Environment and Water Engineering

Homepage: www.jewe.ir

Critical evaluation and formulation of strategic water governance strategies for the Karkheh-Olia watershed with a foresight approach

Mehdi Rahimian [1✉], Fatemeh Sepahvand [2], Seyed Mehdi Hosseini [3]

and Homa Molavi [4]

[1]Department of Agricultural Economics and Rural Development, Faculty of Agriculture, Lorestan University, Lorestan, Iran
[2]Department of Agricultural Extension and Education, Faculty of Agriculture, Bu-Ali Sina University (BASU), Hamedan, Iran
[3]Department of Agricultural Extension and Education, Faculty of Agriculture, Science and Research Branch of the Islamic Azad University (SRBIAU), Tehran, Iran
[4]Department of Mechanical, Aerospace & Civil Engineering, Infrastructure and Resilience, The University of Manchester, Manchester, UK

ARTICLE INFO	ABSTRACT
	Water governance assessment is an important tool that can play a key role in achieving sustainable water resources management. By identifying the strengths and weaknesses of structures, this assessment helps to formulate more effective strategies to improve governance. In the meantime, foresight as an analytical and management tool can help achieve governance and allow policymakers to make appropriate and strategic decisions. In this regard, the present article has examined the current status of water governance in the Karkheh-Olia basin and has used the OECD indicators and the CIA technique in order to assess the status of governance. The sample size was 26 experts, university professors, and leading farmers who were selected in a criterion-based manner. The results of this section showed that compared to the global standard, the Karkheh-Olia basin needs to improve in all indicators. Employing experts in relevant institutions, coordination and coherent communication between the ministry and executive organizations, regular monitoring of regional water conditions and informing the general public, using modern land and plains monitoring technologies to control drilling and information systems and monitor harvesting, and policy-making for the development of non-agricultural businesses were among the items identified as key factors in good water governance in the agricultural sector.
Corresponding author: M. Rahimian ✉ rahimian.m@lu.ac.ir	

Highlights	• Good water governance can prevent future crises in this sector. • The foresight approach can evaluate and analyze the entirety of a system. • The innovation of this research is in using the foresight technique to realize water governance through critical evaluation

1. Introduction

Water is the source of life, but excessive and unsustainable extraction from it has led to a decline in resource levels (FAO, 2023). It is predicted that in the coming decades, 50 percent of cultivated areas will face serious challenges due to water scarcity (Cosin, 2024). The agricultural sector, as the largest water consumer in many countries around the world, is affected by climate change, population growth, and the increasing need for food production; for this reason, effective governance in water resource management can prevent future crises (FAO, 2023). One of the roles of governance is the optimal management of water resources (Cosin, 2024; IPCC, 2021; Grafton & Ward, 2023). One of the most important aspects of water resource governance in agriculture is proper policymaking and adopting comprehensive approaches for the

appropriate allocation and distribution of water resources. One of the most important aspects of water resource governance in agriculture is proper policymaking and adopting comprehensive approaches for the appropriate allocation and distribution of water resources (Pahl-Wostl & Knieper, 2014; Amini et al., 2009). Critical evaluation, through deep analysis and questioning of structures, processes, and outcomes of water governance, helps identify weaknesses and improvement opportunities (SIWI, 2020). Improving governance as one of the key components in sustainable development and utilizing resources for public welfare requires identifying weaknesses through evaluation and providing appropriate solutions, and strategies as pathways to achieving goals play a vital role in guiding policies and reforms (OECD, 2018). To achieve water governance in the agricultural sector, foresight as an analytical and management tool plays a vital role (Munir et al., 2010). Future studies allow for a clearer analysis of risks and opportunities in water management (Pahl-Wostl, 2007). This approach as a decision-making tool can lead to improved water governance in agriculture and help reduce uncertainties in water resource management (Gerlak et al., 2021). The present research has been conducted in line with strategic analysis for improving water resource management in the Karkheh Olia Basin, using a foresight approach. The study area has had problems in water resource management over the past few decades, to the extent that no point in this basin has remained immune from drought risk. On the other hand, the lack of executive coordination and sometimes even conflicts between the goals and programs implemented among institutions and organizations that are somehow related to water resources is another existing problem related to groundwater resource management in the study area (Sepahvand et al., 2022).

In addition to these, poverty and lack of job opportunities have been among the most prominent characteristics of rural communities in this region, and the people of this region mainly have agriculture-based livelihoods, which has increased pressure on water resources. Farmers in this region mainly cultivate crops that have higher sales value. Most of these crops (sugar beet, watermelon, potato, etc.) have higher water consumption compared to other crops (Haghiabi & Mastorakis, 2009). Water pollution is also another major challenge in the Karkheh-Olia Watershed (Ehteshami et al., 2018). The aim of this research is to assess the status of good water governance in the Upper Karkheh watershed and develop strategies to achieve good water governance in this region.

2. Materials and Methods

This research is applied in terms of its purpose, descriptive in terms of data collection type, and future research and normative in terms of data analysis. To achieve the research objectives, the Cross Impact Analysis (CIA) technique was used.

2.1 Study area

Parts of Lorestan Province that fall within the Karkheh-Olia Watershed include the counties of Khorramabad, Selseleh,

Delfan, Kohdasht, Romeshkan, and Pol Dokhtar, collectively referred to as the Karkheh-Olia Watershed (Tajari et al., 2015). The research implementation stages are described step by step below:

2.2 Assessment of good governance status
2.2.1 Data collection tools

To assess the current status of local water governance in the study area, a structured questionnaire derived from OECD (2018) indicators was used. The validity of the questionnaire was confirmed by experts and water management specialists, and its reliability was verified by calculating Cronbach's alpha coefficient. The questionnaire content was as follows: First section: Respondent characteristics (age, gender, place of service, position, and work experience). Second section: Seven standard dimensions of good water governance, namely: Accountability (6 questions), Participation (5 questions), Responsibility (6 questions), Rule of Law (13 questions), Equity and Effectiveness (11 questions), and Political Stability (6 questions).

2.2.2 Statistical population

The statistical population of this research consisted of experts and activists in water resource management in the Karkheh-Olia Watershed. 26 heterogeneous individuals and experts (in terms of education level, type and place of employment, work experience and research in related topics) were determined as the sample size and selected using purposive snowball sampling method. Selection of heterogeneous samples (diverse in terms of expertise, experience and perspective) is recommended for several reasons, including "broader coverage of perspectives, reduction of group bias, increased validity and generalizability of results, and strengthening of consensus process" (Okoli & Pawlowski, 2004). The criteria considered for selecting individuals were:

Having education related to topics directly or indirectly related to water resource management in various institutions (watershed management, forestry, agricultural extension and education, water engineering, environment, etc.); Having research and investigation experience with water resource management areas; Outstanding farmers of the year who are knowledgeable about the topic throughout the region; Officials of related institutions and organizations; and Having work connections in the field of the research topic.

2.3 Factors affecting good governance

In this section, based on semi-structured interviews, the necessary data were collected regarding the factors affecting the improvement of good water governance in the Karkheh-Olia watershed. Each respondent was then asked to briefly write down their opinion anonymously. The collected interviews were analyzed using content analysis. Based on the initial results, 36 strategies were identified, and after eliminating duplicates, 18 final strategies were selected.

2.4 Good governance strategies

There are two major schools of foresight: The Shell School (from the 1960s to the early 21st century) and La Prospective (starting in the 1970s). This study is conducted within the framework of the La Prospective school, which in some

studies is also referred to as the Godet Model. This model uses structural analysis to examine influential drivers. The key characteristics of this school include a general framework and a normative approach. While it is primarily expert-driven, it does not exclude the participation of stakeholders in each issue (Godet & Durance, 2011, Bañuls & Turoff, 2011, Dai et al., 2015). This technique, as a foresight tool, identifies the defining role of a variable in relation to other variables in a system and, by assessing their possible mutual impacts, identifies variables that play a key role in the system's future development (Panula-Ontto et al., 2018; Hajiani, 2017). In this technique, the goal is to identify key drivers among the effective strategies derived from the previous interview section. For this purpose, a cross-impact matrix is developed and returned to the respondents, who are asked to score the interactions. The selected variables are rated on a scale from zero (no impact) to three (direct impact). The data were analyzed using MIC-MAC Software.

3. Results and Discussion

3.1 Demographic characteristics of respondents

The sample size in this study consisted of 26 individuals, including experts, university professors, and leading farmers. According to the descriptive results, 23.07% of the respondents were female, and 76.92% were male. Regarding education level, 46.15% held a master's degree, 30.76% a bachelor's degree, and the remaining 23.07% held a PhD. The results related to work experience showed that the respondents had an average of 12.8 years, with a range between 8 to 25 years.

3.2 The state of good water governance in the region

3.2.1 Accountability

The average score for this dimension in the study area was 2.42, which is below average. A low score in accountability reflects a lack of transparency and the inability of institutions to deliver public information. When compared to the average score in developed countries, typically between 3.5 to 4.5 (UNECE, 2023), the score in this region indicates weak performance in this area of water governance.

3.2.2 Responsibility

Responsibility refers to the extent to which government institutions are committed to their assigned duties and obligations. The score for responsibility in the Karkheh-Olia watershed was 2.84. Compared to countries with good governance, where the average is usually 3.5 to 4.5 (World Bank, 2023), this score is unacceptable. Improving this indicator in the Karkheh-Olia watershed requires strengthening institutional responsibility through increased oversight and performance monitoring. Additionally, through education and awareness, experts should be encouraged to recognize how their responsibility contributes to achieving good water governance.

3.2.2 Rule of Law

This index generally scores above 4 (OECD, 2018). The 0.76 score for this index in the study area reveals serious issues in law enforcement and potential corruption in water resource governance and management in the Karkheh-Olia watershed.

3.2.3 Participation

The score for this dimension was 2.63, which is below the average and indicates a need for planning to increase engagement and participation of all stakeholders and local communities in the decision-making processes in the Karkheh-Olia watershed.

3.2.4 Equity

Equity (Justice) refers to the fair distribution and access to available water resources among all stakeholders during water resource management. The global average for this dimension is generally around 4 (Global Water Partnership, 2022), but the 2.52 score in Karkheh-Olia reflects unequal distribution and weak equity among users.

3.2.5 Effectiveness

Effectiveness measures the degree to which actions taken have succeeded in achieving their goals. In high-performing countries, this indicator typically scores around 4 (FAO, 2023). In the Karkheh-Olia watershed, with a score of 2.48, there is a clear need to review integrated management strategies and to implement more effective irrigation methods.

3.2.6 Political Stability

The average score for this indicator in developed countries is above 4 (IISD, 2023). However, in the Karkheh-Olia watershed, it was only 2.50. Like the other evaluated dimensions, this indicates an unstable political environment in the study area.

3.3 The CIA technique

Table 1 presents the results obtained from the Cross-Impact Analysis (CIA) technique. Each factor was assigned a unique abbreviation (code) for reference in the CIA matrix. In the next step, the Cross-Impact Matrix was developed. The indicators were returned to the same participants, and they were asked to assign weights to the items. In the next step, the scores from the Cross-Impact Matrix were entered into the MIC-MAC software. The results of this analysis show that, among the 18 indicators, five key factors were identified as the most critical. These key factors, in order of importance, are "Employment of specialized personnel in relevant institutions, Coordinated and integrated communication between ministries and executive organizations, Regular monitoring of regional water conditions and public dissemination of information, Use of advanced technologies for monitoring fields and plains to control drilling and manage information systems and extraction monitoring & Policymaking to promote the development of non-agricultural businesses". Pahl-Wostl & Knieper (2014) also identified the employment of experts in relevant institutions as the most important factor in achieving good water governance. Regarding the second factor, Sepahvand et al. (2022) believe that the lack of executive coordination between institutions and organizations related to water resources is one of the fundamental problems in groundwater governance and management in the Karkheh-Olia watershed. Basher (2006) found that systematic and

participatory information-sharing, for example, consulting with farmers when designing messages, builds trust and increases farmers' adherence to irrigation and cropping recommendations.

Table 1 Factors affecting good water governance in Karkheh-Olia

Long name	Code	Long name	Code
Allocation of Required Water Shares for Recharge Wells in Riverbed Areas	1	Policy Making for the Development of Non-Agricultural Businesses	10
Regulating the Conflict between Upstream and Downstream Water Resources within Watersheds	2	Appropriate Actions to Address Water Consumption Imbalance	11
Employing Specialists in Relevant Organizations	3	Implementation of Crop Patterns Suitable for Regional Capacity	12
Financial Support and Expert-Approved Loans for Equipping Farmlands with Modern Irrigation Systems	4	information Systems and Monitoring of Water Extraction	13
Punishment for drilling an unauthorized well	5	Development of Renewable Resources Such as Solar Power in Farms	14
Utilizing Advanced Technologies for Monitoring Lands and Plains to Control Drilling Activities	6	Coordination and Consistent Communication Between Ministries and Organizations in Enforcing Regulations	15
Allocating Necessary Facilities for Greenhouse Development	7	Development of Public Participation in Water Resource Management	16
Avoiding Strategic but Water-Intensive Crops	8	Strengthening the Connection Between Relevant Agencies to Align Management Activities	17
Promoting and Implementing Cultural Programs for Protective Behavior in Rural Communities	9	Regular Monitoring of Regional Water Conditions and Public Awareness	18

4. Conclusion

The findings of this study indicate that in the target region, focusing on several factors are as can simultaneously lead to good water governance.

According to these results, "the employment of specialized personnel in relevant institutions" has been identified as a key factor in achieving good water governance in the agricultural sector. This finding implies that expertise and knowledge in water resource management can enhance the performance of institutions involved in water and agriculture. Furthermore, hiring experts ensures that planning processes are more accurate and aligned with the actual needs of the agricultural sector.

Another factor was "Coordinated and Integrated Communication between Ministries and Executive Agencies". This factor plays a crucial role in improving decision-making and implementing effective water resource management policies. Institutional coordination can prevent duplication of efforts and operational conflicts, ensuring that policies are executed in a cohesive and unified manner.

Another factor was "Regular Monitoring of Water Conditions and Public Awareness". This is another key factor in improving water governance in agriculture. Accurate monitoring of water resources can lead to better management and utilisation. Furthermore, effective communication with the public about water conditions and their changes can raise public awareness and enhance the impact of water management policies.

Statements and Declarations
Data availability

The data used (or generated) in this research are provided within the text of the article.

Conflicts of interest

The authors of this paper declared no conflict of interest regarding the authorship or publication of this paper.

Author contribution

M.Rahimian: Theoretical foundations of the research and questionnaire development; F. Sepahwand: Data collection, data analysis and interpretation, text revision and rewriting; S.M. Husseini: Interpretation of results; and H. Molavi: Translation and editing of the text.

AI Use Declaration

During the preparation of this work, the author(s) used ChatGPT to improve some sentences. The authors have thoroughly reviewed and revised the content as necessary and assumed full responsibility for the final manuscript.

References

Amini, A., Ali, T. M., Ghazali, A. H. B., & Huat, B. K. (2009). Adjustment of peak streamflows of a tropical river for urbanization. *American Journal of Environmental Sciences, 5*(4), 285–294. https://doi.org/10.3844/ajessp.2009.285.294

Basher, R. (2006). Global early warning systems for natural hazards: systematic and people-centred. *Philosophical Transactions of the Royal Society A, 364(1845),* 2167–2182. https://doi.org/10.1098/rsta.2006.1819

Munir A., Hanjra, M., & Ejaz Qureshi. (2010). Global water crisis and future food security in an era of climate change. *Food Policy, 35(5),* 365-377. https://doi.org/10.1016/j.foodpol.2010.05.006

Cosin, K. (2024). Challenges and Opportunities in Water Management for Agriculture and Global Water Security. https://es.linkedin.com/in/carloscosin.

Ehteshami, M., Biglarijoo, N., & Salari, M. (2018). Assessment and Quality Classification ofWater in Karun, Dez and Karkheh Rivers. Environmental Science, https://api.semanticscholar.org/CorpusID:131283204

FAO. (2023). The state of the world's land and water resources for food and agriculture: Systems at breaking point. https://www.fao.org/land-water/solaw2021/en/

Gerlak, A.K., Jacobs, K.L., and Mc Coy, A.L. (2021). Scenario Planning: Embracing the Potential for Extreme Events in the Colorado River Basin. *Climatic Change. 165, 27* https://doi.org/10.1007/s10584-021-03013-3

Global Water Partnership. (2022). The OECD Principles on Water Governance and Implementation Strategy.

Godet, M., & Durance, Ph. (2011) Strategic Foresight for Corporate and Regional Development, UNESCO.

Grafton, R. Q., & Ward, M. B. (2023). Water management: Current and future challenges and research directions. *Water Resources Research*, 51(6), 4823-4839. https://doi.org/10.1002/2014WR016869

Haghiabi, H. A., & Mastorakis, N. (2009). Water Resources Management in Karkheh basin-iran.

IPCC. (2021). Chapter 4: Future Global Climate: Scenario-based Projections and Near-term Information. https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-4/

OECD. (2018). The OECD Principles on Water Governance and implementation strategy. https://www.oecd.org

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: An example, design considerations and applications. *Information & Management, 42(1),* 15–29.

Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change. *Water Resources Management, 21(1),* 49–62. https://doi.org/10.1007/s11269-006-9040-4

Pahl-Wostl, C., & Knieper, C. (2014). The capacity of water governance to deal with the climate change adaptation challenge: Using fuzzy set Qualitative Comparative Analysis to distinguish between polycentric, fragmented and centralized regimes. *Global Environmental Change*, 29, 139-154. https://doi.org/10.1016/j.envsci.2023.03.008

Panula-Ontto, J., Luukkanen, J., Kaivo-oja, J., O'Mahony, T, Vehmas, J., Valkealahti, S., Björkqvist, T, Korpela, T., Järventausta, P., Majanne, Y., Kojo, M., Aalto, P., Harsia, P., Kallioharju, K., Hannele Holttinen & Repo, S. (2018). Cross-impact analysis of Finnish electricity system with increased renewables: Long-run energy policy challenges in balancing supply and consumption. *Energy Policy, 118*, 504-513. https://doi.org/10.1016/j.enpol.2018.04.009

Sepahvand, F. (2022). Strategies for sustainable management of groundwater resources with a foresight approach, PhD thesis, Faculty of Agriculture, *Bu-Ali Sina University. Hamadan.* [In Persian].

Sepahvand, F., Naderi Mahdei, K., Gholamrezai, S. & Bijani, M. (2022). Strategies to sustainable management of groundwater resources in Romeshkan plain. *Environmental Sciences, 20(3),* 155-172. doi: 10.52547/envs.2021.1121[In Persian].

SIWI. (2020). Why water governance is key to tackling climate change. https://siwi.org/latest/why-water-governance-is-key-to-tackling-climate-change/

Tajari, A., Babanejad, M., Kardel, F & Soleimani, Karim. (2015). Analysis of factors affecting hydrological drought. Case study: watersheds of Lorestan province. *Geographical Spatial Planning. 5(11),* 151-164. 10.30491/JCC.16.3.73 [In Persian].

United Nations Economic Commission for Europe (UNECE). (2023). Water Convention Programme of Work for 2022-2024. https://doi.org/10.3390/w14223621