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Normative Assessment of Enabling Factors for Adaptive Water Governance; Evidence and Lessons from the Hirmand River Basin, Iran

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Abstract
Based on analyzing the composing elements of the water governance regime in the Hirmand River Basin, Iran, this paper examines the factors that facilitate the emergence of Adaptive Governance in a Global South context. Although the literature provides valuable insights into the characteristics of a well-established Adaptive Governance regime in the context of the Global North, relatively little research has been conducted on Adaptive Governance's fostering factors in the states in the Global South. To address this gap, this study utilizes an analytical framework upon which the features of water governance regimes are assessed. A combination of primary and secondary qualitative data (survey research and document analysis) is used to evaluate the assessment framework, which aims to analyze the characteristics that enhance resilience to the imposed changes and disturbances in complex environmental and water systems. The analysis suggests that addressing scalar and sectoral tensions, well-functioning reflecting mechanisms, adaptable policies, and flexible financial mechanisms are vital requisites for the transition towards more adaptive forms of water governance. The results also propose that the formal water governance system in the region has felt the urgency to adapt to new circumstances; however, unlike cases from the Global North, it lacks the required agility to escape from the rigidity trap it finds itself in.

Keywords Adaptive Water Governance · Adaptive Management · Adaptation · Complex Water Systems · Hirmand River Basin · Sistan Delta

Introduction

Water systems are subject to continuous evolution, and as a result, novel challenges and issues emerge, necessitating innovative and adaptive approaches to address evolving changes and associated uncertainties effectively. Scholars have well documented the shortcomings of reaction-oriented command-and-control approaches to water governance (e.g., Berkes et al. 2008; Cox 2016; L. H. Gunderson 2000; Holling & Meffe 1996; Hughes et al. 2007; Pahl-Wostl et al. 2007). Despite this academic consensus, adopting technical approaches to water problems that are narrow in focus or scope maintains popularity among water-related policymakers. Opposed to this reductionistic thinking, there is a school of thought that advocates for a holistic approach that embraces uncertainties and complexities. The concept of Adaptive Management, with its roots in the Resilience Thinking theory (Walker & Salt 2012), is characterized by a holistic approach that questions the assumption of "adequate knowledge" and prioritizes learning as a key component that directs adaptation. Adaptive Management's philosophy is searching for the appropriate course of mitigative action as much as the quest for the truth (Norton 2005).

Adaptive Governance is the social context that enables and facilitates the implementation of Adaptive Management (Dietz et al. 2003). With adaptive management as its core

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element (Folke et al. 2005; L. Gunderson & Light 2006), perhaps the most appealing definition of Adaptive Governance is presented by Hurlbert (2018), who states that "Adaptive Governance is a range of political, social, economic, and administrative systems that develop, manage and distribute a resource in a manner that promotes resilience through collaborative, flexible, and learning-based issue management across different scales" (Hurlbert 2018).

A significant portion of the literature on Adaptive Governance has focused on Global North and water-rich regions (Karpouzoglou et al. 2016). This body of literature provides valuable insights into the features of a successful and well-designed Adaptive Governance regime (Almstedt & Reed 2013; Chaffin, Gosnell, et al. 2014; Djalante et al. 2011; Huitema et al. 2009; Schultz et al. 2015). However, only a limited number of studies have investigated the factors that promote Adaptive Governance in a Global South context (Karpouzoglou et al. 2016; Trimble et al. 2022; Vallury et al. 2022; Walch 2019; Yasmin et al. 2019). Such areas are particularly vulnerable to uncertainties and changes, such as climate change, as they rely heavily on activities that are sensitive to climate, possess weak institutions, exhibit low adaptive capacity, and demonstrate inadequate governance (Aryal et al. 2021; Olmos 2001). Therefore, it can be argued that Adaptive Governance is essential for these areas, more so than for the well-developed regions of the world.

The first step of navigating from the current form of water governance to a more adaptive one would include evaluating the extent to which the current arrangements are prepared for such a transition (Chaffin, Gosnell, et al. 2014). This evaluation would help inform the transition and set up a starting point for rethinking water governance systems. With that being said, this study employs an analytical framework that draws heavily on the principles of Adaptive Management and Adaptive Governance. While not entirely new, this framework offers a fresh perspective on the existing frameworks and seeks to investigate the presence of factors that promote or impede the shift towards Adaptive Water Governance. In other words, looking from an "adaptive cycle" perspective (L. H. Gunderson & Holling 2002), the main focus of this study is on the potential through which the reorganization phase (usually known as the "α phase") takes place.

This paper takes a case study in a dry region in West Asia and Eastern Iran. The selection of the Hirmand river basin is of particular importance due to both interjurisdictional reasons (Iran-Afghanistan) as well as vulnerability to climate change (Yohe et al. 2006). Furthermore, the Hamoun lakes are one of the most valuable aquatic ecosystems in this region and are registered wetlands in the Ramsar and UNESCO Biosphere Reserve Conventions (Mianabadi et al. 2021).

Generally, the presented research follows a deductive reasoning approach (Azungah 2018), i.e., building an organizing framework based on pre-existing theories and testing it throughout observation in the case study. The structure of the paper is organized as follows: the Methods and Materials section explains the analytical framework, data collection, and analysis methods utilized, while the case study overview provides a brief description of the Hirmand river basin. The analysis results present an assessment of the water governance system in the area. The Discussion section explores the relevance of the findings to previous studies in Global South cases. Finally, the Conclusion section provides a summary of the main points discussed in the paper.

Methods and Materials

Analytical Framework: Adaptive Water Governance

Adaptive Governance has been applied to various fields of natural resources management, such as land management (Hodge & Adams 2016; Maclean et al. 2013), fisheries management (Datta & Chaffin 2022; Gregg et al. 2018; Sandström & Rova 2009; Webster 2009), forest management (Abrams et al. 2021; Almstedt & Reed 2013; Boyd 2008; Elbakidze et al. 2010), coastal management (Bruckmeier 2014; Bunce et al. 2010; Schmidt et al. 2013), park management (Clark & Clarke 2011), and biodiversity conservation (Basurto & Jiménez-Pérez 2013; Chaffin, Garmestani, Angeler, et al. 2016; K. R. Young & Lipton 2006). However, as mentioned by previous scholars (see, e.g., Karpouzoglou et al. (2016) and Steelman, (2022)), water resources management stands out as the central area of focus in Adaptive Governance research.

To comprehensively analyze the current state of water governance in the area, a meticulous review of the literature on Adaptive Management and Adaptive Governance was carried out to identify the key enablers of Adaptive Water Governance. The framework proposed by Raadgever et al. (2008) was used as a foundation for categorizing the elements of the water governance regime. Modifications were made to put emphasis on learning as the core driver of adaptive governance. The selection of the enabling factors from the literature was guided by two main criteria: theoretical relevance and empirical evidence. This approach ensured that each factor contributed to the theoretical underpinnings and constructs of Adaptive Governance. Furthermore, a great emphasis was placed on the availability of empirical evidence supporting the factors in the literature. The resulting framework is composed of five categories that classify the principal structures and processes identified in the literature as essential for achieving

Adaptive Governance. These categories are Stakeholder Deliberation, Learning, Policy Development, Legal Considerations, and Financial Considerations (Table 1).

Data Collection and Analysis

Due to the qualitative nature of the study, a combination of primary and secondary data was used. Data was collected through semi-structured interviews, questionnaires, and document analysis. The interviews and questionnaires were designed to gather detailed information about the participants' perspectives on the water governance system in the area, while the document analysis was used to supplement and corroborate the findings from the interviews and questionnaires (see Supplementary Materials C and D). The integration of interviews, questionnaires, and document analysis methods in this research represents a triangulated approach to data collection and analysis (Patton 2014). Interviews enabled the exploration of participants' experiences and perspectives in a qualitative manner, while written questionnaires facilitated the collection of standardized quantitative data. Additionally, document analysis offered valuable contextual insights and served to corroborate findings.

A purposive sampling strategy was used to select participants who had the relevant knowledge and experience about water governance in the area (Patton 2014). A total of 150 participants were included in the study, including 17 who were interviewed and 133 who responded to the questionnaire. Additionally, 128 official documents were analyzed (including but not limited to documents on water, agricultural, energy, and economic sectors and climate-related plans, see Supplementary Material A). For the sake of brevity, henceforth, these documents will be referred to with roman numerals in brackets (e.g. [XX]). The reader can find the reference numbers as the associated official documents in Supplementary Material A.

The collected data was imported to Nvivo10, a widely-used qualitative analysis software and analyzed using a thematic analysis approach. The coding schema was guided by the analytical framework. This approach involved identifying key themes and patterns in the data, which were then organized into categories according to the analytical framework.

Case Study

Located in the eastern part of Iran, the Sistan Delta lies at the end of a large transboundary river basin (Fig. 1) named Hirmand/Helmand. Although classified as an arid and semi-arid basin, the basin's financial system is predominantly reliant on water resources, with the people's livelihoods dependent on the Hirmand river's water discharge. Over the course of recent decades, a multitude of interconnected factors have induced changes in freshwater accessibility within the region. These factors comprise but are not limited to instances of drought, upstream developments, the extension of dust storms, evaporation-induced loss, and the deterioration of infrastructural facilities. These fluctuations have had severe consequences in the area, including reductions in agricultural yields, population displacements, security challenges, degradation of water quality, health hazards, deterioration of soil fertility, and a rise in sediment accumulation (Bazrkar et al. 2013; A. Mianabadi et al. 2020). That said, most of the projections show severe changes in hydrological elements in relation to the historical average in the basin (Goes et al. 2016; Maleki et al. 2019; A. Mianabadi et al. 2020; Vaghefi et al. 2019). Throughout history, the endeavors to tackle such issues by the region's water governance system have served to exacerbate the situation, primarily due to the neglect of the complex interplay between the human and natural components of the water systems.

Results

Stakeholder Deliberation

Inclusiveness and mechanisms for engagement

Iran subscribes to a predominantly state-centric water governance paradigm, as demonstrated by the stakeholder hierarchy presented in Fig. 2. The current configuration of the governance system reinforces the status quo as silent voices remain silent and marginal groups find their objections and opinions about plans and policies ignored. Findings indicated that local experts and marginalized local communities are among the most frequently mentioned unheard stakeholders. Excluding locals from governance processes has happened at the expense of losing their support and buy-in. An experienced local stated that "*the water management activities in the area (especially river dredging) used to be completely community-based in the past, but now the same people desperately hope that the government would do something about it*." This is in obvious contradiction with [*XXIII*] and [*XXIX*], which explicitly emphasize public participation in water and environmental management.

Regarding *the abilities and incentives* of the stakeholders, the restrictions placed on the Department of Environment are a matter of concern. Despite its primary obligation to safeguard the environment, this organization possesses minimal power and authority to implement and enforce its plans and regulations (Madani 2014). To illustrate this issue, Article 114 of [*XX*] and Article 38 of [*XXXII*] mandate that any infrastructure or industrial developments must undergo environmental impact assessments before proceeding. Additionally, Article 46 of [*IV*]

Table 1 The Adaptive Water Governance framework

Dimension	Category	Description	Supporting Literature
Stakeholder Deliberation	Participation	Meaningful participation of stakeholders can improve water governance by: (I) preventing "tunnel view" and generating more informed and more creative decision-making processes; (II) Enhancing equity; (III) Reduction in transaction costs; (IV) Improving social learning; and (V) Resource mobilization. For these benefits to be realized, stakeholders must: (i) be inclusively and precisely identified and analyzed, (ii) provided with incentive and ability to participate, and also (iii) be provided with a mechanism for their participation. The focus should not only be on governmental bodies but also the locals (see, e.g., Bizikova et al. (2020) for the benefits of such mechanisms for the farmers and the environment).	(Acevedo et al. 2020; Collins & Ison 2009; Dietz et al. 2003; Howlett et al. 2019; Huntjens et al. 2012; Meffe et al. 2012; Mostert 2003; Reed 2008; Richards et al. 2004; Termeer et al. 2016; Totin et al. 2021; Wehn et al. 2018; Williams et al. 2009)
	Collaboration	"Horizontal" collaboration takes place between different water-related sectors. This form of interaction prevents contradicting objectives and conflicting actions in order to reach a desired level of integration and shared understanding. "Vertical" collaboration occurs across different levels of institutions (e.g., national and local levels). For this type of coordination, lower levels of water governance, ideally the closest to resource, should be involved in the decision-making process all the way to higher levels in order to reach a reasonable distribution of responsibilities between different levels.	(Huntjens et al. 2010; Ostrom 1996; Pahl-Wostl 2008; Raadgever et al. 2008; Sumberg & Okali 2006; Wiens et al. 2017; O. R. Young 2002)
Learning	Objectives and Measures	For learning to occur, the objectives of the water governance system and the measures to achieve those objectives must be clearly defined. Despite not being straightforward and having a social-political context, ambiguity in the objectives has been conceived as an impediment in dealing with complex problems. Furthermore, in order to better account for uncertainties, the agreed-upon measures should maintain a proper degree of diversity (e.g., various time scales and different aspects of defined objectives).	(Adger et al. 2009; Argent 2009; Doremus et al. 2011; Folke 2016; Gupta et al. 2010; Islam & Susskind 2012; J. Rijke et al. 2012; Sanchez & Roberts 2014; Williams & Brown 2018)
	Monitoring	Monitoring acts as the reflecting mechanism for a governance system; without it, various consequences of management actions would remain unknown. These consequences are not limited to ecological impacts, and due to the complexity of the water systems, an evaluation of actions' socioeconomic impacts is no longer optional but necessary.	(Dinshaw et al. 2014; Sanchez & Roberts 2014) (Flynn et al. 2014; Webb et al. 2017)
	Information Management	The success of adaptive governance hinges on the availability of credible and reliable information. Information needs should be precisely specified through an elaborative science-policy dialogue. Furthermore, information must involve multiple water-related disciplines (e.g., biophysical, social, economic, etc.) and various formal and informal sources (i.e., scientific measurements and local stakeholder observations). Local stakeholders are rich and valuable sources of information, mainly due to the tacit and in-depth knowledge they possess, yet they have been overlooked in most governance regimes. Finally, information should be open to the public and shared among stakeholders. Information sharing is considered a counter-stone of trust-building in governance systems and can avoid divergent perceptions among stakeholders.	(Pahl-Wostl 2016; Porras et al. 2018; Sharma-Wallace et al. 2018; Varady et al. 2016)
	Self-Organization	In its simplest definition, self-organization is the spontaneous emergence of global patterns resulting from local interactions. Self-organization can be considered the essence of Adaptive Governance. Successful examples indicate that data acquired from monitoring tools should be meaningfully interpreted into new information, which must be situated in trusted-upon social networks. This is how one can expect constructive behavioral changes and higher levels of adaptation, i.e., self-organization. Self-organization mainly depends on social capital and leadership. Social capital is defined as reliance and interdependency that builds trust and reciprocity among members of society. Besides, leadership can shape and align the transition towards adaptive governance through processes of vision creation, sense-making, linking, and trust-building among different actor groups and mobilizing public/political support. This form of leadership tries to enable the future instead of controlling it. Furthermore, organizations must demonstrate the flexibility to act upon new information. This flexibility can be divided into technical and institutional flexibility. Technical flexibility refers to dealing with technical challenges, such as adopting new technologies. Institutional flexibility results from interactions within the organization that intend to discuss and possibly update the beliefs and mental models based on received feedback.	(Adger 2003; Chaffin, Craig, et al. 2014; Chaffin, Garmestani, Gunderson, et al. 2016; Edalat & Abdi 2017; Folke et al. 2005; Heylighen 2001; Olsson et al. 2004 2006; Ostrom 1995; Pahl-Wostl 2015; Parry et al. 2020; Pretty 2003; J. Rijke et al. 2012; J. S. Rijke 2014; Tzafestas 2018; Uhl-Bien et al. 2007)

Table 1 (continued)

Dimension	Category	Description	Supporting Literature
Policy Development	Uncertainty	Water policies should explicitly consider the inherent uncertainties, ignorance of which has proven to be a substantial pitfall of water governance regimes. Pilot projects or trial initiatives should be embedded in policies to act as experiments that are proven to be effective and necessary for learning and dealing with uncertainties.	(Huitema et al. 2009; Huntjens et al. 2010 2012; Raadgever et al. 2008)
	Time Horizon	Policies should have a long-time horizon, ideally open-ended, striving to keep alternative options and pathways open while respecting the system's history and context.	(Huntjens et al. 2010; Piñeiro et al. 2020; Raadgever et al. 2008; Swanson & Bhadwal 2009)
Legal Considerations	Supportive	Law must support Adaptive Governance. Stakeholders and local decision-makers must be given the legal authority to autonomously make decisions so that self-organization and polycentricity are legalized by current centers of authority. In addition to authority, decision-makers must have the resources and regulatory tools (which are granted by law) to support adaptive decision-making.	(Cosens et al. 2018; DeCaro et al. 2018; Gupta et al. 2010)
	Adaptive	Static rules could be troublesome in times of change, and they are proven ineffective given the dynamic systems they try to govern. Water law must be open to reviews, examinations, and modifications so it would be allowed to adapt successfully to new circumstances. Law must provide guidelines and act as an umbrella for decision-makers at levels close to resources by establishing standards and leaving final solutions to decision-makers.	(Cosens & Gunderson 2018; Green et al. 2013)
Financial Considerations	Sufficiency	Financial sources must be sufficient and diverse. Diversity in sources (e.g., public and private sector) enhances resilience in management regimes since it improves redundancy and flexibility. At the same time, sunk costs must be reduced as much as possible and replaced with recoverable costs.	(Huntjens et al. 2010; Koeppel 2015; Raadgever et al. 2008)
	Variety		

stipulates that the Department of Environment is responsible for preventing water resource contamination. Despite these regulations, evidence shows that the Department of Environment has lost the powerplay to two dominant water-related actors, namely, the Ministry of Energy and the Ministry of Agriculture.

Simultaneously, local communities have displayed a willingness to engage in water governance practices due to factors such as their dependence on water for livelihoods or their deep attachment to their land. However, these communities have not been able to acquire the necessary capacity and technical skills due to their insufficient knowledge and awareness levels. Survey results also showed that only 7.5 percent of people acknowledged the presence of institutions for incentivizing participation in water governance among actors. It is worth noting that there are currently seven locally active NGOs in the area which are concerned with environmental or water-related topics (DoE 2021). The observations indicated that these NGOs are not taken seriously by the government. As stated by a local authority: *"… all they (NGOs) do is just nagging about anything we do; they lack proper environmental knowledge and the required communication skills for public awareness raising*". Fortunately, there are some indications of movement toward awareness-raising. For instance, Article 2 of [*XXI*] appoints national television and other state-dependent media to promote programs relating to saving and optimizing water usage. The law also appoints the Ministry of Education to include water-related information in educational books. Also, the ongoing joint project[1] of UNDP/EU and the Department of Environment pays attention to capacity building.

There are some structural *mechanisms for the participation* of various stakeholders regarding water governance in the area, as shown in Table 2. Observations also indicated that the government holds casual meetings with the farmers. Nevertheless, local residents have reported that these meetings serve more as a means of conveying decisions already made rather than soliciting their opinions. The overall effectiveness of such mechanisms, particularly at lower levels of governance, has come under criticism from respondents, with only 13 percent of those surveyed expressing confidence that these mechanisms are capable of improving outcomes.

[1] "Enhancing integrated natural resource management for the restoration of wetland ecosystems and support to alternative livelihoods development of local communities" in the Sistan and Baluchistan province of Iran is a project developed by UNDP and EU to promote integrated natural resource management for the restoration of wetland ecosystems and support alternative livelihoods.

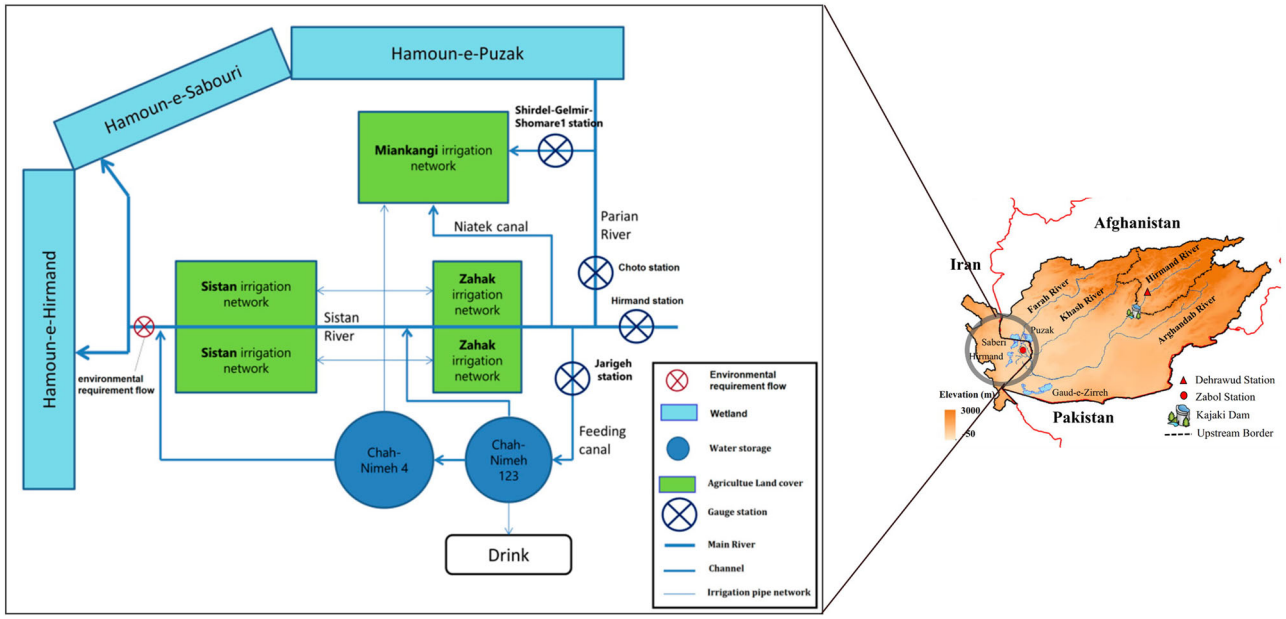

Fig. 1 Schematic Model of Water Resources in the Sistan region, Iran (Farrokhzadeh et al. 2020; A. Mianabadi et al. 2020)

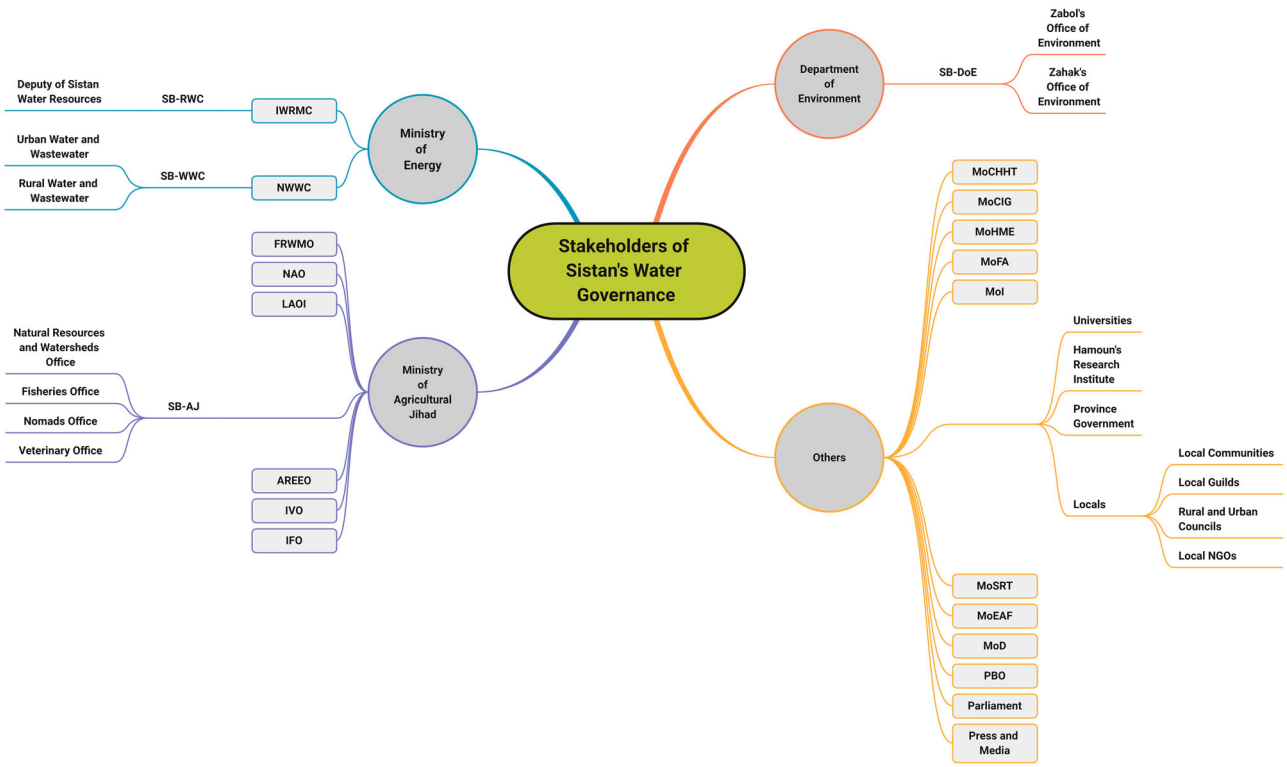

Fig. 2 Hierarchy of Stakeholders in Sistan. Within which, IWRMC Iran Water Resources Management Company, NWWC National Water and Wastewater Company, SB-RWC Sistan and Baluchistan Regional Water Company, SB-WWC Sistan and Baluchistan Water and Wastewater Company, FRWMO Forests, Range and Watershed Management Organization, NAO Nomads Affair Organization, LAOI Land Affairs Organization of Iran, AREEO Agricultural Research Education and Extension Organization, IVO Iran Veterinary Organization, IFO Iran Fisheries Organization, SB-AJ Sistan and Baluchistan Agricultural Jihad, SB-DoE Sistan and Baluchistan Department of Environment, MoCHHT Ministry of Cultural Heritage, Handicraft and Tourism, MoCIG Ministry of Cultural and Islamic Guidance, MoHME Ministry of Health and Medical Education, MoFA Ministry of Foreign Affairs, MoI Ministry of Interior, MoSRT Ministry of Science, Research and Technology, MoEAF Ministry of Economic Affairs and Finance, MoD Ministry of Defense, PBO Plan and Budget Organization

Table 2 Structural Cooperative Mechanisms in the Sistan region, Iran

National Level	Province Level	County Level	Local Level
- **Supreme Water Council**	- Saving Hamoun Wetlands Working Group - Provincial Planning Council - Provincial Spatial Planning Council - Cultural Heritage and Tourism Working Group - Provincial Disaster Management Coordination Council - Biodiversity Working Group	- Water and Agriculture Working Group - Sistan's Water Distribution Working Group - Nomads Working Group - Disaster Management Working Group - Flood Headquarters - Security Council Working Group	- Urban and Rural Islamic Councils - Nomads Union - Animal Husbandry Union - Agriculture House - Dairy Farm Owners' Union - Mat Weavers' Union - Borderline Residents' Union

Collaboration

The current *horizontal collaboration* across various institutional levels has become entangled in bureaucratic hurdles and is devoid of genuine collaborative efforts. This situation is causing frustration among stakeholders and impeding the long-term viability of the water governance system. A local authority stated that *"… even different sections in a single governmental organization are not coordinated*". Beyond collaboration in the name, conflicts between organizations and companies are prevalent on the ground. The most notable of these conflicts is the ongoing tension between the Ministry of Agriculture, which is a major water consumer, and the Ministry of Energy, which is the primary water supplier. An additional challenge that exacerbates this coordination issue is the Iranian government's perception of the agriculture sector as a key driver for employment generation. Therefore, any decrease in agricultural activities results in a direct increase in unemployment rates, making it difficult for the government to impose significant changes in the water allocation and management system. In relation to the management of transboundary waters, it is specified in [*V*] that the responsibility of negotiating with other riparian countries lies with the Ministry of Foreign Affairs. However, the technical committee of the Supreme Water Council acknowledged that the Ministry of Energy shoulders the entire burden of transboundary water management, while the Ministry of Foreign Affairs does not cooperate in this regard.

The water governance paradigm in Iran is characterized by a top-down approach, particularly in terms of *vertical integration*. This is evident in the fact that organizations and companies at each level act only as executive bodies of their higher levels and follow the protocols and guidelines set at the national level. Senior managers at the local level are appointed by those at higher levels, and their budgets are also provided at those levels. In this approach, people are seen only as water receivers, and they are not included in the decision-making process. As a result, the situation, whether at the national or local level, is not favorable for adaptive governance in terms of polycentricity.

Learning

Objectives and Measures

Four groups of objectives can be identified regarding water management in the area: a) Objectives regarding domestic water supply; b) Objectives relating to socio-economics and agriculture; c) Objectives relating to health issues; and d) Objectives associated with ecological values of Hamoun wetlands. Implemented, proposed, or ongoing measures to move towards these objectives are shown in Table 3. The region has a multitude of defined objectives and diverse measures to achieve them. Additionally, there are several ongoing developments in the area, such as demographic and socioeconomic changes, climatic changes, industrial developments, and upstream developments in Afghanistan, which result in a range of possible scenarios for future planning. However, these scenarios are often not taken into account systematically during decision-making processes due to budgetary and financial inflexibility. As stated by a national level authority: "*Our governance system is not familiar with the literature of scenario-based planning; if the budgets are received, all of them have to be spent, no matter what happens*." This issue is a significant impediment to considering various scenarios in planning and policymaking.

Monitoring

Monitoring and evaluation are supported in Iran's official documents (Table 4). However, in practice, monitoring and data collection responsibilities are not distributed properly, leading to systematic issues. One of these issues is that the organization responsible for monitoring is also the executor of the projects, creating a conflict of interest and hindering objectivity in decision-making. The respondents identified a lack of adequate knowledge among those responsible for monitoring, which makes them vulnerable to manipulation and misinformation. Technical limitations are a significant contributing factor to the shortcomings of the monitoring system in Iran's water governance. For instance, despite

Table 3 Water-related measures in the Sistan region, Iran

Implemented or in the Initiation Phase	Proposed		
	Government	Experts	Local People
- Measures to increase intake from the Hirmand river - Measures to increase intake from Chahnimeh reservoirs - Sediment removal from Chahnimeh reservoirs - Quality monitoring mechanisms for Chahnimeh reservoirs - Desalination of Oman seawater and transferring it to the cities - Distribution network for irrigation water supply - Developing greenhouses - Stabilization of sand flowing in Sistan plain and Hamoun lakes - Reducing evaporation losses - Dredging Hirmand river	- Recycling and reusing water - Improving irrigation efficiency - Decreasing per capita water consumption - Crop pattern reform and switching to less water-intensive products	- Taking hydropolitical measures to receive more water from Afghanistan (e.g., offering transportation services or energy in exchange for water) - Creating alternative livelihoods for residents (e.g., tourism, border markets) - Prioritizing Hamoun and Zabol water rights in allocation schemes	- Reducing investment in agriculture - Complementary economic activities besides agriculture - Using drought insurance - Harvesting precipitations - Reviving Qanats - Decreasing irrigated areas - Cultivating drought-resistant plants - Setting irrigation plans based on water need - Attending classes to increase awareness - Migration - Adopting pressurized and drip irrigation

being mentioned in governmental documents on multiple occasions (e.g., [*XVI*], Minutes 5, 7, 24 of [*XXII*]), the implementation of "volumetric delivery of surface water" and "smart-metering instruments on wells" has not been carried out. The survey results also confirmed this fact, as only approximately 4 percent of surveyed individuals believed that the policies and plans were being adequately monitored regarding their progress toward predetermined objectives. Besides, it is also admitted by Supreme Water Council's technical committee that there are no mechanisms for monitoring the implementation of water-related management and mitigations.

The interdependence of monitoring social and physical parameters was highlighted by a local environmental activist who emphasized that people's economic conditions are closely linked to their ability to care for the environment. The area experiences a high prevalence of illegal diversions and pipe drilling due to economic factors. Despite being illegal, these activities are vital for the livelihoods of the local people. Thus, monitoring social parameters, such as economic conditions, is crucial to understand the environmental impact of these activities. The lack of systematic incorporation of trends in social and physical parameters into the water governance system is a major issue. Despite monitoring these parameters, they are not effectively utilized to inform management interventions. Instead, factors such as climate change, international sanctions, and droughts are blamed for trends in these parameters (Madani 2014). In general it is safe to conclude that deficient monitoring is disproportionately responsible for impeding progress toward Adaptive Water Governance.

Information Management

University academics produce the majority of water-related data in the area. A total number of 49 scientific articles (27 published in international and 22 in national journals) along with 40 university dissertations (16 from local universities and 24 from universities outside the region) were analyzed to get an overview of the knowledge creation in the area (see Supplementary Material B). A considerable proportion of the conducted studies (about 29 percent) are concerned with the hydropolitics of the basin and the previous and ongoing tensions between riparian countries. Studies that claimed to be multidisciplinary primarily focused on the economic and environmental dimensions of water resources. Despite its significance scholars have paid relatively little attention to the social aspect of water systems. Specifically, out of the 49 journal papers and 40 dissertations analyzed, only six papers and eight dissertations addressed the social dimensions of water systems. The studies mostly took advantage of formal and scientific data, and with the notable exception of (Sadeghizadeh 2019) and (Nouri

Table 4 Monitoring in official documents

Document	Text
Minute 8 of [XXII]	"All of previous water resource development plans must be evaluated and reviewed based on technical, economic, and environmental relevance."
Minute 20 of [XXII]	"Ministry of Energy must establish qualitative and quantitative monitoring network."
Minute 32 of [XXII]	"Users that exceed the standards must be penalized."
[XXXI]	"Improving monitoring and evaluating system to control water resources and uses more effectively."
[XII]	"Equipping and completing monitoring networks."
[XVIII]	"MoE is appointed to implement smart metering tools in every irrigation well."
[XXIX]	"Continuous monitoring of air, water, soil, radiations, climatic changes."

Table 5 Information sharing in official documents

Document	Text
[XX]	"Right to access to information."
Article 19 of [VII]	"Ministry of Energy & Ministry of Agriculture must establish an integrated database for gathered information."
Minute 24 of [XXII]	"Governmental bodies shall transparently reflect the realities of water shortage to people."
Minute 38 of [XXII]	"A committee must be established to share and publish data."
[XXXVI]	The whole document.

2017), the majority of studies neglected the indigenous and informal sources of knowledge and information.

Furthermore, government-commissioned studies, which form the basis of major projects and plans, are seldom publicly released. This situation inhibits other stakeholders and actors from evaluating and challenging the plans and their rationale. Due to the lack of accessibility, this research relies on the respondents' opinions about them. For instance, a local authority stated, "*Most of the conducted research and studies are formalities and are biased towards governmental interests. Thus, they exaggerate the benefits and understate the weaknesses of the projects. Most studies are done only to receive funds*". Another official asserted, "*Right now, our decisions are not based on realities in the area*." The majority of the survey population, 80 percent, refuted the effective accessibility of the water-related studies and research in the area.

With the mentioned problems for the state-commissioned studies and because the aims and motivations behind academic studies are primarily organic, it is safe to conclude that information needs are not being pragmatically and precisely identified. With the limited science-policy dialogue prevailing in the area, information generation struggles to be problem-driven and to help address real-world issues.

Regarding *information sharing and publication*, Iran has several legal documents regarding information sharing (Table 5). The most prevalent legal document relating to information sharing is the [*XXXVI*]. The efficacy of the aforementioned regulations remains uncertain due to their numerous and ambiguous exemptions. These exemptions offer public organizations ample opportunity to classify a broad range of information as confidential, resulting in reluctance to disclose it. This lack of transparency, coupled with an unwillingness to adopt evidence-based approaches, further exacerbates knowledge gaps and impedes efforts to foster trust. Based on the findings of the survey, less than 9 percent of the respondents expressed a belief that the present condition of information management contributes to transparency in the area. Additionally, only 3 percent of the participants confirmed that these arrangements are enhancing trust in the water governance regime.

Self-Organization

Social capital is a manifestation of informal institutions (Deng et al. 2020) and generally reflects people's attitudes toward each other (linking social capital) and also towards the government (bridging social capital). Although the current economic situation (Melingui 2018) has weakened the ties among people[2], ethnic relationships still play one of the most significant roles in bonding people in the area. Also, different tribes attend each other's meetings, and the number of intertribal marriages has also increased significantly. Furthermore,

[2] This is in line with Marx's Alienation Theory, which states that through the process of social alienation, poverty gives people a sense of powerlessness, meaninglessness, mistrust, and violence which subsequently result in normlessness, social isolation, and disrespect for social values (Lystad 1972).

Table 6 Considering uncertainty in official documents

Document	Text
Minute 37 of [XXII]	"Ministry of Energy shall consider various scenarios regarding floods."
Minute 24 of [XXII]	"In case of a severe drop in the available water, all uses, except drinking, shall be reduced."
[XI]	"Ministry of Energy shall consider three scenarios for its plans: wet, normal and dry year"
Minute 2 of [XXXIII]	"Crop patterns must be adapted to water shortage."
[XXXI]	"Estimating the volume of water which can be planned regarding climate change impact."
[XXXI]	"Strengthening agricultural insurance fund."
[XXXI]	"Integration of climate change impacts in different socioeconomic plans"

people demonstrate some degree of connection to each other based on occupations and accommodations. Nonetheless, as evaluated by Iran's Social Council in 2015, bridging social capital in the region is decreasing (Iran's Social Council 2015). Local communities do not perceive the government as successful, and reciprocity and mutual trust are missing between people and the government. This issue was also evident in the locals' responses, as one of them stated that "*… they (government) have abandoned us, and the situation will not get any better*".

Local leadership plays a dominant role in shaping social dynamics, with a centralized ethnic structure that features an elder from each tribe acting as the leader, commonly referred to as Bozorg-e-Tayfeh. The leaders' decisions influence the activities of their respective tribes to a considerable extent. The study results suggest that the current group of leaders in the region have some level of familiarity with water and environmental concerns, and therefore, possess the inclination and motivation to be involved in environmental adaptation initiatives. However, their full potential for influencing water-related issues in the area is yet to be reached.

The findings also indicate that organizational flexibility in the region suffers on both technical and institutional sides. Less than 8 percent of the surveyed population believed that feedbacks are being discussed effectively in their organizations, and roughly 22 percent believed that there are mechanisms for readjustments in responsibilities and roles of the staff in governmental bodies. Technical flexibility is also limited; evidence like failing to reduce evaporative loss from reservoirs, failing to control leakages, failing to set up greenhouses, and failing to reform crop patterns are proofs of inflexibility in technical practices.

Policy development

Uncertainty

Statements regarding *uncertainties* can be found in various policy documents (Table 6). One can safely conclude that the only type of uncertainty being considered in most policies (although not meaningfully and systematically) relates to the amount of available water, and uncertainties in economic, social, or administrative subsystems are being ignored. Besides, the existing considerations (except the one for [*XXXI*]) follow a reactive approach and deal with uncertainties after they happen. In other words, according to Ardakanian (2005), Iran adopts a more responsive "crisis management" attitude instead of a proactive "risk management" in dealing with water-related issues.

Small-scale *experiments* in the form of pilot projects are supported and implemented in Iran[3] in general and Sistan in particular. "The irrigation of 46000 ha of Sistan Plain" project is an excellent example of a pilot project for 3100 ha of the plain. However, the effectiveness of such projects is questionable, and respondents state that these pilot projects fall into the trap of formalities and fail to deliver the intended goods. Surprisingly, these pilots are considered separate projects because of definite differences from the main project. For example, in the "Irrigation of 46000 ha of Sistan Plain", the pilot intended to provide 1 ha of irrigated land per user; this decision was taken before counting the total number of users. As a result, if the main project follows the approach that the pilot project adopted (in case it does not, there would be the risk of social unrest), all of the areas must be irrigated through a project which was intended to irrigate only one-third of arable lands. Even more oddly, some pilots are set to begin operation after the main project.

Time Horizon

Except for a few examples (such as [*XXVI*], [*XXXII*], or the [*XXX*]), Iran's water-related policies suffer from a lack of a clear and transparent time frame. In practice, however, the thirst for short-term visible benefits, mainly using supply-

[3] E.g., Urmia basin as a pilot project for "Crop pattern reformation"; Golestan Province for "Rice cultivation prohibition"; Maroun-Jarahi basin for "Allocation of wetland rights".

oriented infrastructural hard solutions, is evident. Measures once considered solutions are now part of the problem, narrowing the range of conditions in which the system can survive. There are numerous examples of quick fixes with unintended backfires; some examples are, but not limited to: massive dam and reservoir building policies, known as "hydraulic mission" with a technocratic focus on supply-side which intends to maximize water exploitation, whereas distribution networks are still worn out [*XXIII*]; policies advocating food self-sufficiency regardless of extremely-limited available water and poor land quality in most of the basins [*XXVII*]; water desalination and transferring policies without non-economic assessments (Minute 36 of [*XXII*]); pronatalist population policies which result in a notable escalation in demand-side [*XXVIII*]; substantial governmental subsidization in water and energy sector which act as a disincentive for reasonable use [*XVII*]; registering unlicensed illegal wells as part of populist policies which resulted in severe drops in groundwater level [*XVIII*]. Local respondents also demonstrate pessimistic views on plans that are implemented or being implemented in the area with statements such as "*The 4th Chahnimeh*[4] *dried the lake*" or "*The water transfer project would trigger conflicts among locals*". Nevertheless, on paper, there are some good signs of setting the tone for inversing this trend; as Minute 5 of [*XXII*] sets provisions for stopping building new dams and lowering the pace of ongoing dam constructions or Minute 3 of [*XXXIII*] calls for "Setting tiered tariffs for drinking and hygienic uses that exceed the pattern".

Analyzing Supreme Water Council's minutes indicated that this council is concentrated solely on managing ongoing and current problems. The only evidence of preparing for the far future that can be found in the area's official documents are The 20-Year National Vision (2004) [*XXIV*] and Hamoun Master Plan (2015) [*XXX*]. Surprisingly, the Ministry of Energy issued strategic plans for the water sector's vision eight years later, in 2012. The strategic plans include implications for capacity building, technological, governance structure, integration, and financial improvements. They also emphasize monitoring and managing climate change impacts within a 20-year horizon. Furthermore, the Hamoun Master Plan has some long-term (25-year) strategic objectives regarding water resources in the area (with specific attention to Hamoun wetlands). However, despite being promising on paper, the respondents asserted that the Hamoun Master Plan is not being implemented by the governance system and is somehow forgotten. The survey also indicated that only 7.5 percent of the respondents believed that water-related policy making in the area have a long-term vision.

Complex systems evolve through time; therefore, studying and respecting their *history* can help identify contextual factors influencing the success and failure of plans and policies so that they can be tailored as much as possible to their context. Water management practices in Sistan used to be local and community-based, with numerous participatory mechanisms at the heart of water-related activities. This community-based water management system adopted structural and non-structural measures that were adapted to local conditions. However, a series of events caused the alteration of Iran's traditional water governance system. The most significant of these events was the centralization of water governance (as the result of issuing [*I*]) and the adoption of modern technologies in water management practices that were imported from the western water management models. The introduction of alien fish species to Hamoun wetlands, which resulted in the devouring of the reeds in 1983 (Aman 2016), and locating water-consuming industries in the middle of the desert are only two of the many examples of neglecting the region's history and context. Only 9 percent surveyed individuals believed that the water governance practices in Sistan are appropriate for the region's specific context. Nevertheless, recent evidence indicates a trend in reviving traditional management models. Local authorities claim that the "Irrigation of 46000 ha of Sistan Plain" tends to bring back the traditional community-based allocation mechanism. Moreover, policy documents too show good trends toward respecting this proud history. Some examples are: "Adoption of proper measures to revive qanats" (Article 35 of [*XXXII*]); "Establishing environmental codes and institutionalizing environmental culture and ethics based on Iranian-Islamic models" [*XXIX*]; "Documentation and utilization of traditional knowledge" [*XXXI*]; "Ministry of Energy is responsible for reusing water considering Islamic considerations" [*XXI*].

Legal consideration

Adaptive Law

Despite the recent attempts to develop Iran's Comprehensive Water Law, currently, water governance in Iran lacks an overarching legal framework regarding the quality or quantity of water. Suffering from an "over-legislation" syndrome (Fasihi Harandi 2018), Iran's government tries to manage most water-related problems by issuing new institutions (i.e., rules and regulations), which indeed adds to the complexity of managing this natural resource. Having so many institutions in place may provoke the idea that such an attitude will support *revisions and reviews*. However, as a

[4] Chahnimeh 1, 2, and 3 are big natural holes used for water storage; the 4th Chahnimeh is artificial and holds more storage capacity than the other three combined.

report from Iran's Parliamentary Research Center revealed, this long sequence of both fragmented and overlapping rules and regulations not only did not contribute to solving the problems but also put the system on the verge of a national water crisis (Bagheri et al. 2019). The survey results also confirmed this issue, as only 11 percent of the respondents believed that legal provisions are being effectively updated given the new circumstances. Furthermore, the introduced institutions mainly have two approaches to water governance. They are either too specific, e.g., calculating crops' water needs in Article 1 of [VII], or too general, such as laws associated with increasing agricultural productivity or optimizing water consumption. In both cases, the legal dimension fails to be adaptive.

Supportive Law

Regarding *authorities and resources*, Article 10 of [*XII*], issued in 2003, supports polycentricity, as it clearly states that the management structure of the water resources must be decentralized; thus, public and local organizations' participation must be improved. Considering the regional water company as one of the area's leading actors in water management, Article 22 of the company's Statute [*XI*] gives authority to the senior manager to set procedures for the company activities within legal boundaries. Besides, according to [*IX*] issued in 2001, regional water companies can ration water supply in cases of emergencies. However, the findings of Mirnezami and Bagheri (2017) indicated that regional water companies do not have sufficient independence to make autonomous decisions, as the protocols and budgets are given to them by the central government (Mirnezami & Bagheri 2017). The respondents, too, criticized the fact that water-related decisions about the area are being taken in Tehran (the capital) and not in the region itself.

The 1973 Treaty

In the case of transboundary basins, treaties are one of the most important legal measures used to govern shared waters. In order to be reflexive, treaties should (Green et al. 2013): 1- Share water based on a percentage of available water; 2- Pay explicit attention to extreme events; 3- Have terms on joint monitoring and data sharing; 4- Have mechanisms for conflict management. The Iran-Afghanistan 1973 treaty lacks percentage sharing of water as it is specified that Afghanistan must annually deliver 820 MCM of water to Iran. The treaty only pays partial attention to extreme events: Articles IV and XI include provisions for reductions in flows and droughts, respectively, but there are no provisions regarding joint flood management. Despite the extraordinary national and international importance of the Hamoun Wetlands, the interpretation of the 1973 Helmand Treaty based on the Vienna Convention on the Law of Treaties (1969) shows that the environmental and water right of the Hamoun wetlands have not been considered in the subject and context of the treaty. The treaty does not also contain explicit terms regarding joint monitoring and data sharing. However, Article VIII calls for establishing a joint committee which can be interpreted as a joint monitoring and data sharing mechanism. Regarding conflict management, Article IX of the treaty calls for diplomatic negotiations at first, and if no solutions were produced, the differences could be submitted for arbitration. Nonetheless, the treaty does not support amendments or revisions as, according to Article X, both parties agree to the treaty in a permanent manner. Besides, according to (Thomas & Varzi 2015), the treaty fails to acknowledge the importance of Hamoun wetlands (environmental rights), and the amount of water delivery only covers drinking and agricultural uses.

Financial consideration

Sufficiency

Due to numerous factors such as international sanctions, high rate of inflation, and internal corruption, Iran's economy faces serious challenges, and the water sector is not an exception in this manner. Weak cost recovery and fee collection mechanisms due to heavy subsidies combined with technical limitations have resulted in substantial reliance of the water sector on governmental budgets. The number of unfinished/delayed water-related projects in the country (Ministry of Energy 2018) in general and in the area (Sistan&Baluchistan Regional Water Company 2020), in particular, due to financial limitations, is acceptable proof of this claim. According to survey results, only 8 percent of the respondents believed that the financial resources are meeting the area's water governance needs.

Variety

Water-related practices in the area are being funded primarily through public budgets. However, as mentioned in the Learning section, the budgeting mechanism lacks the flexibility to keep pace with changes and uncertainties. Furthermore, and from a legal point of view, Iran greatly emphasizes facilitating *private sector* investments. For instance, Article 44 of [*XXXVII*], [*X*], or Minute 14 of [*XXII*], all, directly or indirectly, try to include the private sector in water management projects and plans. However, on the ground, given the country's general economic conditions combined with extreme currency fluctuations, the water sector is deprived of meaningful private sector involvement. The findings indicate that the private sector's

reluctance to invest in the water sector is rooted in the amount of associated risks and the long-term nature of water projects. It is worthy of mentioning, given the fact that Hamoun wetland is a Ramsar[5] designated site, it receives some (limited) international funds through various projects.

Discussion

Based on the overall findings presented in Table 7, it is evident that the water governance practices in Sistan, Iran generally fall short of meeting the desired qualities necessary for facilitating AWG. Figure 3, which provides a summary of the survey results, further indicates that a majority of the respondents expressed disagreement regarding the presence of AWG's fostering factors in the area. Nonetheless, upon analyzing the available documents, it was observed that the formal water governance system in the area, to some extent, acknowledges the current situation and has somehow envisioned the system's desired future. The primary challenge appears to lie in the development of an effective pathway, overcoming resistance to change, and successfully navigating toward the desired state(s) of the system. In simpler terms, there is a considerable gap between what is aimed for and what is being done; i.e., in Ostrom's terms, the rules-in-form are inconsistent with the rules-in-use (Ostrom 2009). Lukat et al. (2022) also suggest that such challenges arise due to the interplay between formal and informal institutions and are commonly observed in the Global South cases.

The analysis revealed that multiple factors hinder the emergence of adaptive water governance in the area, and these factors appear to be common among regions in the Global South. While certain aspects of the system showed promise, such as the presence of supportive laws and the potential for self-organization, a critical rethinking is needed for the remaining categories.

Sistan's water governance system primarily relies on a rigid command-and-control paradigm, which proves inadequate for addressing the ever-growing uncertainties and complexities. The results indicate the existence of serious scalar tensions between national and local institutions, a challenge commonly observed in Global South regions (Di Gregorio et al. 2019; Sidibé et al. 2018). Similar to other cases in the Global South ., (Fallon et al. 2021; Makaya et al. 2020; Sehring 2020), fragmented governance and

Table 7 Conditions of different characteristics of the water governance system in the Sistan Delta in terms of facilitating AG (wherein (−) represents that the characteristic is not supported in the area, **(0)** shows that the character is moderately supported and (+) indicates that the water governance system supports the mentioned characteristic)

Dimension	Category	Condition
Stakeholders	Participation	(−)
	Collaboration	(−)
Learning	Objectives and Measures	(0) ~ (+)
	Monitoring	(−)
	Information Management	(−) ~ (0)
	Self-Organization	(0) ~ (+)
Policy Development	Uncertainty	(0) ~ (+)
	Time Horizon	(−)
Legal Considerations	Supportive	(+)
	Adaptive	(−) ~ (0)
Financial Considerations	Sufficiency	(−) ~ (0)
	Variety	(−)

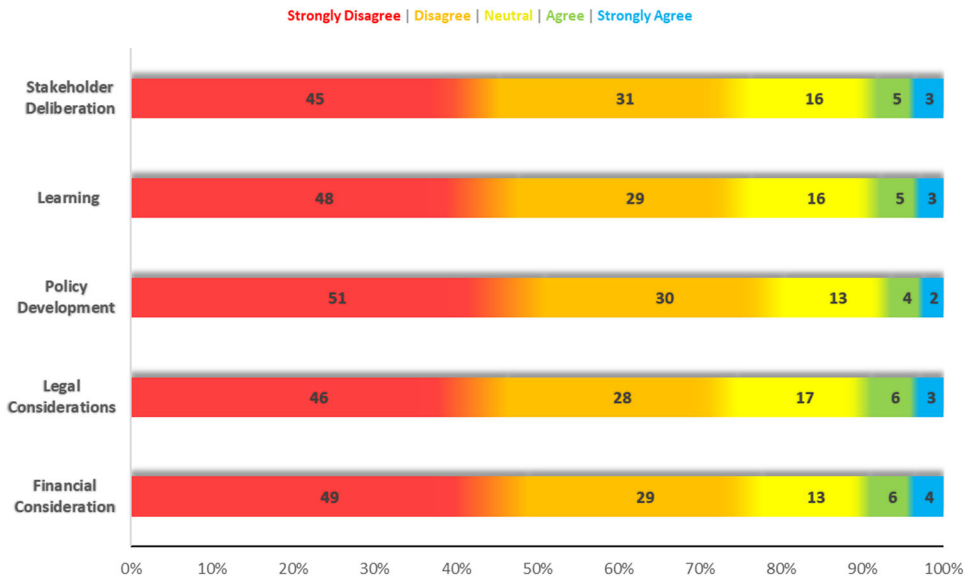

Fig. 3 Summary of questionnaire results

bureaucracy-oriented collaboration hinder the attainment of long-term benefits in the region.

Moreover, the malfunction of reflecting and feedback mechanisms has led to a gap between management practices and ground truth in the area, preventing the achievement of sustainable outcomes, as highlighted by Bagheri (2006). Furthermore, the results regarding knowledge creation corroborated the findings of Ricciardi et al. (2020), which suggest that research publications may not effectively address the actual problems faced by farmers in low- and middle-income nations due to a lack of alignment between research needs and efforts. In this sense, lessons learned from cases like Senegal, Mali, and Ghana can help set up an effective science-policy interface that allows the scientific community and policymakers to work together to identify the research priorities and propose agreed-upon solutions to the problems (Zougmoré et al. 2019).

Additionally, in line with the findings of Piñeiro et al. (2020) regarding Global South cases, there is a clear inclination toward seeking short-term solutions and adopting non-contextualized approaches in water-related policies. This issue can be attributed to the state-centric structure of governance and limited administrative periods, which leave little room for embracing the inherent complexity of the water system.

Outdated and unreviewed laws and regulations are also a significant concern, not only in the Global South but globally, impeding the governance system's ability to adapt to new circumstances (see e.g., Cosens & Gunderson (2018); Garmestani & Benson (2013); Green et al. (2015)). Even further, inflexible financial mechanisms and organizational structures in the area create rigidity traps that impede adaptability. As these structures become increasingly procedure-bound, their ability to respond and adjust to changes and uncertainties is significantly slowed down.

Conclusions

Adaptive governance, although a growing paradigm, has been argued to be a sustainable way of responding to changes and uncertainties. Widespread approval of the concept gives rise to setting the stage for its emergence. It seems essential to appraise the extent to which the current governance systems are ready for such a transition. The framework utilized in this study explicitly puts emphasis on learning as the core element of adaptive governance. It sought to comprehensively capture the underpinning structure and processes of a governance regime, and unlike conventional attempts, it focused on enabling factors of collective learning in lieu of its outcomes. The framework can help determine which aspect of the governance system shall be tackled more seriously to pave the way for a more adaptive and resilient form of governance. Although the framework was applied to a challenging water-related case to be evaluated, it can hold its transferability and be applied to other governance systems since its components are not specific to water systems.

There were also several limitations to the present work. Most importantly, in this paper, the enabling factors of adaptive governance were studied independently of each other. Nevertheless, the authors acknowledge the cross-relations of these enabling factors and that assessment of these factors in isolation may bring the risk of falling into the reductionism trap. An inclusive and exhaustive evaluation of reciprocal interactions among these factors, if not impossible, would go well beyond this paper's scope and require much more extensive data and information (which are not currently available). Altogether, the authors argue that the assessment done in this paper would serve as a helpful starting point and guidance for transformation towards adaptive modes of governance in the area.

This study shed light on the underlying issues hindering the facilitation of AWG in Sistan, Iran, with a primary focus on identifying the core issues at hand. While the findings of this research have provided valuable insights into the nature of these challenges, there is a need for further investigation to address the question of "how" to effectively overcome these obstacles. The water system in the region is confronted with numerous deep uncertainties, encompassing factors such as shifting climate patterns and evolving socio-economic and political dynamics. Given the presence of these uncertainties, the pursuit of AWG becomes increasingly vital in ensuring the long-term sustainability of water management and governance practices. However, the transition towards AWG demands a thoughtful and in-depth exploration of practical strategies that are tailored to the unique socio-economic, institutional, political, and environmental contexts of Sistan, Iran. Subsequent research endeavors should be dedicated to examining the specific mechanisms, policies, and governance frameworks that can facilitate the successful implementation of AWG in this particular region.

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Compliance with Ethical Standards

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