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Institutional analysis of top-down regulatory: evidence from Iran local governance

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ABSTRACT

Population growth, along with climate change, has exacerbaed the water crisis in local communities. The simplest and quickest response of governments to such problems is direct intervention in local governance. Such solutions are usually proposed without regarding the indigenous knowledge of the local people. These also include top-down policies on water issues, which disrupt local institutional arrangements and eliminate the possibility of collective action by stakeholders in reaching an agreement. A case study of one of the water basins in Chaharmahal Bakhtiari in Iran (the Gorgak River in Sureshjan city) using an institutional analysis and development (IAD) framework shows that in the past, people acted collectively to solve the asymmetric distribution and drought problem. But government intervention, which initially sought to improve water conditions, has disrupted the region's institutional arrangements and power asymmetries between exploiters. Our study used the IAD framework to examine changes in institutional arrangements due to the introduction of technology and government intervention by the game theory. It clarifies that government intervention in local institutional arrangements, even if designed with the intention of improving conditions, may lead to greater inequality due to disregarding physical and social conditions and local knowledge. This inequality can eventually worsen the situation.

Key words: Collective action, Government intervention, IAD framework, Institutional analysis, Water governance

HIGHLIGHTS

- Government intervention in local institutional arrangements may lead to greater inequality due to disregarding local knowledge and local institutions.
- Using the institutional analysis and development framework and game theory, we identified the effective institutional factors in our case study.
- Our study shows the consequences of a wrong government intervention, which crowd out the self-governance of local communities.

1. INTRODUCTION

Water provision has been one of the most critical challenges in recent years in different parts of the world. These challenges, which in some areas have led to critical living conditions, are due to factors such as the successive occurrence of droughts, climate change, lifestyle changes, and economic patterns based on severe exploitation of limited natural resources (Foster & Chilton, 2003; Alavian *et al.*, 2009; World Economic Forum, 2019).

Even in areas where rivers play a key role in water supply, there are water crises (Mekonnen & Hoekstra, 2016; Nouri *et al.*, 2019)

Changes in the methods of water resource exploitation, cultivation patterns, lifestyles, and the application of command-and-control management are among the measures taken to meet the water challenge (Khatibi & Arjjumend, 2019). But some argue that the water problem requires a change in approach to water management (Madani, 2014). In some regions, governments consider themselves the owners of natural resources and do not grant public property rights to those who would exploit them. Therefore, regardless of the principles of natural resource management, especially in relation to water, governments intervene, which leads to intensified water conflicts between the users and, sometimes, the collapse of local management systems and the waste of water resources.

This occurrence is more important in arid and semi-arid climates, including Iran, which have limited water resources. Due to its geographical and climatic conditions, Iran faces severe water limitations in large parts of its territory (Hosseini Abari, 2000). These conditions have led to the formation of various management organizations in different parts of the country for the usage of water resources. Organizational structures such as those of Mirab, Baneh, Rustaq, the agricultural calendar, and water share based on water rights in different regions of Iran are among such organizations (Safey Nejhad, 2011).

The consequences of the water crisis have led to direct and short-term government intervention. Numerous assessments of government intervention in water resource management, weakening or elimination of local water management institutions, and asymmetric power in exploitation due to lack of knowledge of local communities have made exacerbated water challenges (Saedi *et al.*, 2014).

The challenge of water supply, in addition to being rooted in the lack of rainfall and the occurrence of drought, has become more acute in some parts of the world due to changes in technology and methods of water extraction (Gunasekara *et al.*, 2014). Accordingly, the intervention of governments or national organizations to address this challenge has been proposed. However, given that efforts have been made without proper understanding of the structure of the problem and its evolution over time, of technological developments, and of the effect of external interventions, they have only led to a worsening of the situation (Madani & Mariño, 2009). Historical studies show that the intervention of governments and national organizations is not effective enough to meet the challenges associated with water supply (Ostrom, 2005). Water is a common resource in its surface form; there has long been a conflict between upstream and downstream users due to the asymmetry of power in exploitation. However, in the past, the exploiters, especially on a small scale basis, were able to resolve the issue and prevent conflict by developing certain forms of self-government commensurate with the characteristics of the source and their own status (Ostrom, 1990).

To this end, and to understand the institutional developments in shared resources such as groundwater or surface water, Ostrom and her colleagues at the 'Workshop in Political Theory and Policy Analysis at Indiana University' proposed the institutional analysis and development (IAD) framework as a result of their extensive studies. This framework, while simplifying the existing complexities, provides a set of concepts that are internally related. The researcher can change one variable and check its effects on user interactions and on the resource and evaluate those effects from the perspective of the stakeholders. (Ostrom, 1990; Pahl-Wostl, 2017).

This framework can provide a list of essential variables and their relationships for the analysis of the actors' actions. However, as Ostrom & Basurto (2011) pointed out, the analyst assumes that the structure of action is stable in the short run. This assumption can be useful because the structure has remained unchanged for decades. But with the change of circumstances, the way actors interact with each other changes, and the analysis of the consequences necessitates determining the relationships between the variables. Ostrom separates the three analytical levels of framework, theory, and model. In a particular framework, there can be different theories, and in the form of a specific theory, there can be different modeling methods. Models make precise assumptions about a limited set of parameters and variables aimed at understanding the behavior of actors and their consequences (Ostrom *et al*., 1994). For example, to analyze the strategic structure of actor interaction, noncooperative game theory can provide a suitable method. However, depending on the different institutional and physical compositions, certain types of game theory models can be used (Ostrom, 2010). For example, various methods have been used to model water conflict, including the Interactive Computer-Assisted Negotiation Support system (ICANS), Graph Model for Conflict Resolution (GMCR), Shared Vision Modeling, Adjusted Winner (AW) mechanism, Alternative Dispute Resolution (ADR), Multivariate Analysis Biplot, and Fuzzy Cognitive Maps (Madani, 2010). However, the game theory has features that make it suitable for analyzing water issues. First, water is a scarce resource that makes it the object of competition. Second, water is exposed to various side effects such as the effect of upstream on downstream exploiters; and third, there is asymmetric information and uncertainty between users (Dinar & Hogarth, 2015). Other advantages of using the game theory over-optimization and quantitative simulation methods are their ability in simulating different aspects of the conflict, combining various features of the problem, and predicting possible solutions in consequences where there is an absence of quantitative information. In most cases, noncooperative game theory can help resolve conflicts based on qualitative knowledge of player outcomes (i.e., ranking the results of different situations). This makes it possible to address the socioeconomic aspects of conflict and plan and design policy issues in the face of easy access to quantitative information (Madani, 2010).

An interesting case to study is that of small rivers and the institutions created over time by a small number of exploiters to solve the problem of asymmetric power through self-governance. The present article deals with the case study of small river users in Shahrekord, Iran. The reason for choosing this case study is the distinctive feature of the region in the allocation of river water in conditions of asymmetric access. The villagers of this region have been able to design a sustainable mechanism for the allocation of river water resources by creating informal rules and a hard infrastructure. This soft technology in the region has made its study attractive.

The first goal of this study is to understand how self-governance was established in the past using the IAD framework. Advances in water exploitation, irrigation technologies, government intervention for the community, fulfilling the goals of agricultural development programs in the form of issuing permits for wells, and subsidizing the installation of new irrigation technologies have led to changes in the institutional arrangements of self-governance. The second goal of the paper is to analyze the structural changes related to water conflicts between exploiters and their consequences using the game theory (including conflict resolution or aggravation or reaching only short-term solutions).

2. RESEARCH METHODS

2.1. Case study area

The case study of this research is Laran district, which is part of the Chaharmahal and Bakhtiari province of Iran. The most important source of water supply in the area is the Gorgak River. The region is an example of cases where there is water-related tension due to asymmetric power. Below, its biophysical and social characteristics are given.

2.1.1. Biophysical conditions

2.1.1.1. Location. The Gorgak water basin is a part of the Behesht Abad river basin and the Karun basin. This subbasin is known by the hydrological code 2358. The Gorgak basin is located in the mountainous area of the Karun basin. In this basin, there are five rural settlements (Harouni, Asadabad, Katak, Vanan, and Khoi) and one urban settlement (Surashjan). The geomorphic conditions of the basin have rendered its aquifers weak, and direct exploitation from the river through dams is the most essential method of exploiting it.

2.1.1.2. Water resources. The most important water source in the region is the Gorgak River, which originates from the Haruni Heights in the Zahrmar Pass (border of the Karun Basin and Zayandehrud) and merges with the Bidkan River in the south of Surashjan. The daily hydrograph of the river shows that in March and April, it has the highest flow rate which is 5–10 m^3/s. With the start of the agricultural season, which coincides with the dewatering of dams and water supply canals, the river discharge decreases. It reaches less than 100 L/s in August and September (Rahimi, 2017; Shahrekord Management & Planning Organization, 2018). With the end of the agricultural season, the flow rate increases due to the release of the dams. The Laran region has 25 wells, 78 aqueducts, 51 springs, and 12 embankment dams. The Bidkan dam, with a capacity of 20 million cubic meters, is the biggest embankment dam in the region.

The method of exploiting the water resources in the region is the use of diversion dams on the river in the upstream areas of each village. Thus, by opening the diversion dam on the water transfer canal, the flow rate after it almost reaches zero; however, due to the intervention of groundwater and the reproduction of water from irrigation, the flow rate increases before reaching the next diversion dam. For this reason, drilling wells between any two diversion dams reduce the water resources in the region and create various water-related, social, and economic tensions.

2.1.1.3. Climatology. The average annual temperature of the region is 11.5 °C, with an absolute minimum of −20 °C, and an absolute maximum of 38 °C. December with an average of at least −8.8 °C and July with an average of 22 °C are the coldest and warmest months of the year.

The annual rainfall of the region is equal to 480 mm, of which more than 50% is in winter, 27% in spring, 20% in autumn, and 3% in summer. The rainfall regime is of the Mediterranean region, and its climate is Mediterranean with wet and cold winters and mild and dry summers (Statistical Center of Iran, 2016).

2.1.2. Characteristics of the community

The existence of historical experience in the management and utilization of natural resources, especially shared resources, has an effective role in the success of programs related to development and environmental sustainability. Such experience, known as indigenous local knowledge, includes knowledge of the demographic, ethnic and social structures, and the hierarchies in each society (Hosseini Abari, 2000).

Studies of the human, historical, and social geography of the Laran region show that this region has historical monuments belonging to pre-Islamic settlements. Archaeological excavations have led to the discovery of settlement artifacts in the villages of Vanan, Khoy (Gordeneh Rimali area, the Old Castle, and Janat Valley), Surashjan (historical castle of Surashjan), and the ancient historical hill of Asadabad village (historical studies of Chaharmahal and Bakhtiari province in 2003). In addition, reviews of the historical geography of the region show the linear settlement of villages along the Gorgak River. Historical and economic studies of the region show that agriculture and animal husbandry were the most important economic activities of the inhabitants; the existence of ancient artifacts and agricultural tools and sheep cages in the ancient castle of Vanan, Assadabad hill, and the original location of Khoy village (Dam Tang) is evidence for this.

Examples of institutions that facilitate collective action can be found in this area. For example, the relocation of the Asadabad and Khoy villages (Dam Tang, Rim Ali, Qaleh Kohneh, Darreh Jannat, and the current location) indicates collective action to deal with natural hazards such as floods. Rural demographic studies show that intra-rural communication based on kinship has been very strong due to the existence of the shared river. The connection between the villages is enduring and is an important social asset. The Gorgak River is a unifying factor in establishing socioeconomic ties, such that the oral history of the people of the region indicates cooperation among the villagers in the event of natural disasters such as drought or flooding in supplying water from other areas, dredging, dam construction, and the like. Collective actions between villages are also significant. For example, the droughts of 1958–1967 led to collective action in the construction of a canal to transfer water from the Bidkan to the Gorgak River.

Moreover, resolving social and family disputes through local groups, participating in public ceremonies and rural development, constructing public and sanitary facilities, removing canals, protecting rangelands (by determining grazing time), and participating in the management of natural hazards such as drought are samples of the most important aspects of the cooperation between, and collective action of, the residents in each village. Besides, participation in social ceremonies and marriages between villagers is one of the manifestations of social unity and cultural similarity (Management and Planning Organization, 2003).

The study area has two cities named Surashjan and Harouni, and three villages named Asadabad, Vanan, and Khoy, which are located in the Laran section of Shahrekord city in Chaharmahal and Bakhtiari province. The towns and villages of this region are located on the banks of the Gorgak River with a linear settlement pattern. The distance from the first population center (Haruni village) to the last (Surashjan) is about 18 km, with all distances between centers being approximately equal. The population of the study area (including the three villages and two cities), as shown in Table 1, was 20,038 in 2016, which has grown by about 3% compared to the previous decade (Statistical Center of Iran, 2016). Meanwhile, the population of the country has grown by 13.4% in this period, which means that the subject of emigration in the region is significant. Most people are from Bakhtiari Lori and speak the Lori dialect. The clothing of men and women has remained unchanged.

Although the residents of different villages know each other and have family ties, most of their social interactions are within their own village; this may be due to the way the river water is distributed, which does not require much interaction between villages. To develop their village, the residents of each village have taken successful collective action such as building mosques, constructing parking lots for heavy vehicles (Khoy village), or determining the number of charity wedding gifts each year. Farmers in each village also work in activities such as dredging canals (occurred especially in the past when canals were dug with simple tools and required a great deal of labor), cementing soil canals, leveling and consolidating land, and even establishing pressurized irrigation on the land. Collective action has been a successful experience. For example, the cementing of canals was well done in the seventies with the financing of the Jihad-e-keshavarzi organization and the labor of the farmers. Changing some unsavory rural traditions by mutual agreement is another example of successful collective action in the

Table 1. | Population by population case study of centers in 2006 and 2016.

Village name	Population of 2006	Population of 2016	Growth rate of 2006–2016
Assadabad	719	607	−5.15
Surashjan	11,124	12,308	10
Harouni	1,884	1,601	−15
Vanan	3,044	2,750	−6.9
Khoi	2,697	2,772	7.2
Total	19,468	20,038	9.2

Source: Authors' calculations based on the general population and housing census of Iran Statistics Center 2006–2007.

village, which is also being done in these years. For example, due to rising costs, funerals have been reduced from three to one. They have also imposed restrictions on the type of fruit and food that can be served at funerals.

2.2. Institutional analysis and development framework

The IAD framework is a tool for understanding how institutions function and change over time. This framework, while identifying and classifying the effective factors and variables in an action environment, relates them to each other using a specific logic (McGinnis, 2011; Ostrom, 2011). Briefly, IAD means accessing the proper way to untangle complex systems into their components. The IAD framework paves the way for 'nested action environments' analysis (Tarko, 2017).

The core of IAD analysis is the action situation. In the action situation, players take action after receiving information and enter into an interaction pattern that will eventually end in the result. Each action situation is affected by three categories of external variables: resource characteristics, characteristics of individuals in the society, and the rules governing the environment of action (McGinnis, 2011) (Figure 1). For example, in a water-related action situation, water scarcity, canal length, and water storage capacity are examples of source characteristics; the number of households, group size, and water dependence are characteristics of individuals in the community (Wang, 2011). Rules also assure the common understanding of individuals of the necessary, permissible, and prohibited actions in the action situation, which ultimately, along with the characteristics of the environment and the characteristics of individuals, will lead to the formation of the action situation (Ostrom & Basurto, 2011).

In this framework, people as actors take on different roles in different situations. For example, crucial institutional roles in the use of water resources are those of the resource exploiter and the government that define the rules for the use of water resources (Tarko, 2017). Governments usually make changes to the structure of institutions in order to modify the interactions or their consequences. After government intervention, the action situation leaves its original state in which either there are no rules or simple rules are established, and a new action situation is formed (Villamayor-Tomas *et al.*, 2019).

2.3. Data collection method and analysis

The data were collected using field and library studies. Data related to the physical features of the area were mainly collected in the field, and data related to other properties of the region were collected mainly from library studies. Data collection for this study occurred during the summer and autumn of 2019 through interviews with focus groups, individual interviews with government officials and residents of Sureshjan city, direct observation, and access to secondary data. Table 2 shows the data collection methods.

As mentioned, the article has two main goals. The first goal is to understand how self-governance was established in the past using the IAD framework. The second is to examine changes in institutional arrangements

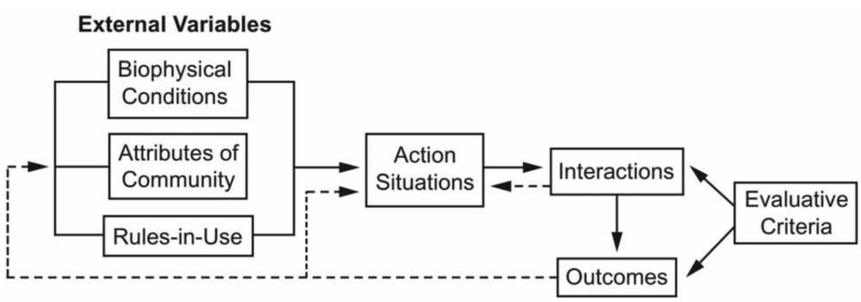

Fig. 1. | Institutional Analysis Framework (Ostrom, 2011).

Table 2. | Data collection method.

Data source	Interviewee	Number
Focus group discussions	Different groups of rural occupations	5
Individual interviews	Residents of the studied villages	10
Interviews with local government	Semistructured interviews with informed local and nonlocal government employees	5
Interviews with regional experts	Semistructured interviews with experts from governmental and nongovernmental organizations	3
Direct observation	Observation of the river, bands, and channels	
Secondary data	Using the rural employment plan and the Statistics Center of Iran	

due to the introduction of technology and government intervention using the game theory. The first goal is reached descriptively and only at the level of the variables in the IAD framework (and not the theory or model). The second goal is reached with the help of modeling. To do this, a simple game is used between two players (exploiters): upstream and downstream. The conceptual model of the research is shown in Figure 2.

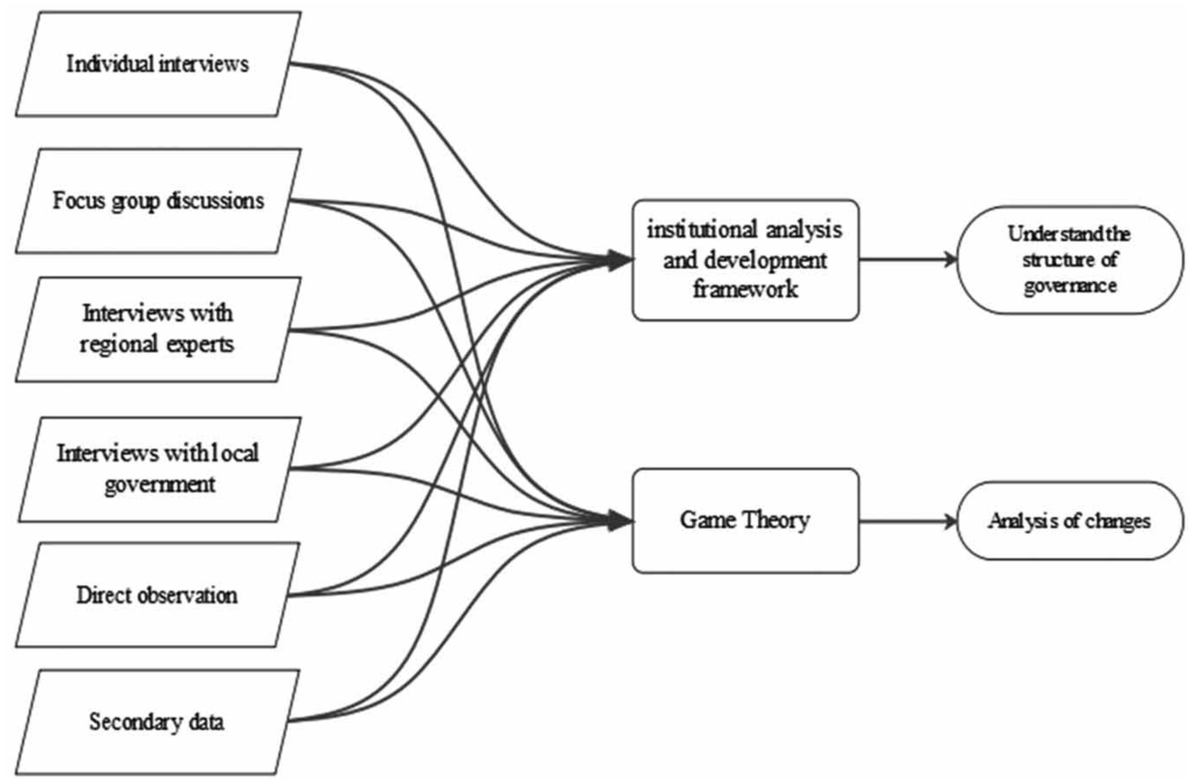

Fig. 2. | Conceptual model of research.

2.4. Features of the case study in the IAD framework

In the past, the exploitation system of this region was based on a kind of feudal system, and the land belonged to the Bakhtiari Khans. They were given ownership of their subjects in the land reform program. In this system, most production was through labor and livestock (for plowing and threshing) and was, therefore, traditional production. The main aim of wheat production was to procure food for the year. The production system was of the subsistence type, since after subtracting the lord's share, the wages of the craftsmen and creditors, and the annual food supply from the harvest, there was not much left for trade with other villages and regions. Thus, all employment was dependent on the agricultural sector.

Due to fluctuations in rainfall, some years have had rainfall and others have been dry. Because this was not predictable, the villagers found a way to manage the risk, in that water was divided into two parts, i.e., reliable and unreliable, and consequently, the land was divided. Reliable water resources were allocated to the land used for wheat cultivation (autumn cultivation). The remaining land was dedicated to spring cultivation. If the rainfall improved that year, this cultivation could also help the family's livelihood, and in case of drought, it would be left to lie fallow. Another type of adaptation to the amount of water available was the choice of product type. In case of water shortage, the vegetables and summer crops, which were among the most widely used plants and crops such as barley which consume less water, were cultivated.

The irrigation system of the riverbanks had unique features that were due to the topographic characteristics of the region. The system was based solely on the flowing waters of the area. Due to the steep slope of the lands along the river, a dam was used to mount water onto the lands, which in some cases increased the water height up to about 3 m. The dam then entered excavated canals which were based on the alignment of the land and transferred the farmers' shared water. The water was divided based on each farmer's share of land.

Several dams (about 14, small and large in size) in a row along the river completely blocked the movement of the river water and transferred it to the canals. Given that the river water dried up entirely on the other side of the dam, the higher villages had more power in transferring water. First, how was this asymmetry in exploitation resolved? Second, if the river dried up after each dam, how did water accumulate behind the next dam?

This problem is solved considering several features: (1) the limited depth of the soil prevents the drainage of upstream groundwater from sinking into the deeper layers of earth. (2) The steep slope of the lands perpendicular to the river path causes the drainage water to reenter the riverbed at subsurface levels. (3) The steep slope of the river causes the drainage water to reach the surface again. These three factors have created, according to the estimates of the locals, about 70% of agricultural water to return to the water cycle. (4) The existence of small and large springs in the course of the river compensates for the amount of water that does not enter the cycle. Therefore, the amount of water released from the cycle is compensated by the springs between the two dams. Factors of institutional analysis and development of the research is shown in (Figure 3).

3. RESULTS AND DISCUSSION

3.1. Changes in the exploiting system

3.1.1. Intervention of the government as a precondition for changing the rules of the game

In the past, governments in Iran, especially in the Qajar era, had the least intervention in the economy especially since the system of government was provincial, and local rulers, especially the Khans, had the power. But gradually, from the time of the Constitution, the presence of the government in economic issues, such as those related to water and land, increased until it finally reached its maximum in the current era with the laws of water nationalization, land reform, and the emergence of governments prioritizing development.

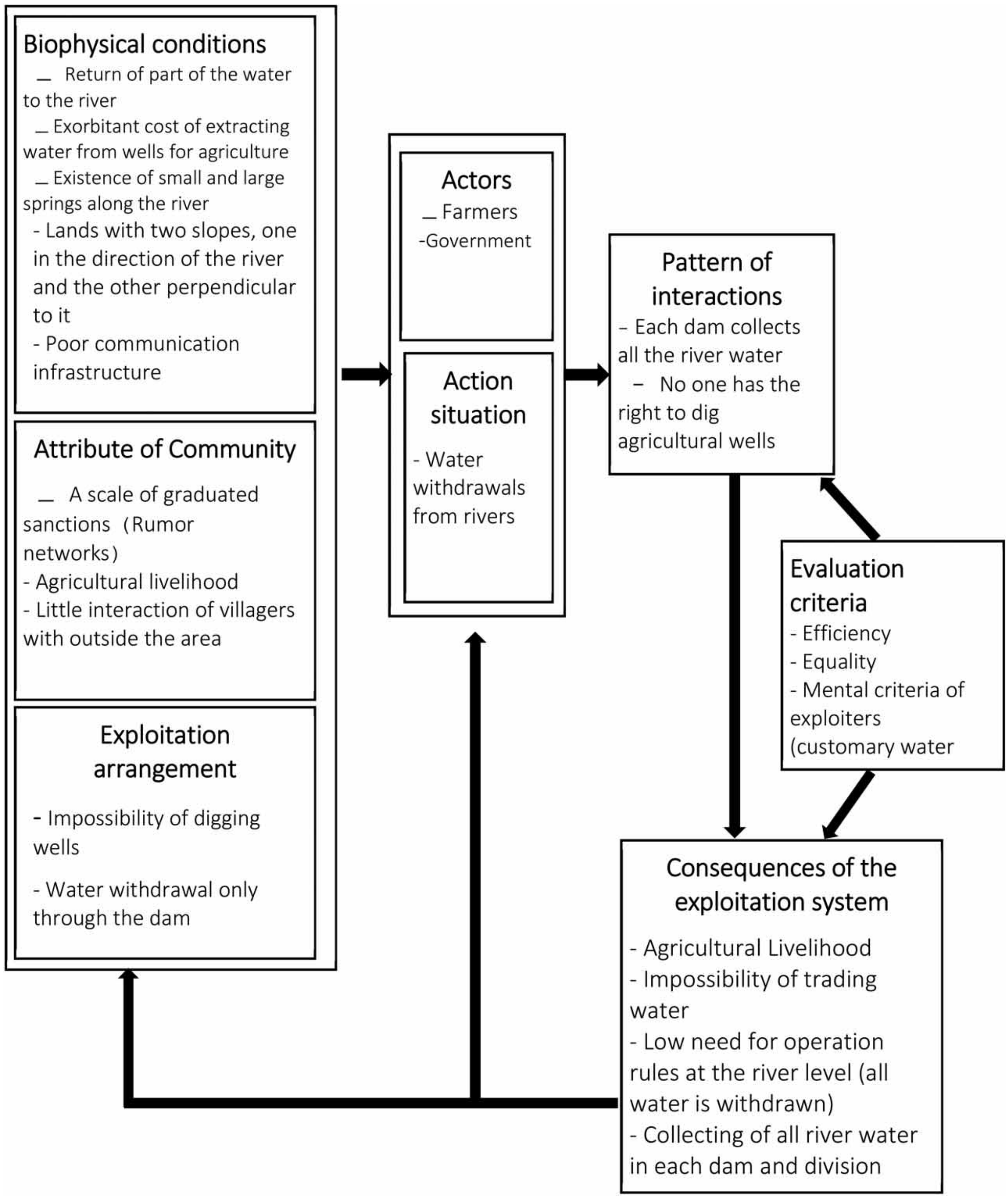

Fig. 3. | Factors of institutional analysis and development of the research. *Source:* Research findings

The reform of the law on land, i.e., the abolition of the landlord and serfdom aimed at making fundamental changes in the amount and manner of land ownership, especially agricultural land, was approved by the National Assembly in 1961 (Kian *et al.*, 2020). The purpose of this law was to redistribute land among the peasants and remove large landowners from the community. This led to a change in land ownership in the study area, and, consequently, to an increase in the number of actors which paved the way for increase in the water disputes of upstream and downstream exploiters and their bargaining as water owners with the government.

Before 1928, and the enactment of the Civil Code, water management was exercised through local community agreements on water ownership, the most important of which determined how water was shared. With the enactment of this law, the intervention of the government in water-related issues found a legal basis with the division of water ownership into three categories: private, shared, and public. With the introduction of deep-well drilling technology in the country in 1955, and the need for new legislation, the 'Water Law, and how to nationalize it' was approved in 1968 (Davary *et al.*, 2019). This law made water a national treasure and turned it into government property. Accordingly, the allocation of water between the exploiters and determining the interests of the owners and beneficiaries of water also became the prerogative of the government.

3.1.2. Government intervention and well drilling permits

Before the Islamic Revolution, rural infrastructure was weak, and there was a self-sufficient lifestyle. Later, with the development of infrastructure in ways such as asphalting roads and supplying electricity to villages, circumstances justified the commercializing of agricultural products. On the other hand, villagers faced new consumer needs such as televisions, refrigerators, and urban housing, which necessitated an increase in revenue. Due to the limited amount of land in mountainous areas, achieving this goal required an increase in agricultural water. Achieving the goals of postwar agricultural development programs also required an increase in agricultural production, which was in line with farmers' demands.

Due to their limited land and because of successive droughts, farmers in the area have pressured local authorities into increasing their water supply. Because of the time-consuming and costly construction of a dam (Bidkan Dam was built on another river upstream of the region, but its water has not yet entered the region), in the 2010s, drilling wells was considered the feasible response to this pressure. The first group of farmers in Vanan village received a permit to drill a well. Because the law prohibits drilling wells in rivers, the initial idea was that this well would be fed from an aquifer (not the springs), and therefore would not affect the flow of the river, but would increase it through return water. But in fact, this was not the case, and the water of this well was supplied from the drainage of agricultural waters and from springs. Since the depth of the soil in this area is limited and the size of the river basin is small, no studies have so far been done. Therefore, most decisions are made based on the judgment of experts which is in turn based on the statements of local residents or well drilling stakeholders. Also, the government had issued the permit at a time of the year which it thought would lead to fewer water disputes due to the abundance of water. Due to a lack of water flow meters, it was not possible to assess the effect of wells on the river water.

3.1.3. Early consequences of government intervention

Asymmetric power increased notably during the drought and caused disputes among the villagers. In the past, farmers punished violators by using social punishments. In the current situation, the downstream farmers initially decided to punish the offending farmers because appealing to the government to solve the problem could take years, and additionally, farmers, based on their relation to the local government system, resolve disputes internally. But the punishment was not a reasonable settlement of the conflict, since in the institutional arrangements of the irrigation system, digging deep and semi-deep wells had not been foreseen due to the modernity of its technology which had not existed.

With the passage of time, the easing of tensions, and the high cost of continued conflict, rationality once again prevailed. But the government played a vital role in the conflict because it created the problem and had the legal power to resolve it. Contrary to expectations, the government's solution was not to revoke the permit issued for the third village, as this faced several obstacles. First, governments typically do not have a mechanism for acknowledging their mistakes at the micro-level of policy implementation because decisions are made locally by experienced experts at the expense of another party – in this case, the person who owned the well. The stabilization of the well for the third village and the losses to the downstream villages (fourth and fifth) increased the bargaining power to obtain well permits. The government also wanted to end the conflict, which eventually led to well permits for other villages.

3.2. Quantifying water conflict with the game theory

Modeling of water users' interactions is done with simple assumptions derived from reality. Although there are five villages in the area, to avoid complexity, it is assumed that there are only two villages (players), i.e., upstream (P_u) and downstream (P_L). An essential point in modeling is the historical order of development in institutional arrangements. First, the government owns the water and issues well permits for groundwater exploitation, then water exploitation technology is developed, and its costs are drastically reduced. Subsequently, irrigation technology is developed (pressurized irrigation technology); finally, the government seeks to transfer water from outside the watershed.

The main modeling assumption is the amount of water that reaches P_u, which is considered to be equal to 10 units. The number 10 is a hypothetical number, and the other values of the variables are normalized based on it. The quantities of the variables have been extracted from interviews, and experts have confirmed their approximation to reality. Accordingly, the following hypotheses have been used to describe the structure of the water conflict problem in the form of game theory:

- Water efficiency in the traditional irrigation system is equal to 1 unit. Therefore, the amount of water income for the village will be 10 currency units.
- The rate of return water in case the well is not drilled by P_L is equal to 0.7.
- The springs between the two dams add three units of water to the river discharge.
- The cost of pumping water from wells using traditional methods is five units.
- The social cost of drilling wells (blaming, fights, and sabotage) for P_u by P_L is equal to four currency units.
- The income of each village from the establishment of a well is 0.3 of the available canal water. That is, having a well increases the amount of available water by 1.3 times.
- If a well is drilled in the upstream village, the return water rate will decrease from 0.7 to 0.3.
- The cost of water exploitation from wells using modern technology methods (such as an electric pump) is one unit.
- The cost of equipping farms with pressure irrigation systems is two units.
- Irrigation efficiency in the pressure irrigation system is 1.3, i.e., it increases the revenue flow by 1.3 times.

Based on the presented hypotheses, the course of the developments in the irrigation system of the region is shown using the game theory.

3.2.1. Situation 1: old water exploitation technology and no government intervention

This situation, also called the base situation, illustrates the situation in which governments were small and did not intervene in water governance. In addition, extracting water from wells was done with old agricultural technology. Drilling a well reduces the return water. This is reflected in the increase in the amount of water available to the player to 1.3, and the decrease in the return water coefficient from 0.7 to 0.3. Thus, in this game, P_L and P_u each have two strategies of drilling a well, and not drilling a well. If P_L does not drill a well, drilling a well by P_u can incur a social cost. It is shown in Table 3.

Table 3. | No government intervention, and old water exploitation technology.

		P_u	
		No digging wells	**Well digging**
P_L	No digging wells	(0.7*10 + 3), (10)	(0.3*10 + 3), (10*1.3 – 5 – 4)
	Well digging	(0.7*10 + 3)*1.3 – 5, (10)	(0.3*10 + 3)*1.3 – 5, (10*1.3 – 5)

Due to the high cost of pumping water from wells, the dominant strategy of both players is not to dig them. As the IAD analysis of the baseline situation showed in Section 2.4, the water dispute between the exploiters was resolved with the help of hard infrastructure; this means that each player draws all the water from the dam and has no incentive to dig a well.

3.2.2. Situation 2: old water exploitation technology and government intervention

According to the historical course of the irrigation system, the government, by acquiring water resources and as the custodian of the country's water resources, can authorize the drilling of wells for both players. This leads to the crowding out of the P_u player's penalty motivation by the P_L player and a change in the two players' earnings, according to Table 4.

As the analysis of the second game shows, although the government's intervention reduces the cost of drilling a well for P_u, it does not change the balance of the game because the strategy of the two players is still not to drill any wells. Historical facts show that despite the passage of several decades since the issuing of well drilling permits, no attempt was made to drill in the village until the last decade.

3.2.3. Third position (hypothetical): modern water exploitation technology and no government intervention

Although this situation is not in line with the historical course, it is important to study it because it seeks the effect of technological progress on the motivations of actors in the absence of government intervention.

In the analysis of the third game, according to the revenues of Table 5, the dominant strategy of the upstream player is to dig a well. Thus, the second player does the same, although his income from doing this is only 0.8. The comparison of the second and third games shows that it is not the intervention of the government that changes the balance point of the game, it is the entry of technology that plays a major role. Also, the equilibrium point efficiency (i.e., the total revenue of P_u is equal to 12, and the revenue of P_L is equal to 8.6) is equal to 18.8, which is less than the balance of the base game, i.e., 20 units.

3.2.4. Situation 4: modern water exploitation technology and government intervention

The analysis of the fourth game (Table 6) is similar to that of the third because the government's intervention is actually in P_u's favor; P_u's dominant strategy will still be to dig a well. The only difference is that perhaps in the

Table 4. | Government intervention and old water exploitation technology.

		P_u	
		No digging wells	**Well digging**
P_L	No digging wells	(0.7*10 + 3), (10)	(0.3*10 + 3), (10*1. 3 – 5)
	Well digging	(0.7*10 + 3)*1.3 – 5, (10)	(0.3*10 + 3)*1.3 – 5, (10*1.3 – 5)

Table 5. | No government intervention and the development of water exploitation technology.

		P_u	
		No digging wells	**well digging**
P_L	No digging wells	(0.7*10 + 3), (10)	(0.3*10 + 3), (10*1.3 – 1 – 4)
	Well digging	(0.7*10 + 3)*1.3 – 1, (10)	(0.3*10 + 3)*1.3 – 1, (10*1.3 – 1)

Table 6. | Government intervention and the development of water exploitation technology.

		P_u	
		No digging wells	**Well digging**
P_L	No digging wells	(0.7*10 + 3), (10)	(0.3*10 + 3), (10*1.1.3 – 1)
	Well digging	(0.7*10 + 3)*1.3 – 1, (10)	(0.3*10 + 3)*1.3 – 1, (10*1.3 – 1)

third game, the upstream player would find himself morally obligated to compensate a small part of the damage to the lower player, while with the intervention of the government, such an incentive would not stand.

3.2.5. Introduction of modern irrigation technology and its consequences

As mentioned, with the introduction of modern water exploitation technology and government intervention, both players start drilling wells. Still, the problem of decreasing or at least stagnant efficiency, as well as increasing inequality, arises because of government intervention (according to Table 6). Therefore, if the criterion for government intervention in such situations is, in the first stage, to increase efficiency (according to the requirements of agricultural development programs) and, in the second stage, to reduce inequality to reduce conflicts between farmers, it does not achieve anything. Therefore, the government tries to intervene in the next step by other means such as subsidizing the construction of new irrigation facilities.

The decision of each player to develop or not develop irrigation technology depends only on its cost (according to the second assumption) and its benefits (30% increase in water efficiency), and not on the decision of another player. Calculations show that the efficiency increase for P_u is higher due to a bigger water supply and is negligible for P_L. Therefore, although efficiency has increased from the baseline (old water exploitation technology and no government intervention), inequality has also increased. Thus, technology cannot significantly improve the two criteria set by the government, and conflicts remain in place, especially since the P_L player's income has not yet reached the first base position of 10 units, and additionally, in times of drought, both players find themselves in a worse situation. This is because the efficiency of new technology (water exploitation technology and establishing pressurized irrigation) is entirely dependent on the river water base.

Thus, the government is starting a water transfer program operating from outside the river basin; since there are no negative effects on the farmers in the basin of origin, this can increase efficiency. But the government has two choices. One is the use of the old arrangements (directing the transferred water into the river), and the other is the direct transfer of water to each dam by pipe.

Assuming that the amount of transfer water is 20 units (equivalent to the amount of efficiency in the first base case), the calculations in Table 7 show that in both methods, the efficiency increases significantly (from about 20 to more than 50, as is shown).

Table 7. | Comparison of different methods of water transfer.

	P_L	P_u	Efficiency	Equality
Transferring by pipe	(10 + 7.8)*1.3 − 2 − 1	(10 + 13)*1.3 − 2 − 1	50.04	0.75
Transferring with old arrangements	1.3*30*0.3*1.3 − 1 − 2	(20 + 13)*1.3 − 2 − 1	52.11	0.31

But in the second method of water transfer, although the efficiency is reduced by only about 4%, the inequality is much improved (from 0.31 to 0.75). Therefore, the method of transfer through the river creates a great deal of inequality which is even worse than transferring water.

3.3. Evaluating the consequences

According to the IAD framework, each player has one or more evaluation criteria by which any change in outcome is evaluated. Table 8 shows a summary of the earnings of the two players in different situations and the amounts of different evaluation indicators.

As Table 8 shows, all developments increase inequality, which indicates the nature of asymmetric power and its activation in a variety of interactions. However, the best case should be considered the transfer of water by pipe to the back of the straps, which increases efficiency and improves the position of the two players compared to the base position, in addition to presenting the lowest degree of inequality.

4. CONCLUSION

For a long time, the farmers of the Gorgak River Basin were able to design and use their own basin system to solve the problem of asymmetric power between the upstream and downstream villages by creating institutional arrangements. As mentioned in the IAD framework, these arrangements were tailored to the physical and social conditions. The most crucial method of solving this problem is considering the biophysical features of

Table 8. | Summary of two players' payoff and amounts of evaluation indicators.

					Comparison of players' payoff with basic status	
Type of game or interaction	P_u payoff	P_L payoff	Efficiency (total payoffs)	Inequality (P_L payoff to P_u payoff)	P_L	P_u
Basic game (old water exploitation technology, no government intervention)	10	10	20 (no difference)	1	–	–
Old water exploitation technology, government intervention	10	10	20 (no difference)	1 (no difference)	No difference	No difference
Modern water exploitation technology, no government intervention	12	6.8	18.8 (decrease)	0.57 (much worse)	Better	Worse
Modern water exploitation technology, government intervention	12	6.8	18.8 (decrease)	0.57 (much worse)	Better	Worse
Improving irrigation technology	15.9	9.14	25.4 (increase)	0.57 (much worse)	Better	Worse
Transferring with old arrangements	26.9	20.14	47.04 (increase)	0.75 (much worse)	Better	Better
Transferring by pipe	39.9	12.21	42.11 (increase)	0.306 (much worse)	Better	Better

the basin, including limited soil depth, steep slope of the land toward the riverbed, steep slope of the river, the presence of small and large springs along the river, and the low width of the land along the river (maximum 200 m). Accordingly, the water rises behind the first dam and flows into the first canal. These long canals, which may sometimes bring water from two villages behind, carry the shared water of several farmers divided according to the share of village land for each (Huba). Irrigation drainage water flows to the riverbed due to the steep slope of the lands and comes to the surface again from a lower point, flowing into the riverbed. The amount of water that returns is also compensated by springs located between the two canals. In this way, water is distributed without the need for soft regulation on the river surface.

This traditional exploitation system was sustainable due to its characteristics. By dividing their land into two parts, i.e., autumn wheat cultivation and spring barley cultivation, farmers had adapted to wet and dry conditions.

With the social changes that took place after the land reform and the growth of the middle class in the cities, the demand for commercial cultivation increased, and as a result, IAD action situation has changed. Major rules, such as the water law and the manner of its nationalization in 1968, paved the way for a change in the system of exploitation and the intervention of a powerful actor in the name of the government.

The government had two goals: to increase agricultural production and to respond to the demands of the villagers. Therefore, in a country such as Iran, the solution is to increase agricultural water resources by issuing permits for digging deep wells and constructing dams. Accordingly, one of the villages is allowed to have a well and reduces the return water, thus activating the asymmetric power between the actors. As shown with the game theory and IAD framework, this has disrupted the former institutional arrangements, necessitated more government intervention in issuing well permits for other villages, and has ultimately led to instability in the exploitation system. This unstable situation necessitates the introduction of water into the watershed to reduce dissatisfaction with the government's wrong intervention. Despite the increase in rural incomes due to government policies, their dissatisfaction has not decreased. Because these policies have always increased inequality among the villagers. The ignorance of local institutions and knowledge, as well as physical conditions, has led to the failure of even well-intentioned policies.

Water policy should be adopted according to the action situation and its understanding by the game theory. Not prioritizing local stakeholders in water policy leads to the crowding out of local arrangements and indigenous knowledge and transforms water policy from a local issue to a political issue. Therefore, water policy becomes an unsolvable problem.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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