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ORIGINAL ARTICLE

Identifying the Knowledge Components of Institutional Water Literacy: An Exploratory Study in the Agricultural Sector of Qarchak County

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ABSTRACT

Water literacy, as an emerging concept in water resources management, plays a fundamental role in enhancing knowledge, attitudes, and behaviors associated with sustainable water use. Within this framework, "institutional water literacy" goes beyond individual awareness and refers to organizational knowledge and decision-making structures related to water governance, thereby providing a basis for effective policymaking and macro-level decision-making. As the largest water-consuming sector in Iran, agriculture requires improvement at this level of literacy to enhance water productivity and the sustainability of water resources through scientific management and organizational knowledge capacities. The present study sought to identify the knowledge components of institutional water literacy within the organizational structure of water management in the Agricultural Jihad Organization of Qarchak County, using a qualitative approach based on thematic analysis. Data were collected and analyzed through semi-structured interviews and homogeneous purposive sampling with 17 informed and key stakeholders in the water sector and staff of the Agricultural Jihad Organization. To ensure the trustworthiness of the findings, Lincoln and Guba's four criteria, credibility, transferability, dependability, and confirmability, were applied, supported by participant review and the use of direct quotations. The findings identified 12 key knowledge categories: knowledge of the natural and environmental system of water resources; the socio-environmental consequences of the water crisis; policy and regulations; formal and customary property rights; the economics of water use and resource valuation; strategic, foresight, and contextual knowledge; participation and intersectoral governance; technical knowledge of efficient water use; productivity analysis and water-use measurement; data-driven knowledge and information technology; the water-agriculture-food security nexus; and communication and extension. The results indicate that enhancing institutional water literacy requires strengthening multidimensional knowledge capacities, including analytical, data-driven, technical, legal, and participatory capabilities; such an approach can support informed decision-making and effective water resource management in the agricultural sector. Accordingly, the study's operational model is organized around four pillars: ecosystem adaptation knowledge, integrated governance, technical-economic knowledge, and communication-extension knowledge. This model can serve as a roadmap for institutional transformation in other organizations involved in agricultural water management.

KEYWORDS

Institutional Water Literacy Knowledge, Institutional Stakeholders, Agriculture, Qarchak County.

Introduction

Over the past decades, Iran's agricultural sector has faced an intensifying water crisis, manifested in declining groundwater levels, deterioration of water quality, restrictions in cropping patterns, increasing livelihood instability among farmers, and escalating conflicts over water use. The water problem is not merely the result of physical scarcity but also involves social-ecological and institutional complexities (Daneshmehr et al., 2019). In Iran, prolonged droughts, declining precipitation, population growth, and unsustainable consumption patterns have placed considerable pressure on water resources (Khorsandi et al., 2023). Within this context, agriculture is a major source of pressure on the country's water resources. Therefore, overcoming the water crisis cannot rely solely on technical solutions; it also requires strengthening the knowledge capacities and institutional capabilities of organizations involved in water and agricultural management.

In recent years, the concept of water literacy has evolved beyond individual awareness and has expanded into social and managerial domains. Water literacy refers to a multidimensional set of water-related knowledge, attitudes, values, and action capabilities that support understanding of water systems and responsible decision-making for sustainable water use (McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022). It encompasses not only scientific knowledge about water resources but also hydrosocial and local knowledge and the ability to apply practical strategies for protecting and restoring water resources (McCarroll & Hamann, 2020). Drawing on these multidimensional accounts, the present study conceptualizes institutional water literacy at the organizational level as a knowledge capacity embedded in decision-making, coordination, and organizational learning. Research has examined both the human and natural dimensions of water literacy (Mostacedo-Marasovic et al., 2022, 2023), while explicit conceptualization of water literacy as an organizational or institutional capability remains comparatively limited. This gap is especially important in water-stressed agricultural settings such as Qarchak County, where water management requires an integrated understanding of ecological, social, economic, and institutional dimensions.

Qarchak County, located in the southeastern part of Tehran Province, is a semi-arid agricultural area facing serious water resource constraints. Increasing pressure on groundwater resources, declining precipitation, reduced cultivable land, and challenges related to sustainable water use make the county an important case for examining institutional capacities in agricultural water management (KhabareOstan, 2015). Nevertheless, many previous studies have primarily focused on technical and engineering aspects of water management, while paying less direct attention to the knowledge and organizational dimensions that shape institutional decision-making. Accordingly, the present study aims to identify and conceptualize the knowledge components of institutional water literacy within the organizational structure of agricultural water management in Qarchak County and to explain how such knowledge is represented and utilized in decision-making and water-management processes.

Methodology

Given that the objective of this research is to identify the knowledge components of institutional water literacy from the perspective of stakeholders and actors involved in agricultural water management, the study was designed using a qualitative approach and conducted through thematic analysis. The qualitative approach was selected because the concept of institutional water literacy is complex, context-dependent, and multidimensional, requiring an in-depth exploration of stakeholders' experiences, perceptions, and interpretations within real decision-making and operational contexts. In this framework, data analysis followed a systematic thematic analysis process in which textual data were examined across different levels of abstraction, including initial codes, organizing categories, and overarching themes (Attride-Stirling, 2001).

The study population consisted of key stakeholders and informed actors involved in agricultural water resource management in

Qarchak County. This group included water and soil specialists, officials from the Agricultural Jihad Organization and water-management agencies, agricultural consultants, and representatives of farmers' associations. These participants were selected because of their professional experience, specialized knowledge, and executive or decision-making roles in water management. Sampling was conducted purposively using a homogeneous strategy, and participants were selected based on criteria such as professional experience, familiarity with agricultural water issues, and involvement in managerial processes. Data collection continued until theoretical saturation was achieved, meaning that no new information emerged that could further develop or modify the conceptual categories (Nascimento et al., 2018). Ultimately, 17 face-to-face semi-structured interviews were conducted.

Semi-structured interviews served as the primary data collection instrument and were designed to explore participants' perceptions, knowledge, experiences, and challenges related to the formation of institutional water literacy. Data analysis began simultaneously with data collection and proceeded through an iterative and cyclical process. First, all interviews were fully transcribed, followed by line-by-line coding of the data. In the next stage, initial codes were grouped into conceptually similar categories, and finally these categories were synthesized to identify the core themes and conceptual patterns associated with institutional water literacy.

To ensure the rigor and trustworthiness of the findings, the four criteria of credibility, transferability, dependability, and confirmability proposed by Lincoln and Guba (1985) were applied. Credibility was strengthened through techniques such as member checking, the use of direct quotations, and the inclusion of diverse stakeholder groups. Transferability was achieved by providing rich and contextualized descriptions of the research setting and participants' characteristics. Dependability was enhanced through systematic documentation of all stages of data collection and analysis, as well as verification of the coding process by an independent coder. Finally, confirmability was ensured by maintaining an audit trail of analytical decisions and by conducting peer review of the research process.

Results

The findings revealed that the knowledge dimension of institutional water literacy in agricultural water management in Qarchak County extends beyond purely technical knowledge and emerges from an interconnected set of knowledge domains. The analysis identified twelve key knowledge components forming the conceptual foundation of institutional water literacy:

1. Knowledge of natural and environmental water systems
2. Socio-environmental consequences of the water crisis
3. Policy and regulatory knowledge
4. Formal and customary water rights
5. Economics of water use and resource valuation
6. Strategic, foresight, and contextual knowledge
7. Participation and intersectoral governance
8. Technical knowledge of efficient water use
9. Productivity analysis and water-use measurement
10. Data-driven knowledge and information technology
11. The water-agriculture-food security nexus
12. Communication and extension

Through the final synthesis of themes, these twelve components were organized into four broader domains:

1. Ecosystem adaptation knowledge

This domain refers to knowledge related to understanding the natural, ecological, and environmental characteristics of water resources. Institutions responsible for water management must be able to assess water conditions not only in quantitative terms but also in relation to ecological capacity, water quality, environmental impacts of extraction, and the socio-ecological consequences of water scarcity. Emphasizing this domain transforms water management from a purely administrative task into a process grounded in ecological understanding and environmental awareness.

2. Integrated governance
This domain encompasses policy and regulatory frameworks, formal and customary water rights, stakeholder participation, and cross-sectoral governance mechanisms. The findings indicate that sustainable water management cannot be achieved without institutional coordination, recognition of both formal and informal rules, and meaningful engagement of local stakeholders. Institutional water literacy therefore requires a comprehensive understanding of governance structures, collaborative decision-making processes, and mechanisms of inter-organizational interaction.

3. Technical-economic knowledge
This domain includes technical expertise in efficient water use, productivity assessment, consumption monitoring, data-driven management, information technologies, and economic analysis of water use. The results suggest that addressing agricultural water challenges requires integrating technical knowledge with economic and analytical capabilities. Institutions must be able to monitor water consumption, evaluate productivity, employ data in decision-making, and assess the economic implications of different water allocation and use patterns.

4. Communication-extension knowledge
This domain highlights the importance of communication, education, knowledge transfer, and effective interaction with water users. The findings indicate that without effective communication between policy institutions, field experts, and farmers, even the most technically sound policies and programs are unlikely to achieve their intended outcomes. Institutional water literacy therefore includes the capacity for dialogue, persuasion, collaborative learning, and the facilitation of extension and educational processes.

Moreover, the final analysis indicates that institutional water literacy should be understood as a dynamic and hierarchical system in which these four domains interact with one another. The findings also identify three fundamental transitions in water resource management within the organization:

- Transition from stand-alone technical knowledge to integrated and socially oriented governance
- Transition from reactive crisis management to strategic and systemic resilience
- Transition from experience-based practice to data-driven and intelligent decision-making

Conclusion

The findings demonstrate that the knowledge dimension of institutional water literacy within the Agricultural Jihad Organization of Qarchak County extends beyond purely technical knowledge and constitutes a multidimensional and strategically significant body of institutional knowledge. The thematic analysis identified twelve knowledge components spanning ecological, social, technical, economic, legal, participatory, and data-driven dimensions. This interpretation is consistent with multidimensional water-literacy frameworks (McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022, 2023) and with national studies emphasizing participatory and governance dimensions in water management (Behboudi & Ghorbani, 2023).

The analysis further revealed three key conceptual shifts in water-management practices within the organization. The first shift involves moving from a purely technical and engineering perspective toward integrated and participatory water governance. The identification of dimensions such as participatory knowledge, legal knowledge (formal and customary), and communication-extension knowledge suggests that successful agricultural water management depends on understanding social networks, engaging stakeholders, and managing local conflicts. These findings support previous studies emphasizing participatory governance in water management (Behboudi & Ghorbani, 2023).

The second shift involves moving from reactive crisis management toward a strategic and resilience-based approach. Knowledge domains related to ecological systems, socio-environmental consequences, economic analysis, and foresight highlight the importance of understanding interactions among natural, social, and economic systems in water management. This multidimensional integration is consistent with water-literacy frameworks (McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022, 2023) and supports evidence-based adaptation under conditions of climate uncertainty (Boon, 2024; Deslatte et al., 2024).

The third shift reflects the transition from experience-based decision-making to data-driven and technologically supported management. The identification of data-driven knowledge and information-technology capabilities alongside knowledge of efficient water use indicates that institutional water literacy requires the integration of monitoring and analytical tools into water-management practices. Combining conventional technical knowledge with data-based monitoring, geographic information systems, and forecasting models is consistent with recent work emphasizing the integration of domain knowledge, data, and knowledge infrastructures in water modelling and governance (Duan et al., 2024; Deslatte et al., 2024).

Overall, the findings suggest that the knowledge dimension of institutional water literacy represents an integrated institutional capability emerging from the interaction of technical, social, economic, legal, participatory, and technological knowledge. From a policy perspective, strengthening institutional water literacy requires a systematic and multi-level approach. At the macro level, a strategic framework for enhancing institutional water literacy within agricultural organizations can promote coherence among capacity-building programs, governance mechanisms, strategic resilience, and digital transformation. At the organizational level, establishing a water-data monitoring and analysis mechanism and strengthening structured stakeholder participation can facilitate the operationalization of this concept within managerial processes.

Finally, unlike studies that focus primarily on educating water users at the individual level, the present study adopts an institutional perspective. Without strategic investment in institutional literacy as a driver of change and a basis for redefining governance structures, the goals of sustainable agriculture and regional water security cannot be fully realized. The study indicates that institutional water literacy can provide an important enabling condition for the transition from traditional to modern and sustainable water resource management

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«مقاله پژوهشی»

از دانشِ نهادی حکمرانی آب تا سواد آبی سازمانی: مطالعه‌ای در جهاد کشاورزی شهرستان قرچک

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چکیده

سواد آبی به‌عنوان مفهومی نوظهور در مدیریت منابع آب، نقشی اساسی در ارتقای دانش، نگرش و رفتارهای مرتبط با بهره‌برداری پایدار ایفا می‌کند. در این چارچوب، «سواد آبی نهادی» فراتر از آگاهی‌های فردی، به دانش سازمانی و ساختارهای تصمیم‌گیری مرتبط با حکمرانی آب اشاره دارد و زمینه‌ساز سیاست‌گذاری‌های کارآمد و تصمیم‌گیری‌های کلان است. بخش کشاورزی، به‌عنوان بزرگ‌ترین مصرف‌کننده آب در ایران، نیازمند ارتقای این سطح از سواد است تا از طریق مدیریت علمی و ظرفیت‌های دانشی سازمانی، بهره‌وری و پایداری منابع آبی را تقویت کند. پژوهش حاضر در پی شناسایی مؤلفه‌های دانشیِ سواد آبی نهادی در ساختار سازمانی مدیریت آب سازمان کشاورزی شهرستان قرچک، با رویکرد کیفی مبتنی بر تحلیل مضمون، انجام شد. داده‌ها با استفاده از مصاحبه‌های نیمه‌ساختاریافته و روش نمونه‌گیری هدفمند از نوع متجانس، از ۱۷ نفر از ذینفعان آگاه، بااطلاع و کلیدی حوزه آب و کارکنان جهاد کشاورزی گردآوری و تحلیل گردید. برای اطمینان از اعتبار یافته‌ها، چارچوب چهارگانه لینکلن و گوبا شامل اعتبار، قابلیت انتقال، قابلیت اتکا و تأیید به کار گرفته شد و با بازبینی مشارکت‌کنندگان و استفاده از نقل‌قول‌های مستقیم پشتیبانی شد. یافته‌ها حاکی از شناسایی ۱۲ مقوله دانشی کلیدی است که شامل دانش نظام طبیعی و محیطزیستی منابع آب، پیامدهای اجتماعی-محیطزیستی بحران آب، سیاست‌گذاری و مقررات، حقوق رسمی و عرفی مالکیت، اقتصاد بهره‌برداری و ارزش‌گذاری منابع، راهبردهای آینده‌نگر و موقعیتی، مشارکت و حکمرانی بین‌بخشی، دانش فنی مصرف بهینه، تحلیل بهره‌وری و سنجش مصرف، داده‌محوری و فناوری اطلاعات، پیوند آب، کشاورزی، امنیت غذایی و ارتباطات و ترویج است. نتایج نشان می‌دهد ارتقای سواد آبی نهادی مستلزم تقویت ظرفیت‌های دانشی چندبعدی شامل توانمندی‌های تحلیلی، داده‌محور، فنی، حقوقی و مشارکتی است؛ رویکردی که می‌تواند زمینه‌ساز تصمیم‌گیری آگاهانه و مدیریت مؤثر منابع آب در بخش کشاورزی باشد. بر این اساس، الگوی عملیاتی پژوهش بر سه محور «نهادینه‌سازی آموزش، توسعه سامانه پایش و تقویت حکمرانی مشارکتی» استوار شده که می‌تواند نقشه راهی برای تحول نهادی در سایر سازمان‌های مرتبط با مدیریت آب کشاورزی باشد.

واژه‌های کلیدی

دانش سواد آبی نهادی، ذی‌نفعان نهادی، کشاورزی، شهرستان قرچک.

Introduction

Water crises have intensified in recent decades and, as previously emphasized (UNESCO, 2006), continue to signal the inadequacy of conventional approaches to natural resource management (UNESCO, 2023). In the twenty-first century, these crises are intertwined not only with technical or ecological problems but also with crises of meaning, understanding, and governance (Pahl-Wostl, 2007). Under these conditions, water literacy has moved beyond the level of an educational tool and has become an interdisciplinary framework for understanding and managing human-water relationships. Water literacy encompasses not only scientific knowledge of the water cycle and water resources, but also values, attitudes, and capacities for action that enable responsible and sustainable decision-making about water (McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022). In recent literature, water literacy is treated as a multidimensional concept that facilitates understanding of complex human-water relationships within natural, cultural, and social contexts (Hawke, 2012; McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022). It includes systematic knowledge about water, historical and local understandings of resources, ethical and cultural values, analytical skills, and social participation (McCarroll & Hamann, 2020). Accordingly, understanding water-related issues is important not only at the individual level but also within political and cultural contexts. The Middle East and North Africa is one of the world's most water-scarce regions (de Waal et al., 2023), and a reciprocal relationship exists between the water crisis and underdevelopment in the region (Daneshmehr et al., 2019).

Iran is among the countries facing high levels of water-resource wastage and inefficient consumption (Asadollahzadeh Mousavi, 2011; Afshani & Shiri-Mohammadabad, 2020). Structural and environmental factors, including prolonged droughts, declining precipitation, population growth, and unsustainable consumption patterns, have intensified the country's critical water situation (Babaee & Alijani, 2013; Khorsandi et al., 2023). In this context, the agricultural sector, which consumes approximately 90% of the country's total water resources, plays a central role in increasing pressure on water resources (Afshani & Shiri-Mohammadabad, 2020; Amotaghi & Faeghi, 2024). Recent research estimates indicate that Iran's net agricultural water consumption is approximately 42.43 billion cubic meters per year, of which only 1.61 billion cubic meters is associated with virtual-water exports, while the majority is used domestically. In addition, satellite data estimate evaporation from agricultural land in 2020 at approximately 55.27 billion cubic meters, indicating the continued intensity of water consumption and losses in the agricultural sector (Khorsandi et al., 2023). Alongside high levels of withdrawal and consumption, low irrigation efficiency and the predominance of traditional irrigation methods also contribute to extensive resource losses. Scenario-based evidence indicates that reforming irrigation methods, improving on-farm technologies, and changing cropping patterns can significantly reduce water consumption (Karandish, 2021). Nevertheless, the problem is not limited to technical inefficiency; a substantial part of the crisis is rooted in the inability of decision-making institutions to understand and manage the social-ecological complexities of water (Daneshmehr et al., 2019). The absence of an integrated understanding of water issues within executive institutions, together with the persistence of sectoral and uncoordinated policymaking, can lead to ineffective decisions (Ashtarian, 2025; Pahl-Wostl, 2007). At the same time, studies of Iranian water governance point to substantial gaps between formal policy arrangements and institutional implementation (Rahbarqazi & Taleihur, 2024). Therefore, in confronting this complex set of challenges, water literacy should be considered at the institutional level as an analytical and capacity-building framework capable of generating a more comprehensive understanding of the social-ecological dynamics of water and strengthening institutional capacity for effective and sustainable decision-making (Al-Jayyousi, 2004; Deslatte et al., 2024).

Despite the importance of institutions such as the Agricultural Jihad Organization in water resource management, Iranian water governance has been characterized by centralized and insufficiently participatory institutional arrangements, with limited integration of local capacities (Ashtarian, 2025; Ahmadipour & Ahmadi, 2021). These governance conditions can create gaps between policymaking and implementation and hinder participatory governance. At the same time, the knowledge dimensions of water literacy have received limited direct attention within organizational settings. Studies of Iranian water governance nevertheless show that institutional complexity and centralized decision-making make the organizational knowledge dimension particularly salient (Rahbarqazi & Taleihur, 2024; Bagheri et al., 2021; Ahmadipour & Ahmadi, 2021).

At the international level, research has focused on climate-related water literacy and drought preparedness (Boon, 2024), links between water literacy, sustainable water management, and Sustainable Development Goal 6 (Maniam et al., 2021), cross-cultural approaches to water education (Hawke, 2012), and standards for learning about the human and natural dimensions of water systems (Mostacedo-Marasovic et al., 2022, 2023). By contrast, explicit conceptualization of water literacy as an organizational or institutional capability remains comparatively limited, although water-management scholarship emphasizes the importance of organizational learning, knowledge creation, and knowledge infrastructures for effective governance (Al-Jayyousi, 2004; Deslatte et al., 2024). Accordingly, the present study adopts a policy-oriented approach and focuses on the knowledge dimension of water literacy at the organizational level. By examining the perspectives and practices of institutions responsible for water management, it seeks to identify knowledge gaps and pathways for improvement, thereby highlighting the need to address water literacy at institutional and managerial levels.

Qarchak County, located in southeastern Tehran Province, is a prominent example of a semi-arid agricultural area and has been recognized as an independent county since 2012. Despite its considerable capacity for producing crops such as wheat and barley, the area has in recent years faced worsening water scarcity resulting from declining precipitation, persistent drought, and mismanagement of water resources. Population growth, overexploitation of groundwater, and competition between urban and agricultural institutions over limited water resources have further intensified existing ecological pressures (Mehr News Agency, 2015). As a consequence, of Qarchak's total 7,000 hectares of agricultural land, only about 3,900 hectares remain under active cultivation, while more than 40% of the land has been left unused because of water scarcity (KhabareOstan, 2015). The water crisis has even led some farmers to use unconventional sources, such as untreated wastewater, for irrigation, with serious environmental and health consequences (Chareh News, 2023). In response to these conditions, projects such as the transfer of treated wastewater from southern Tehran to the Varamin Plain, including the counties of Varamin, Pishva, and Qarchak, are under implementation (IRNA, 2020). Until such projects are fully realized, however, water scarcity will remain a structural and persistent challenge to agricultural development in Qarchak. In this context, a qualitative analysis of organizational knowledge within the water-management structure of the Agricultural Jihad Organization of Qarchak County can help identify the knowledge components of organizational water literacy more precisely and show how this knowledge is redefined within institutional structures and applied in processes related to water governance and resource management. Accordingly, using a qualitative thematic analysis approach, this study seeks to answer the following question: How is the knowledge dimension of water literacy redefined in institutional discourses, and which components of local and organizational knowledge does it encompass? Answering this question can provide a basis for designing institutional capacity-building programs and revising educational policies toward multilevel and locally adapted water governance in Iran.

Water literacy, as a relatively new concept in interdisciplinary water studies, has emerged in response to water crises and the need for public participation in resource management (United

Nations, 1992; McCarroll & Hamann, 2020). In recent years, this concept has acquired increasing importance in discussions of water sustainability, management, and governance (Maniam et al., 2021). It refers to a multidimensional set of water-related knowledge, attitudes, and behaviors that supports understanding of water systems and informed action toward sustainable water use (McCarroll & Hamann, 2020; Maniam et al., 2021). In the research literature, water literacy is defined as a set of cognitive, attitudinal, and behavioral capabilities that enable understanding, evaluation, and decision-making concerning water resources (McCarroll & Hamann, 2020).

Water literacy comprises interrelated cognitive, affective, and behavioral dimensions, commonly expressed through knowledge, attitudes and values, and behavior or action (McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022). Among these, the knowledge dimension provides the cognitive basis for informed analysis and action in water management and has been conceptualized by scholars in several ways.

Key dimensions and indicators of water knowledge: McCarroll and Hamann (2020) distinguish four specific cognitive knowledge sets within water literacy: (1) science and systems knowledge, including awareness of hydrological and ecological systems; (2) hydrosocial knowledge, concerning the complex social, institutional, cultural, and historical relationships between humans and water; (3) local knowledge, concerning local water sources, infrastructure, uses, and demands; and (4) functional knowledge, concerning how water can be used, protected, and restored sustainably. Mostacedo-Marasovic et al. (2022) identify five broad categories within the human dimensions of water literacy: human settlements; the water-food-energy nexus; public health; impacts of human activities on water quality and quantity; and water-resources management. Drawing on these multidimensional accounts, the present study operationalizes five institutionally relevant knowledge areas: institutional knowledge of water resources, including awareness of the region's surface and groundwater resources and their place within the local hydrological system; knowledge of consumption and use, including understanding water-allocation patterns, points of water loss, and water-productivity indicators across sectors; knowledge of pollution and its consequences, including recognition of pollution sources such as agricultural and industrial wastewater and their environmental effects; knowledge of the impacts of water on ecosystems and health, including understanding the interrelationships between water quantity and quality, soil health, biodiversity, and food security; and knowledge of conservation and recycling solutions, including familiarity with technologies and methods for saving water, modifying cropping patterns, and recovering water.

Embedding these knowledge dimensions within decision-making, resource allocation, and organizational learning processes provides an analytical basis for what the present study terms organizational water literacy. The importance of institutional knowledge creation and organizational learning in water management has long been emphasized in the water-management literature (Al-Jayyousi, 2004). Accordingly, the present study focuses on this knowledge framework to identify and analyze its dimensions within the institutional structure of the Agricultural Jihad Organization of Qarchak County. Given the vital application of the knowledge dimensions of water literacy in agricultural water-management institutions such as the Agricultural Jihad Organization, this study concentrates on analyzing these dimensions. Within the cognitive domain, water literacy includes declarative knowledge ("knowing what") and procedural knowledge ("knowing how"), together with the ability to apply such knowledge in water-related practices and decisions (Mostacedo-Marasovic et al., 2022).

The literature emphasizes that the knowledge dimension underpins effective attitudes and behaviors in sustainable water governance. Given the central role of institutions such as the Agricultural Jihad Organization in water resource management, enhancing organizational water literacy by strengthening its knowledge dimensions is a strategic necessity. On this basis, the present study identifies and analyzes the knowledge dimensions of water literacy within the institutional structure of the Agricultural Jihad

Organization of Qarchak County.

A critical review of the literature shows that attention to water literacy, particularly its knowledge and organizational dimensions, in agriculture has increased in recent years.

At the domestic level, studies by Amotaghi and Faeghi (2024, 2025) have examined managerial and behavioral dimensions of water literacy in the agricultural sector of Qarchak County. The present study's emphasis on the institutional complexities of water governance, knowledge gaps and conflicts among laws is consistent with the study by Yadegari et al. (2018) in the Zayandeh-Rud Basin. The principal difference is that the present study traces these discontinuities at the micro level of a local executive institution (the county Agricultural Jihad Organization) under the concept of "institutional water literacy." This convergence highlights the central role of the institutional dimension in the water crisis, such that strengthening institutions' analytical and knowledge capacities is necessary for the success of technical solutions. Afsari et al. (2018) and Behboudi and Ghorbani (2023) likewise underscore institutional and governance dimensions of water management, although they do not directly address organizational water literacy. At the individual level, studies such as Biniyaz (2025) and Bakhtiari Hamadani (2020) identify increased knowledge among water users as a factor in sustainable development, but transferring such knowledge to the institutional level requires more effective mechanisms. Jafari (2019) emphasizes the importance of expert training, while Amjadian (2022) highlights the role of the media in increasing water awareness.

At the international level, Dean et al. (2016) demonstrate a relationship between water knowledge and water-related behaviors and policy support; Blomquist et al. (2005) show the importance of institutional arrangements and stakeholder participation in river-basin governance; and recent studies highlight the roles of knowledge co-production and knowledge infrastructures in collective action and adaptive water governance (Seiferth et al., 2024; Deslatte et al., 2024). Mostacedo-Marasovic et al. (2022) also show that affective, social, and emotional dimensions are less strongly represented than cognitive dimensions in water-related educational standards.

Despite references in some domestic studies to narrower dimensions such as water economics or expert training, a comprehensive account of water literacy at the level of decision-making institutions remains largely absent. At the global level, too, comprehensive approaches linking organizational knowledge to the executive and cultural structures of institutions have received limited attention, despite the emphasis placed on the influence of knowledge on conservation behaviors. Accordingly, by qualitatively focusing on the knowledge dimension of water literacy in the Agricultural Jihad Organization of Qarchak County, the present study addresses this conceptual and practical gap and seeks to contribute to stronger knowledge capacity, informed decision-making, and sustainable water resource management at the institutional level.

Research Methodology

Given the aim of the present study to identify the knowledge components of "water literacy" from the perspective of stakeholders, the research was designed using a qualitative approach and thematic analysis. This method enables an in-depth examination of the data and the extraction of conceptual patterns embedded in participants' language (Iman & Noshadi, 2011; Mohammadpour, 2013). Accordingly, the data-analysis process was based on a three-stage model of thematic analysis in which data were organized at three levels of abstraction: initial coding, organization into categories, and the formation of global (theoretical) themes (Attride-Stirling, 2001).

The target population consisted of stakeholders and key informants involved in water resource management in the agricultural sector of Qarchak County, including a broad range of water and soil experts, officials from the Agricultural Jihad Organization and water-resource agencies, advisors to farmers' associations, and experts from operating companies. Sampling was purposive and based on expertise, practical experience, and decision-making roles. The final sample size was determined according to the principle of theoretical saturation; that is, sampling continued until no new information concerning relationships among the categories emerged and data saturation was reached (Nascimento et al., 2018).

The primary data-collection instrument consisted of semi-structured, face-to-face interviews designed to explore the concept of "institutional water literacy" in depth and from multiple dimensions. Analysis began with the first interview and involved three interconnected stages: first, line-by-line coding of the data; second, organization of the codes into related categories; and finally, conceptual inference to develop the study's key themes (Saldaña, 2016). This iterative and gradual process enabled the identification of latent patterns in the rich interview data.

To ensure the quality and trustworthiness of the findings, Lincoln and Guba's (1985) four-criterion framework was applied. Credibility was strengthened through triangulation involving different participant groups, the return of interview summaries to participants for review and final confirmation, and the use of direct quotations to represent their voices accurately. Transferability was supported through rich, contextualized descriptions of the research setting and participant characteristics. Dependability was assessed through detailed documentation of all stages of the study and examination of agreement between two coders (including an independent coder) (Iman & Noshadi, 2011). Finally, confirmability was ensured by documenting decisions in the research log and using scientific peer review.

Research Findings

1. Demographic Characteristics of the Participants

The study involved 17 stakeholders and key informants associated with water resource management in the agricultural sector of Qarchak County. The sample consisted of 10 men and 7 women. Participants ranged in age from 26 to 66 years, and their mean length of service was 10 years; the shortest period of service was 2 years (Interviewee 5), and the longest was 25 years (Interviewee 15). In terms of educational attainment, participants ranged from a high-school diploma (Cases 1 and 15) to a doctoral degree (Case 6). Most participants held bachelor's degrees (7 participants) or master's degrees (7 participants). Regarding area and level of responsibility, of the 17 participants, 11 worked in executive roles and 6 held managerial responsibilities. It should be noted that some participants served in both executive and managerial capacities (e.g., Cases 3, 4, 7, and 10), whereas others were active in only one area (either executive or managerial). For example, the only participant with a doctoral degree (Case 6) held a managerial position and had no executive role.

The findings from the 17 interviews comprise the basic, organizing, and global coding of the knowledge dimension of institutional water literacy. Of the 210 initial codes extracted, 45 basic themes, 12 organizing themes, and 4 global themes remained after refinement. This analytical structure confirms the richness of the data and provides a comprehensive representation of the dimensions under examination. (Details of these findings are presented in Tables 2–10.)

1. Scientific Understanding of the Natural and Environmental Systems of Water Resources and Related Risks

Table 1. Qualitative Analysis of Scientific and Environmental Knowledge of Water Resources and Related Natural Systems

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 11: “As an expert, I have repeatedly observed that many of our colleagues still lack a precise understanding of the stages of the hydrological cycle. However, understanding evaporation, infiltration, and precipitation is essential for providing agricultural recommendations.”	Familiarity with the hydrological cycle (evaporation, precipitation, infiltration, etc.)	Foundational knowledge of the water cycle, water resources, and renewability	Knowledge of the natural and environmental system of water resources and related risks

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 7: “Many frontline staff still do not clearly distinguish between surface water resources such as rivers and groundwater sources such as wells, although each requires distinct policies and management approaches.” Code 4: “In regional planning, our experts must understand that heavy reliance on groundwater imposes additional pressure on aquifers.”	Understanding surface and groundwater resources	Foundational knowledge of the water cycle, water resources, and renewability	Knowledge of the natural and environmental system of water resources and related risks
Code 15: “Some colleagues still do not fully understand the difference between groundwater recharge and over-extraction; this indicates the need for stronger emphasis in training programs.” Code 6: “Non-renewable water resources, particularly in critical plains such as Varamin, are assets needed by future generations. However, this perspective has not yet been institutionalized within our expert system and requires further training.”	Recognizing the distinction between renewable and non-renewable water resources	Foundational knowledge of the water cycle, water resources, and renewability	Knowledge of the natural and environmental system of water resources and related risks
Code 10: “Water resources in Qarchak change from year to year; one year rainfall is high, another year is critical. An expert who does not understand this dynamic cannot properly guide farmers.” Code 8: “For water-oriented land-use planning, we must acknowledge that water resources are not static. Training experts about this dynamism should be a priority.”	Awareness of the natural dynamics and variability of water resources	Foundational knowledge of the water cycle, water resources, and renewability	Knowledge of the natural and environmental system of water resources and related risks
Code 1: “When we export water-intensive crops, we are effectively exporting the country’s water. Therefore, it is important to understand the concept of virtual water.” Code 2: “If experts lack proper understanding of water trade, policy decisions regarding cropping patterns and exports will focus solely on economic profit rather than national water resources.”	Familiarity with the concept of virtual water and water trade	Environmental knowledge related to water	Knowledge of the natural and environmental system of water resources and related risks
Code 9: “We must know how much water each kilogram of product consumes and be able to explain it to farmers. This awareness is essential for decision-making.”	Understanding the concept of the water footprint of products	Environmental knowledge related to water	Knowledge of the natural and environmental system of water resources and related risks

2. Environmental Knowledge of Water Resources and the Consequences of Water Crises

Table 2. Qualitative Analysis of Environmental Knowledge of Water Resources and the Consequences of Water Crises

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 4: "Farmers often use traditional irrigation methods such as 'water rotation', which are in fact more efficient than some modern systems; however, experts are not familiar with this indigenous knowledge." Code 8: "In our region, some qanats are still active. If these local experiences are not documented and transmitted, a significant part of local water literacy will be lost."	Recognition of indigenous knowledge and traditional irrigation practices	Environmental knowledge related to water	Knowledge of the natural and environmental system of water resources and related risks
Code 12: "The climate of Qarchak has changed considerably; rainfall has become irregular and evaporation has increased. If experts do not recognize these changes, their recommendations will not be accurate."	Understanding climate change and its impacts	Environmental knowledge related to water	Knowledge of the natural and environmental system of water resources and related risks
Code 2: "We must know which areas are red zones in terms of water resources. In places like Qarchak or Varamin, many wells are no longer even eligible for license renewal."	Recognition of critical zones and their impacts on water resources	Consequence-oriented knowledge of water crises	Socio-environmental consequences of water crises
Code 4: "When rainfall declines, the first outcomes are reduced cultivation and unemployment. Some households even struggle to secure their livelihoods, which we must take into account."	Recognition of the impacts and consequences of water scarcity and drought	Consequence-oriented knowledge of water crises	Socio-environmental consequences of water crises
Code 6: "We need an accurate analysis of groundwater table decline, as it has led to reduced productivity and even soil salinization."	Awareness of the consequences of groundwater table decline	Consequence-oriented knowledge of water crises	Socio-environmental consequences of water crises
Code 7: "As wells become deeper, the land becomes hollow and begins to subside. Land cracks around Qarchak are visible to the naked eye; this is not merely a geological issue, it is water-related."	Understanding the relationship between land subsidence and groundwater depletion	Consequence-oriented knowledge of water crises	Socio-environmental consequences of water crises
Code 17: "When disputes arise among farmers over water allocation, it signals social tension. As the Agricultural Jihad Organization, we must intervene early to manage the situation."	Awareness of the socio-security consequences of water crises (migration, social tensions)	Consequence-oriented knowledge of water crises	Socio-environmental consequences of water crises

3. Knowledge of Water Resource Policy, Law, and Regulations

Table 3. Qualitative Analysis of Knowledge of Water Resource Policy, Legal Frameworks, and Regulations

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 6: "In many training courses, agricultural water regulations are not explained at all, whereas they should constitute fundamental knowledge for experts."	Familiarity with water-use directives and regulatory guidelines	Legal and policy knowledge of water resources	Knowledge of water resource policy-making, legal frameworks, and regulations

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 4: “We must be familiar with consumption standards based on crop type and region, since monitoring water-use efficiency is grounded in these standards.”	Mastery of agricultural water consumption standards and regulations	Legal and policy knowledge of water resources	Knowledge of water resource policy-making, legal frameworks, and regulations
Code 1: “The National Water Document contains extensive provisions, yet little is visible at the implementation level because experts are unfamiliar with its content.” Code 13: “Often, macro-level policies exist, but we do not clearly understand what is expected from us; for example, what exactly is the role of the Agricultural Jihad Organization in land-use planning?”	Understanding macro-level water policies (e.g., the National Water Document)	Legal and policy knowledge of water resources	Knowledge of water resource policy-making, legal frameworks, and regulations
Code 2: “We ourselves must be aware of the Agricultural Jihad Organization’s water-saving initiatives before we can educate farmers.”	Awareness of Agricultural Jihad Organization programs related to water-use efficiency	Legal and policy knowledge of water resources	Knowledge of water resource policy-making, legal frameworks, and regulations

4. Technical Knowledge for Efficient Water Use and Conservation of Water Resources

Table 4. Qualitative Analysis of Technical Knowledge for Efficient Water Use and Conservation of Water Resources

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 15: “I installed a drip irrigation system, yet for some colleagues the difference between this system and similar ones such as tape irrigation or subsurface irrigation is still not entirely clear; this indicates the need to reassess technical extension knowledge.”	Technical knowledge of modern irrigation methods (drip, sprinkler, subsurface)	Technical knowledge in water-use management	Technical knowledge for optimal water use and conservation of water resources
Code 8: “Water recycling in rural areas can be vital, yet many staff members do not know how to implement it.”	Familiarity with water recycling and reuse practices	Technical knowledge in water-use management	Technical knowledge for optimal water use and conservation of water resources
Code 14: “We introduced soil amendments, which reduced water consumption; however, experts must know which type of soil requires which amendment.”	Awareness of soil improvement methods for reducing water consumption	Technical knowledge in water-use management	Technical knowledge for optimal water use and conservation of water resources

5. Knowledge of Water Productivity Assessment

Table 5. Qualitative Analysis of Water Productivity Assessment Knowledge

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 13: “There are now drought-tolerant seeds, but since we haven’t been trained, colleagues recommend them less often.”	Understanding the role of drought-tolerant species in reducing water stress	Technical knowledge in water-use management	Technical knowledge for efficient water use and conservation of water resources

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 4: "Technologies like pressure-regulating valves and low-flow nozzles are available, but their application is not yet common among experts, and adequate training hasn't been provided."	Familiarity with water-saving technologies in agriculture	Technical knowledge in water-use management	Technical knowledge for efficient water use and conservation of water resources
Code 1: "If local treatment is taught, many livestock farmers can manage it; but they lack the technical training."	Familiarity with water recycling and local treatment technologies	Technical knowledge in water-use management	Technical knowledge for efficient water use and conservation of water resources
Code 12: "We still have colleagues unfamiliar with subsurface methods, let alone accurately calculating the flow rate (discharge) for them." Code 14: "Mastery of irrigation methods means knowing when, at what pressure and flow rate to irrigate."	Mastery of modern irrigation methods (drip, subsurface, etc.)	Technical knowledge in water-use management	Technical knowledge for efficient water use and conservation of water resources
Code 2: "Sometimes irrigation is fine, but the soil is saline or the plant is sensitive; the integration of these factors in training is lacking."	Familiarity with Integrated Water-Soil-Plant Management	Technical knowledge in water-use management	Technical knowledge for efficient water use and conservation of water resources
Code 4: "In our region, rice cultivation is no longer logical, but the indigenous cropping pattern hasn't been reformed because the experts' knowledge is insufficient."	Knowledge of cropping patterns appropriate for the climate and water resources	Technical knowledge in water-use management	Technical knowledge for efficient water use and conservation of water resources
Code 6: "These improved cultivars must first be experienced by the experts themselves before they can promote them."	Understanding the role of drought-tolerant species in cultivation	Technical knowledge in water-use management	Technical knowledge for efficient water use and conservation of water resources
Code 9: "Water productivity index doesn't just mean using less water. You need to know exactly how much water you used and exactly how much product you got in return. Many of our colleagues still don't know this simple ratio numerically."	Knowledge of water productivity indicators	Water productivity assessment knowledge	Knowledge of productivity analysis and water-use measurement
Code 6: "Water productivity isn't just about consuming less; we need to know how much product each cubic meter of water yields. These indicators are still ambiguous for many experts."	Knowledge of water productivity indicators in agriculture	Water productivity assessment knowledge	Knowledge of productivity analysis and water-use measurement
Code 6: "Many beneficiaries don't know they can examine water consumption and production relatively; experts need to learn this so they can teach it."	Ability to analyze water resource consumption and performance data	Water productivity assessment knowledge	Knowledge of productivity analysis and water-use measurement

6. Data-Driven Knowledge and Information Technology in Water Management and Agriculture-Food Security Linkages

Table 6. Qualitative Analysis of Knowledge Dimensions (Data-Driven, Systemic, and Extension-Oriented) in Water Management

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 1: "We have software that can show real-time data on well discharge or groundwater level, but personnel need to learn how to use it."	Familiarity with water resource monitoring and analysis software	Data-driven and analytical knowledge using information technology in water management	Data-driven and analytical knowledge using information technology in water management
Code 4: "Many experts just print maps, but they still don't know how to analyze spatial layers."	Mastery of GIS and spatial systems in resource management	Data-driven and analytical knowledge using information technology in water management	Data-driven and analytical knowledge using information technology in water management
Code 13: "We developed a Rainfall-Runoff model that showed when to plant to require less irrigation, but only one person in the office knows how to work with it."	Familiarity with rainfall and consumption forecasting models (hydrological)	Data-driven and analytical knowledge using information technology in water management	Data-driven and analytical knowledge using information technology in water management
Code 2: "Right now, we don't know exactly how much water is withdrawn from each farm because we lack an assessment model or don't know how to implement it."	Mastery of water resource assessment concepts at farm and regional scales	Data-driven and analytical knowledge using information technology in water management	Data-driven and analytical knowledge using information technology in water management
Code 2: "In our region, when water scarcity increased significantly, wheat production dropped sharply, which means the people's food security is directly dependent on water management."	Understanding the link between food security and the water crisis	Interdisciplinary knowledge of the water-food nexus	Systematic knowledge of the water-agriculture-food security nexus
Code 16: "If I know how to use water correctly but cannot communicate it to the farmer in simple language, it is useless. Transfer is a skill, not just knowledge."	Skill in transferring water knowledge to water users	Communication and extension knowledge in the water sector	Communication and extension knowledge in water resource management
Code 1: "Some colleagues only inform via SMS or brochures, whereas nothing is transferred unless you go to the field and talk face-to-face with the farmer."	Knowledge of effective communication patterns	Communication and extension knowledge in the water sector	Communication and extension knowledge in water resource management
Code 5: "Much of what we learn is from the experiences of the elders; this is intergenerational knowledge that should not be lost, but nowadays few people transfer these experiences."	Tacit knowledge and intergenerational knowledge transfer	Communication and extension knowledge in the water sector	Communication and extension knowledge in water resource management
Code 7: "There are many educational videos about water scarcity on social media, but some are not scientific, and some experts don't know how to use these resources properly."	Water-related media literacy	Communication and extension knowledge in the water sector	Communication and extension knowledge in water resource management

7. Legal and Economic Knowledge in Water Resource Management

Table 7. Qualitative Analysis of Data-Driven Knowledge and Information Technology Tools in Water Management, and Legal and Economic Knowledge in Water Resource Management

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 5: “A few people in Jihad know how to work with GIS, but most of it is for land mapping, not for analyzing water consumption or determining high risk areas.” Code 6: “If we can show with GIS where water is lost or overused, we can make much better decisions.”	Knowledge of the use of Geographic Information Systems (GIS) in water management	Knowledge of functional assessment and monitoring of water resources	Data-driven and analytical knowledge in water resource management
Code 8: “Monitoring means knowing if efficiency truly increased after implementing drip irrigation or not; currently, this is only assessed based on personal feeling.”	Functional assessment and monitoring of resources	Knowledge of functional assessment and monitoring of water resources	Data-driven and analytical knowledge in water resource management
Code 9: “There are software tools for productivity assessment, but we still work very manually; for example, Excel is the limit!” Code 10: “If experts knew how to work with software like AquaCrop, they could advise farmers more accurately.”	Familiarity with water productivity assessment software and tools	Knowledge of functional assessment and monitoring of water resources	Data-driven and analytical knowledge in water resource management
Code 8: “In some areas, they get twice the product with the same amount of water. This means we must learn to compare data from different regions.”	Ability to compare data across time and space for productivity analysis	Knowledge of functional assessment and monitoring of water resources	Data-driven and analytical knowledge in water resource management
Code 2: “In local water committee meetings, instead of formal laws, they often use religious criteria like time priority, which they call Ab-Avval (Water-First).”	Knowledge of customary and religious water rights	Legal knowledge of water rights and resource ownership	Knowledge of formal and customary water rights in ownership and water disputes
Code 4: “We are mostly dealing with conflicts between agricultural well owners who over-extract and harm others; the solution is mostly local understanding and compromise rather than judicial action.”	Water disputes and methods of conflict resolution	Legal knowledge of water rights and resource ownership	Knowledge of formal and customary water rights in ownership and water disputes
Code 6: “When water shares are not precisely documented, conflict arises. These shares must be documented, otherwise everyone claims, ‘My share is bigger’.”	Water entitlement system (haghabeh)	Legal knowledge of water rights and resource ownership	Knowledge of formal and customary water rights in ownership and water disputes
Code 2: “We in Jihad have tried to show that every liter of water must lead to a specific economic return, not just crop yield.”	Economic understanding of water consumption	Water economics knowledge	Economic knowledge of water use and resource valuation
Code 3: “When the price of water is zero, there is no incentive to save. But in areas where water is sold volumetrically and with a tariff, farmers pay closer attention.” Code 4: “Water pricing is a sensitive issue because farmers usually resist, but if it is accompanied by training, it is acceptable.”	Water pricing	Water economics knowledge	Economic knowledge of water use and resource valuation

8. Strategic, Foresight, and Contextual Knowledge in Water Resources

Table 8. Qualitative Analysis of Economic Knowledge in Water Resource Management and Strategic, Foresight, and Contextual Knowledge in Water Resources

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 10: “The difference between someone producing vegetables with one cubic meter of water and someone planting wheat is huge, but we don’t consider the added value in water planning.”	Knowledge of value added and water pricing in agriculture	Water economics knowledge	Economic knowledge of water use and resource valuation
Code 12: “If you tell a farmer they will receive a reward or discount for saving, they cooperate better than just telling them to ‘consume less’.”	Economic incentives for conservation	Water economics knowledge	Economic knowledge of water use and resource valuation
Code 10: “Economic cropping pattern means both preserving resources and increasing profit. Experts must master this to provide accurate advice to farmers.”	Familiarity with economic cropping patterns	Water economics knowledge	Economic knowledge of water use and resource valuation
Code 12: “We had an emergency plan for rotational irrigation shutdown, but many beneficiaries weren’t even aware; crisis management must be participatory, not just administrative.”	Awareness of water crisis management	Knowledge of crisis, risk, and resilience in water resource management	Strategic, foresight, and contextual knowledge in water resource management
Code 4: “Resilience is not only technical, it is also cultural; some people are unwilling to change patterns because the land is ancestral, even if there is no water.”	Understanding farmer resilience	Knowledge of crisis, risk, and resilience in water resource management	Strategic, foresight, and contextual knowledge in water resource management
Code 15: “We usually start looking for solutions only when drought hits; whereas we should teach adaptation methods beforehand, such as using mulch or resistant cropping patterns.” Code 9: “Some farmers said that if we knew it would be a dry year by Esfand (late February/early March), they would plan differently; thus, predictability is very important.”	Predictability, preparedness, and knowledge of drought adaptation strategies	Knowledge of crisis, risk, and resilience in water resource management	Strategic, foresight, and contextual knowledge in water resource management
Code 3: “We need to analyze different consumption and rainfall scenarios, but this type of foresight has not yet been established in Jihad.”	Risk analysis, foresight, and scenario analysis	Knowledge of crisis, risk, and resilience in water resource management	Strategic, foresight, and contextual knowledge in water resource management
Code 7: “If our region’s climate changes from semi-arid to permanently arid, all water plans must change; but this awareness is not yet widespread.”	Awareness of climate-related hazards	Knowledge of crisis, risk, and resilience in water resource management	Strategic, foresight, and contextual knowledge in water resource management
Code 3: “In some plains, like northern Qarchak, we have little surface water, but the groundwater is fuller; this must be determined with hydrogeological data, not guesswork.” Code 12: “Some areas drilled wells without precise investigation and are now experiencing land subsidence; if groundwater location mapping had been done beforehand, this problem would not have occurred.”	Hydrogeological site identification	Knowledge of crisis, risk, and resilience in water resource management	Strategic, foresight, and contextual knowledge in water resource management

9. Participatory, Intersectoral, and Socio-Interactive Knowledge in Water Resource Governance

Table 9. Qualitative Analysis of Participatory, Intersectoral, and Socio-Interactive Knowledge in Water Resource Governance

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 16: "Sometimes the region's water is allocated to the city or industries without farmers being informed; this means sectoral governance, not inter-sectoral."	Agriculture-urban-industry interactions	Intersectoral and context-oriented knowledge in water governance	Participatory, intersectoral, and socio-interactive knowledge in water resource governance
Code 14: "I was in a meeting where the Regional Water Authority and Jihad had their own opinions; if institutions are not synergistic, plans will not be implemented."	Understanding institutional synergy among relevant bodies	Intersectoral and context-oriented knowledge in water governance	Participatory, intersectoral, and socio-interactive knowledge in water resource governance
Code 15: "In some villages of Qarchak, there are still Water Councils where people set the rotation schedule themselves; these are examples of successful local governance that must be strengthened." Code 8: "If governance is only top-down, people will not cooperate; but when the residents themselves have a role in water decisions, management improves."	Models of local water governance	Indigenous and local knowledge of water resource governance	Participatory, intersectoral, and socio-interactive knowledge in water resource governance
Code 14: "When you consider people partners in water planning from the start, they stick with the work. But if you only invite them for implementation, they feel their opinion is not important." Code 2: "To gain participation, you shouldn't just hold meetings. You must show them that their participation truly influences water decisions."	Familiarity with methods for fostering participation	Participatory governance knowledge	Participatory, intersectoral, and socio-interactive knowledge in water resource governance
Code 8: "Many farmers are dissatisfied with the way water is divided; some say their share has decreased because their voice doesn't reach the officials." Code 11: "Dissatisfaction increases when there is no transparency. For example, they don't know why some take more water; this mistrust reduces participation."	Understanding grievances	Participatory governance knowledge	Participatory, intersectoral, and socio-interactive knowledge in water resource governance
Code 2: "Participation requires a facilitator; if there is no one to connect people and the government, interaction will not form." Code 13: "Managing participation means knowing the groups: elders, women, youth; each has a different role and must be given space."	Social management of participation	Participatory governance knowledge	Participatory, intersectoral, and socio-interactive knowledge in water resource governance

Sample Quotation	Basic Code	Organizing Code	Global Theme
Code 9: “Conflict over water is not uncommon in the villages, but if there is a customary dispute resolution system, they refer less to formal institutions.”	Customary knowledge and conflict dynamics	Participatory governance knowledge	Participatory, intersectoral, and socio-interactive knowledge in water resource governance
Code 3: “We have local councils in a few villages in Qarchak, but they must be trained and supported for their function to become serious.”	Familiarity with participatory water-management methods and local water councils	Participatory governance knowledge	Participatory, intersectoral, and socio-interactive knowledge in water resource governance

Based on the study findings and the analyses presented in the Discussion section, the thematic network of the knowledge components of institutional water literacy is presented in Figure 1. This network reflects the complexity and multidimensionality of water literacy at the institutional level:

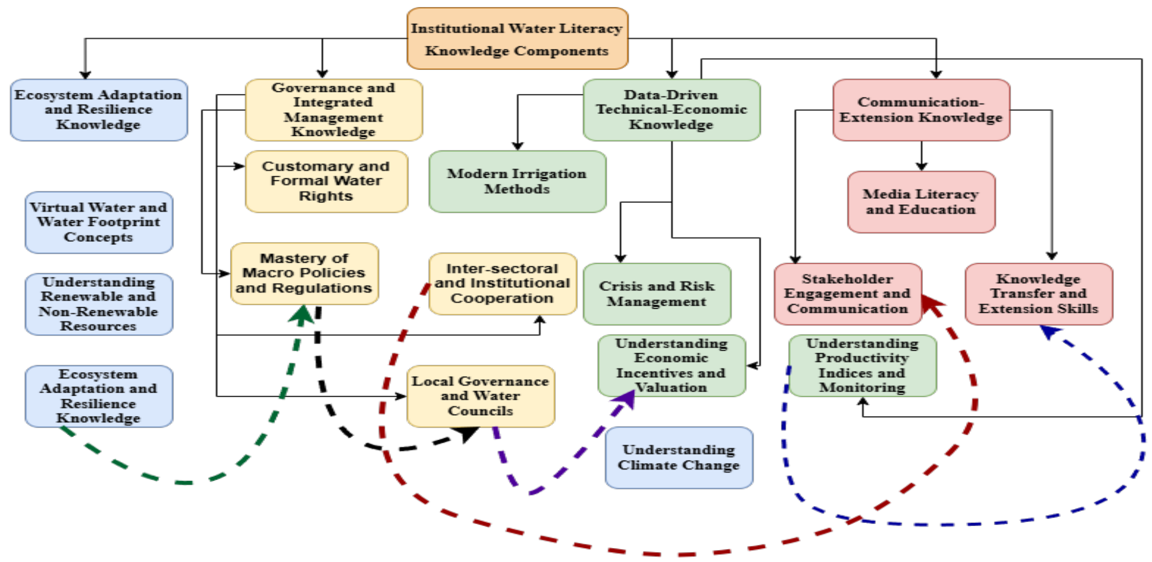

Figure 1. Thematic Network of the Knowledge Components of Institutional Water Literacy in the Agricultural Sector of Qarchak County

Based on the qualitative analysis and using the thematic-network framework of Attride-Stirling (2001), Figure 1 maps the thematic network and presents institutional water literacy as a hierarchical and dynamic system comprising four overarching domains: "ecosystem adaptation knowledge," "integrated governance," "technical-economic knowledge," and "communication-extension knowledge." Through their dialectical interaction, these domains shape institutional capacity for sustainable water management. The diagram illustrates the interactive relationships among these dimensions, including the direct influence of "understanding climate change" on "macro-level policies" and the mediating role of "economic incentives" in translating policy into action. It thereby emphasizes the integrated and systemic nature of institutional water literacy, encompassing the 12 identified dimensions, and can serve as a roadmap for institutional capacity development in water governance.

Conclusion

The findings of this study show that the knowledge dimension of institutional water literacy in the Agricultural Jihad Organization of Qarchak extends beyond purely technical knowledge and constitutes a multidimensional and strategically significant body of institutional knowledge. As explained in the theoretical framework and literature review, concepts related to institutional awareness and governance were manifested empirically in this study through 12 key categories. In alignment with multidimensional water-literacy frameworks (McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022, 2023), the findings simultaneously complement and extend domestic studies (Amotaghi & Faeghi, 2024, 2025; Afsari et al., 2018; Behboudi & Ghorbani, 2023) and international research, conceptualizing water literacy in the Qarchak organization not merely as an informational asset but as a complex and strategic capability that requires a redefinition of the institution's role in water governance. Consistent with Yadegari et al. (2018), the study addresses the breadth of institutional knowledge and the role of emerging technologies, participatory knowledge, and interorganizational governance. These dimensions, extending from ecological and social knowledge to technical, legal, and data-driven knowledge, indicate that water literacy at the institutional level is an "integrated capability" that requires redefining the organization from an isolated unit into a "facilitator and network builder" in water governance.

In-depth analysis of the data revealed three fundamental transitions in water resource management within this organization, each representing a shift from traditional paradigms toward newer approaches:

1. Transition from Stand-Alone Technical Knowledge to Integrated and Socially Oriented Governance

The identification of "participatory knowledge," "legal knowledge (formal and customary)," and "communication-extension knowledge" indicates that successful water management depends on moving beyond a purely engineering approach. This finding is consistent with previous emphasis (Afsari et al., 2018; Behboudi & Ghorbani, 2023) on the need for stakeholder participation, while adding a new insight: "customary legal knowledge" and the capacity to manage conflicts underpin local legitimacy and the institution's mediating role. In other words, institutional water literacy is incomplete without an understanding of social networks and local rights; in this respect, the present study extends findings related to participatory governance.

2. Transition from Reactive Crisis Management to Strategic and Systemic Resilience

The dimensions of "knowledge of natural and environmental systems," "socio-environmental consequences," "economic knowledge," and "foresight knowledge" shape institutional resilience in the face of water crises. Integrating forms of knowledge such as the "water footprint" with "cost-benefit analysis" moves the organization beyond fragmented analyses and enables financial incentives to be targeted on the basis of productivity. This integration is consistent with multidimensional water-literacy frameworks (McCarroll & Hamann, 2020; Mostacedo-Marasovic et al., 2022, 2023) and supports evidence-based adaptation under conditions of climate uncertainty (Boon, 2024; Deslatte et al., 2024). By emphasizing the need to strengthen human and cultural dimensions alongside technical and economic ones, this study responds in practical terms to the finding by Mostacedo-Marasovic et al. (2022) that affective, social, and emotional dimensions are less strongly represented than cognitive dimensions in water-related standards.

3. Transition from Experience-Based Practice to Data-Driven and Intelligent Decision-Making

The "data-driven and information technology knowledge" dimension, together with "knowledge of optimizing water use," indicates a paradigm shift from reliance on intuition and past experience toward decision-making based on objective evidence. In this paradigm, conventional technical knowledge (such as modern irrigation) is combined with data-based monitoring and analytical capabilities (GIS and forecasting models), reflecting managerial maturity. This finding is consistent with recent work emphasizing the integration of domain knowledge, data, and knowledge infrastructures in water modelling and governance (Duan et al., 2024; Deslatte et al., 2024) and shows that the present study's innovation lies in emphasizing this dimension as an inseparable component of institutional water literacy at the local and context-specific level.

Policy Implications and Final Conclusion

Based on the three transitions described above and the dynamic interaction among the 12 identified dimensions, this study outlines a roadmap for institutionalizing institutional water literacy. Its implications can be interpreted at three levels:

Macro level: A "Strategic Document for Enhancing Institutional Water Literacy" should be developed for provincial agricultural organizations, centered on network governance, strategic resilience, and digital transformation, so that capacity-building programs can be designed in an integrated manner.

Organizational level (Agricultural Jihad Organization of Qarchak): Operationalizing the findings at this level requires establishing a "Water Data Monitoring and Analysis Unit" and institutionalizing a "Water Governance Committee with Local Stakeholder Participation" within the organizational structure.

Research level: This framework provides a basis for quantitatively measuring the dimensions, examining the relationship between institutional water literacy and performance indicators (such as reduced conflict or increased productivity), and extending the framework to other regions.

Finally, unlike studies that focus solely on educating water users at the micro level (Bakhtiari Hamadani, 2020; Biniyaz, 2025), the conclusion of the present study is macro-level: without strategic investment in "institutional literacy" as a driver of change and a basis for redefining governance structures, the goals of sustainable agriculture and regional water security cannot be realized. The study indicates that institutional water literacy can provide an important enabling condition for the transition from traditional to modern and sustainable water resource management in the twenty-first century.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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