Groundwater for Sustainable Development 21 (2023) 100892

Contents lists available at ScienceDirect

Groundwater for Sustainable Development

journal homepage: www.elsevier.com/locate/gsd

Research paper

Importance of good groundwater governance in economic development: The case of western Iran

Taraneh Sarami Foroushani [a], Hamid Balali [a,*], Reza Movahedi [a], Alishir Kurban [b,c,d,e], Rando Värnik [f], Ivana Janeska Stamenkovska [g], Hossein Azadi [h]

[a] College of Agriculture, Bu-Ali Sina University, Hamedan, Iran
[b] Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, 818 South Beijing Road, Urumqi, 830011, China
[c] Research Center for Ecology and Environment of Central Asia, Chinese Academy of Sciences, 818 South Beijing Road, Urumqi, 830011, China
[d] Sino-Belgian Joint Laboratory for Geo-Information, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, 830011, China
[e] College of Resources and Environment, University of Chinese Academy of Sciences, Beijing, 100049, China
[f] Institute of Agricultural and Environmental Sciences, Chair of Rural Economics, Estonian University of Life Sciences, Tartu, Estonia
[g] Faculty of Agricultural Sciences and Food-Skopje, Ss. Cyril and Methodius University in Skopje, 1000, Skopje, Macedonia
[h] Department of Geography, Ghent University, Ghent, Belgium

HIGHLIGHTS

- This study analyzed the water resources governance indices of Economic Co-operation and Development (OECD).
- Policymaking, information, data and stakeholder engagement had the greatest effect on the groundwater governance.
- The availability of information and data will increase the participation of people and elites in all government processes.
- The absence of clear policies in water resources governance leads to contradiction and conflict in water management.
- Lack of stakeholders and non-governmental sector participation is one of the reasons for the inefficiency of water policies.

GRAPHICAL ABSTRACT

ARTICLE INFO

Keywords:
Groundwater indicators
Effectiveness
Efficiency
Trust and engagement
Agricultural development

ABSTRACT

Over the previous half century, increased groundwater mining has had significant social and economic implications that are still going on. Many solutions and frameworks have been proposed in the world to overcome these problems. In this study, we attempted to analyze the conditions of Hamedan-Bahar plain in terms of groundwater governance (GG). The groundwater governance indicators were evaluated using the Structural Equation Modeling (PLS-SEM). In general, the status of the groundwater governance (GG) indicators in the region shows that these indicators are all lower than the standard level and are not in good condition. Based on the results, the constructs of policy-making (β = 0.867), information and data (β = 0.866), and stakeholder engagement (β = 0.859) had the greatest effect on the latent variable (i.e., groundwater governance), while the

* Corresponding author.
E-mail address: h-balali@basu.ac.ir (H. Balali).

https://doi.org/10.1016/j.gsd.2022.100892
Received 16 January 2022; Received in revised form 3 December 2022; Accepted 11 December 2022
Available online 5 January 2023

other constructs had a moderate effect. Among the three constructs of water governance, the efficiency construct ($\beta = 0.404$) with the indicators of information and data, budget, legislation, and innovative measures had the greatest impact on the governance of groundwater resources in Hamedan-Bahar plain. Finally, the overall goodness of fit (GOF = 0.77) reflects the excellent fit of the model. According to the results obtained, the water system managers and policy makers in the province should increase stakeholders' knowledge and awareness about new frameworks of water resources governance. A robust framework is presented for policy makers and planners to identify the gaps and problems of water resources. Furthermore, various aspects and features should be emphasized simultaneously so as to achieve sustainable governance of groundwater resources.

1. Introduction

The legal right of landowners to use and access bodies of water close to their properties is known as water right. Based on the many types of water that border or exist on a property, different types of water rights exist (Jackson, 2018). Depending on whether the surface water is permanent, ephemeral, or artificially created, water rules might differ even within the class of surface water. Water law may be separated broadly into two substantive areas: rights to utilize water and limitations on groundwater contamination (Macpherson, 2019).

Groundwater is considered as one of the main resources of water worldwide (FAO, 2018). Increasing groundwater exploitation brings about negative impacts (e.g., ecosystem damage, surface water dewatering, landslides, etc.) on meeting the long-term needs for water by natural systems and individuals (Rani et al., 2022). The dramatic increase in groundwater use over the last half century has had significant social and economic implications, as well as many consequences such as ecosystem damage, surface water drying out, landslides, and sea water penetration, all over the world (Balali and Viaggi, 2015). Agricultural production largely depends on water, and water resources are increasingly at risk (OECD, 2016). In recent years, agricultural areas have increased worldwide, leading to an increase in water demands (Miao et al., 2021). In this respect, unsustainable practices have led to serious groundwater depletion and degradation in many regions of the world, thereby leading to a series of negative effects on people and the environment (Agudelo Moreno et al., 2020; Asfaw and Ayalew, 2020; Balali et al., 2011; Jia et al., 2020). Agricultural production has been influenced by major droughts, resulting in a decrease in groundwater and surface water reserves (Miao et al., 2021). Pumping groundwater intensively for irrigation has resulted in the depletion of aquifers.

It might negatively affect environmental externalities and exert a considerable economic effect on the water sector and beyond. The FAO project related to the governance of groundwater (2018) indicates three times increase in extraction of groundwater over the last 50 years (1960–2010) (Barati et al., 2019). For example, groundwater is used for irrigation of nearly 100 million hectares of arable lands and more than 40% of uses through irrigation water (Döll et al., 2012; OECD, 2016; Siebert et al., 2010). Furthermore, about 11% of the groundwater discharge is consumed for irrigation in the international food trade (Dalin et al., 2017). In a number of developing nations, including Iran, frequent droughts along with intensive exploitation of surface and groundwater resources through a large network of hydraulic infrastructure and deep wells have brought the country's water to a critical level (Agutu et al., 2020; Balali et al., 2011; Custodio et al., 2016; Hamer et al., 2020; Havril et al., 2018; Wu et al., 2020; West et al., 2019). Although complexity and uncertainty, as well as climate change, have increased over recent decades (Castells, 2010), the development of new social, technical, environmental, and economic subjects is important and needs to be addressed (Franco-Torres et al., 2021). Under these circumstances, by increasing the dependence on groundwater, water managers and policy makers should be aware about the quality and quantity of groundwater, and they should make rational decisions concerning the preservation and allocation of resources. Added to this, we have to emphasize that the groundwater considerations should be taken into account in agricultural, energy, and land-use planning as well as in urban development and environmental policies (Rani et al., 2022). Moreover, in order to achieve an integrated water management portfolio with adaptability and resilience to climatic change and drought, it is critical to have effective groundwater management. As mentioned by Popovici et al. (2021), Van Dijk (2012), Gondo et al. (2020), and Franco-Torres et al. (2021), it is not the lack of resources or knowledge, financial constraints, or technical issues that hinder sustainable development of the water sector; rather socio-institutional challenges, including governance, hinder its development. Furthermore, debate and negotiation on the best way to reconcile the benefits and consequences of using groundwater are first and foremost a governance challenge rather than a technical issue (Foster and Garduño, 2013). Extensive research has shown that problems and challenges cannot be overcome by technological upgrades alone; instead, what is emphasized and considered today is attention to social and organizational factors and their communication and interaction with each other (Bayat et al., 2015). The challenge of water is seen as a problem of governance in the current century, the defined local institutional capacity of which has been weakened by certain factors of social, economic, and political stress (Uker and Fanany, 2011; Popovici et al., 2021). According to the Global Water Partnership (GWP), the water issue is primarily a governance catastrophe, and this concept is frequently cited by international institutions such as the World Bank, the OECD, and the UN (Franco--Torres et al., 2021). As a governance system, water management involves various forms of control and management in water access (Meissner and Jacobs, 2016; OECD, 2015a). Various public frameworks have been proposed to improve the governance of groundwater resources, and most have confirmed that there is no plan for good governance that will work everywhere (Foster and Ait-Kadi, 2012; Moench et al., 2013).

Yet, many aquifers are at risk due to poor governance (Wijnen et al., 2012) and inadequate legal frameworks that do not take into account geological and/or sociological-political, environmental, and economic complexities (Gupta and Conti, 2017). It has been recognized that governance is an important challenge in reaching the long-term sustainability of water resources (OECD, 2015a; Pahl-Wostl, 2017). In this regard, water governance means an environmental empowerment in which water management regulates or influences water resources strategies, policies, plans, incentives, and financial structures related to water resources. When there is effective water governance, relevant regulatory and legal frameworks and institutions are provided; they enhance responsible measures and actions for protecting and ensuring water resources sustainability and optimizing the services and advantages achieved from these resources (Roy et al., 2011). In most regions of Iran, groundwater is the main water resource (Hojjati and Boustani, 2010), and most of Iran's agricultural lands depend on it (Barati et al., 2019). In addition, population growth has been estimated to reach 95 million over the next two decades (Iran currently has a population of more than 80 million), and the quality and quantity conditions of water resources could be worsened by the expansion of climate change (Sadeghi, 2017). The characteristics of arid and semi-arid regions, like Iran, include high evaporation, unequal spatial and temporal distribution of water resources, and low rainfall. Agricultural water governance is particularly important in such areas. To this end, water security and food security are influenced by decision-making (Nazemi et al., 2020).

As noted in the contemporary history of legislation and policy-making of water resources in Iran, negligence of the significance of water rights (both economically and legally) and water markets in addressing sustainability challenges is noticeable. Moreover, there are not any clear criteria in legislation related to water to establish transparency in the water governance system (Nabavi, 2017). The main factors for groundwater exhaustion in Iran include the absence of optimal water governance (Hojjati and Boustani, 2010; Moridi, 2017) and mismanagement (Nabavi, 2017). For instance, groundwater level decline, land subsidence, and poor agricultural water efficiency are some of the main effects of ineffective water administration and management in Iran (the biggest water-consuming sector) (Sadeghi, 2017). Groundwater governance is seriously challenging, and it has been considerably neglected despite a large number of works allocated to groundwater assessment (Barati et al., 2019). Therefore, the main aim of this study was to investigate the principles of water governance and its effects on development of rural areas based on the model proposed by OECD.

The overuse of groundwater tables has posed serious problems and issues such as sinkholes and subsidence in agricultural lands. Therefore, different countries have used different models and frameworks to cope with these implications and to improve groundwater tables depending on their social, economic, and legal conditions. Most activities on groundwater management in the world address the issues and barriers of attracting the cooperation and presence of stakeholders in the process of decision-making and implementation. However, the OECD model has introduced an operational framework at a wide range for studying different factors influencing water resources considering the social, economic, and geographical systems. Thus, the OECD water resources governance framework can identify the present and future problems and challenges by investigating the factors underpinning groundwater management and conservation in Hamedan-Bahar plain.

According to Pahl-Wostl (2009) and Poudyal et al. (2019), resource difficulties are caused by bad governance, exposing the inadequacy of existing governance regimes to deal with current and future challenges. Nonetheless, understanding of resource governance systems and how they develop is extremely limited. Major structural traits of governance regimes include the impact of formal and informal institutions, the function of state and non-state actors, the pattern of multi-level interactions, and the relative significance of administrative hierarchies, markets, and networks. Change is seen as the result of society learning, which develops in stages as it moves from single to double to triple-loop learning. Informal networks are thought to be extremely important in such learning processes. Governance systems with a wider range of complexity and diversity are more adaptable. The application of common conceptual frameworks that account for the true complexity of governance regimes can thus produce the knowledge base required to advance current understanding to a level that enables providing insightful policy advice. Goal conflicts are evident in this respect, as demonstrated by the evaluation by van der Voorn et al. (2020), and policy makers must compromise between aims. Conflicts or synergies result from the method chosen to handle these trade-offs. The multi-dimensional aspects of goal conflicts are thought to be better accounted for in multi-target backcasting scenarios. As a result, this calls for a thorough multi-target backcasting strategy that combines the advantages of backcasting, nexus approaches, and multi-criteria analysis.

In previous studies, the management of water resources was carried out to prevent water reduction and to solve the problems such as monitoring, development, and daily operations to maintain water resources under optimal conditions. However, when discussing governance, different structural and institutional dimensions, in which management activities are regulated, are mentioned. Due to the fact that previous studies could not take into account the different dimensions of the groundwater resource system and resolve the existing problems in the area of water resources, in this study, we attempted to find and identify problems in the area of groundwater resources using the governance framework.

Water governance contains several features that help to define the topic from many perspectives. Various and extensive frameworks, such as the Ostrom's IAD framework (Blomquist and deLeon, 2011; Bushouse, 2011; Heikkila et al., 2011; Oakerson and Parks, 2011; Ostrom, 2011), have been proposed in the field of water resources governance. Almost all these frameworks identify different and hidden dimensions and issues including norms, stakeholders, structures, and laws that affect the sustainable governance of water resources. These frameworks also examine the role and relationship of these components in the governance of water resources by considering different socio-cultural, institutional, political. In addition, this framework assesses economic dimensions such as the Ostrom's SES framework which establishes communication and interaction among the resource system, resource unit and stakeholders, governance system, etc., to achieve sustainable governance of resources. The majority of these frameworks place a strong emphasis on governance indicators like legislation and public involvement, which are crucial for implementing water policy. The focus on other elements, such as communication and monitoring, is evidence of the policy applicability of research to water governance, which frequently looks at recent changes in water regulations.

The indicative evidence gathered from a number of sources reveals that groundwater pollution has become a concern for the safety of drinking water in several regions of Iran. Even on a worldwide scale, the socio-economic dependence on groundwater transcends the traditional distinctions between "arid, semi-arid, and humid" regions, stressing the need for governance solutions that are specifically tailored to the circumstances in which groundwater issues arise. Furthermore, due to the relative "youth" of intensive groundwater use, the gap between society and science-technology is wider in the case of groundwater than it is in the case of surface water resources.

The availability of freshwater resources in Iran has come under scrutiny due to the combined effects of rising demand and numerous "layers" of supply, including canals from large but remote reservoirs, dozens to hundreds of wells, and small dams. Therefore, there is a growing need to develop a groundwater governance framework that is pertinent to India's particular groundwater situation, while Iran struggles with managing its groundwater resources keeping in mind that millions depend on this resource and that vulnerability to scarcity and contamination is on the rise. A framework for groundwater governance in Iran is being developed as a result of this study, and it is anticipated that these ideas will eventually be developed into more specific institutions, practices, and policies that will make up the foundation of groundwater governance in Iran.

The OECD water resources governance framework is a universal framework as the experiences of 17 OECD members, 13 Latin American countries, and some Asian and African countries, e.g., Jordan and Tunisia, have been used in its development (World Health Organization, 2017). The key novelty and contribution of this work is that groundwater governance appears to be lacking even in situations when there is a high demand for water and a limited supply. Through an integrated examination along the three dimensions—the features of the groundwater resource, negative externalities issues, and governance institutions—this study looked at the social and institutional traditions. In the area of Iran's subsurface water resources, this framework and its indicators have not been researched. Therefore, the most significant feature of the uniqueness of this study is its evaluation of the OECD water resource governance metrics for Iran's groundwater sector.

The purpose of this study was to evaluate the indicators of the OECD water resources governance in the improvement of underground water management in Dasht Bahar in Hamedan. In this regard, the specific objectives of this study are as follows:

(1) The identification of gaps and shortcomings through the examination of the groundwater governance parameters using the OECD governance model; (2) The determination of governance inadequacies in various levels and sectors of groundwater; (3)

The Identification of barriers to effective groundwater management.

In addition to these objectives, the OECD principles are based on the premise that there is no comprehensive and universal solution for the challenges and issues of water resources, but the principles developed in different parts of the world are applicable.' Therefore, the present research aims to use the OECD principles composed of diverse sections, including the legal system, administrative system, capacities, and cooperation and communications, to explore these principles and indices as per the local conditions of the Hamedan-Bahar region considering the geographical and climatic conditions of the studied region.

2. Theoretical background: groundwater governance (GG)

Water governance is defined as practices, processes (formal and informal), and rules through which decisions are made and implemented to manage water resources and services, with stakeholders expressing interest and decision makers being accountable (OECD, 2015a).

Historically, groundwater management was launched for highlighting the best practices in GG in 2011, and the GG project was inserted into political goals and decisions in 2016 (Groundwater Governance, 2018). GG is about decision-making on groundwater, involving individuals and/or entities organized at various levels (Kulkarni et al., 2015).

Comparing Strom's framework as a multi-level governance framework and the OECD, it should be noted that Strom's framework deals less with the institutional and structural dimensions of organizations and laws in indicators such as responsibility and accountability or innovation in actions. However, the framework provided by Pahl-Wostl (2009) deals more with the investigation of adaptive capacity and systematic learning processes to analyze the characteristics of governance structures. In addition, this framework can provide other hidden layers to identify existing problems in the field of water resources and can be used as a complement to other frameworks such as the OECD framework (Pahl-Wostl, 2009; McGinnis and Ostrom, 2014).

However, based on this study, the OECD framework has a codified structure in examining and identifying different dimensions in the field of water resources governance. It is noteworthy that the initial framework of the OECD groundwater governance was proposed on the basis of researches on the institutional framework of water governance in 17 OECD countries (Organisation for Economic Co-operation and Development, 2018) and 13 Latin American countries (2012) and also by conducting in-depth multilateral political discussions of national participation in support of water reforms in Mexico (2013), the Netherlands (2014), Jordan (2014), Tunisia (2014), and Brazil (2015). OECD framework provided guidelines have been prepared and compiled according to the experiences of different countries with different regional conditions (OECD, 2015a). Therefore, considering that the OECD framework presents different and extensive dimensions in identifying the problems related to water sector and reaching a suitable and stable situation, the aim of this study was to assess the governance status of the groundwater resources of Hamedan-Bahar plain.

According to van der Voorn et al.'s (2017) research, access to clean drinking water has long been a top concern in many regions of the world. To enhance water governance and how water requirement is defined and controlled, address access disparities, safeguard water quantity and quality, and reuse it, industrialized nations (such as Germany and the US) have implemented a number of legal measures and institutional changes (Voltz and Grischek, 2018). For instance, in big cities, creative solutions like subsidized connection have been implemented to aid the most underprivileged neighborhoods. However, the current political climate emergency necessitates a reevaluation of the problems with water and its governance due to its particularly detrimental effects on water. In areas where there is a danger of water shortage and drought, preserving water sustainability is essential, according to van der Voorn et al. (2017), as explicitly mentioned in the Sustainable Development Goals. The AWRA presented ten recommendations about sustainable groundwater management in the beginning of 2018. These recommendations are summarized as follows: (1) to assess the resource; (2) to build partnerships; (3) to create a legal framework; (4) to include groundwater considerations; (5) to maintain sustainability; (6) to respect ecosystems; (7) to engage stakeholders; (8) to commit to understanding; (9) to safeguard assets; and (10) to use interdisciplinary approaches (AWRA, 2018). GG comprises a collection of regionally unique institutional, social, and economic structures with various roles as a result of various water locations and the connections between their constituent parts (Gondo et al., 2020; Veettil et al., 2011; Barati et al., 2019; Kulkarni et al., 2015). In addition, it can be described as a process that determines who receives water, when, and how much (UNDP, 2015). The main goal of the FAO-led GG is raising awareness on the outstanding significance of groundwater resources as well as their sustainable management to avoid the threat of water crisis (D'Agostino et al., 2019; Dillon et al., 2012; Pahl-Wostl et al., 2013). A framework has been developed by the project for action on GG, which includes some institutional and policy guidelines and best practices and recommendations fitting to local contexts for improving GG at cross-border, national, and local levels (Morgera et al., 2020). The purpose of designing the GG was to raise awareness of the importance of groundwater resources for many world regions and to identify and promote best practices in GG as a way for achievement of the sustainable management of groundwater resources. It presents a framework related to regulations, customs, and laws for groundwater use, as well as the processes for engagement of the private and public sectors and civil society (Shah, 2014). The water-related challenges are more complicated and locally diverse.

Policy makers should attempt to boost the overall efficiency of water use by the agricultural sector, decrease the impact of the sector on freshwater resources, and enhance its flexibility against water risks (OECD, 2014). Therefore, as advocated by the OECD, multiple policy responses are needed at different levels, each of which fitted to specific water resource systems.

In order to help policy makers and address water resource issue, the OECD analysis and indicators formulate policy responses, define paths for making necessary policy changes, and facilitate their implementation for moving agriculture towards sustainable water management (OECD, 2017). Furthermore, political guidance and thematic knowledge have been developed on the participation of stakeholders (OECD, 2015c), the sovereignty of water regulators (OECD, 2015c), and water sovereignty in cities (OECD, 2016). With the OECD's water governance standards, water sovereignty has achieved its pinnacle (Fig. 1). 35 OECD member nations participated in a high-level process in June 2015 to develop the OECD principles to promote effective, equitable, and efficient water policy (OECD, 2015a).

Different stakeholders (researchers, practitioners, policy makers, etc.) use the OECD principles as a framework to assess the efficiency of water management and to be effective through discussions in a particular subdivision. These indicators carry out specific tasks that are required to close the gaps found and offer stakeholders and governments a framework for self-assessment. There are several definitions of water governance in terms of the many aspects of water policy, law, and government, which are frequently regarded in the literature as performance factors (OECD, 2015a). Water rights, decentralization, pricing, accountability, participation by the private sector and user groups, integration, and the institutional foundation of water management are among these factors (Rola et al., 2012; Araral and Yu, 2013; Tatar et al., 2019).

The term "governance" stretches back to ancient Greece, when it was used to the state, and the World Bank merely adds that strong governance is important for growth and progress (Plattner, 2013). Not

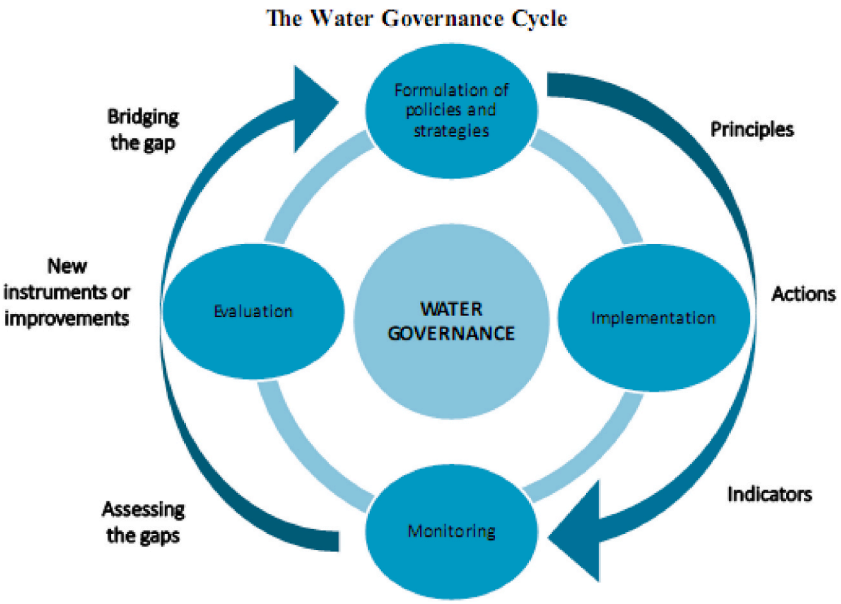

Fig. 1. Water Governance cycle (source: OECD, 2015a).

surprisingly, the definitions and conception of governance have grown in recent times and have been used in different areas. The term was generally expanded to include non-governmental actors such as civil society, private sector, and non-governmental organizations (NGOs) rather than simply the state (Bernauer and Betzold, 2012; Hasmath et al., 2019). Since the late 1980s, the World Bank has raised the issue of good governance (Mundy and Verger, 2015; Erkkilä and Piironen, 2014). The report of the International Organization for Migration (IOM) in 1989, for the first time, defined good governance as providing efficient public services, a reliable judicial system, and an accountable administrative system (Bertoncello et al., 2015). The OECD defines good governance as the ability to work with different environments to achieve balance at various local and international levels (Olfat and Pishdar, 2020). While hundreds of different and varied definitions can be found by a comprehensive search for governance, definitions of key thinkers continue to be prepared: The water organization has different purposes and services which include identifying the formation of water governance in a variety of contexts, in performance evaluation, and in designing lessons in different areas and for different reasons (Araral and Wu, 2013). Water governance is seen as a range of social, political, administrative, and economic systems designed for regulating the management and development of water resources and providing water services at various levels of society (Pahl-Wostl, 2017; Woodhouse and Muller, 2017).

The use of multi-center governance is focused on analyses at national and sub-levels as a type of water management (Knieper and Pahl-Wostl, 2016; Marshall et al., 2013; Thiel, 2015), with a finite investigation of boundary watershed (Akamani and Wilson, 2011; Da Silveira and Richards, 2013; Myint, 2012). National and secondary actors have tested various forms of watershed governance with regional environmental history (Cook et al., 2016) and catchment or river basin-based authorities (Huitema and Meijerink, 2017; Suhardiman et al., 2012) in recent decade's research. Akram et al. (2011) investigated the effect of the governance indicators on poverty and inequality and found that poor governance has an impact on increasing poverty in the long run. In addition, Baltutis and Moore (2019) estimated the indicators of good governance based on the quality of the services provided by the government. In the case of water, it is often aimed to optimize the allocation of resources for human use.

Water is a crucial issue for all nations. Therefore, most countries suffering from water crises in some of their regions have developed and implemented plans for the control or optimal use of their water resources. One of the fundamental plans is associated with the use of groundwater resources, which account for the largest part of available fresh water in the world.

3. Methodology

3.1. Study area

Hamedan-Bahar plain is situated in Hamedan province, Iran, at latitudes 34°49′ N and 35°02′ N and longitudes 48°17′ E and 48°33′ E. Hamedan-Bahar aquifer has a total area of 480 km^2, and the aquifer is unconfined (Balali and Viaggi, 2015). It has a semi-arid and cold climate with a mean annual temperature of 11 °C and an average annual precipitation of 324 mm (Balali and Viaggi, 2015; Balali et al., 2011; Zamani et al., 2020). Hamedan-Bahar plain is one of the groundwater restricted areas. Groundwater extraction has had enormous social and economic effects during the last half-century, which continues to date (Nozari and Zali, 2013).

The plain, which is also called Simineh River, covers an area of 2459 km^2 in the northern slopes of Alvand Mountains. The area of the plain is 880 km^2, with the surface area of the main aquifer of the plain amounting to 468 km^2 and the area of the mountains amounting to 1579 km^2 (Balali et al., 2011). The aquifer is recharged by the direct infiltration of rainfalls, the infiltration of surface flow, the water returning from agricultural, urban, and industrial uses, and the underground inflows, and it is discharged by the abstraction of the groundwater for different uses and underground outflows (Balali et al., 2011). Increasing uncontrolled use of groundwater in this plain has caused a sharp reduction in the level of the station in the area and created problems such as increasing the depth of the wells, increasing pumping costs, and reducing water quality (Nozari and Zali, 2013). Accordingly, the groundwater level has constantly declined in recent decades, which threatens the groundwater aquifer life in this region (Regional water company Iran, 2018). Groundwater resources are the most important sources of agricultural water supply in the area. More than 80% of the water needed by the agricultural sector and 50% of urban drinking water are provided from the groundwater resources of the plain (Seydan and Ghadami Firoozabadi, 2018). As indicated by the research on the groundwater balance of the research area, by adjusting agricultural policies, optimal groundwater exploitation can be ensured in the

agriculture sector, considering the broad amount of aquifer water used in this region (Balali et al., 2011).

3.2. Data collection method

The aim of this study was to evaluate the GG indices based on the OECD model through a survey method. In light of the survey research design, this descriptive-analytical study took advantage of 254 farmers in Hamedan-Bahar plain. The study used the PLS-SEM process for evaluating the measurement and structural models through Smart PLS (version 3) software. The objective of the current work was to adapt this method to be appropriate for exploratory studies and theory development (Ali et al., 2018; Hair et al., 2017). In order to measure and investigate GG, the indicators and principles of the OECD model were used (Fig. 3). Then a questionnaire was developed. All the items were evaluated using a 10 point Likert's scale from 0 (strongly low) to 10 (strongly high). The "Effectiveness" indicators of the OECD are related to government's contribution to determining clear policies and goals in the sustainability of water resources at all levels of government. This requires the careful allocation of roles and responsibilities in water resources management as well as water policies on the proper scale and at different levels in the face of the challenges and complexities of water issues. This indicator includes four items: capacity, policy coherence, optimization, and clear roles and responsibility (Fig. 3). The "Efficiency" indicators are related to government participation for maximizing the sustainable management benefits and water well-being with the lowest cost for the community, relying on sharing data and information about water, mobilizing water resources, implementing regulatory frameworks, and supporting innovative water management practices (cooperation among municipalities, rural and urban partnerships, etc.). For this indicator, the OECD has proposed four items including information and data, budgeting and financing, regulatory framework, and innovative governance. The "Trust and Engagement" indicators are related to government's share of public trust and assuring the inclusion of stakeholders through democratic legitimacy and fairness related to the entire society (see Fig. 4).

The promotion of routine monitoring and evaluation to be adjusted as necessary, trade management among water consumers, urban and rural areas, and generations. Trust and interaction with the mainstream of honesty and transparency. For this part, four items including integrity and transparency, stakeholders' engagement, trade-offs, and monitoring have been presented. Finally, we first developed a questionnaire based on the indices and sub-sections provided by the OECD. Then, its items and indices were validated by experts. The validity and reliability of the indices were fitted by the structural equation model. Given the results of the model fitting, it can be used in other regions and by other researchers.

4. Results

4.1. Demographics

The demographic characteristics of the farmers indicated that all farmers were male and in the age range of 22–80, with a mean value of 46 years. In terms of educational level, 38% had secondary education or a 12-year high school diploma, 50% had a primary or secondary school degree, and 12% were illiterate. As for membership in the associations like village councils or cooperatives, 45% were members of these associations, but 55% were not. Regarding water ownership status, 58.7% had private property, 18.5% were tenants, and 22.8% only had a partial right to use water (Hagh-abeh in Persian). In terms of the water supply method, 70% used wells, 14% springs, and 16% aqueduct. In terms of

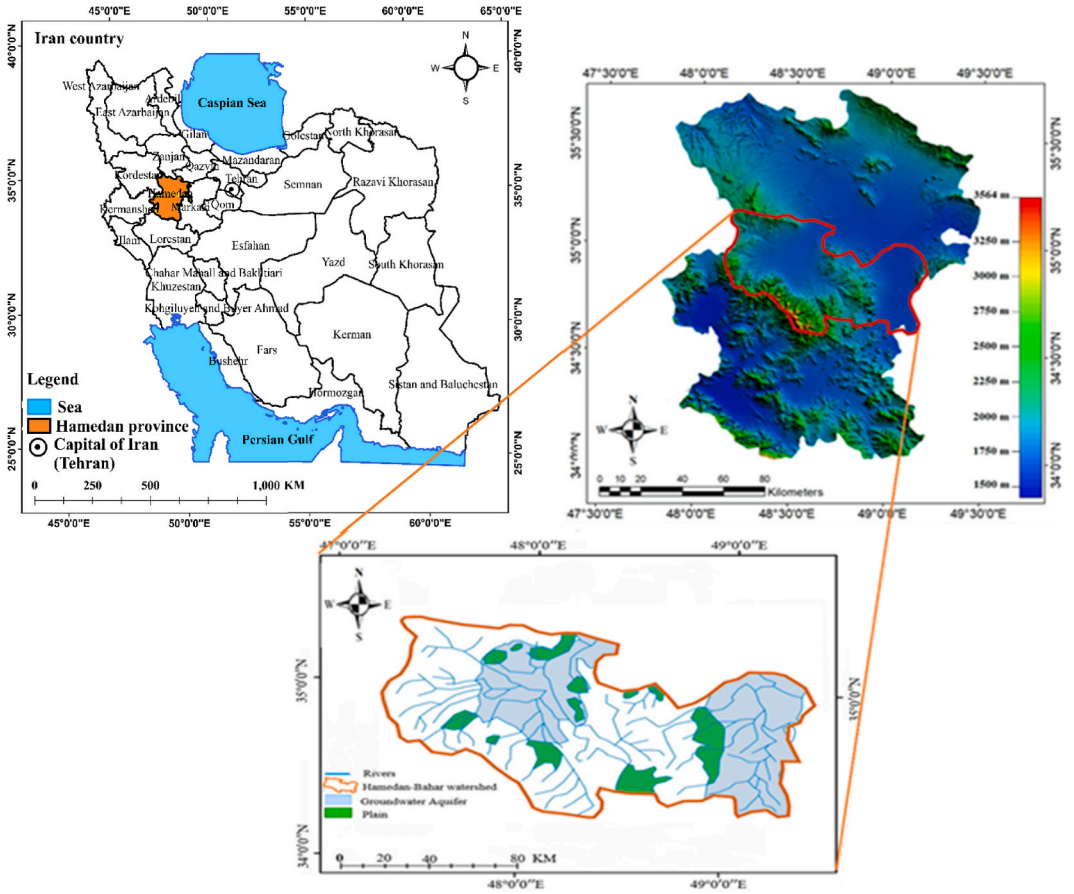

Fig. 2. Study area of Hamadan–Bahar watershed in Hamadan province, Iran.

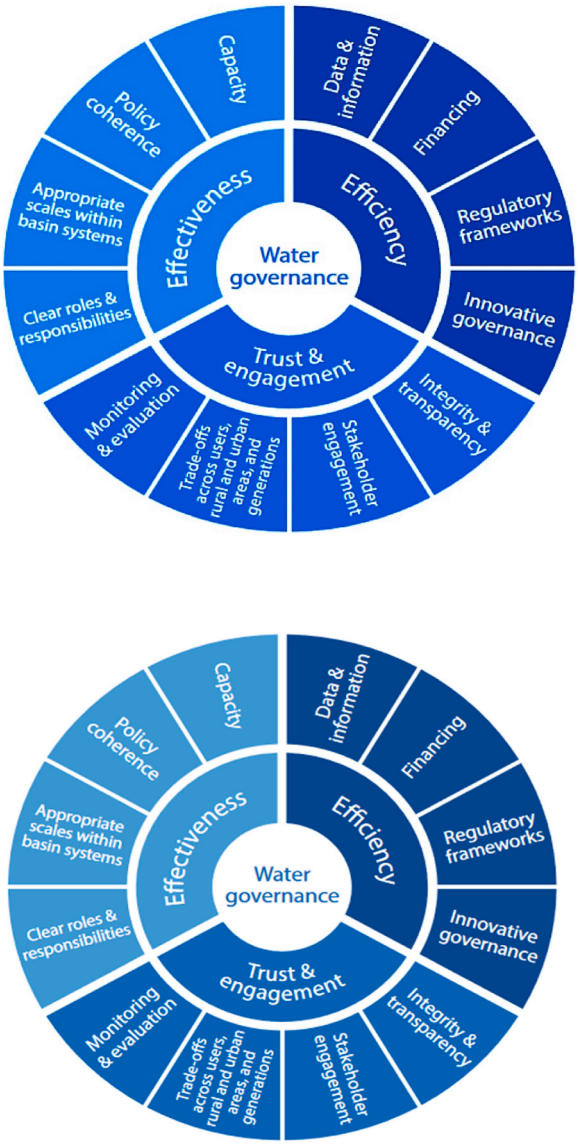

Fig. 3. Overview of OECD Principles and items on water governance (*Source*: OECD, 2015a).

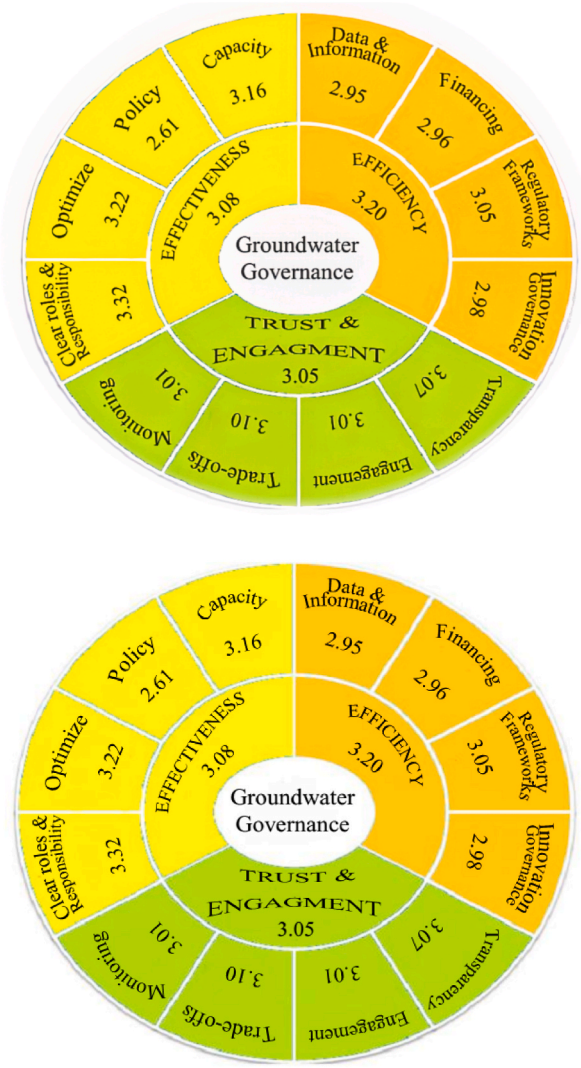

Fig. 4. The circular chart of GG indicators (*Source*: research findings).

irrigation methods, 43.1% used rainy irrigation, 9.5% used drip irrigation, and 54.7% used furrow irrigation.

4.2. The adequacy of indices and items (measurement model)

The PLS-SEM analysis of the 254 samples was done using Smart PLS 3.0 software (Ringle et al., 2015) to assess the measurement and structural models. The PLS-SEM analysis was done through three steps. First, the measurement model (outer model), through the analysis of validity and reliability and confirmatory factor analysis, was investigated. In the second stage, the structural model (internal model) was investigated using the path estimation among the variables (Holland, 1999). In the final stage, the model's overall fit was investigated. The outer model complies with the PLS measurement model in structural equations. Therefore, Table 1 presents the typical load fitting indicators in PLS models that assess latent finding variables. Furthermore, the indicators that determine the suitability of the measurement of variables in the PLS models are as follows: the average variance extracted (AVE), Cronbach's alpha, loading factor, R square, and composite reliability (CR). According to Table 1, all indicators are at the appropriate level. In the following models, the factor and the coefficients of determination among items and indicators have been shown. All constructs in the present work showed a CA and a CR above 0.70. Moreover, the value of the loading indicator for all the items was above 0.5. It is acceptable assuming that the AVE and CR establish the required thresholds (Ali et al., 2018). Moreover, the AVE of all the constructs was above 0.5, indicating an acceptable convergent validity, as suggested by Fornell and Larcker (1981). The discriminant validity is assessed using the Heterotrait-Monotrait (HTMT) ratio, and in contrast to the traditional criterion proposed by Fornell and Larcker (1981), it is possible to use it to assess covariance- and variance-based structural equation models. Therefore, when the HTMT ratio is used, the correlation value should be smaller than 0.85. As demonstrated by Voorhees et al. (2016), the cut-off value of 0.85 for the HTMT ratio is at a very good level. In the current work, an HTMT of 0.85 is used for evaluating discriminant validity. The results of the discriminant validity assessment for the measurement model using the HTMT ratio are given in Table 2. The final results of the path analysis of the measurement model are presented in Table 4.

Fig. 5 shows the output of the PLS algorithm command. This command is used to extract the coefficients of external loads and path coefficients (see Fig. 6).

4.3. General model fit (GOF criterion)

The GOF criterion is used to evaluate the general model fit that

Table 1
Results of indicators items in the GG.

Indicators	Items	Average	AVE	Cronbach's Alpha	Load indicator	R square
Efficiency	Information and Data	3.980	0.699	0.957	0.931	0.86
α = 0.978	Budgeting and Financing	4.166	0.706	0.944	0.905	0.81
	Regulatory Framework	3.908	0.663	0.941	0.914	0.83
	Innovative Governance	3.920	0.701	0.943	0.921	0.84
Effectiveness	Capacity	4.581	0.741	0.939	0.834	0.69
α = 0.974	Policy	4.435	0.768	0.967	0.931	0.86
	Optimize	3.935	0.656	.0.956	0.824	0.67
	Clear Roles & Responsibility	3.891	0.725	0.947	0.862	0.74
Trust & Engagement	Integrity & Transparency	4.717	0.654	0.947	0.824	0.67
α = 0.969	Stakeholders Engagement	3.842	0.747	0.974	0.927	0.85
	Trade- offs	4.270	0.757	0.916	0.781	0.61
	Monitoring	5	0.754	0.949	0.883	0.77

(*Source*: SPSS output from farmers' view points)

Table 2
Discriminant validity using HTMT ratio.

Indicators	Efficiency	Effectiveness	Trust and Engagement
Efficiency	1		
Effectiveness	0.826	1	
Trust and Engagement	0.815	0.682	1

(*Source*: PLS output from farmers' view points).

includes three values: 0.01, 0.25, and 0.36 as weak, medium, and strong values for GOF, respectively (Manuel et al., 2009; Vinzi et al., 2010 ((Table 3).

In order to fit the overall model, which controls the measurement and structural models, the criterion is calculated as follows:

$$GOF = \sqrt{\text{Communalities} \times R^2}$$

$$GOF = \sqrt{(9.34 \times 9.2 / 12)} = 0.77$$

GOF was calculated to be 0.77, which is higher than the recommended value of 0.36. Therefore, it can be concluded that the research model had, in general, an optimal fit.

4.4. Path analysis results and investigating research hypotheses

The PLS-SEM was employed as an approach of statistical analysis in the present study, and the indicators contributing to GG in Hamdan-Bahar plain areas were investigated. The three indicators discussed in this study included Efficiency, Effectiveness, and Trust and Engagement, each demonstrating a significant and positive impact on GG. To perform a path analysis, first, a path diagram must be drawn, which illustrates the direct and indirect effects of each variable, i.e., the effect of X on the other variable of Y. Additionally, the bootstrap method was used to assess the path coefficients of the structural model with 5000 samples. As shown by the results, the impact of high levels of Efficiency ($\beta_{EFIC} \rightarrow GG = 0.404$, $p < 0.001$), Effectiveness ($\beta_{EFCT} \rightarrow GG = 0.38$, $p < 0.001$), and Trust and Engagement ($\beta_{TAE} \rightarrow GG = 0.29$, $p < 0.001$) had a positive relationship with GG, which supports the hypothesis. Hence, H1, H2, and H3 were confirmed. The significance of the effects and path coefficients are presented in Fig. 2 and Table 4. Therefore, it can be concluded that these variables are important in inducing the improvement of GG effective on the site in Hamdan-Bahar plain [Insert Table 4].

5. Discussion

Groundwater resources have long been considered by human societies and are considered strategic resources in all regions. At present, the role and significance of water resources sustainability and, in particular, their role in the sustainability of the rural and agricultural community are being considered at different levels. Therefore, water resource management has been proposed to protect and enhance groundwater resources through involvement and cooperation of the government and the public. In this study, the status of the GG indicators in Hamadan-Bahar plain of Iran has been assessed by using the definitions and the framework provided by the OECD.

In general, the status of the GG indicators in the region showed that these indicators are all lower than the standard level and are not in good condition. This result is in conformity with that of the previous studies by Thomann et al. (2020) who studied lack of evaluation of actions and plans in management of groundwater and lack of transparency in the guidelines of groundwater governance; Mirnezami and Bagheri (2017) assessed the ineffectiveness of water governance un terms of capacity to carry out policies; Ghafouri Fard et al. (2015) investigated close interaction and participation in decision-making in water governance; Ghaemi et al. (2016) assessed emphasis on public participation (training

Table 3
Evaluation of the overall model fitting.

	monitoring	Trade offs	Engagement	Responsiveness	Responsibility	optimize	Policy	capacity	Innovation	Regulatory	Finance	Data
Communality	0.83	0.74	0.86	0.76	0.67	0.79	0.81	0.76	0.81	0.74	0.78	0.77
GOF	$\sqrt{Communalities \times \bar{R}} = 0.77$											

Table 4
Beta coefficient values of the effect of X1, X2, and X3 on Y (GG).

Hypothesis	Direct Path X	Y	Standardized Estimate (Beta)	Std. Error	t- value	Sig.	Results
H1	Efficiency	GG	0.404	0.023	17.800	0.000	Confirm
H2	Effectiveness	GG	0.389	0.31	12.730	0.000	Confirm
H3	Engagement	GG	0.295	0.027	11.098	0.000	Confirm

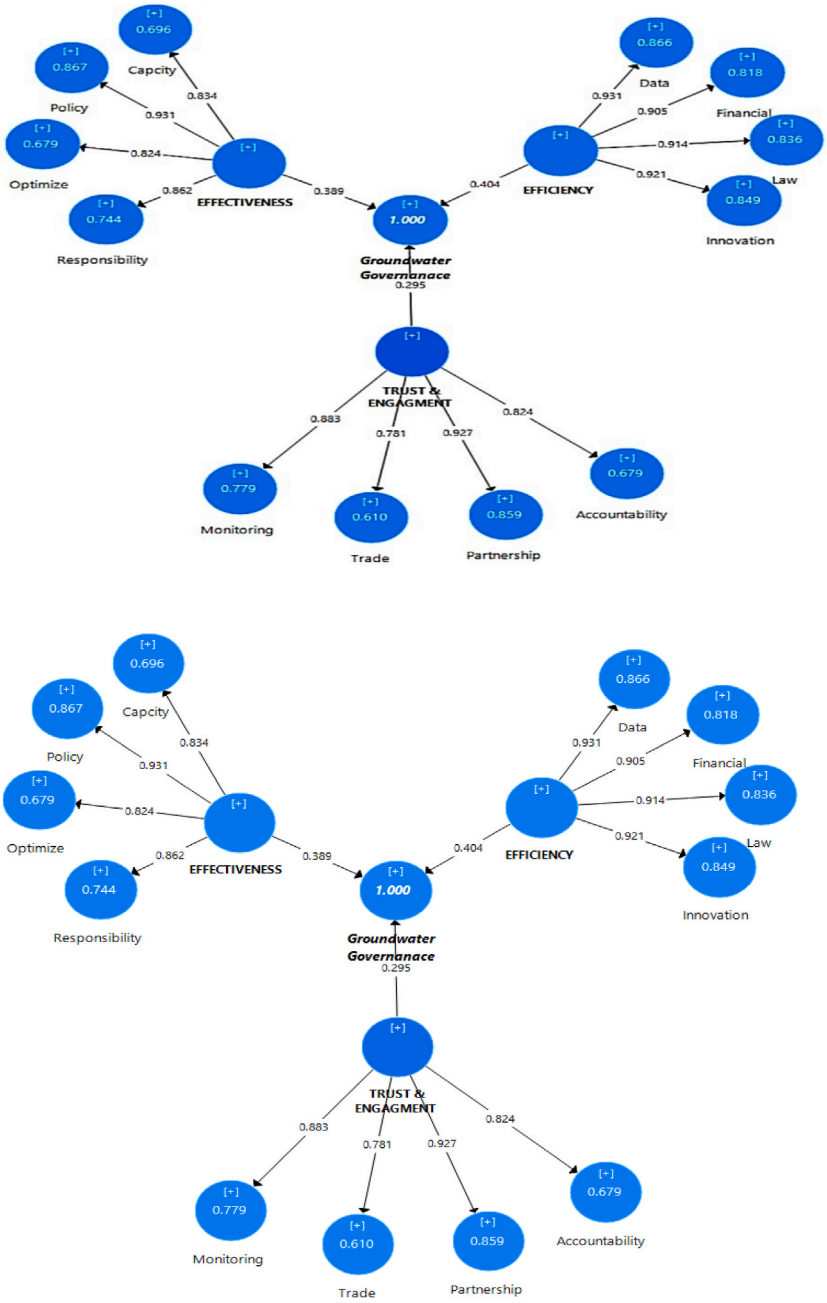

Fig. 5. Conceptual model of research with path coefficients and external loads.

and capacity building) in water governance. There were weaknesses in some indicators such as accountability, transparency, responsibility, legislation, and capacity building, which prevent some organizations and institutions from performing their duties well and from achieving water resources protection goals in a critical situation. This is in line with the findings of other studies. For example, Agudelo Moreno et al. (2020) assessed knowledge upgrade and sustainable management of groundwater resources, Asfaw and Ayalew (2020) analyzed management and protection of groundwater resources, and Hérivaux and Grémont (2019) investigated increasing awareness and tackling environmental problems.

Among the three dimensions of water governance, the efficiency dimension, with the indicators of information and data, budget, legislation, and innovative measures, has the greatest impact on the governance of groundwater resources in Hamadan-Bahar plain and can be said to be a precondition for other dimensions of water governance. This dimension focuses on accurate and transparent information, which requires for a budget and strong regulations to access and provide.; this should be sought in the relevant legal documents. Therefore, in order to access sustainable and appropriate water governance in the region, serious attention should be paid to accurate and reliable information and data for decision-making and policy-making. This finding is in agreement with the study by Thomann et al. (2020) who studied lack of transparency in guidelines of groundwater governance; Mirnezami and Bagheri (2017) assessed weakness of water governance in implementing policies and poor capacity; Hamer et al. (2020) investigated accessible database system, the importance of knowledge in policy-making, and appropriate legislation; Custodio et al. (2016) and Barati et al. (2019) evaluated increasing the penetration rate and reducing the exploitation rate of groundwater resources.

A single indication is more crucial and efficient in every aspect of government. In the efficiency dimension, information and data, in the

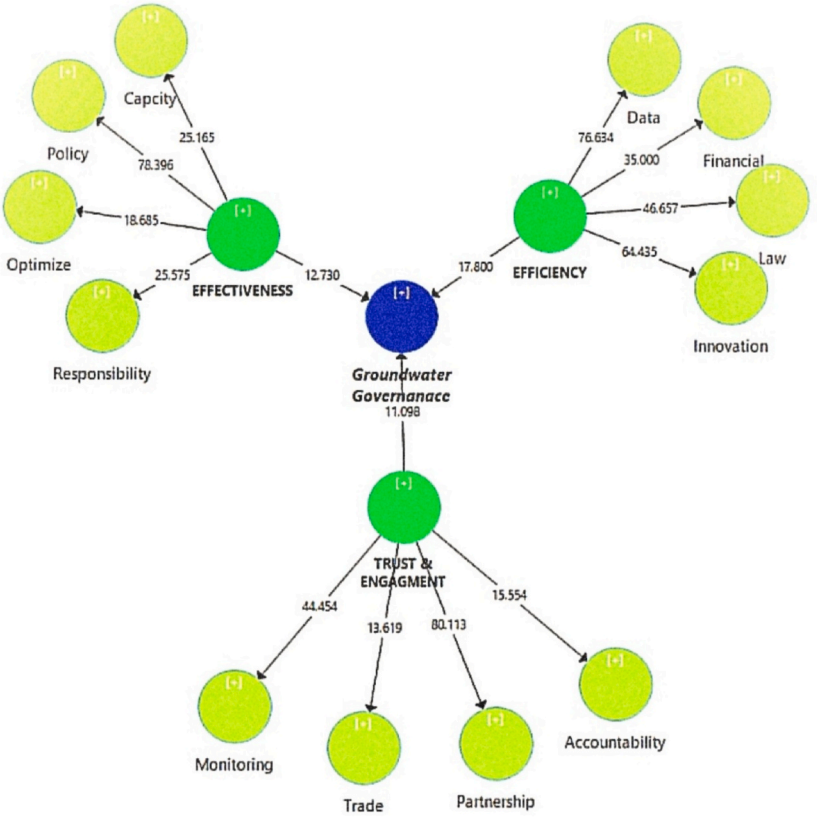

Fig. 6. Conceptual model of research with T-value.

effectiveness dimension, policy, and in the trust and engagement dimension, the indicators of stakeholder engagement are more important and effective. The indicator of information and data is one of the most important elements in a decision-making system. Without awareness of the current situation, planning to achieve the desired situation will not be possible. The transparent and reliable information and data help organizations, policy makers, and stakeholders to protect the valuable assets of groundwater resources and increase their productivity and added value.

Dissemination of free statistics and information is the first step to achieving transparency, and transparency is the first step towards gaining the trust of people. The trust of the people is the seedbed of their participation in a decision-making or management process. Moreover, transparency of information makes organizations and individuals more responsible in their duties. Today, governments around the world believe that, systematically, access to more information for the public is an important asset for positive social and economic changes. In general, it can be concluded that the availability of information and data will increase the participation of people and elites in all government processes (including problem finding, recognizing and prioritizing problems, formulating strategies, implementation, monitoring, and evaluation of government processes). Furthermore, it makes a country's water management system accountable, responsible, and optimized. This finding is in harmony with the findings of the study by Enteshari and Safavi (2019). Transparency is the first step in reforming governance and achieving good governance; Javadzadeh et al. (2020) assessed anthropogenic activity (Excessive exploitation of groundwater for irrigation); Hérivaux and Grémont (2019) investigated the valuing of ecosystem services via raising awareness and involving stakeholders in the assessment process.

In the effectiveness dimension, the policy indicator has a special role and importance. This indicator provides the necessary basis for the effective participation of stakeholders. Thus, with the relevant policy, the engagement and participation of stakeholders and their representatives can be legally provided in the process of decision-making. Furthermore, the absence of clear policies in water resources governance in the agricultural sector leads to contradiction and conflict in this sector and in water management. This finding is in conformity with the investigations by Vahid and Ranjbar (2019). Lack of stakeholders and non-governmental participation in the water resources policy-making process is one of the reasons for the inefficiency of water policies (Mirnezami and Bagheri, 2017). Lack of solidarity and coordination (coherence) in the components of governance results in non-implementation of groundwater protection policies.

The stakeholders' engagement is another important factor influencing the governance of water resources. In fact, one of the basic principles of water governance is the involvement and participation of all stakeholders in the decision-making process and implementation and policy-making process of water resources management. These results have been supported by the previous findings by Ghaemi et al. (2016). Emphasis on public participation, education, and capacity building should be considered by policy makers in a decision-making and planning process. Based on Islam et al.'s (2020) findings, there is a gap in creating coordination, technical capacity, transparency, implementation, and citizen participation. Singh et al. (2019) emphasized a coherent approach including inclusive knowledge and technology, new policy-making, and community participation. Thomann et al. (2020) achieved the expected results of stakeholders communication through transparency in planning. Sarami et al. (2022) considered policy factors, innovation and creativity in actions, and financing as the three important indicators in improving the governance of groundwater resources.

Unfortunately, the government does not interpret interaction correctly and still considers it the only way to improve the situation and to control (externally) the consumption behavior of stakeholders. The majority of the remedies that have been suggested are of the engineering, construction, and external control type rather than measures for

democratic participation. What is important is that the same and unified policies must be considered in line with the vision of sustainable development based on resource capacity and participatory governance.

Finally, it should be noted that each of the dimensions and indicators of governance is important and effective, and ignoring any of them will cause imbalance and failure to achieving sustainable development goals and programs. As a result, all aspects and indicators of water governance should be addressed, and a synergy should be established by developing and strengthening each of them in order to ensure sustainable governance of groundwater resources. In fact, the governance should be also about strategic planning and based on a guiding vision. A guiding perspective can actually unify disparate policies and expand the various levels covered by governance. (Van der Voorn et al., 2012). According to Van der Voorn et al. (2012), vision formation is critical to success, but visions have been increasingly prevalent since humans acquired a need to know what would happen in the future. In truth, visioning is a process used to assist a group of stakeholders in generating a common future vision. These visions can be found in a variety of circumstances, albeit in differing shapes (e.g., corporate, political, religious, and personal) and with varying levels of content detail. Future visions, on the other hand, will frequently arise without any significant investigation. According to research by Van der Voorn et al. (2012), a powerful vision gains power from the authoritative leader pursuing it and steering participants in the desired path. Though it is possible that what comes out of visioning will not be as robust, authoritative, and unambiguous as the powerful vision that makes structural couplings possible. As a result, the existing governance environment is very fragmented and maintains a significant distance from the ideal future prospects. In order to fulfill the objectives of sustainable development, this necessitates a broad mobilization in water governance.

According to the findings of this study, it can be concluded that in order to overcome the limitations related to the socio-cultural aspects of the OECD framework, the attitudes of community members should be considered. As shown in the study of Van der Voorn (2008), the power distance is a measurement of the acceptance of a hierarchy of power and wealth by the individuals who make up the general population of a nation, culture, or business. This criterion measures the degree to which less powerful members of society are expected to accept and value unequally distributed wealth and power. The great power gap shows that inequality of power and wealth has been instilled in a society. In contrast, low power distance represents a society in which the differences between power and wealth of the people seem to be in harmony. Opportunities and equality for all are constrained in such societies. Accordingly, socio-cultural aspects in the framework of the OECD can be classified into the following five criteria:

- Low versus high power distance: The power gap influences societal acceptance of hierarchical position differentiation. It assesses how much less powerful individuals of a society tolerate and expect inequitable distribution of power and income. Power and wealth disparities are ingrained in society, as evidenced by a high power distance. A short power distance, on the other hand, indicates a society in which discrepancies in power and wealth appear to be synchronized.
- The acceptability of hierarchical position differentiation in a society is influenced by the power differential. It investigates the degree to which a society's weaker members accept and anticipate unequal power and wealth distribution. Inequalities in power and wealth have permeated society, as shown by a sizable power distance. Additionally, a society with a minimal power distance is one in which the differences in power and wealth seem to be balanced. In such societies, there are limits on everyone's equality and opportunity.
- Individualism versus collectivism: Individuals are incorporated into organizations through strong links in a collectivistic culture. It strengthens extended families and collectives in which everyone is responsible for their group's members. Individuals in an individualistic society have poor bonds with one another.
- Masculinity versus femininity: The acceptance of gender role diversity in a society is emphasized by this criterion. Men and women share the same caring values of life in feminine societies. Females are treated equally in all social aspects in such communities, with no differentiation and discrimination between genders. Moreover, in a patriarchal society, these ideals are decisive and competitive, and there are deep gaps between the values of men and women. It implies a significant degree of gender discrimination and differentiation as well as the dominance of males in the social and political sectors. Short versus long-term orientation: This indicates if national cultures are more long-term or short-term focused in their decision-making processes. A long-term oriented civilization works for compatibility with its changing environment. To do so, such a society seeks to adapt its existing rituals and traditions to new situations (challenges or threats). Short-term oriented societies, on the other hand, tend to stick to ancient traditions and customs, regardless of future changes in the unfixed environment.

This study was faced with two main limitations. First, accessing the location of the study and data gathering were difficult because of the limitations caused by the COVID-19. Secondly, some limitations were related to the OECD model which was concentrated more on social and economic aspects, while other issues were ignored (i.e., technical and infrastructures ones). For future studies, it is recommended that the socio-economic aspects of the OECD model be considered alongside with other aspects.

6. Conclusion

With regard to current management strategies as well as macro plans and policies, it is imperative to pay attention to the indicators and components of groundwater resource governance. In this regard, what is important is the interrelated cycle among the different dimensions of the governance model, as any defect in any of its dimensions and indicators will upset the balance and governance cycle of groundwater resources. In this study, due to the comprehensiveness of the dimensions of water resources governance presented by the OECD model, the status of the groundwater resources governance indicators in Hamadan-Bahar plain was investigated. The results of construct validity estimation, including factor loading, AVE, convergent validity, divergent validity, and CR and GOF indicators, indicate the quality and proper fit of the groundwater resource governance measurement model. Based on the results, some reasons, such as lack of organizational innovation, lack of clear and imperative laws, lack of transparent information, and collective management, cause the inability of institutions to implement water resources management. Regarding the lack of organizational innovation, the current situation is in a manner that the organizations in charge of water resources management follow a magisterial and hierarchical system, and this has weakened the interaction among organizations and key actors. Therefore, to get out of this problem, it is suggested to use a responsible, creative, and innovative team for the groundwater resources management system in a coordinated and structured way that can implement the goals and policies of water resources governance well. The next item that will improve the governance of groundwater resources is the existence of a formulated, practical, and innovative legal framework. The transparent and innovative laws such as the law of reducing the government's role and leaving tasks to the people play an important role in this regard. Therefore, it is necessary to be creative and innovative in passing and implementing new laws about reducing the role of the government, increasing the interaction and participation of people, and leaving tasks to them. Another solution is the availability of transparent, accurate, and timely information in policy-making. However, a correct policy will lead to adoption of appropriate laws that are compatible with the conditions of the region, the involvement of

stakeholders, and ultimately better governance of groundwater resources.

Another problem with groundwater resource governance is that it does not adequately support collective management. For example, water users' associations can be involved in decision-making projects, but this is a rare occurrence, and their role and importance are not taken into account. Evidence and many studies indicate that local, collective, and participatory management can be the most effective approach to establishing good governance. One of the benefits of participation is the increase in the sense of beneficiaries' ownership and the improvement of governance outputs. If a bottom-up participatory approach is implemented, the participation will be stronger and local stakeholders' empowerment will be increased.

The intended amount of engagement is determined by the regional circumstances that we wish to promote in local collective management; organizations and associations will be more supportive. The supportive laws and mechanisms will be one of the effective items and ways to improve stakeholders' participation.

Regarding the many capacities, opportunities, and advantages that exist in terms of human resources and natural capital in the region, these potentials must be used to achieve the goals of groundwater resources management in the region. It is suggested that through the consensus and collaboration of elites and experts, existing challenges and weaknesses be identified and effective measures be taken to improve the governance of water resources. For this purpose, changing the existing rules and structures and adopting effective strategies are essential to strengthen the private sector, government, and society.

In general, the results show that the OECD water resources governance framework is useful for studying and identifying the needs and implementing policies and new plans. Since this framework has 12 principles and related subsections, it has successfully encompassed all dimensions and factors that are important for identifying and advancing the goals. The point to consider is that the framework has a comprehensive mode that needs to be customized based on local conditions and features. Therefore, its comprehensiveness causes all factors to be aggregated and helps draw the attention of officials and policy makers. It also contributes to raising the awareness of officials and stakeholders about what they had no awareness of and making them responsible and accountable. Since water and water resources are among the important and challenging topics of all areas, water officials and policy makers should welcome new knowledge and frameworks in order to be able to manage water and its related issues in the best possible way. Eventually, these studies are very helpful in creating awareness and knowledge among officials and policy makers, thereby influencing their decisions and programs.

The research evaluated the governance of groundwater resources in Hamedan-Bahar plain quantitatively using a questionnaire. However, it seems necessary to supplement quantitative research with qualitative research in order to identify individual and environmental attributes of each region and the local stakeholders' motives in attempts for developing region-specific policies and programs. It is recommended that future research consider different factors and aspects underpinning groundwater management and maintenance in addition to identifying the status quo and proposing approaches.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Questionnaire for Evaluation of Governance of Groundwater Resources

Greetings and Regards

Dear Farmer, this questionnaire has been prepared to fulfill a doctoral thesis on agricultural development major at Bu ali Sina University, Hamedan, in order to evaluate the governance of groundwater resources in Hamedan-Bahar plain. Please read the questions carefully and express your opinions. It should be noted that all information will be used in line with this thesis and will remain confidential. Thank you in advance for your cooperation. Thanks, research team each of the following items is related to the responsibility of managers and organizational experts. Please mark your opinion in the requested places from 1 to 10 points.

Items	Points from 0 to 10 (0 (not at all) the least … 10 the most)
Transparency and clarity of duties and responsibilities of authorities in all government organizations in the field of groundwater water resources	0 1 2 3 4 5 6 7 8 9 10
Responsibility in policymaking and strategic planning in the field of groundwater water resources	0 1 2 3 4 5 6 7 8 9 10
Responsibility in the implementation of groundwater resources policies, especially in providing financial resources and budgeting	0 1 2 3 4 5 6 7 8 9 10
Responsibility in providing information and data related to groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Responsibility in getting farmers to participate in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
responsibility in capacity building among farmers (creating cooperatives and organizations)	0 1 2 3 4 5 6 7 8 9 10
Responsibility in executive management, especially service delivery, infrastructural operations and investment	0 1 2 3 4 5 6 7 8 9 10
Responsibility in the evaluation of strategic and operational plans and policies in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Responsibility in approving and implementing regulations in the field of tariff regulation, standards, licensing, control and inspection, conflict management.	0 1 2 3 4 5 6 7 8 9 10
Responsibility in helping to resolve conflicts common and non-common interests through coordination at all levels within and outside organization and outside the organization	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent are there any of the following in the field of innovative measures in the governance of groundwater resources?

Items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
Acceptance and implementation of innovative measures in the field of water resource governance, such as conducting trials and pilots	0 1 2 3 4 5 6 7 8 9 10
Using the successful and unsuccessful experiences of other regions in the field of water resources governance	0 1 2 3 4 5 6 7 8 9 10
Creating social learning networks and facilitating dialogue and consensus through digital media, information and communication technologies, ICT	0 1 2 3 4 5 6 7 8 9 10
Using innovative methods to attract cooperation, mobilize resources and capacities through urban-rural interactions	0 1 2 3 4 5 6 7 8 9 10
The existence of mediators and common centers in order to eliminate the gap between scientific findings and the methods of management and governance of water resources	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent are each of the following things observed in the field of optimal use of water resources in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least … 10 the most)
Optimum use of water resources considering long-term environmental, social and economic goals	0 1 2 3 4 5 6 7 8 9 10
Integrated management of water resources to prevent the risks of drought and …	0 1 2 3 4 5 6 7 8 9 10
Correct management of the hydrological cycle of water resources in order to receive, distribute and return water efficiently	0 1 2 3 4 5 6 7 8 9 10
Plans and practical measures based on specific and consistent rules and framework for optimal use of water resources	0 1 2 3 4 5 6 7 8 9 10
Implementation of effective management programs in watersheds in line with national policies and local conditions	0 1 2 3 4 5 6 7 8 9 10
Comprehensive cooperation between farmers, stakeholders and the government in the field of improving water resources management.	0 1 2 3 4 5 6 7 8 9 10
Increasing cooperation in the field of using border water resources in the region and village	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent each of the following matters exists in the field of water resources policy in the governance of groundwater water resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
Coordination and proportionality between water related policies in agriculture and environment sectors (absence of conflict in water and agriculture policies)	0 1 2 3 4 5 6 7 8 9 10
Coordinating and consistent communication between ministries and organizations in the implementation of policies and programs in the field of groundwater resources.	0 1 2 3 4 5 6 7 8 9 10
Developing appropriate policies in the field of exploitation and maintaining the quality of water resources	0 1 2 3 4 5 6 7 8 9 10
Development of policies in the field of water resources demand management in different sectors	0 1 2 3 4 5 6 7 8 9 10
Identifying and evaluating the obstacles in internal and external policies and regulations in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Reviewing, monitoring and reporting on the implementation of existing policies and programs in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Setting regulations to reduce conflict between sectors in the field of water resources	0 1 2 3 4 5 6 7 8 9 10
Providing solutions and incentives for water management based on local conditions and custom.	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent each of the following matters exists in the field of capacity building of water resources in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
The existence of abilities and qualifications of officials and experts in the field of implementation and management of water resources (ability in planning, financial affairs and risk management, etc.)	0 1 2 3 4 5 6 7 8 9 10
The relevance of the technical, financial and institutional capabilities of experts and officials with the problems facing groundwater resources	0 1 2 3 4 5 6 7 8 9 10
The ability of experts and officials to identify and provide the necessary solutions in the field of water resources	0 1 2 3 4 5 6 7 8 9 10
The presence of competent officials and specialists in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Strengthening and updating the knowledge and expertise of officials and experts in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Continuous knowledge sharing and collaboration with stakeholders	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent are each of the following items in the field of information and data in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
Existence of methods to share data and information in the field of water resources (such as SMS)	0 1 2 3 4 5 6 7 8 9 10
Effective coordination between organizations producing information and data with farmers	0 1 2 3 4 5 6 7 8 9 10

(*continued on next page*)

(*continued*)

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
Clear and accessible information on groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Exchange of information and data in the field of groundwater resources between farmers and organizations and institutions	0 1 2 3 4 5 6 7 8 9 10
Updating and evaluating information and data in the field of groundwater resources in order to improve policy making	0 1 2 3 4 5 6 7 8 9 10
Participation of stakeholders in the design and implementation of information systems in the field of water resources, such as creating a data bank	0 1 2 3 4 5 6 7 8 9 10
Existence of coordinated and compatible information systems with watersheds (boundary waters, cross-border agreements)	0 1 2 3 4 5 6 7 8 9 10
Having a specific process (system) for collecting, using, sharing and disseminating data and information	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent each of the following matters exists in the field of water exchange management in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
Management of water transfer and distribution between cities and remote and vulnerable areas without discrimination	0 1 2 3 4 5 6 7 8 9 10
Empowering farmers in the field of removing technical and administrative obstacles in transferring water to agricultural lands	0 1 2 3 4 5 6 7 8 9 10
Informing about the risks and costs of drought, floods and water pollution in over-harvesting	0 1 2 3 4 5 6 7 8 9 10
Creating agreements with people for better payment and pricing in the field of groundwater	0 1 2 3 4 5 6 7 8 9 10
Using the evaluation results of water transfer and distribution policies for citizens and consumers in order to make better decisions	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent are each of the following items in the field of budgeting and financing in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
Attracting and allocating financial resources in the field of groundwater water resources in an effective, transparent and timely manner	0 1 2 3 4 5 6 7 8 9 10
Considering taxes and fines on excessive extraction of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
Existence of macro and strategic financial planning in order to ensure future investments	0 1 2 3 4 5 6 7 8 9 10
Existence of correct and transparent budgeting and accounting procedures and methods in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
The existence of efficient and transparent mechanisms in the allocation of government credits	0 1 2 3 4 5 6 7 8 9 10
Reduction of public costs through the elimination of bureaucratic obstacles	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent each of the following matters exists in the field of legislation in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
The existence of a comprehensive legal and organizational framework in order to enact laws, formulate standards and guidelines in the field of groundwater	0 1 2 3 4 5 6 7 8 9 10
Ensuring the implementation of laws and supervision within public, private and government organizations	0 1 2 3 4 5 6 7 8 9 10
Ensuring the existence of transparent laws and coordinated legislative bodies	0 1 2 3 4 5 6 7 8 9 10
Participatory and non-discriminatory legislative processes	0 1 2 3 4 5 6 7 8 9 10
Using legal tools (supervisory and advisory mechanisms) in order to increase the quality of legislative processes and ease public access to them.	0 1 2 3 4 5 6 7 8 9 10
Establishing clear and appropriate cost-effective rules and procedures for the reward and penalty system in the field of groundwater resources	0 1 2 3 4 5 6 7 8 9 10
There are laws that can be pursued in court for compensation	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent each of the following matters exists in the field of transparency and accountability in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
The level of access to managers and officials of the organization and their accountability in the field of groundwater	0 1 2 3 4 5 6 7 8 9 10
The right to access information and data in the field of groundwater	0 1 2 3 4 5 6 7 8 9 10
The level of accountability of decision makers and managers towards the management and governance of water resources	0 1 2 3 4 5 6 7 8 9 10
Adherence to honesty and transparency at the local, regional and national levels regarding groundwater	0 1 2 3 4 5 6 7 8 9 10
Existence of monitoring and auditing mechanisms for transparent implementation of water policies	0 1 2 3 4 5 6 7 8 9 10

(*continued on next page*)

(*continued*)

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
The possibility of identifying the promoting and inhibiting factors in organizations and institutions in charge of water resources	0 1 2 3 4 5 6 7 8 9 10
Acceptance of methods, tools in order to identify and fix gaps and weaknesses in the governance of water resources	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent each of the following matters exists in the field of participation in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
The level of participation and influence of actors (public sector, private sector and NGOs) in decisions and results related to water	0 1 2 3 4 5 6 7 8 9 10
Attention to the participation of all classes and groups (youth, women, local people and other water users) as well as new people such as investors in the governance of water resources.	0 1 2 3 4 5 6 7 8 9 10
Existence of a mechanism to use financial and intellectual contributions of stakeholders in decision-making	0 1 2 3 4 5 6 7 8 9 10
Improving the capacity of stakeholders related to water resources through timely, accurate and reliable information	0 1 2 3 4 5 6 7 8 9 10
Existence of a mechanism to evaluate the results of the participation of stakeholders in water resources management (including the determination of profit and cost)	0 1 2 3 4 5 6 7 8 9 10
Interaction between legislative centers, organizations and responsible authorities, in order to pay attention to local conditions, needs and capacities	0 1 2 3 4 5 6 7 8 9 10
Determining the level and type of participation of stakeholders according to the needs and adapting to the changing conditions	0 1 2 3 4 5 6 7 8 9 10

In your opinion, to what extent are each of the following in the field of monitoring and evaluation in the governance of groundwater resources.

items	Points from 0 to 10 (0 (not at all) the least …. ….10 the most)
Existence of competent centers and authorities (having the necessary resources and tools) in order to monitor and evaluate water governance policies	0 1 2 3 4 5 6 7 8 9 10
Existence of mechanisms to effectively monitor and report future decisions	0 1 2 3 4 5 6 7 8 9 10
The degree of achievement of the expected goals in the field of water governance policies	0 1 2 3 4 5 6 7 8 9 10
Transparent and timely sharing of water resources governance evaluation results	0 1 2 3 4 5 6 7 8 9 10
The possibility of adapting water governance strategies to new changes and developments	0 1 2 3 4 5 6 7 8 9 10

References

Agudelo Moreno, L.J., Zuleta Lemus, D.D.S., Lasso Rosero, J., Agudelo Morales, D.M., Sepúlveda Castaño, L.M., Paredes Cuervo, D., 2020. Evaluation of aquifer contamination risk in urban expansion areas as a tool for the integrated management of groundwater resources. Case: coffee Growing Region, Colombia. Groundwater for Sustain. Dev. 10, 100–298.

Agutu, N.O., Awange, J.L., Ndehedehe, C., Mwaniki, M., 2020. Consistency of agricultural drought characterization over Upper Greater Horn of Africa (1982–2013): topographical, gauge density, and model forcing influence. Sci. Total Environ. 709, 135–149.

Akamani, K., Wilson, P.I., 2011. Toward the adaptive governance of transboundary water resources. Conserv. Letters 4, 409–416. https://doi.org/10.1111/j.1755-263X.2011.00188.

Akram, Z., Wajid, S., Mahmood, T., Sarwar, S., 2011. Impact of poor governance and income inequality of poverty in Pakistan. Far East J. Psychol. Bus. 4, 43–55.

Ali, F., Rasoolimanesh, S.M., Sarstedt, M., Ringle, C.M., Ryu, K., 2018. An assessment of the use of partial least squares structural equation modeling (PLS-SEM) in hospitality research. Int. J. Contemp. Hospit. Manag. 30, 514–538.

American Water Resources Association (AWRA), 2018. AWRA policy statements. http://www.awra.org/policy/policy-statements-groundwater.

Araral, E., Yu, D.J., 2013. Comparative water law, policies, and administration in Asia: evidence from 17 countries. Water Resour. Res. 49, 5307–5316. https://doi.org/10.1002/wrcr.20414.

Asfaw, D., Ayalew, D., 2020. Modeling megech watershed aquifer vulnerability to pollution using modified DRASTIC model for sustainable groundwater management, Northwestern Ethiopia. Groundwater for Sustain. Dev. 100375.

Balali, H., Viaggi, D., 2015. Applying a system dynamics approach for modeling groundwater dynamics to depletion under different economical and climate change scenarios. Water 7, 5258–5271.

Balali, H., Khalilian, S., Viaggi, D., Bartolini, F., Ahmadian, M., 2011. Groundwater balance and conservation under different water pricing and agriculture policy scenarios: a case study of the Hamedan-Bahar plain. Ecol. Econ. 70, 863–872.

Baltutis, W., Moore, M., 2019. Degrees of change toward polycentric transboundary water governance: exploring the columbia river and the Lesotho highlands water project. Ecol. Soc. 24 https://doi.org/10.2307/26796934.

Barati, A.A., Azadi, H., Scheffran, C.J., 2019. A system dynamics model of smart groundwater governance. Agric. Water Manag. 221, 502–518. https://doi.org/10.1016/j.agwat.2019.03.047.

Bayat, P., Saboohi, M., Kikha, A.A., Ahmadpour, M., Karami, E., 2015. The concept of water institution and a look at the experience of water institution reform in other countries. Strategic and Macro Policies 3 (11), 115–138.

Bernauer, T., Betzold, C., 2012. Civil society in global environmental governance. J. Environ. Dev. 21 (1), 62–66. https://doi.org/10.1177/1070496511435551.

Bertoncello, C., Buja, A., Silenzi, A., Specchia, M.L., Franchino, G., Lazzari, A., Baldo, V., Ricciardi, W., Damiani, G., 2015. Good governance competencies in public health to train public health physicians. Int. J. Publ. Health 60, 737–749. https://doi.org/10.1007/s00038-015-0702-y.

Blomquist, W., & deLeon, P. (2011). The design and promise of the institutional analysis and development framework.

Bushouse, B.K., 2011. Governance structures: using IAD to understand variation in service delivery for club goods with information asymmetry. Policy Studies Journal 39 (1), 105–119.

Castells, M., 2010. The Rise of the Network Society. Wiley-Blackwell.

Cook, H., Benson, D., Couldrick, L., 2016. Partnering for bioregionalism in england: a case study of the westcountry rivers trust. Ecol. Soc. 21, 38. https://doi.org/10.5751/ES-08504-210238.

Custodio, E., Cabrera, M.D.C., Poncela, R., Puga, L.O., Skupien, E., Del Villar, A., 2016. Groundwater intensive exploitation and mining in Gran Canaria and Tenerife, Canary Islands, Spain: hydrogeological, environmental, economic and social aspects. Sci. Total Environ. 557–558, 425–437.

Da Silveira, A.R., Richards, K.S., 2013. The link between polycentrism and adaptive capacity in river basin governance systems: insights from the river rhine and the zhujiang (pearl river) basin. Ann. Assoc. Am. Geogr. 103, 319–329.

Dalin, C., Wada, Y., Kastner, T., Puma, M.J., 2017. Groundwater depletion embedded in international food trade. Nature 543, 700–704. https://doi.org/10.1038/nature21403.

Dillon, P., Fernandez, E.E., Tuinhof, A., 2012. Management of aquifer recharge and discharge processes and aquifer storage equilibrium. IAH contribution to GEF-FAO Groundwater Governance Thematic Paper 4. Global Environment Facility(GEF)-Food and Agriculture Organization of the United Nations (FAO). http://hdl.handle.net/102.100.100/98677?index=1.

Döll, P., Hoffmann-Dobrev, H., Portmann, F.T., Siebert, S., Eicker, A., Rodell, M., Strassberg, G., Scanlon, B., 2012. Impact of water withdrawals from groundwater

and surface water on continental water storage variations. J. Geodyn. 59–60, 56–143.
D'Agostino, D., Borg, M., Hallett, S.H., Sakrabani, R.S., Thompson, A., Papadimitriou, L., Knox, J.W., 2019. Multi-stakeholder analysis to improve agricultural water management policy and practice in Malta. Agric. Water Manag. 105920 https://doi.org/10.1016/j.agwat.2019.105920.
Enteshari, S., Safavi, H.R., 2019. Investigation of administrative-institutional system of water management in the zayandehrud basin using qualitative method of grounded theory. J. of Water and Wastewater 30, 1–17. https://doi.org/10.22093/wwj.2019.149029.2749.
Erkkilä, T., Piironen, Ossi, 2014. (De) politicizing good governance: the World Bank Institute, the OECD and the politics of governance indicators. Innovat. Eur. J. Soc. Sci. Res. 27 (4), 344–360. https://doi.org/10.1080/13511610.2013.850020.
FAO, 2018. Groundwater Governance - a Global Framework for Action. FAO.
Fornell, C., Larcker, D., 1981. Evaluating structural equation models with unobservable variables and measurement error. J. Market. Res. 18, 39–50.
Foster, S., Ait-Kadi, M., 2012. Integrated water resources management (IWRM): how does groundwater fit in? Hydrogr. J. 20, 415–418. https://doi.org/10.1007/s10040-012-08319.
Foster, S., Garduño, H., 2013. Groundwater-resource governance: are governments and stakeholders responding to the challenge? Hydrogr. J. 21, 317–320. https://doi.org/10.1007/s10040-012-0904-9.
Franco-Torres, M., Kvålshaugen, R., Ugarelli, R.M., 2021. Understanding the governance of urban water services from an institutional logics perspective. Util. Pol. 68, 101–159. http://www.elsevier.com/locate/jup.
Ghaemi, A., Larijani, M., Shabiri, S.M., Sarmadi, M., 2016. Presenting a conceptual model of sustainable governance in the integrated management of the country's water resources with emphasis on education and capacity building. J. of Water and Wastewater. 4, 112–117.
Ghafouri Fard, S., Bagheri, A., Shajari, S., 2015. Stakeholders assessment in water sector (case study: rafsanjan area) using DPSIR framework and relying on improving the governance system. In: The Second National Conference on Water Crisis. Shahrekord University.
Gondo, R., Kolawole, O.D., Mbaiwa, J.E., Motsholapheko, M., 2020. Demographic and socio-economic factors influencing water governance in the Okavango Delta, Botswana. Scientific African 10. https://doi.org/10.1016/j.sciaf.2020.e00602.
Groundwater Governance, 2018. A global framework for action. Developing a Global Framework for Action. http://www.groundwatergovernance.org/.
Gupta, J., Conti, K., 2017. Global climate change and global groundwater law: their independent and pluralistic evolution and potential challenges. Water Int. 42, 741–756. https://doi.org/10.1080/02508060.2017.1354415.
Hair, J.F., Sarstedt, M., Ringle, C.M., Gudergan, S., 2017. Advanced Issues in Partial Least Squares Structural Equation Modeling. SAGE Publications, Thousand Oaks, CA.
Hamer, T., Dieperink, C., Tri, V.P.D., Otter, H.S., Hoekstra, P., 2020. The rationality of groundwater governance in the Vietnamese Mekong Delta's coastal zone. Int. J. Water Resour. Dev. 36, 127–148.
Hasmath, R., Hildebrandt, T., Hsu, J.Y.J., 2019. Conceptualizing government-organized non-governmental organizations. J. Civ. Soc. 15 (3), 267–284.
Havril, T., Tóth, Á., Molson, J.W., Galsa, A., Mádl-Szőnyi, J., 2018. Impacts of predicted climate change on groundwater flow systems: can wetlands disappear due to recharge reduction? J. Hydrol. 563, 1169–1180.
Heikkila, T., Schlager, E., Davis, M.W., 2011. The role of cross-scale institutional linkages in common pool resource management: Assessing interstate river compacts. Policy Studies Journal 39 (1), 121–145.
Hérivaux, C., Grémont, M., 2019. Valuing a diversity of ecosystem services: the way forward to protect strategic groundwater resources for the future? Ecosyst. Serv. 35, 84–93.
Hojjati, M.H., Boustani, F., 2010. An assessment of groundwater crisis in Iran, case study: Fars province. World Acad. Sci. Eng. Technol. 70, 476–480.
Hojjati, M.H., Boustani, F., 2010. An assessment of groundwater crisis in Iran case study: Fars province. International Journal of Humanities and Social Sciences 4 (10), 2066–2070.
Holland, R., 1999. Reflexivity. Human Relations 52, 463–484.
Huitema, D., Meijerink, S., 2017. The politics of river basin organizations: institutional design choices, coalitions, and consequences. Ecol. Soc. 22, 42. https://doi.org/10.5751/ES-09409-220242.
Islam, M.R., Chowdhury Sarwar, J., Md Ferozur, R., Quamrul, H.M., 2020. Governance status in water management institutions in Barind Tract, Northwest Bangladesh: an assessment based on stakeholder's perception. Sustain. Water Res. Manage. 6, 1–14.
Jackson, S., 2018. Water and Indigenous rights: mechanisms and pathways of recognition, representation, and redistribution. Wiley Interdisciplinary Reviews: Water 5 (6), e1314.
Javadzadeh, H., Ataie-Ashtiani, B., Hosseini, S.M., Simmons, C.T., 2020. Interaction of lake-groundwater levels using cross-correlation analysis: a case study of Lake Urmia Basin, Iran. Sci. Total Environ. 10, 729. https://doi.org/10.1016/j.scitotenv.2020.138822. Epub 2020 Apr 26.
Jia, X., Hou, D., Wang, L., O'connor, D., Luo, J., 2020. The development of groundwater research in the past 40 years: a burgeoning trend in groundwater depletion and sustainable management. J. Hydrol. 587, 125006.
Knieper, C., Pahl-Wostl, C., 2016. A comparative analysis of water governance, water management, and environmental performance in river basins. Water Resour. Manag. 30, 2161–2177. https://doi.org/10.1007/s11269-016-1276-z.
Kulkarni, H., Shah, M., Shankar, P.S. Vijay S., 2015. Shaping the contours of groundwater governance in India. J. of Hydrol. Reg. Studies. 4, 172–192. https://doi.org/10.1016/j.ejrh.2014.11.004.
Macpherson, E.J., 2019. Indigenous Water Rights in Law and Regulation. Cambridge University Press.
Manuel, J., Francisco, J., Félix, A., 2009. Exploring the Impact of Individualism And Uncertainty Avoidance in Web-Based Electronic Learning: an Empirical Analysis. In: European Higher Education. Comput. Educat., vol. 52, pp. 588–598.
Marshall, N.A., Park, S., Howden, S.M., Dowd, A.B., Jakku, E.S., 2013. Climate change awareness is associated with enhanced adaptive capacity. Agric. Syst. 117, 30–34.
McGinnis, M.D., Ostrom, E., 2014. Social-ecological system framework: initial changes and continuing challenges. Ecology and society 19 (2).
Meissner, R., Jacobs, I., 2016. Theorising complex water governance in africa: the case of the proposed epupa dam on the kunene river. Int. Environ. Agreements Polit. Law Econ. 16, 21–48.
Miao, F., Zhang, Y., Li, Y., Liang, X., Lin, Q., Zhou, Y., 2021. Establishing a weighted methodology for human health risk assessment of cadmium based on its equilibrium speciation in groundwater. J. Clean. Prod. 322, 129053.
Mirnezami, S.J., Bagheri, A., 2017. Assessing the water governance system for groundwater conservation in Iran. Iranian J. of Water Res. Res. 13, 32–55.
Moench, M., Kulkarni, H., Burke, J., 2013. Trends in Local Groundwater Management Institutions/user Partnerships. FAO-UN, Rome. GEF Groundwater Governance–Thematic Paper 7. http://www.groundwatergovernance.org/resources/thematic-papers/en/.
Morgera, E., Webster, E., Hamley, G., Sindico, F., Robbie, J., Switzer, S., Berger, T., Silva Sànchez, P.P., Lennan, M., Martin-Nagle, R., Tsioumani, E., Moynihan, R., Zydek, A., 2020. The Right to Water for Food and Agriculture. FAO, Rome. https://doi.org/10.4060/ca8248en.
Moridi, A., 2017. State of water resources in Iran. Int. J. Hydrol. 1, 00021.
Mundy, K., Verger, A., 2015. The World Bank and the global governance of education in a changing world order. Int. J. Educ. Dev. 40, 9–18.
Myint, T., 2012. Governing International Rivers: Polycentric Politics in the Mekong and the Rhine (November 30, 2014). Governing International Rivers: Polycentric Politics in the Mekong and the Rhine. Edward Elgar Publishing Inc., Cheltenham, UK. Available at: SSRN: https://ssrn.com/abstract=2532163.
Nabavi, E., 2017. Ground)Water governance and legal development in Iran. 1906–2016. Middle East Law Gov 9, 43–70.
Nazemi, N., Foley, R.W., Louis, G., Keeler, L.W., 2020. Divergent agricultural water governance scenarios: the case of Zayanderud basin, Iran. Agric. Water Manag. 229, 105921.
Nozari, H., Zali, A., 2013. Investigation of groundwater abstraction status of Hamedan-Bahar plain aquifer. Water and Soil Knowledge 23 (4), 277–289.
Oakerson, R.J., Parks, R.B., 2011. The study of local public economies: Multi-organizational, multi-level institutional analysis and development. Policy Studies Journal 39 (1), 147–167.
OECD, 2015a. OECD Principles on Water Governance. Retrieved from. http://www.oecd.org/governance/oecd-principles-on-water-governance.htm.
OECD, 2015c. Stakeholder Engagement for Inclusive Water Governance. Author, Paris.
OECD, 2016. Water Governance in Cities. Author, Paris.
OECD, 2017. Managing water sustainably is key to the future of food and agriculture. Available in: Water and agriculture – OECD, ⟩agriculture. https://www.oecd.org.
Olfat, L., Pishdar, M., 2020. Application of Interval Type-2 Fuzzy DEMATEL for Evaluation of Environmental Good Governance Components. International Journal of Resistive Economics 8 (1), 51–69.
Organisation for Economic Co-operation and Development (OECD), 2014. Water Governance in Jordan: Overcoming the Challenges to Private Sector Participation; OECD Studies on Water. OECD Publishing, Paris, France.
Organisation for Economic Co-operation and Development (OECD), 2018. The OECD Water Governance Initiative. http://www.oecd.org/cfe/regional-policy/watergovernance-initiative.html.
Ostrom, E., 2011. Reflections on" Some unsettled problems of irrigation. American Economic Review 101 (1), 49–63.
Pahl-Wostl, C., 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environ. Change 19 (3), 354–365.
Pahl-Wostl, C., 2017. An evolutionary perspective on water governance: from understanding to transformation. Water Resour. Manag. 31, 2917–2932. https://doi.org/10.1007/s11269-017-17271.
Pahl-Wostl, C., Conca, K., Kramer, A., Maestu, J., Schmidt, F., 2013. Missing links in global water governance: a processes-oriented analysis. Ecol. Soc. 18 (2) https://doi.org/10.5751/es-05554-180233.
Plattner, M.F., 2013. Reflections on governance. J. Democr. 24 (4), 17–28. https://doi.org/10.1353/jod.2013.0058.
Popovici, R., Erwin, A., Linda S, Z.M., Prokopy Zanotti, L., Bocardo Delgado, E.F., Cáceres, J.P.P., Zeballos, E.Z., Salas O'Brien, E.P., Bowling, L.C., Arce Larrea, G.R., 2021. Outsourcing governance in Peru's integrated water resources management. Land Use Pol. 101, 105105.
Poudyal, B.H., Maraseni, T., Cockfield, G., 2019. Scientific forest management practice in Nepal: critical reflections from stakeholders' perspectives. Forests 11 (1), 27.
Rani, M., Pande, A., Kumar, K., Joshi, H., Rawat, D.S., Kumar, D., 2022. Investigation of Groundwater Recharge Prospect and Hydrological Response of Groundwater Augmentation Measures in Upper Kosi Watershed, Kumaun Himalaya, India, vol. 100720. Groundwater for Sustain. Dev.
Regional water company Iran, 2018. Reporting Water Resource Management Hamedan-Bahar. www.hmrw.ir.
Ringle, C., Wende, S., Becker, J., 2015. Smartpls 3. SmartPLS GmbH, Boenningstedt, Version 3.2.7.
Rola, A.C., Pulhin, J.M., David, C.C., Wensley, C., Paragas, V.S., Tabios III, G.Q., Lizada, J.C., Gazmen, P.G., Dayo, M.H.F., 2012. Towards good water governance in

the Philippines. Transactions of the National Acad. of Sci.e and Technol. 34 (2), 299–323.
Roy, D., Barr, J., Venema, H.D., 2011. Ecosystem Approaches in Integrated Water Resources Management (IWRM). IISD.
Sadeghi, N., 2017. Water challenges of Iran. Fanack Water in the Middle East and North (Africa).
Sarami, T., Balali, H., Movahedi, R., 2022. Identify and Evaluate Stakeholders in Groundwater Resource Governance (Case Study: Hamedan-Bahar Plain). Journal of Water and Sustainable Development 9 (1), 25–38.
Seydan, S., Ghadami Firoozabadi, A., 2018. Estimation of virtual water exchange of major crops (Case study of Hamadan province). Irrigat. and Water Engin. of Iran 9 (33), 102–111.
Shah, T., 2014. Groundwater governance and irrigated agriculture. TEC BACKGROUND. PAPERS Global Water Partnership Technical Committee (TEC). No. 19.
Siebert, S., Burke, J., Faures, J.M., Frenken, K., Hoogeveen, J., Döll, P., Portmann, F.T., 2010. Groundwater use for irrigation – a global inventory. Hydrol. Earth Syst. Sci. 14, 1863–1880. https://doi.org/10.5194/hess-14-1863.
Singh, A., Saha, D., Tyagi, A.C., 2019. Emerging Issues in Water Resources Management: Challenges and Prospects. Water Governance: Challenges and Prospects. Springer.
Suhardiman, D., Giordano, M., Molle, F., 2012. Scalar disconnect: the logic of transboundary water governance in the Mekong. Soc. Nat. Resour. 25, 572–586. https://doi.org/10.1080/08941920.2011.604398.
Tatar, M., Papzan, A., Ahmadvand, M., 2019. Explaining the good governance of agricultural surface water resources in the gawshan watershed basin, kermanshah, Iran. J. Appl. Sci. Technol. 21 (6).
Thiel, A., 2015. Constitutional state structure and scalar re-organization of natural resource governance: the transformation of polycentric water governance in Spain, Portugal and Germany. Land Use Pol. 45, 176–188.
Thomann, J.A., Werner, A.D., Irvine, D.J., Currell, M.J., 2020. Adaptive management in groundwater planning and development: a review of theory and applications. J. Hydrol. 586, 124–871.
Uker, D., Fanany, R., 2011. The traditional decision-making process of berkaul in Tanjung Emas, West Sumatra: its nature and significance. Sojourn 26, 1–15. https://doi.org/10.1355/sj26-1a.
United National Development Program (UNDP), 2015. Water Governance Facility (WGF)/the United Nations Children's Fund (UNICEF). Accountability in Wash: Explaining. The Concept. UNDP-WGF/UNICEF.
Vahid, M., Ranjbar, M., 2019. Political dimension of water governance in Iran (1989-2013). A Critical Study. Publ. Pol. 4, 3–23.
Van der Voorn, T., 2008. The hidden language of rural water supply programmes. Groundw. Sustain. Development: Prob. Perspect. Challenges 423–434, 2008.
Van der Voorn, T., Pahl-Wostl, C., Quist, J., 2012. Combining backcasting and adaptive management for climate adaptation in coastal regions: a methodology and a South African case study. J Futures 44, 346–364.
Van der Voorn, T., Quist, J., Pahl-Wostl, C., Haasnoot, M., 2017. Envisioning robust climate change adaptation futures for coastal regions: a comparative evaluation of cases in three continents Mitigation and Adaptation Strategies for Global Change 22, 519–546.
van der Voorn, T., Svenfelt, Å., Björnberg, K.E., et al., 2020. Envisioning carbon-free land use futures for Sweden: a scenario study on conflicts and synergies between environmental policy goals. Reg. Environ. Change 20, 35.
Van Dijk, M.P., 2012. Introduction. Int. J. Water 6, 137–154. https://doi.org/10.1504/IJW.2012.049493.
Veettil, P.C., Speelman, S., Frija, A., Buysse, J., Huylenbroeck, G.V., 2011. Complementarity between water pricing, water rights and local water governance: a Bayesian analysis of choice behavior of farmers in the Krishna river basin, India. J. of Ecol. Econ. 70, 1756–1766. https://doi.org/10.1016/j.ecolecon.2011.04.018.
Vinzi, V.E., Chin, W.W., Henseler, J., Wang, H., 2010. Handbook of Partial Leastmquares. Springer, Germany: Berlin.
Voltz, T., Grischek, T., 2018. Energy management in the water sector–Comparative case study of Germany and the United States. Water-Energy Nexus 1 (1), 2–16.
Voorhees, C.M., Brady, M.K., Calantone, R., Ramirez, E., 2016. Discriminant validity testing in marketing: an analysis, causes for concern, and proposed remedies. J. Acad. Market. Sci. 44, 119–134.
West, H., Quinn, N., Horswell, M., 2019. Remote sensing for drought monitoring & impact assessment: progress, past challenges and future opportunities. Remote Sens. Environ. 232 https://doi.org/10.1016/j.rse.2019.111291.
Wijnen, M., Augeard, B., Hiller, B., Ward, C., Huntjens, P., 2012. Managing the Invisible: Understanding and Improving Groundwater Governance. Water Papers. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/17228 License: CC BY 3.0 IGO.
Woodhouse, P., Muller, M., 2017. Water governance—an historical perspective on current debates. World Dev. 92, 225–241.
World Health Organization, 2017. UN-water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) 2017 Report: Financing Universal Water, Sanitation and Hygiene under the Sustainable Development Goals.
Wu, H., Gao, X., Wu, M., Zhu, Y., Xiong, R., Ye, S., 2020. The efficiency and risk to groundwater of constructed wetland system for domestic sewage treatment-A case study in Xiantao, China. J. Clean. Prod. 277, 123384.
Zamani, O., Azadi, H., Mortazavi, S.A., Balali, H., Movahhed Moghaddam, S., Jurik, L., 2020. The impact of water-pricing policies on water productivity: evidence of agriculture sector in Iran. Agric. Water Manag. 245 https://doi.org/10.1016/j.agwat.2020.106548.