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Structural characteristics of governmental and non-governmental institutions network: case of water governance system in Kor River basin in Iran

Majid Rahimi[1] · **Mehdi Ghorbani**[1] · **Hossein Azadi**[2]

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Abstract
Water has been the source of life since it was found. In recent years, the false assurance of the permanence of water services in Iran has led to the creation of institutional structures related to water in an inappropriate and incompatible manner with environmental changes, and when water crises occur, such as droughts, floods, and, on a larger scale, climate changes, they do not have the flexibility and resilience to these changes. To this end, recognizing the current water governance system in the country is considered an essential need. The present study examines the regime of water governance and its structural characteristics in the Kor River basin, which is one of the areas facing water shortage challenges. In order to analyze these characteristics and determine the regime of the water governance system, the method of social network analysis (SNA) was used in the network of formal and informal institutions of Kherameh county downstream of the Kor River basin. This research has been done in a period of 9 months and includes designing questionnaires, field visits, completing questionnaires and analyzing the results. The results showed that the water governance network in this region has an unstable and weak structure and as a result, the level of cooperation and coordination between the institutions is low and the level of power centralization is high. As a result, the governing regime is centralized, and therefore, the establishment of a polycentric governance system requires the improvement of horizontal relations between formal and informal institutions and protection and development institutions.

Keywords Water governance system · Water governance regime · Social network analysis · Power distribution · Coordination and collaboration

✉ Mehdi Ghorbani
mehghorbani@ut.ac.ir

[1] Faculty of Natural Resources, University of Tehran, Karaj, Iran

[2] Department of Geography, Ghent University, Ghent, Belgium

1 Introduction

Climate change and the increase in acute weather events, which have far-reaching impacts on human populations, economic assets, and physical infrastructure, have demonstrated the vulnerabilities of current water management and governance systems (Navarro-Navarro et al., 2017). Experts examining human-environmental interactions have emphasized the need for fundamental changes in paradigms and the replacement of machine-building and piracy strategies, as these types of strategies have failed by ignoring the complexity and dimension of human response to recent challenges (Gleick, 2003; Holling & Meffe, 1996; Pahl-wostl, 2007, 2015).

Pahl-wostl's (2015) research on the conceptual frameworks of complex adaptive systems analysis is lacking in the social sciences, and most governing assessments offer static descriptions and focus on a few key processes (for example, they focus on institutions). Young (2008) also found the knowledge of the nature of transition in socio-ecological systems' institutional dimensions to be fairly new and incomplete.

Water ecosystem services are offered in the research and assessment of water-related services because human survival is largely dependent on ecosystem biodiversity and integrity. Hundreds of millions of people in downstream watersheds and wetlands have been impacted by biodiversity in the areas of water, food, livelihood, welfare, and energy supply, all of which are ecosystem services that are directly tied to ecological functions. Humans rely on biodiversity conservation and the "judicious use of wetlands" (Ramsar Convention Secretariat, 2010, 2013).

The watershed, as a natural ecosystem that is like a container of water resources, especially rivers and wetlands, is made up of components that interact with each other. The human component is an integral and influential part of this ecosystem (Bodin & Prell, 2011). To this end, one of the most important ways to preserve these valuable resources is to manage them based on the participation of local stakeholders. Successful management of natural areas of water resources requires planning in which human role is considered as the most important factor influencing natural areas, and the views of stakeholders in natural areas are considered in management decisions (Huxham, 2005; Rouillard, 2014).

Self-governance is excessively complicated due to the diversity of individuals and processes at various levels. If we add management to it, another hidden layer of complexity will be added. Water management will be inadequate despite complicated regulatory frameworks owing to a lack of water managers' expertise or a lack of financial resources to invest in certain technology (Pahl-wostl, 2018). Governance enacts laws that govern management. In today's and new interpretations of governance, we consider the complete complexity of legal processes and their interaction (Pahl-Wostl, 2018).

The ruling regime is a set of interdependent institutions that are introduced as the main feature of the governing system (Pahl-Wostl, 2009). The institution is defined here as the rules that control actors' conduct (Scott, 2008), and the formality and informality of these norms are tied to the nature of the planning, programming, communications, and implementation processes (Pahl-wostl, 2015).

If formal institutions succeed and the goal of institutional arrangements is the same and consistent, the two forms of governmental structures complement each other. For example, informal community-based initiatives for nature conservation strengthen the application of formal rules for river revitalization.

The goal of many participatory methods in general policy development is to establish such a rise. The effectiveness and profitability of governance systems improve because of

this. If formal institutions fail and political institutions pursue opposite goals, both kinds of governance may be forced to compete with one another. Formal legislation controlling the distribution of scarce water resources, for example, can be substituted by allocation systems based on informal structures of power and cultural networks. The governance mechanisms' efficacy and performance are hampered as a result. The high levels of non-transparent decision-making procedures, corruption, and power dominance are likely connected to this kind of government (Pahl-Wostl & Knieper, 2014). This is common in many poor nations, where strong environmental rules exist but are seldom enforced in practice. These distinctions need to be understood so that we can better acknowledge the nature of governance failures, opportunities, and obstacles to reform the governance, and the role of informal institutions in these processes (Pahl-Wostl, 2015).

According to Pahl-Wostl and Knieper's (2014) study on water governance regime categorization, they are divided into four groups depending on the level of partnership and coordination, as well as political reform (Pahl-Wostl, 2015): polycentric, fragmented, centralized, and organized and centralized rent-seeking regimes. The effective collaboration across many centers and across different geographical levels reflects the allocation of authority and power in polycentric regimes. Polycentric systems have a single structure that improves resilience and the capacity to absorb shocks and disturbances. Organized decision-making centers with a certain level of independence will aid in experimentation and learning. As a result, polycentric regimes are seen to function well, particularly in terms of adaptability and reaction to new issues such as climate change (Ostrom, 2001 and 2010; Folke et al., 2005; Pahl-wostl, 2009; Pahl-wostl et al., 2012).

Centralized regimes operate under a hierarchical system of government. At the national level, a dominating state actor has all the power and authority. Centralized governments lack accountability and flexibility in terms of a decentralized, coherent structure, even though top-down control is in place. Higher flexibility argumentation has been the main argument and confirmation of the decentralization of management functions (Hooghe & Marks, 2003). There is a distinction between coordinating centralized regimes and centralized rent-seeking regimes in terms of coordination. The feature of centralized, uncoordinated regimes is their rent-seeking. Rent-seeking conduct makes it difficult to communicate effectively, and a lack of collaboration encourages rent-seeking behavior. Rent-seeking refers to when government and bureaucracy personnel abuse their authority and position in the hierarchy to get more advantages (Tullock, 2008).

The governing class under centralized rent-seeking regimes has little motivation to address new concerns, and the ability for adaptation is thought to be poor. During the decision-making process in centrally coordinating regimes, lower-level players are consulted. However, subordinate centers have little self-control and mostly implement high-level decisions. This reduces the capacity to deal with the complex and contradictory issues of governance and to consider regional contextual conditions. It will be concluded that centralized regimes as a whole have less adaptive capacity and are less able to meet new challenges than polycentric regimes (Pahl-Wostl, 2015).

Kellner et al. (2019) examined the ability of a polycentric governing regime to adapt to regime change in water resources under the conditions of climate change in Oberhasli, Switzerland, using a semi-structured interview method, document analysis, and monitoring of water institution participation. The past has been increasingly inconsistent, but the evolution of polycentric governance processes has compensated for the inconsistency in the regime. Polycentric governance improves water use coordination if there is mutual compatibility, trust, and activation of general rules between actors with similar and opposite interests. They also concluded that the inconsistency of institutional regimes may be

an important obstacle to adapting to climate change, but that polycentric governance processes can reduce the challenges posed by regime inconsistency.

Morrison et al. (2019) in a study on the black box of power in the polycentric governance regime of the environment examined the formation of various types of power and the implementation of policies in the polycentric governance regime and concluded that this regime includes many power centers. They work together to achieve a common goal.

Pittman and Armitage (2019) examined the network governance style in the Lesser Antilles archipelago in the Caribbean Sea and found that the governance style in the region is shifting in a networked manner. Their results also showed that participation in projects has been a factor in initiating this transition. In addition, successful network governance transfer requires two essential factors: (1) facilitating the leadership of central actors and the main guiding group to manage the network and (2) finding solutions to fit the hidden capacity of local communities and informal institutions in governance networks.

Aartsen et al. (2018) and Urbinatti et al. (2020) in their study of systematic assessment of water governance in Ahmadabad, India, used a comprehensive assessment of integrated water resources management and then examined water pollution challenges and reduced groundwater levels in the face of population growth and urbanization in this city. Then, by assessing the capacity of water governance, they concluded that the governance system needs to improve the situation regarding the principle of learning and participation of local stakeholders and informal institutions, and regime change in combination with governance methods has been proposed with increasing network governance.

Hegger et al. (2017) and Kapetas et al. (2019) examined the role of stakeholders in adapting to climate change in the Netherlands, as well as their role at strategic levels, market and networking, in relation to environmental governance in the face of floods, sewage, and temperature changes. They found that the role of local residents in adapting to climate change was important, and addressing all three types of governance (Metagovernance) could increase the legitimacy, awareness, and ability of communities to innovate and adapt to environmental changes.

According to Payste et al. (2020), uncertainty over the selection of high governance standards, particularly in the field of natural resources, is becoming a significant worry for researchers. The fundamental reason for this problem is that natural resources have both natural and social components. In fact, in the sphere of natural resources, the disparity between these two aspects exacerbates the lack of integration, stakeholder disaffiliation, and management holism. Recognizing, implementing, and assessing effective governance indicators will, without a doubt, enhance natural resource management. Conflicts regarding natural resources are rising, according to Jannatichenar et al. (2020), due to the shortage or constraint of natural resources and rising demands for growing populations. As a consequence, to resolve disagreements, a conflict resolution strategy and advanced negotiating tactics are required.

Kolahi et al. (2013) found that the need to analyze the efficacy of management in protected areas is growing across the world in enhancing monitoring and evaluation of governance. The most important factors were legal status, resource inventory, land and water use planning, regulations, and objectives, while the least important factors were awareness and education, society co-management, regular work strategy, bounding demarcation, visitor facilities, funding sources, training of staff, safety systems, and management plans. As a result, various remedies should be implemented, such as increased financing, improved building capacity, management, organizational management and community engagement. Furthermore, Kolahi et al. (2012) argued that in order for Iran's management system to develop, policies and planning tools must be realistically supported. Furthermore, active

management must be implemented to restore habitat, promote education and awareness, shift behaviors toward international organization principles, create capacity, and increase operational efficiency and co-management by local populations. In the field of water resources management, especially in areas that have water scarcity due to mismanagement in recent years, one of the most important solutions can be to pay attention to the existing social capital in the region along with the management of official institutions. On the one hand, the analysis focuses on the present level of knowledge on the elements that influence the effectiveness of water governance systems. On the other hand, it places a heavy focus on conversion and changing processes in water governance, which is seen as a fundamental obstacle in achieving more sustainable water governance and management. Since this lake is one of the most important aquatic habitats and is the second largest inland lake in Iran, it is extremely important for the livelihood of the people of the region, especially farmers. However, in recent years, it has undergone climate change and is heading toward drought. Therefore, the main goal of this study is to investigate the current status of water resources in the watershed of Tashk–Bakhtegan Lake using the method of social network analysis (SNA). For this purpose, the following hypotheses have been defined:

H1 Is there a positive and significant relationship between the governance of water resources and official institutions?

H2 Is there a positive and significant relationship between the governance of water resources and informal institutions?

H3 Will changing the water governance system by considering the capacities of non-governmental organizations and creating a governance structure have a positive and significant effect on the water management situation in the study area?

2 Methods

2.1 Study area

Tashk and Bakhtegan International Wetlands are located in the west of Neyriz city and south of Arsanjan city in Fars Province (Fig. 1). The geographical position is from 53° 24' 9" to 54° 12' 30" east longitude and from 29° 13' 35" to 29° 55' 9" north latitude. These wetlands are among the most important habitats in Fars Province and are the second largest inland lakes in terms of area and are classified as national parks according to the country's domestic laws. According to the Ramsar Convention, it is part of the saltwater lakes (Ramsar Convention Secretariat, 2016).

The most important source of water supply for these lakes is the Kor River, which originates 300 km north of Fars Province and the Zagros Mountains in Eghlid county and after passing through the counties of Eghlid, Marvdasht, and Kherameh, it flows into these lakes. Along this river, there are two dams of MullaSadra and Doroudzan. The water stored in these two dams is used for urban consumption in Shiraz and Marvdasht cities. The second priority, if the annual rainfall is sufficient and after the release of dam water, has been agricultural consumption and high water requirements (such as rice) in these cities in recent years. Finally, if all these needs are met, the environmental rights of Tashk and

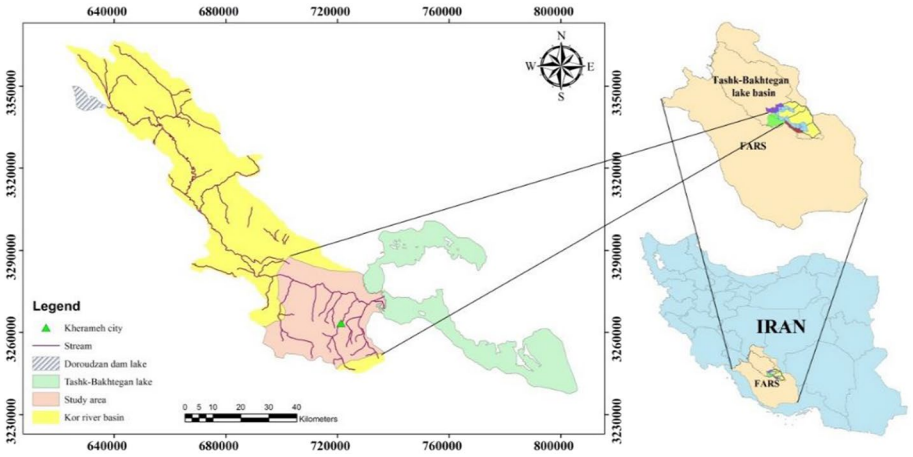

Fig. 1 Location of the study site in Iran

Bakhtegan Lakes will be provided. However, in recent years, due to severe droughts, this need has not been met (Sajedipour et al., 2017).

The downstream watershed of the Doroudzan Dam alone includes the political borders of Marvdasht and Kherameh counties. Therefore, water management in this area is divided between formal (governmental agencies) and informal organizations (farmers, local communities, and non-governmental organizations) (Moghimi Benhangi et al., 2018). As a result, the complexity of managing common water resources arises from the challenge of political boundaries and water governance (Pahl-Wostl, 2015).

In this study, the downstream of the Kor River basin is determined by combining the political boundary of Kherameh county and the hydrological boundary of the basin area, and the organizational network (including governmental organizations and non-governmental organizations related to water) is studied without considering the local communities.

2.2 Identify water-related institutions

In order to identify and determine water-related institutions in Kherameh county, the snowball sampling method was used. Based on this, they were first identified by referring to the basic water management institutions in the county, including Water Resources Department, Agricultural Jihad Management and Governorate, groups, and other water-related institutions. Then, by referring to the mentioned institutions, 21 governmental organizations (formal institutions) and 2 non-governmental organizations (informal institutions) related to water were identified (Table 1).

2.3 Determining the water governance regime

In order to determine the regime of water governance, it is necessary to determine the status of the two categories of cooperation and coordination and the level of power distribution among activists, so the method of social network analysis was used to achieve this

Table 1 Water-related institutions

Abbreviation	Institution	Role
Mw-Kh	Rural Water and Sewerage Management	Management of allocation and consumption of domestic water in rural and local communities (Development)
Wr-Kh	Water Resources Department	Management of exploitation and allocation of groundwater for agricultural purposes (Protection)
Nr-Kh	Department of Natural Resources and Watershed Management	Management and protection of natural resources and management of watersheds (Protection)
Ma-Kh	Agricultural Jihad Management	Management of agricultural affairs, food production, and livestock affairs (Development)
Kb-Kh	Agricultural Bank	Development of projects related to agricultural affairs and their financial support (Development)
Ep-Kh	Environmental Protection Office	Environmental management and protection, wildlife and environmental flow rights (Protection)
Ch-Kh	Department of Cultural Heritage, Handicrafts, and Tourism	Management and development of cultural activities, local-indigenous products, and handicrafts (Development)
Gw-Kh	Office of Cooperatives, Labor, and Social Welfare	Management of economic affairs, job search, and fight against unemployment (Development)
Re-Kh	Imam Khomeini Relief Committee	Management and support of communities with financial and human weakness (Development)
Go-Kh	Governorate	Local government management at the county level (Development)
Im-Kh	Department of Industry, Mining, and Trade	Management and operation of industries and mines (Development)
Mr-Kh	Department of Roads and Urban Development	Road Management and Urban Development (Development)
Ba-Kh	District Manager	Local government management at the district level (Intermediate)
Cvj-Kh	Village Council	Rural Affairs and local water management to resolve conflicts (Intermediate)
Po-Kh	Disciplinary Command	Management and resolution of water conflicts in the county (Development)
Ju-Kh	Department of Justice	Manage and resolve legal disputes at the county level (Development)
Me-Kh	Power Distribution Management	Management, power generation, and operation of hydroelectric powerhouses (Development)
Od-Kh	Petroleum Products Distribution Company	Manage and distribute energy to local industries and farmers (Development)
Ir-Kh	Irrigation and Drainage Office	Management, planning, and operation of surface water in the county (Development)
Gv-Kh	Rural Cooperative Management	Local Community Welfare and Cooperation Management (Development)
De-Kh	Department of Education	Management of education and culture of water consumption and protection (Development)
HDngo-Kh	Bakhtegan Long-term Memorizers Association (NGO)	Voluntary and nature-friendly activities related to Bakhtegan Lake and the Kor River (Protection)
EKngo-Kh	Kamjan International Wetland Rehabilitation Group (NGO)	Volunteering and doing nature-friendly activities related to Kamjan International Wetland and Kor River (Protection)

important goal. For this purpose, water institutional relations network in Kherameh county has been extracted using the social network analysis questionnaire, and then, two indicators of network density and centralization based on a two-dimensional framework of water governance regimes have been used (Pahl-Wostl, 2015).

2.4 Social network analysis method

Today, one of the important tools for studying, analyzing, and modeling the structures of the governance system among water-related institutions is the method of social network analysis. The social network analysis method is able to visualize social relations and economic exchanges between individuals in the form of a visual network structure based on quantitative criteria and indicators (Afkhami et al., 2021; Bodin & Prell, 2011; Ghorbani & Azadi, 2021). In order to analyze the network of water institution relations and determine the regime of water governance in the study area, the indicators of the macro-level of the network, including density and centralization, were used. Furthermore, the indices of transitivity, reciprocity, average distance, E-I, and core–periphery index were calculated for the structural analysis of the institutional network (Ghorbani et al., 2021; Moghfeli et al., 2021) (Table 2). To calculate these indicators, the UCINET software version 6 was used.

3 Results

Based on the mentioned results, due to the location of the Kor River basin (downstream of Doroudzan Dam) within the political borders of Marvdasht and Kherameh counties, specialized water management in development, operation, and protection has been provided for various institutions and no coordination exists between these institutions. This study only looked at horizontal relationships between formal and informal water-related institutions and did not consider public relations between government agencies and the local community (indigenous exploiters). So, this study focused on recognizing horizontal relationships between formal and informal water-related institutions in the area. In Kherameh county, we can identify the regime of water governance and the assessment of the current state of water governance in this region (see Pahl-Wostl, 2015).

Water management in the Kor River basin can be seen according to Table (1) and the role of each water-related institution. As 15 institutions have a developmental role in water usage, 5 institutions have a protective role in water regeneration, and 2 institutions have an intermediary role between developmental and protection institutions. On the other hand, the identified water management-related institutions in the study area have direct and indirect roles, while indirect roles are more than direct roles.

As a result, after completing the social network analysis questionnaire and determining water-related relationships among the identified institutions in Kherameh city, the macro-level indicators of the network were calculated (Appendix 3). The results show that the density of the water-related institution's network in the study area is 48% which indicates a low level of cooperation and coordination in the management of sectarian management in the study area. Furthermore, the rate of the reciprocity index is 46.11 percent and indicates the low level of mutual relations and cooperation between actors present in the network and weakens the stability of the network.

The network centralization index, with a rate of 54.34 percent, indicates a relatively high concentration of power in the hands of certain institutions. The transitivity index, with

Table 2 Social network analysis indicators used in the research

Indicator	Description	Equation
Density	Density is defined as the ratio of the total number of communication links available between individuals to the maximum possible communication links in the network. The rate of this indicator varies between zero and one, as well as zero and one hundred percent. If the number of available links has a high proportion of total possible links, then the network in question can be considered as a dense network and can be called a coherent network. High-density networks form highly interconnected social contexts in which actors can share information and strengthen areas of collaboration and coordination	$D = \frac{L}{n(n-1)/2}$ where "L" represents the number of existing lines (links) and "n" represents the number of nodes within the network
Reciprocity	This index is used to determine the stability of the network of relationships and the degree of interaction. The higher the value of this index in the network of relationships, the higher the degree of interaction and cooperation between the actors present in the network, which ensures the stability of the network of relationships. The results of this index are presented as 100% and vary between zero and one hundred percent. As the rate of this index in the network increases, the rate of the social system's resilience to environmental changes and stresses will increase	
Transitivity	This indicator is derived from the sharing of links between three actors, one of which is a bridge between the other two. In other words, if actor "A" has a bond with actor "b" and "b" has a bond with actor "c," then transferability is an opportunity for "a" to be linked to "c." The greater the number of transferable actors, the higher the rate, and thus the stability and permanence of the relationship between the actors. This index is also used to measure the stability of the network and the balance and equilibrium of relationships in the network and is displayed as a percentage or a number between zero and one	
Average geodesic distance	This indicator indicates the shortest path between the two pairs of actors based on the information exchange and collaboration links. The lower the index, the faster the data are circulated and distributed among actors, so less time and money will be spent coordinating network actors to implement integrated and continuous management	
Centralization	This index is based on the stated percentage and is generally known as the centralization level. A network with a zero concentration indicates that all actors have the same number of links in the network, and a network with the centralization of one indicates that all links are at and around one activist	$C_D = \frac{\sum_{i=1}^{g}\left[C_D(n^*) - C_D(n_i)\right]}{\left[(g-1)(g-2)\right]}$

Table 2 (continued)

Indicator	Description	Equation
		where "C_D" is the total centralization of the network, "g" is the number of links, and "n" is the number of network nodes. This index shows the level of participation and cooperation of individuals and organizations in decision-making for a particular issue
Intra-group and extra-group relations (E-I)	It is important to examine the extent of intra-group and extra-group relations, and through the results of this index, it is possible to determine the extent of intra-group and extra-group relations; the term "extra-group relations" also refers to network connections in the network, through which individuals can enter more resources and information into their subgroups and gain more support. The difference between internal and external relations and their relationship to the total number of connections in the network is known as the E-I index	
Core–periphery index	This index is evaluated for network analysis at the intermediate level. In general, the subject of this level is the analysis of the subgroups in the network. This indicator shows which nodes are in the center and which nodes are located around the network. By this index, all members are divided into two categories: core and periphery. The central group has a lot in common, and as a result, their network density is high, but in the peripheral category, their relationships are low, and as a result, their network density is low. Central actors can better coordinate their actions, but the surrounding actors are less cohesive. Thus, central actors have the advantage of being able to interact with the surrounding actors	

a value of 32.76 percent, indicates the instability of relations between water actors in the study area. Finally, the index of average geodesic distance with 1.52 has a relatively high rate, and as a result, the speed of circulation and distribution of information among actors is low, so more time and money will be spent to coordinate network actors to implement integrated management.

Figure (2) shows the geometric position of the actors, water management institutions, and the water governance network in general in the study area based on the micro-level indicators of the social network, including the degree of centrality and the efficiency size (Effsize). Accordingly, key institutions with more power and influence in water management have a greater degree of centrality and Effsize, and accordingly, the Go-Kh institution has the most power, and in general, development institutions have significant power and influence over conservation institutions.

According to the E-I index, among developmental, intermediate, and protective subgroups (Appendix 4), conservation institutions have more extraterrestrial relationships and, as a result, have a positive index number. Intermediary institutions also have a positive index number due to their intermediate role, but more developmental institutions have intergroup relations and have a negative E-I index number. The results of this index are shown in Fig. (3). On the other hand, the density of relations between the three subgroups of developmental, intermediary, and conservation institutions in Appendix 5 indicates the low level of cooperation and coordination between development and conservation institutions.

The core–periphery index in the network also identifies the relationships between water-related institutions in the study area and central and peripheral institutions in this network and represents the central and effective institutions in water governance (Appendix 6). Furthermore, the rate of density among central and peripheral institutions indicates the high rate of density in the relations of peripheral institutions to central institutions and vice

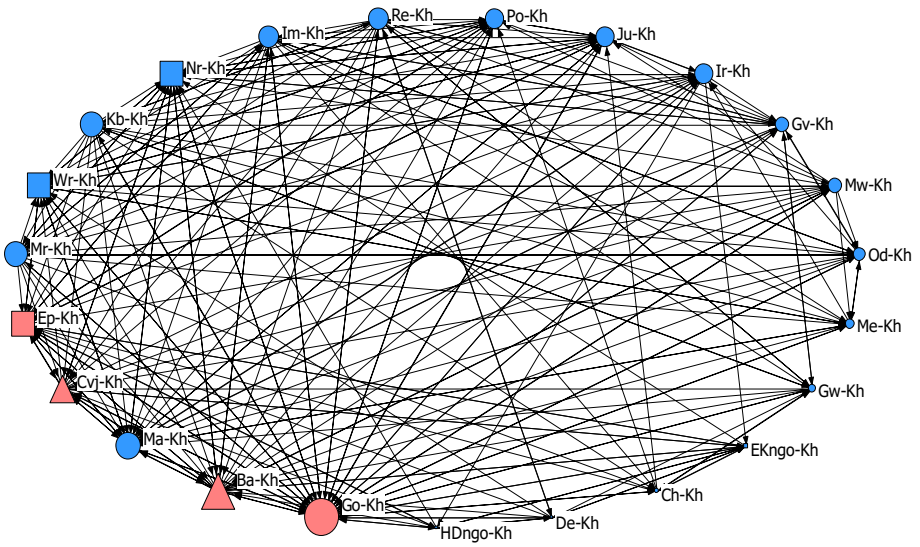

Fig. 2 The geometric graph of actors in the institutional network (shape size: degree centrality, circle: developmental institutions, triangle: intermediate institutions, square: conservation institutions, red: actors with the most Effsize in the network)

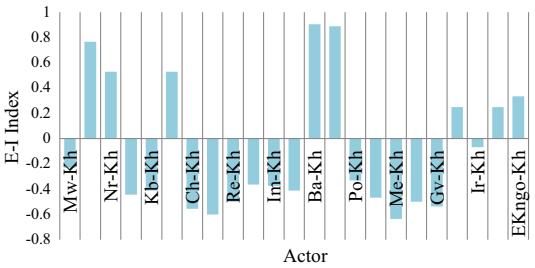

Fig. 3 E-I index in development, protection, and intermediate institutions

versa, as well as the rate of low density in the relations of central institutions with respect to peripheral institutions (Appendix 7).

Finally, in order to determine the water governance regime in the study area, using two indicators of network density and network centralization (Fig. 4), the water governance regime in Kherameh county is a centralized regime and shows a low level of cooperation and coordination. Furthermore, a high level of centralization of power is in the hands of one or more specific institutions.

4 Discussion and conclusion

The current scenario in this water basin is one of merging crises in both water system quality and governance mechanism performance. The necessity for quick and fundamental reform of governance structures and instruments becomes more critical as crises become more complicated and catastrophic. The following points describe the present governance perspective based on the evaluation in the sections above:

Donor-driven drainage basin administration continues to be heavily reliant on donor financing. Some would be unlikely to continue if they did not receive such aid. As a consequence, governmental choices and programs, including privatization, tend to follow donor preferences. However, rather than being proactive, governance continued to be primarily bilateral and reactive. Treaties and other types of agreements have been shown to be useful in creating political norms for obtaining a peaceful resolution of water problems when all parties obey them. International organizations will likely continue to play a key role as third-party mediators in the implementation of these water management agreements. Enhancing water relations and continuous process require better information collecting, analysis, sharing, and openness. Positive improvements have been most obvious in this area of water governance in recent years, while they are still quite unequal across this region.

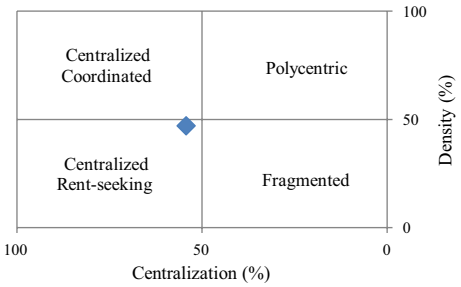

Fig. 4 Determining water governance regime in Kherameh institutional network

The creation of channels for timely processing and exchange of information from upstream to downstream nations is particularly important.

This study used the social network analysis method as well as the macro-level indicators of the network including density and centralization index. Using these approaches, the type of water governance regime in Kherameh county and the downstream area of the Kor River basin, centralized water governance regime, has been identified, demonstrating a low and unacceptable level of cooperation and coordination. Thus, the high power centralization is at the disposal of governmental agencies regarding water decision-making (see Navarro-Navarro et al., 2017).

On the other hand, the social network analysis method shows the ability to recognize the structural characteristics of water governance network in the study area, so according to the reciprocity index, the relationship between formal and informal institutions related to water management in the study area is inappropriate, which indicates instability and incompatibility in the water governance system in this region. The transitivity index also slightly evaluated the interrelationships between the three water management actors, which show the low level of social capital in the institutional network of water governance and the strength and institutionalization of executive protocols related to water management in a low and unsatisfactory situation. In this regard, the average geodesic distance index also confirms this important finding and indicates the low rate of data transfer speed and lack of sufficient coordination to implement water-related laws and the inability of laws to restore water status in this area.

Recognition of the fundamental role of formal and informal institutions in relation to water; their division into developmental, intermediary, and protective institutions; and the use of the E-I index in the network of the water governance system in this region show the greater focus of development institutions on inter-group relations and their unilateralism. Conservation institutions also have more bridging relationships, but due to the relatively low density (65%) among conservation institutions, these bridge relationships have not been able to provide direction in order to provide protection protocols for the water governance system in the study area.

The use of micro-level social network analysis indicators in identifying key institutions in the study area's water governance network can be considered to better understand this network, optimize the association with both formal and informal institutions related to water, and effectively improve the structural features of the social network water governance (see Pahl-Wostl et al., 2013).

In this paper, by examining the structural characteristics of the social network and the relationship between formal and informal institutions in water management downstream of the Kor River basin, located in the political border of Kherameh county, we examined the water governance system in this area. The structural characteristics of the institutional network can be analyzed by quantitative evaluation of the characteristics of the social network analysis method. Furthermore, in order to determine the water governance regime, the level of cooperation and coordination, as well as the amount of distribution or concentration of power among water-related institutions (Pahl-Wostl, 2015), can be calculated using the social network analysis method and density and centralization indicators.

The results of this study showed that the water governance regime downstream of the Kor River basin is the centralized rent-seeking regime, which indicates a low level of cooperation and coordination and a high concentration of power among water-related institutions (Pahl-Wostl, 2018; Pahl-Wostl & Knieper, 2014). The participation of stakeholders in water management, policy, and decision-making has not taken place, and, as a result, the situation of the water governance system is in an unfavorable situation.

The social network analysis method has a good ability to recognize the water governance regime, and as a result, this method can be used to analyze, optimize, and make appropriate decisions in policymaking and improving administrative relations and water governance. In order to optimize the water governance regime in order to improve the water governance system and achieve the polycentric water governance regime, we need to increase the level of cooperation, coordination, and distribution of decision-making power regarding water among formal and informal institutions (Pahl-Wostl, 2009; Scott, 2008). As a result of the improvement of bilateral relations between official institutions and the increase of protectionist relations with development institutions, achieving a polycentric water governance regime will be possible.

4.1 Policy implications

Planning (the creation of planning and management plans and policies in governance and non-governance networks) is an essential and frequently necessary tool for supporting and improving management. This planning allows us to (1) identify the current level of water resources, as well as concerns and expectations about their usage, establish visions, define goals and targets, and therefore guide operational management; (2) guide operational management by defining visions, objectives, and priorities; (3) organize policy-relevant analysis and citizen engagement in a system; and (4) increase the authority, public approval, and even support for how resources would be distributed or managed, especially during periods of stress. In addition, managers and partners in governance and non-governance networks will be able to collaborate, negotiate, and coordinate more easily, and a management strategy or agenda will serve as a shared point of reference. Many of the challenges and problems that water supply planners and managers are dealing with today are close to those that planners and managers encountered in the past. The majority of the recent ones are the products of two trends: (a) increased awareness of the necessity for a bottom-up "grassroots" participation approach to politics and non-governance planning, management, and decision-making and (b) an increasing concern for the protection of natural environments. Overall, it can be argued that the network of governmental and non-governmental institutions: to control water supplies in the Kor Basin increases productivity and can be used effectively. One of the main conditions for its implementation is public acceptance and social concern in natural resource conservation.

Appendix

See appendix Tables 3, 4, 5, 6, 7.

Table 3 Results of macro-level indicators in Kherameh institutions network

Average geodesic distance	Transitivity	Centralization	Reciprocity	Density	Kherameh
1.52	32.76	54.34	46.11	48	Institutions network

Table 4 E-I index results

E-I	Institution	E-I	Institution
0.905	Ba-Kh	− 0.231	Mw-Kh
0.889	Cvj-Kh	0.765	Wr-Kh
− 0.333	Po-Kh	0.529	Nr-Kh
− 0.467	Ju-Kh	− 0.444	Ma-Kh
− 0.636	Me-Kh	− 0.412	Kb-Kh
− 0.5	Od-Kh	0.529	Ep-Kh
− 0.538	Gv-Kh	− 0.556	Ch-Kh
0.25	De-Kh	− 0.6	Gw-Kh
− 0.067	Ir-Kh	− 0.5	Re-Kh
0.25	HDngo-Kh	− 0.364	Go-Kh
0.333	EKngo-Kh	− 0.375	Im-Kh
		− 0.412	Mr-Kh

Table 5 Density index matrix at the level of institutional subgroups

Intermediate	Protect	Development	Institution
65.6	48.8	47.1	Development
80	65	33.8	Protect
100	80	37.5	Intermediate

Table 6 List of core and peripheral institutions

Periphery	Core
Mw-Kh	Wr-Kh
Kb-Kh	Nr-Kh
Ch-Kh	Ma-Kh
Gw-Kh	Ep-Kh
Re-Kh	Go-Kh
Mr-Kh	Im-Kh
Me-Kh	Ba-Kh
Od-Kh	Cvj-Kh
Gv-Kh	Po-Kh
De-Kh	Ju-Kh
Ir-Kh	
HDngo-Kh	
EKngo-Kh	

Table 7 Density matrix in core–periphery blocks.

Periphery	Core	Kherameh
30.8	83.3	Core
31.4	60.8	Periphery

References

Aartsen, M., Koop, S., Hegger, D., Goswami, B., Oost, J., & Van Leeuwen, K. (2018). Connecting water science and policy in India: Lessons from a systematic water governance assessment in the city of Ahmedabad. *Regional Environmental Change, 18*(8), 2445–2457.

Afkhami, M., Ghorbani, M., Banafsheh, Z., & Azadi, H. (2021). Role of social network measurements in improving adaptive capacity: The case of agricultural water users in rural areas of Western Iran. *Society & Natural Resources, 34*(10), 1338–1357.

Bodin, Ö., & Prell, C. (2011). *Social networks and natural resource management uncovering the social fabric of environmental governance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511894985

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Ann Rev of Environ and Res, 30*, 441–473.

Ghorbani, M., & Azadi, H. (2021). A social-relational approach for analyzing trust and collaboration networks as preconditions for rangeland comanagement. *Rangeland Ecology & Management, 75*, 170–184.

Ghorbani, M., Naderi, A., & Janeˇckov´a, K., Skleniˇcka, P., Azadi, H., Witlox, F.,. (2021). Sustainable Co-Management of arid regions in southeastern Iran: Social network analysis approach. *Journal of Arid Environments*. https://doi.org/10.1016/j.jaridenv.2021.104540

Gleick, P. (2003). Global freshwater resources: Soft-path solutions for the 21st century. *Science, 302*, 1524–1528.

Hegger, D. L., Mees, H. L., Driessen, P. P., & Runhaar, H. A. (2017). The roles of residents in climate adaptation: A systematic review in the case of the Netherlands. *Environmental Policy and Governence, 27*(4), 336–350.

Holling, C., & Meffe, G. (1996). Command and control and the pathology of natural resource management. *Conservation Biology, 10*, 328–337.

Hooghe, L., & Marks, G. (2003). Unraveling the central state but how? Types of multi-level governance. *American Political Science Review, 97*, 233–243.

Huxham, C., & V.S. (2005). *Managing to collaborate: The theory and practice of collaborative advantage*. Routledge.

Jannatichenar, M. A., Kolahi, M., & Mesdaghi, M. (2020). Social conflicts and rangeland management: A case study at rangelands of Kalatnader County Iran. *Iranian Journal of Applied Ecology, 9*(3), 77–97.

Kapetas, L., Kazakis, N., Voudouris, K., & McNicholl, D. (2019). Water allocation and governance in multi-stakeholder environments: Insight from Axios Delta Greece. *Science of the Total Environment, 695*, e133831. https://doi.org/10.1016/j.scitotenv.2019.133831

Kellner, E., Oberlack, C., & Gerber, J. D. (2019). Polycentric governance compensates for incoherence of resource regimes: The case of water uses under climate change in Oberhasli, Switzerland. *Environmental Science & Policy, 100*, 126–135.

Kolahi, M., Sakai, T., Moriya, K., & Makhdoum, M. F. (2012). Challenges to the future development of Iran's protected areas system. *Environmental Management, 50*(4), 750–765.

Kolahi, M., Sakai, T., Moriya, K., Makhdoum, M. F., & Koyama, L. (2013). Assessment of the effectiveness of protected areas management in Iran: Case study in Khojir national park. *Environmental Management, 52*(2), 514–530.

Moghfeli, Z., Ghorbani, M., Rezvani, M. R., Khorasani, M. A., Azadi, H., & Scheffran, J. (2021). Social capital and farmers' leadership in Iranian rural communities: Application of social network analysis. *Journal of Environmental Planning and Management*. https://doi.org/10.1080/09640568.2021.2008329

Moghimi Benhangi, S., Bagheri, A., & Abolhassani, L. (2018). Assessment of social learning capacity of water institution in the Tashk-Bakhtegan basin. *Iran-Water Resources Research, 14*(2), 100–118.

Morrison, T. H., Adger, W. N., Brown, K., Lemos, M. C., Huitema, D., Phelps, J., et al. (2019). The black box of power in polycentric environmental governance. *Global Environmental Change, 57*, e101934.

Navarro-Navarro, L. A., Moreno-Vazquez, J. L., & Scott, C. A. (2017). Social networks for management of water scarcity: Evidence from the San Miguel Watershed, Sonora Mexico. *Water Alternatives, 10*(1), 41.

Ostrom, E. (2001). Vulnerability and polycentric governance systems IHDP (international human dimensions programme on global environmental change). *News UPD, 3*(1), 3–4.

Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review, 100*, 641–672. https://doi.org/10.1257/aer.100.3.641

Pahl-Wostl, C. (2018). Editorial special issue: The Nexus of water, energy and food – an environmental governance perspective. Editorial special issue: The Nexus of water, energy and food – An environmental governance perspective. Inpress

Pahl-Wostl, C. (2007). Transition towards adaptive management of water facing climate and global change. *Water Resources Management, 21*(1), 49–62.

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change, 19*, 354–365.

Pahl-Wostl, C. (2015). *Water governance in the face of global change: From understanding to transformation*. Springer.

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.

Pahl-Wostl, C., Lebel, L., Knieper, C., & Nikitina, E. (2012). From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. *Environmental Science & Policy, 23*, 24–34.

Pahl-Wostl, C., Vörösmarty, C., Bhaduri, A., Bogardi, J., Rockström, J., & Alcamo, J. (2013). Towards a sustainable water future: Shaping the next decade of global water research. *Current Opinion in Environmental Sustainability, 5*(6), 708–714. https://doi.org/10.1016/j.cosust.2013.10.012

Payste, M., Kolahi, M., & Omranian Khorasani, H. (2020). Criteria and indicators; requirement for cognition, applying and evaluating good governance in natural resources. *Journal of Water and Sustainable Development, 7*(1), 13–22.

Pittman, J., & Armitage, D. (2019). Network governance of land-sea social-ecological systems in the lesser antilles. *Ecological Economics, 157*, 61–70.

Ramsar Convention Secretariat. (2016). The list of wetlands of international importance (the Ramsar List), retrieved from https://www.ramsar.org/search?f%5B0%5D=type%3Adocument#search-documents

Ramsar Convention Secretariat. (2010). *Wise Use of wetlands concepts and approaches for the wise use of wetlands* (4th ed.). Gland: Ramsar Convention Secretariat.

Ramsar Convention Secretariat. (2013). *The Ramsar convention manual a guide to the convention on wetlands (Ramsar, Iran, 1971)* (6th ed.). Gland: Ramsar Convention Secretariat.

Rouillard, J., Reevesa, A. D., Heal, K. V., & Ball, T. (2014). The role of public participation in encouraging changes in rural landuse to reduce flood risk. *Land Use Policy, 38*, 637–645.

Sajedipour, S., Zarei, H., & Oryan, S. (2017). Estimation of environmental water requirements via an ecological approach: A case study of Bakhtegan Lake. *Iran Ecological Engineering, 100*, 246–255. https://doi.org/10.1016/j.ecoleng.2016.12.023

Scott, R. W. (2008). *Institutions and organizations: Ideas and interests* (3rd ed.). Sage Publications.

Tullock, G. (2008). *Public goods*. Edward Elgar Publishing.

Urbinatti, A. M., Fontana, M. D., Stirling, A., & Giatti, L. L. (2020). Opening up' the governance of water-energy-food nexus: Towards a science-policy-society interface based on hybridity and humility. *Science of the Total Environment, 774*, e140945. https://doi.org/10.1016/j.scitotenv.2020.140945

Young, O. R. (2008). Building regimes for socioecological systems: Institutional diagnostics. In O. R. Young, L. A. King, & H. Schroeder (Eds.), *Institutions and environmental change: Principal findings, applications, and research frontiers* (pp. 115–144). MIT Press.