40, 79 individuals aged 40 to 50, and 13 individuals above the age of 50.

Out of the participants, 15 individuals had a bachelor's degree, 71 individuals had a master's degree, and 84 individuals had a doctoral degree. Additionally, 45 individuals had work experience of less than 10 years, 66 individuals had work experience between 10 to 20 years, and 59 individuals had work experience between 20 to 30 years.

This section of the research has been designed within the framework of structural equation modeling using the approach of partial least squares. To test the

conceptual model of the research, the fit of measurement models is first assessed to ensure the validity of the relationships within the measurement models. In this stage, the measurement of constructs is determined. In the subsequent stage, after the model components are clearly defined and depicted, factor loading coefficients and tests of reliability and validity are calculated and presented, providing the researcher with the ability to interpret the relationships within the model.

Measurement Model of Sustainable Development: Confirmatory factor analysis is used to examine the relationships between observed variables (questionnaire items) and the latent variable in the sustainable development model. The following diagrams illustrate the measurement model of sustainable development based on factor loadings and t-values (Figure 2).

Table 1. Demographic Characteristics.

Age Group	Frequency	Percentage of Frequency	Education Level	Frequency	Percentage of Frequency	Work Experience	Frequency	Percentage of Frequency
Under 30	12	7.1	Associate's Degree	15	8.8	Under 10 years	45	26.5
30 to 40	66	38.8	Bachelor's Degree	71	41.8	10 to 20 years	66	38.8
40 to 50	79	46.5	Master's Degree	84	49.4	20 to 30 years	59	34.7
Over 50	13	7.6	-	-	-	-	-	-
Total	170	100	total	170	100	total	170	100

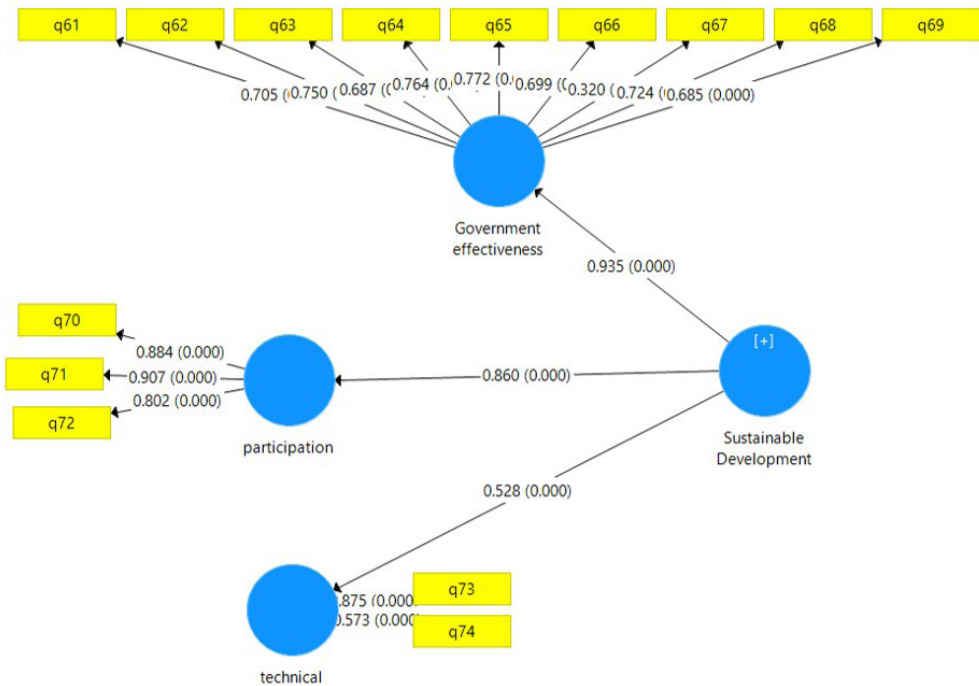


Figure 2. Measurement Model of Sustainable Development based on Factor Loadings and Significance Levels.

The significance criterion of each path and related factor is that the corresponding t value is greater than 1.96 and the factor loading coefficient is not less than 0.4. The results of confirmatory factor analysis and examination of factor loading coefficients and t-values indicate that all factor loading coefficients of the items are greater than 0.4, and the significance level of all items is greater than 1.96. This suggests that the variance of the indicators with their corresponding construct is acceptable, indicating the suitability of the items for measuring the latent variable of sustainable development. This also indicates the significant relationship between the correlations of the items and the latent variable of sustainable development. The specifications of the items in the measurement model of sustainable development are presented in Table 2.

Measurement Model of Technical Factor: Confirmatory factor analysis is used to examine the relationships between observed variables (questionnaire items) and the latent variable in the technical factor model. The following diagrams illustrate the measurement model of the technical factor based on factor loadings and t-values (Figure 3).

The results of confirmatory factor analysis and examination of factor loading coefficients and t-values indicate that all numbers except for item 6 have t-values greater than 1.96. This suggests that the variance of the indicators with their corresponding construct is acceptable, indicating the suitability of the items for measuring the latent variable of the technical factor. The specifications of the items in the measurement model of the technical factor are presented in Table 3.

Measurement Model of Economic Factor: Confirmatory factor analysis is used to examine the relationships between observed variables (questionnaire items) and the latent variable in the economic factor model. The following diagrams illustrate the measurement model of the economic factor based on factor loadings and t-values (Figure 4).

The results of confirmatory factor analysis and examination of factor loading coefficients and t-values indicate that all numbers have t-values greater than 1.96. This suggests that the variance of the indicators with their corresponding construct is acceptable, indicating the suitability of the items for measuring the latent variable of the economic factor. The specifications of the items

Table 2. Specifications of items in the measurement model of the sustainable development.

t-value	Factor loading	Item	Indicator
58/740	0/935	Government effectiveness	Government effectiveness
13/023	0/705	Is there fair access to water by the people?	q61
17/006	0/750	To what extent is the public's trust in officials regarding water governance?	q62
12/052	0/687	What extent of government policy-making in water governance do you consider desirable?	q63
23/558	0/764	What extent of government service quality in water governance do you consider desirable?	q64
17/189	0/772	To what extent is attention given to the issue of cultural change in water governance?	q65
16/587	0/699	To what extent is the follow-up by officials on water issues and problems?	q66
3/288	0/320	In what manner is the level of transparency and provision of accurate information regarding water affairs by managers and employees of operating companies?	q67
16/070	0/724	Are the tariffs set for water projects considered appropriate?	q68
14/539	0/685	How do you evaluate the handling of offenders and water-related violations?	q69
50/247	0/860	Participation	participation
40/334	0/884	How do you evaluate the level of farmers' participation in the maintenance and repair of irrigation networks?	q70
79/530	0/907	How do you evaluate the level of farmers' participation in irrigation network policy-making?	q71
26/395	0/802	How do you evaluate the performance of irrigation cooperatives?	q72
6/180	0/528	technical	technical
10/038	0/875	What is the extent of farmers' use of modern irrigation methods?	q73
3/666	0/573	Do you think farmers waste water?	q74

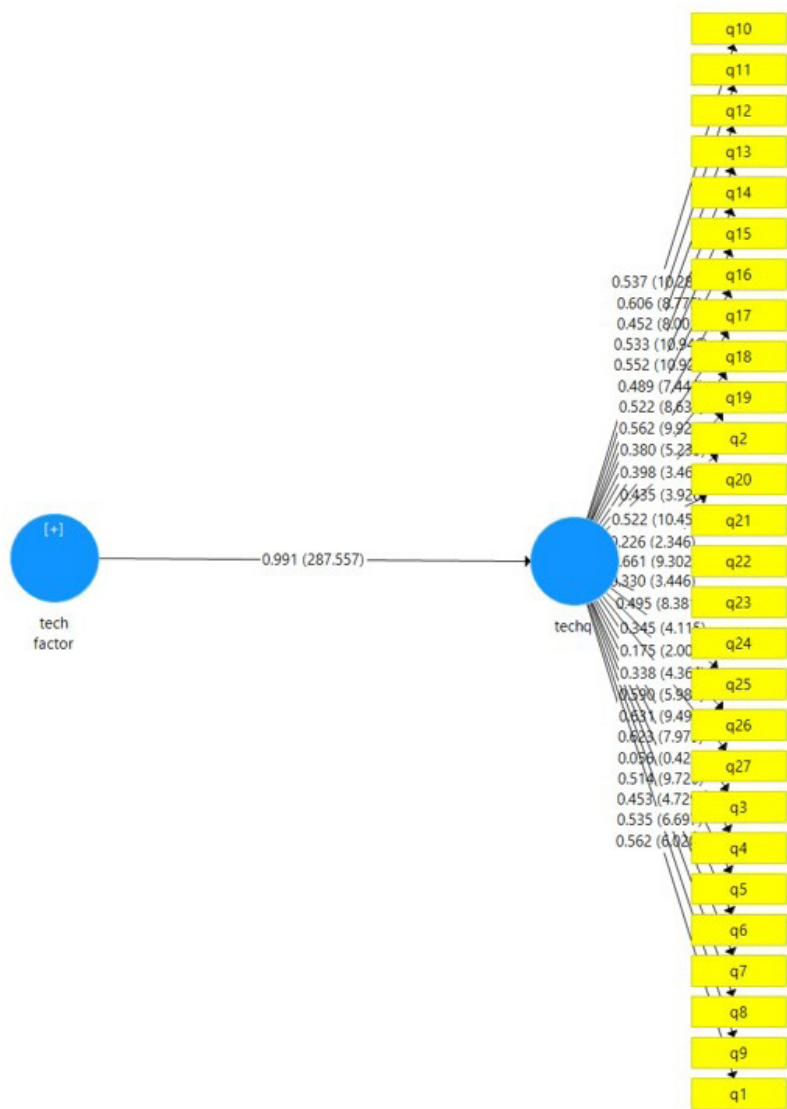


Figure 3. Measurement Model of Technical Factor based on Factor Loadings and t-values.

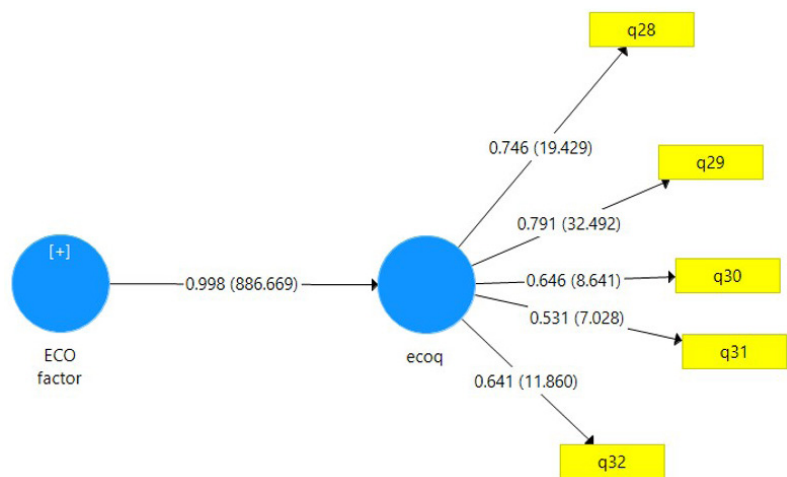


Figure 4. Measurement Model of Economic Factor based on Factor Loadings and T-values.

Table 3. Specifications of items in the measurement model of the technical factor.

t-value	Factor loading	Item	Indicator
6/020	0/562	Equipping farms with modern irrigation methods is effective in improving water governance.	q1
3/926	0/435	Using water-saving devices is effective in improving water governance.	q2
5/985	0/590	Having suitable water transfer infrastructure is effective in improving water governance.	q3
9/495	0/631	Removing weeds and debris along waterways to prevent water wastage is effective in improving water governance.	q4
7/979	0/623	Implementing soil conservation measures to preserve groundwater is effective in improving water governance.	q5
0/423	0/056	Deepening plowing to optimize water consumption is effective in improving water governance.	q6
9/720	0/514	Irrigating plants according to their water needs through understanding the water requirements of plants is effective in improving water governance.	q7
4/729	0/453	Eliminating bends and curves in traditional water channels is effective in improving water governance.	q8
6/697	0/535	Integrating and leveling the lands to reduce water loss at the farm level is effective in improving water governance.	q9
10/287	0/537	Reducing the distance between the water source and the land is effective in improving water governance.	q10
8/775	0/606	Covering water supply channels and canals is effective in improving water governance.	q11
8/005	0/452	Transferring spring crops to autumn crops based on regional conditions in Qom province is effective in improving water governance.	q12
10/946	0/533	Converting earthen channels to concrete ones is effective in improving water governance.	q13
10/923	0/552	Using salt-tolerant plants in Qom province is effective in improving water governance.	q14
7/444	0/489	Optimizing the use of surface water is effective in improving water governance.	q15
8/638	0/522	Implementing precision irrigation is effective in improving water governance.	q16
9/925	0/562	Performing soil texture tests to determine the soil type before crop cultivation, in terms of water consumption, is effective in improving water governance.	q17
5/235	0/380	Expanding greenhouse cultivation based on the regional conditions in Qom province is effective in improving water governance.	q18
3/464	0/398	Implementing crop rotation to preserve soil moisture is effective in improving water governance.	q19
10/458	0/522	Nighttime irrigation, due to lower water surface levels and reduced evaporation rates during the middle of the day, is effective in improving water governance.	q20
2/346	0/226	Electrifying diesel-powered wells is effective in improving water governance.	q21
9/302	0/661	Employing appropriate cropping patterns based on the conditions of Qom province is effective in improving water governance.	q22
3/446	0/330	Considering new water resources such as saline water and wastewater in improving water governance is effective.	q23
8/381	0/495	Installing gates, meters, and measuring devices in the field is effective in improving water governance.	q24
4/115	0/345	Creating transparency and monitoring the implementation of volumetric water delivery through the installation of smart meters is effective in improving water governance.	q25
2/003	0/175	Developing and promoting dry farming in agriculture is effective in improving water governance.	q26
4/366	0/338	Providing training and promoting technical knowledge by experts is effective in improving water governance.	q27

in the measurement model of the economic factor are presented in Table 4.

Measurement Model of Social Factor: Confirmatory factor analysis is used to examine the relationships between observed variables (questionnaire items) and the latent variable in the social factor model. The following diagrams illustrate the measurement model of the social factor based on factor loadings and t-values (Figure 5).

The results of confirmatory factor analysis and examination of factor loading coefficients and t-values indicate that all numbers have t-values greater than 1.96. This suggests that the variance of the indicators with their corresponding construct is acceptable, indicating the suitability of the items for measuring the latent variable of the social factor. The specifications of the items in the measurement model of the social factor are presented in Table 5.

Measurement Model of Institutional and Administrative Factor: Confirmatory factor analysis is used to examine the relationships between observed variables (questionnaire items) and the latent variable in the institutional and

administrative factor model. The following diagrams illustrate the measurement model of the institutional and administrative factor based on factor loadings and t-values (Figure 6).

The results of confirmatory factor analysis and examination of factor loading coefficients and t-values indicate that all numbers have t-values greater than 1.96. This suggests that the variance of the indicators with their corresponding construct is acceptable, indicating the suitability of the items for measuring the latent variable of the institutional and administrative factors. The specifications of the items in the measurement model of the institutional and administrative factors are presented in Table 6.

Measurement Model of Legal and Normative Laws Factor: Confirmatory factor analysis is used to examine the relationships between observed variables (questionnaire items) and the latent variable in the legal and normative laws factor model. The following diagrams illustrate the measurement model of the legal and normative laws factor based on factor loadings and t-values (Figure 7).

Table 4. Specifications of items in the measurement model of the economic factor.

t-value	Factor loading	Item	Indicator
19/429	0/746	Providing targeted subsidies in the water sector is effective in improving water governance.	q28
32/492	0/791	Paying attention to insurance for buildings, facilities, infrastructure, irrigation canals, and agricultural wells is effective in improving water governance.	q29
8/641	0/646	Creating an attractive investment environment in the water sector to attract private sector participation through institutions, for example, providing customs exemptions for importing goods and equipment needed for the implementation and operation of water projects, and establishing intelligent and flexible tariffs, is effective in improving water governance.	q30
7/028	0/531	Imposing taxes on farmers who excessively withdraw water is effective in improving water governance.	q31
11/860	0/641	Providing low-interest loans to farmers and extending the repayment period is effective in improving water governance.	q32

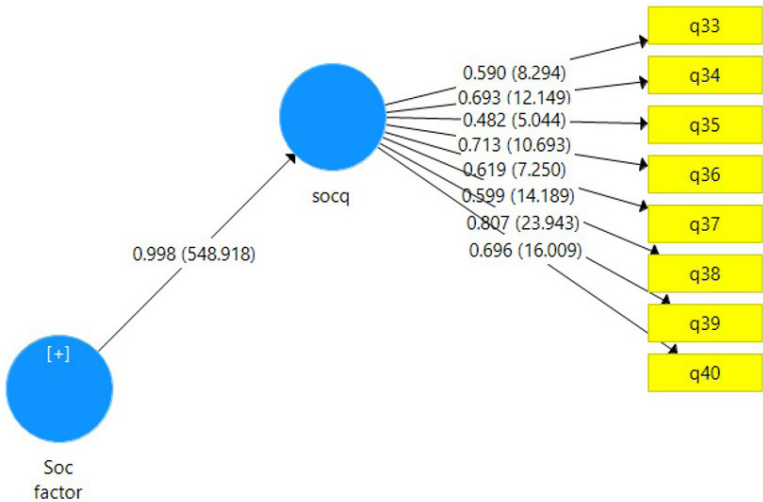


Figure 5. Measurement Model of Social Factor based on Factor Loadings and T-values.

Table 5. Specifications of items in the measurement model of the social factor.

t-value	Factor loading	Item	Indicator
8/294	0/590	Strengthening community-based organizations in the water sector, such as water user associations, is effective in improving water governance.	q33
12/149	0/693	The participation of farmers in water resource management, such as utilizing indigenous knowledge, local capabilities, and social capital in the region, to improve the alignment of canals, modify project designs, and enhance project management during and after implementation, is effective in improving water governance.	q34
5/044	0/482	Paying attention to participatory and active learning methods in the field of water is effective in improving water governance.	q35
10/693	0/713	Distributing magazines and brochures related to water awareness in the community is effective in improving water governance.	q36
7/250	0/619	Using text messages and sending messages to promote social awareness is effective in improving water governance.	q37
14/189	0/599	Supporting local technologies and innovations in the field of water in Qom province is effective in improving water governance.	q38
23/943	0/807	Utilizing the capacity of national media and organizing effective conferences and programs to raise social awareness in the water sector is effective in improving water governance.	q39
16/009	0/696	Emphasizing and highlighting the social responsibility of individuals about water, raising awareness among people about the vulnerability of water, and fostering the belief that the water issue is intertwined with their destiny is effective in improving water governance.	q40



Figure 6. Measurement Model of Institutional and Administrative Factor based on Factor Loadings and T-values.

The results of confirmatory factor analysis and examination of factor loading coefficients and t-values indicate that all numbers have t-values greater than 1.96.

This suggests that the variance of the indicators with their corresponding construct is acceptable, indicating the suitability of the items for measuring the latent variable

Table 6. Specifications of Items in the Agent-Based Measurement Model of Institutional and Administrative Factors.

t-value	Factor loading	Item	Indicator
7/633	0/506	Government support for water-efficient products is effective in improving water governance.	q41
3/467	0/317	Introducing new industries that align with the water capacity of the region is effective in improving water governance.	q42
11/117	0/619	The activation and collaboration of various entities in the form of a Water Management Coordination Council is effective in improving water governance.	q43
5/230	0/423	Conducting explanatory sessions and training workshops at the level of managers and experts in the Ministry of Energy to clarify the key areas that are effective in improving water governance.	q44
8/109	0/522	Increasing strictness in issuing well permits is effective in improving water governance.	q45
9/329	0/521	Identifying and engaging with international centers and institutions, as well as actively participating in important international conferences and events, is effective in improving water governance.	q46
19/194	0/717	Utilizing specialized experts and managers in the field of water is effective in improving water governance.	q47
30/742	0/755	Developing and supporting water-efficient industries is effective in improving water governance.	q48
15/967	0/670	Increasing the skills of the organization's experts through in-service training is effective in improving water governance.	q49
7/138	0/485	Giving special attention to environmental considerations in the implementation of projects is effective in improving water governance.	q50
14/323	0/638	Educating and training specialized water professionals is effective in improving water governance.	q51
8/370	0/578	Increasing collaboration between water-related institutions and provincial universities through organizing conferences and seminars is effective in improving water governance.	q52
5/578	0/455	Increasing supervision over lower-level experts in organizations to prevent corruption and issues such as bribery is effective in improving water governance.	q53
8/800	0/560	Providing annual performance reports of participants and assessing the level of success in implementing programs, while highlighting challenges and deficiencies, is effective in improving water governance.	q54
6/834	0/499	Holding regular seminars and meetings specifically focused on ways to reduce household water consumption in rural areas is effective in improving water governance for rural water and sanitation.	q55
10/013	0/591	Establishing a water police force to enhance water enforcement and prevent violations is effective in improving water governance.	q56

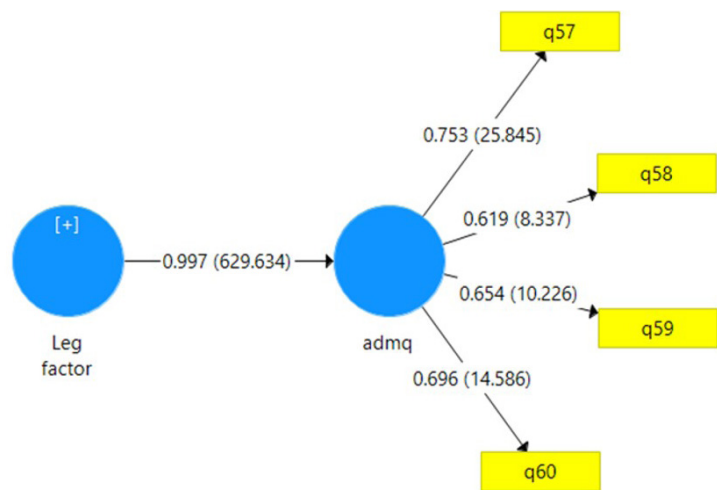


Figure 7. Measurement Model of Legal and Normative Laws Factor based on Factor Loadings and T-values.

Table 7. Specifications of Items in the Measurement Model of Legal and Customary Laws.

t-value	Factor loading	Item	Indicator
25/845	0/753	Issuing water permits for water rights holders is effective in improving water governance.	q57
8/337	0/619	Considering water rights as an independent academic discipline is effective in improving water governance.	q58
10/226	0/654	Increasing penalties for unauthorized well drilling is effective in improving water governance.	q59
14/586	0/696	Separating water ownership from land is effective in improving water governance.	q60

of the legal and normative laws factor. The specifications of the items in the measurement model of the legal and normative laws factor are presented in Table 7.

4. Discussion and Conclusion

Water resources around the world are increasingly under pressure as climate change only exacerbates the existing challenges. It is now widely accepted that at the global to local scale, “the heart of the global water crisis is rooted in power, poverty, and inequality, not physical availability” (United Nations, 2003; Rogers and Hall, 2003; Watkins, 2006). In a dynamic and rapidly changing context - with continuous changes in political, legal, economic, social, and technological aspects related to water - it is important to ensure that efforts to improve water resource management and services provide the best long-term outlook. Additionally, minimizing the impact of disasters on water resources and services is equally important. Strengthening the capacity to adapt and cope with turbulence, challenges, and external changes is crucial for learning, self-organization, rapid response, and improvement (Arnold t al., 2017). These objectives have attracted attention in terms of sustainable development and resilience concepts, both in increasing interest in the literature (Hugé et al., 2013) and embedding these concepts in the global agenda for 2030. Creating sustainable, resilient, and inclusive communities. If, in 1410, all the water resources inside and outside Qom province will be used for drinking and sanity consumption total production will be equal to consumption and this means being in a very critical situation.

In such a situation, it will not be possible to provide water for the industry. Agricultural development and residential units fall in spaces where there is water.

However, more than 75% of the province's drinking water is imported from outside the province, and in this sense, it is in a more difficult situation compared to the rest of the provinces (Web site of Iran Water News Network, 2021).

Water governance in Qom province has been the main subject of this study, Because, on the other hand, water governance plays a vital role in sustainable rural development in developing countries, and on the other hand, lack of water leads not only to environmental pressures but also to social tensions.

For this reason, providing the ideal model of water governance and or reforming the current water governance

in Qom province in line with sustainable rural development is the main topic of this thesis.

According to the International Patent Classification (IPC), water technologies include innovations related to water supply, distribution, treatment, and wastewater, such as irrigation technologies, water collection and distribution, groundwater extraction, desalination, and more (Moro et al., 2018).

Numerous studies have shown that technological advancements in water can contribute to efficient water consumption. For example, Wang et al. (2020) found that advancements in water technology have led to a decoupling of water consumption in China from economic growth. Song et al. (2018) analyzed factors affecting water resource efficiency and highlighted the significant role of technological improvements in enhancing water efficiency. Zhang et al. (2019) identified innovative agricultural irrigation technologies as a crucial measure to combat water scarcity. Researchers have also studied regional inequalities in this regard. Technological advancements had a positive impact on the overall efficiency of industrial water resources in western China but had a negative impact in central China (Jin et al., 2019). Zou and Cong (2021) created an index system to assess the efficiency of water resource utilization and found that technological advancements have led to improved efficiency. However, the impact of technological progress is not one-sided. Li et al. (2022) found that mandatory energy-dependent technological advancements have resulted in increased coal consumption. Liao and Ren (2020) discovered that when the level of technological progress is below a certain threshold, it has a positive impact on resource efficiency, or vice versa. In summary, technological advancements have dual effects.

Jiménez and Pérez-Foguet (2013) emphasize the importance of technology in water storage by examining the relationship between technology and the performance of rural water points. Ni et al. (2020) reviewed China's rural water conservation development and technology needs. Blanki (2007) study examines water conservation technology and water conservation in China and all of them have emphasized the importance of the technical factor in water management and the role of governance and development of rural areas.

According to the results, it has been identified that institutional and administrative support is the second most influential factor in designing the water governance

model. It should be noted that rural water, along with mismanagement, has become a problem in most developing countries (Moses, 2015). The consequence of this mismanagement includes increased poverty, significant healthcare costs for individuals, as well as other social inequalities and gender disparities. Larson (2010) states that water management is not only about addressing resource scarcity but also encompasses complex interactions of cultural, social, political, and environmental aspects of water. Political ecology theories have been instrumental in understanding the dynamics of water resource management. In the modern era, water is connected to broader meanings beyond being a natural resource. This has led to the definition of water resource management as the use of structural and non-structural measures to control natural and productive water systems for beneficial human and environmental purposes (Grigg, 1996). Jiménez and Pérez-Foguet (2013) reached this conclusion by examining the relationship between technology and the performance of rural water points to several weaknesses that continue to undermine poverty eradication strategies at different administrative levels (from local to national). Low-quality water service, Unsustainability of built infrastructure, Difficulties in targeting the poor, and internal information systems have been inadequate.

Hutchings (2018) in his article on the necessity of institutional alignment to deal with the challenge of rural water supply as one of the problems of social participation or case collective action to realign the discourse and collective management conceptualization of Rural water supply.

Social factors have been considered as the third influential factor in designing the water governance model in rural communities of Qom province. Studies show how traditional water management systems actively involve local communities in managing and administering water resources (Abeywardana et al., 2018). Thus, the role of local elites belonging to social classes, tribes, or dominant castes can be observed in some traditional water management systems at the community level (Krishan, 2011). By reclaiming norms and social traditions, the process of modern development enhances community-based participatory mechanisms that empower communities in decision-making, management, and budget allocation (Mansuri and Rao, 2004).

Previous sources and studies show alignment with the findings of this research. Shunglu et al. (2022) in the study of barriers to participatory water governance: Critical analysis examined the developments of the society and stated that participatory approaches in development programs include shared resources to revive the role of society in the management of these resources. Of course, social participation is essential to ensure the successful and equitable use of such resources. Hutete and Sibanda (2023) by studying water governance and social equity in rural areas of South Africa showed that Socioeconomic, environmental, institutional, and governance factors strongly affect water services. Also, achieving social equality in a society which deeply rooted in inequality, realizing human rights, and achieving universal access

to water, requires an integrated approach to sustainable development.

The economic factor has been identified as the fourth influential factor in designing the water governance model. In explaining this, it is stated that there is often a discussion that water services should be subsidized and under government control for several reasons: water is essential for life, water supply has natural monopoly characteristics, and it is a vital infrastructure. As a critical infrastructure, ensuring water supply requires precise coordination of its main transactions to maintain technical integrity and economic coherence in the system (Ménard, 2009). Revilla (2021) in recognizing the role of non-water factors in water governance situations: The evaluation of external water governance states that traditionally, the governance of water problems has been approached and framed from a water-centered perspective. However, influencers, actors, and institutions at different scales Outside the water sector (i.e., non-water actors) increasingly drive the processes and outcomes of water governance in an interconnected world. Examples of non-water factors are demographic drivers, energy policies, and institutional investors in the financial sector.

For these reasons, governments worldwide continue to regulate the pricing, quality, and standards of water services. At least 85% of water companies globally are under government control, although it is also true that many of these companies often have poor performance. This raises the important, yet unresolved question: How can public water company management be improved to make them more efficient, responsive, and sustainable? Many studies (Araral Junior, 2008; Rogers and Hall, 2003; Weimer and Vining, 2017) suggest that giving them autonomous status is a key solution, but the political economy of water makes this challenging in practice.

Effective rule of law and organized government are essential for successful water governance, and water policy and strategy stem from government actions and public participation. Structural norms in Iran mostly refer to economic factors and their purpose is to ensure private investment in the development of the economic potential of this resource. while the regulatory norms are related to the regulatory aspect and non-profit aspects of water governance.

Grigg (2011) in his study "Water Governance: From Ideals to Effective Strategies" showed that Integrated water solutions require effective governance as well as appropriate technologies and management tools How can decision makers identify the actions needed for policy, empowerment, and control as well as progress even as other organizational arrangements continue to evolve?

It acknowledges the fact that, in addition to formal government actions, water decisions are influenced by informal forces, networks, and behavioral patterns. Such descriptions of water governance quickly become complex, but its three main functions (policy, empowerment, and control) are the key elements of success. By combining these aspects with the three core elements of management (planning, implementation, and operations), the governance requirements for a wide range of water-related decisions and trade-offs can be demonstrated.

Each of the five factors in the water governance model in Qom province can be considered as a separate topic of research. Also, sustainable development is one of the important issues that can be considered from other angles. And its results be compared with the present research.

One of the limitations of this research is the administrative bureaucracy in Iran's offices and the slow and time-consuming way of conducting the research. Another limitation of this research is the difficulty of accessing statistics and information, as well as the limitation of this research to other researchers and their perspectives on this subject.

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