Water Security Assessment in Central Asia: connecting conceptual frameworks and policy perspectives

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Abstract

Water Security Assessment in Central Asia:

Connecting conceptual frameworks and policy perspectives in Central Asia

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Water security has been widely discussed as one of the security risks because of global warming, population growth, intense industrialization, growing water scarcity, and rapid urbanization. Water security was always crucial for Central Asia countries sharing one of the complex transboundary river basins because of the uneven distribution of surface water resources and interconnected water infrastructure. Water security challenges escalated after the dissolution of the USSR because of regional fragmentation causing disputes on water allocation in transboundary rivers of the Aral Sea basin.

This thesis contributes to understanding how water security is perceived in Central Asia, what water security priorities for each Central Asia country are suggested by scholars and practitioners, and whether river basin management can strengthen water security in Kazakhstan. The exploratory mixed research design integrated qualitative and quantitative data collection and analysis and consisted of four phases: the bibliometric analysis and the content analysis of scholarly literature, the Delphi survey among regional and international experts to explore water security priorities in each Central Asia country, multinomial logistic regression to reveal behavioral patterns in setting water security priorities, and interviews of stakeholders using the DPSIR framework to investigate river basin management in Kazakhstan.

A comparison of academic debate and experts' practical-technical knowledge revealed the difference in water security interpretation for Central Asia and Afghanistan. Scholars highlighted

the environmental dimension of water security because of the mismanagement of water resources, the potential impact of climate change on water resources, and complex environmental change in vulnerable arid and semiarid areas. Practitioners emphasized the high relevance of the economic dimension and urban & household dimension of water security in the region by reflecting on current water challenges and needs in investing in infrastructure reconstruction for agricultural productivity enhancement, hydropower production, and urban water systems. The contradiction in ranking water security aspects among scholars and practitioners showed differences in cultural preferences, including water risks perceptions in prioritizing and managing water challenges. The case of Kazakhstan demonstrated an example of how ecological (local) knowledge and stakeholder engagement can help coordinate and resolve water disputes at the river basin level, which can be a path to adapt to climate changes and build resilience at the local level. River basin management and planning can be an operational tool to ensure water security by contributing to a sustainable balance between the social, economic, and environmental needs for water and promoting trust and cooperation among stakeholders in the basin.

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Abbreviations

ADB	Asian Development Bank
AWDO	Asian Water Development Outlook
BA	Balkhash-Alakol
DPSIR	Driver-Pressures-State-Impact-Response framework
GDP	Gross Domestic Product
GWS	Global Water Security Index
IWRM	Integrated Water Resources Management
ML	Maximum Likelihood
MNL	Multinomial Logistic Regression
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
RBI	River Basin Inspectorate
RBO	River Basin Organization
RCB	River Basin Council
SDG	Sustainable Development Goal
USSR	Union of Soviet Socialist Republics
WEF	Water-Energy-Food

Chapter 1

Introduction

1 INTRODUCTION

This thesis reconceptualized water security and discussed conceptualization challenges, operationalization gaps, and context specificity of achieving water security. The concept of water security has gained increasing importance under the high uncertainties of the climate crisis and rising water demand. However, the concept is still in the stage of development. The water security concept originates from the securitization theory, built around military capabilities, power distribution, and resources. While the Copenhagen School presented alternative interpretations and emphasized the constructive nature of the security concept. Since then, academics and practitioners have scrutinized water security from different angles by highlighting the complex interconnected socio-economic-environmental systems and diverting from a fragmented understanding of water security in terms of only water availability. This thesis aims to understand how water security is perceived in Central Asia as a complex transboundary river basin case study. This thesis presents an exploratory and interdisciplinary study synthesizing heterogeneous knowledge, including the academic publications on water security in the region, pragmatic understanding of practitioners gained from the two rounds of the Delphi method, and local expertise about river basin management collected from stakeholders. This thesis demonstrated the complex nature of the water security concept and attempted to shift the focus from the conventional definition in terms of water availability causing disputes over water allocation and water management and water insecurity in Central Asia in the long term.

1.1 Background

Water security is fundamental for sustainable development, economic growth, and human well-being (GWP, 2000; IPCC, 2021; OECD, 2013; UN Security, 2007). Only 3% of the total water on Earth is freshwater, where two-thirds accounts for glaciers, about one-third in groundwater, and less than 1% in lakes and rivers. Water security has been widely discussed by policy and academic communities as one of the security risks because of global warming, growing water scarcity, competing freshwater demands, population growth, intense industrialization, and urbanization (AWDO, 2016, 2020; Grey & Sadoff, 2007; IPCC, 2021; UNEP-DHI and UNEP, 2016; Zeitoun et al., 2016). Countries across the globe are dealing with similar water challenges in terms of aging water infrastructures, water pollution, lack of funding, inadequate water governance mechanisms, and the impact of climate variability but on different scales (Allan, 2003; Octavianti, 2020; Thapliyal, 2011; WB, 2020). Moreover, water-related risks such as droughts, floods, unsafe drinking water, and environmental pollution spotlight further the importance of water security (AWDO, 2013, 2020; OECD, 2013; Risk and Resilience portal, 2021). The risks may also include social disruption, tensions, and migration within the country and between countries because of unmet water demands, water pollution, and ecosystem degradation (Mirumachi, 2013; Thapliyal, 2011; Tortajada & Fernandez, 2018). Water security is essential for developing and developed countries, even though they face different water-related risks.

The securitization concept was first met in international relations and was developed during the Cold War, maintaining an inherent military focus (Charrett, 2009; Stritzel, 2014; Thapliyal, 2011). Securitization theory states that national security policy does not appear independently; instead, it is carefully designed by policymaking dynamics. Security policies are formulated around 'dangerous,' 'threatening,' 'hazardous' issues (Stritzel, 2014). The traditional approach of dealing with the securitization issue is built around military capabilities, power distribution, and resources. The Copenhagen School presents an alternative approach to analyzing water security within international relations, which emphasizes non-military aspects of security (Charrett, 2009; Octavianti, 2020; Stritzel, 2014; Thapliyal, 2011). Scholars are studying securitization attempt to understand the nature, reasons, and conditions of security issues. The Copenhagen School broadens security agenda and links with economic, societal, and environmental sectors, including water (Grey & Sadoff, 2007; Thapliyal, 2011).

The water security concept was proposed in the 1990s but has been widely discussed by scholars, practitioners, and international organizations after the announcement of the UN Security Council in 2007 that water is one of the future potential security risks. Moreover, in 2000 the

Ministerial Declaration on water security in the XXI century was adopted at the World Water Forum by highlighting water security for advanced and developing countries (Gerlak et al., 2018; Xenarios et al., 2019). The term of water security has been discussed from different angles and perspectives. However, there is still no standard threshold when water refers to a security issue (Thapliyal, 2011). Water security is frequently interpreted as the physical availability of freshwater resources from the hydrological and geophysical perspectives. So often, the primary unit of analysis of water security is water availability per capita (Briscoe, 2009; Cook & Bakker, 2012; Gerlak et al., 2018; Octavianti & Staddon, 2021). Consequently, the focus of practitioners and policymakers narrows to water scarcity. In contrast, environmentalists and ecologists interpret water security in healthy and sustainable ecosystems, which are resilient to water-related hazards (Babel & Shinde, 2018; Grey & Sadoff, 2007; Thapliyal, 2011). Moreover, water security was studied from a political economy focusing on the politico-military point of view regarding safety and security issues beyond the water sector (Charrett, 2009; Scott et al., 2013; Thapliyal, 2011).

There is no universally used definition for the concept (Stucki & Sojamo 2012). The widespread interpretations of water security discussed in Chapter 2. As stated by the Global Water Partnership, water security implies several conditions as "*every person has access to enough safe water at an affordable cost to lead a clean, healthy, and productive life while ensuring that the environment is protected and enhanced*" (GWP, 2000, p. 12). The widely used definition is "*the availability of adequate quantity and quality of water for livelihoods, health, ecosystems, and production* (Grey & Sadoff, 2007, p. 548). The Asian Development Bank (hereafter ADB) highlights that "…*water security is more than just providing sufficient water for people and economic activities. It is also about having healthy aquatic ecosystems and protecting us against water-related disasters…*" (AWDO, 2016, p. xiv). Different interpretations of water security reveal the complexity and multidimensionality of the concept, including interdependency between geophysical and socioeconomic components.

Academic institutions and international organizations introduced various metrics, indicators, and indexes to assess water security (AWDO, 2013, 2016, 2020; Babel & Shinde, 2018; Gain et al., 2016; OECD, 2013). According to the Organization for Economic Co-operation and Development (hereafter OECD), achieving water security means identifying and managing water risks (OECD, 2013). The ADB introduced the national water security assessment framework consisting of five interdependent dimensions: household, urban, economic, environmental, and resilience to water-related disasters (AWDO, 2013, 2016, 2020). The metrics of global water security were suggested to achieve sustainable development goals (hereafter SDG) (Gain et al., 2016). The basin-scale water security framework was assessed considering water productivity, water availability, watershed health, water-related hazards, and water governance (Babel & Shinde, 2018). As a result, selecting indicators and variables in the water security indexes are based on various interests and angles (Octavianti & Staddon, 2021; Xenarios et al., 2019). Different metrics vary in scale (local or global assessments) and thematic focus. Still, indexes were criticized on three grounds: 1) for being biased on some aspects, 2) for not being adequately data-based or data-driven, or 3) for oversimplifying the complex water-society interrelations (Dickson et al., 2016; Gerlak et al., 2018; Octavianti & Staddon, 2021).

The frameworks on water security mentioned earlier reveal the complexity of the concept and acknowledge the need for a cross-disciplinary approach to properly operationalize such an elusive concept (Cook & Bakker, 2012; Grey & Sadoff, 2007; Tortajada & Fernandez, 2018). Worse, scholars and practitioners understood that inadequate metrics might derail policy interventions and problem solutions, as management guru Peter Drucker says, '*we cannot manage what we cannot measure'*. The variety of potential variables and methods is one of the main obstacles in operationalizing the concept of water security (Gerlak et al., 2018; Norman et al., 2013; Zeitoun et al., 2016). So, while it is understood that the water security concept is comprehensive and cross-disciplinary, during the implementation and operationalization stages, the concept of water security needs to be narrowed down and adequately framed. Therefore, conceptualization and operationalization of water security, including water security assessment, is context-specific (AWDO, 2020; Babel & Shinde, 2018; Octavianti, 2020).

1.2 Study area

Central Asia is an ideal setting to study water security perceptions and interpretations. Five republics share a common history of managing transboundary rivers with interconnected infrastructure when water-energy trade-offs existed between upstream and downstream counties. Since gaining independence, countries have promoted national interests (conflicting interests in water) and discussed water resources in terms of water allocation, representing the fragmented understanding of the water security concept causing disputes over water management and water insecurity in the region. Water is a fundamental factor for food security, energy production, and economic growth in Central Asia, with more than 70 million population. According to climate change scenarios, the rise of annual temperature will change the peak of river discharge, increase evapotranspiration in summer, reduce snow accumulation, which increases the vulnerability of the region to water-related disasters (Didovets et al., 2021; IPCC, 2021; Reyer et al., 2017; Sorg et al., 2012). All these factors will impact irrigated agriculture with 10 million hectares, which employs around 25% of the population in Central Asia (Adelphi and CAREC, 2017; World Bank, 2021).

Transboundary Syrdarya and Amudarya rivers constitute the Aral Sea basin (Figure 1.1). The Syrdarya river forms in the mountains of Kyrgyzstan, passes through Uzbekistan, Tajikistan, Kazakhstan, and flows into the Aral Sea. The Amudarya river originates in the mountains of Tajikistan and Afghanistan, crosses Turkmenistan, Uzbekistan and no longer flows into the Aral Sea. Hence, this thesis also included Afghanistan as part of the Aral Sea basin, sharing the Amudarya river with Central Asia countries.

The importance of water security in Central Asia has increased after the dissolution of the Union of Soviet Socialist Republics (hereafter USSR) (Abdolvand et al., 2015; Stucki & Sojamo, 2012; Wegerich, 2011; Xenarios et al., 2020). In the Soviet era, when all five countries were members of the USSR, water security was interpreted and ensured by a set of large-scale engineering projects of surface water management, mainly for irrigation and hydropower generation (Abdullaev et al., 2019; Adelphi and CAREC, 2017; Assubayeva, 2021; Djumaboev et al., 2019). In the USSR water-energy trade-offs existed between upstream states (Tajikistan and Kyrgyzstan) and downstream riparian republics (Kazakhstan, Uzbekistan, and Turkmenistan). Namely, upstream water-abundant countries ensured water for irrigation in summer to downstream states, and, in exchange, they supplied energy sources (gas, coal) in winter (Abdullaev & Rakhmatullaev, 2016; Froebrich & Wegerich, 2007; WB, 2020). However, the environmental aspect was neglected in the water-energy trade-off resulting in the Aral Sea crisis.

Figure 1.1 The map of Central Asia and the Aral Sea basin

Source: Adelphi and CAREC (2017, p.1)

With the end of the USSR, the former regional approach to water and energy management was replaced by national strategies, which raised disputes between upstream and downstream neighbors. Despite different political situations and economic development in the region, Central Asia countries remain connected in terms of sharing water resources. However, the transboundary water system of the region has two facets: on the one hand, there is the issue of water dependence to each other because of both geophysical and hydrological conditions and, on the other hand, there is the issue of interconnected infrastructural assets constructed in the Soviet era (Abdullaev et al., 2019; Chan, 2010; Djumaboev et al., 2019; Wegerich, 2011).

The benefit-sharing scheme devised during the Soviet times was replaced by unilateral water-energy policies in Central Asia (Conrad et al., 2016; Granit et al., 2012; Varis & Kummu, 2012; WB, 2020). After the break of the USSR, water has become a subject of policy disagreements and a source of disputes. Central Asia countries associate water security mainly with food security and energy security (Guillaume et al., 2015; Jalilov et al., 2018; Stucki & Sojamo, 2012). Table 1.1 presents the importance of water resources in the agricultural sector of Uzbekistan with high freshwater withdrawals and low availability of internal renewable freshwater resources but employing about one-fourth of total employment and contributing about 25% to GDP and in 2020. A similar situation is Turkmenistan, also a downstream country in the region. At the same time, upstream countries, Kyrgyzstan and Tajikistan, prioritize energy security with high dependency on hydroelectric sources (more than 85%) with high renewable internal freshwater resources and low freshwater withdrawals. Scholars noted that resource-based regional cleavage in resources, which pits upstream water-rich countries and downstream energy-abundant states against one another, has led to debates and frictions (Bernauer & Siegfried, 2012; Chan, 2010; Weinthal, 2006; Zakhirova, 2013). Upstream countries proposed to treat water as a commodity that the downstream countries should pay for, while downstream countries retorted that water in transboundary rivers should be shared among all riparian states (Granit et al., 2012).

Table 1.1 Socioeconomic and water resource indicators

	Afghanistan	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Population (million)						
1991	13.3	16.4	4.5	5.4	3.8	20.9
2020	38.9	18.7	6.6	9.5	6	34.2
Agriculture, value added (% of GDP)						
1991	-	23.3 (1992)	35.3	32.2	36	37
2020	26.8	5.4	13.5	23.8	10.8	25.1
Employment in agriculture (% of total employment)						
1991	63.4	36.9	35.5	54	33	40.7
2019	42.5	14.9	19.3	44.7	20.7	25.7
Annual freshwater withdrawals (billion cubic meters)						
1997	20.8	27	9.9	11.6	24.3	53.6
2017	20.3	22.5	7.7	10.4	27.8	58.9
Renewable internal freshwater resources per capita (cubic meters)						
1992	3 255	3 914.5	10 836.2	11 533	360.3	761.8
2017	1 299	3 567.5	7 894.2	7 146.2	244	504.5
Electricity production from hydroelectric sources (% of total)						
1991	-	8.4	64	93.3	4.7	11.1
2015	-	8.7	85.2	98.5	0	20.6

Source: World Bank, 2021

As several studies mentioned that in the post- Soviet time, Central Asia countries were restructuring national priorities, and water security has become an increasingly salient issue due to financial difficulties, social instability, and policy uncertainties in Central Asia countries (Abdullaev & Rakhmatullaev, 2016; Bekchanov & Lamers, 2016; WB, 2020) but was still based on technical (engineering) solutions (Abdullaev et al., 2019; Abdullaev & Rakhmatullaev, 2016; Soliev et al., 2015). Nowadays, water security is discussed by policymakers in terms of water allocation in Central Asia (Abdullaev et al., 2019; Adelphi and CAREC, 2017; Djumaboev et al., 2019; WB, 2020). It was highlighted that Central Asia republics focus on national and short-term interests rather than regional and long-term development (Guillaume et al., 2015; Himes, 2017; Keskinen et al., 2016). Water and security in the region can be understood and interpreted in various ways because of national interests and needs (Stucki & Sojamo, 2012). However, fragmented interpretation of water security only in terms of water allocation in Central Asia can create misunderstanding of water security by affecting bilateral and multilateral negotiations in the region (Abdullaev et al., 2019; Xenarios et al., 2018, 2020; Zakhirova, 2013).

1.3 Problem statement and research questions

Transboundary water resources are vital in ensuring food, energy, and environmental security in Central Asia (Abdullaev & Rakhmatullaev, 2016; Granit et al., 2012; Guillaume et al., 2015; Krasznai, 2019). The region is abundant in water resources if someone looks only at water quantity in absolute terms, but water resources are unevenly distributed and water resources per capita vary among Central Asia countries (Table 1.1). Hence, Central Asia, as a region, is perceived to be a water-scarce because of the geophysical aspect of the region with diverse hydrology and the excessive use of water resources to export water-intense cotton production and generate hydroelectricity (Abdullaev & Rakhmatullaev, 2016; Guillaume et al., 2015; Jalilov et al., 2018; Krasznai, 2019; Stucki & Sojamo, 2012). Agriculture plays important role in regional socioeconomic development with employment from 44% of total employment in Tajikistan to 15% in Kazakhstan (World Bank, 2021); and agriculture remains a major water consumer in the region with low water productivity, poor irrigation practices and leaky irrigation infrastructure. Widespread water pollution, poor environmental regulations, and water infrastructure decay are common challenges in the region. Furthermore, freshwater availability per capita is predicted to be scarcer in the future in Central Asia because of the interplay of population growth, urbanization, and global warming (IPCC, 2021; Lioubimtseva, 2014; Porkka et al., 2012; Sorg et al., 2012).

In addition to uneven water distribution, the issue of water allocation is becoming an urgent policy problem among Central Asia countries, including among different river basins and water users because of competing interests and needs in water resources. Central Asia countries signed the 1992 Almaty agreement and the 1998 Syrdarya agreement on water allocation in the Syrdarya river, but water allocation remained according to the criteria and volumes from the Soviet time, which are still under dispute (Abdullaev et al., 2019; Djumaboev et al., 2019; Krasznai, 2019;

Wegerich, 2011; Ziganshina, 2009). Regional organizations for water resources management were criticized for limited promotion of transboundary cooperation and agreement and remained as platforms for some consultations and information interchange (Krasznai, 2019). After the break of the USSR, the centralized water administration and planning in the Aral Sea basin was replaced by national water policies to satisfy the country's needs in water (Abdullaev & Rakhmatullaev, 2016; Allouche, 2007). Any changes in upstream water policies will directly impact downstream economies, namely irrigated agriculture (Abdullaev et al., 2019; Howard & Howard, 2016; Keskinen et al., 2016; Krasznai, 2019). Different water policies and lack of agreement on water allocation in the Aral Sea basin might cause water security conflicts among neighboring countries (Abdolvand et al., 2015; Lee & Jung, 2018).

While policymakers and scholars alike have been aware of the saliency of water security issues, little progress has been made as to how such a question could be addressed. Worse, policymakers' decisions (or lack thereof) do not seem to reflect the lessons learned in the scholarly literature adequately. To some extent, this suboptimal communication between politicians and scholars demonstrates that water security is a broad phenomenon with several aspects and subdimensions. Despite the many metrics and indexes devised to measure water security, there is not yet much consensus on how water security should be measured or the best way to do so. Assessment of water security perceptions and their understanding in the Central Asia context remains a relatively understudied area of scholarly inquiry.

Hence, given the issues highlighted above, this thesis aims to contribute to understanding how water security is perceived in Central Asia, what water security priorities are set for each Central Asia country by scholars and practitioners and how water security can be achieved in Kazakhstan in consideration to economic and policy implications. The thesis consisted of four stages discussed in Data & Methodology. Four sub-research questions were tested with the following hypotheses:

Hypothesis 1: if water security in Central Asia is discussed in the academic literature through different dimensions, then techno-economic aspects are more distinguished.

Hypothesis 2: if water security priorities in Central Asia are suggested in the literature, then similar prioritizations should be supported by experts and practitioners.

Hypothesis 3: if there are different interpretations of water security between scholars and practitioners, then water security is perceived in equivocal terms.

Hypothesis 4: If institutional mechanisms of river basin management will be improved, then water security in Kazakhstan can be strengthened.

From a research perspective, the thesis attempted to fill the gap of conceptualization and operationalization of the water security concept in the context of Central Asia. The current research aimed to identify relevant economic, social, and environmental dimensions of water security in Central Asia by assessing the different and collective perceptions and interpretations of water security in the regional context neglected and understudied in the literature. The thesis introduced a new methodology for understanding water security and contributed to how water security perceptions can be explored and interpreted in the case of transboundary river systems. From the policy perspective, water security priorities for each Central Asia country were identified that might help to reach a common understanding of water security in the region considering the national needs and the transboundary complexity of river basin systems and to prevent water conflicts in the region because of growing and competing water demands. Policy recommendations on improving river basin management were provided to strengthen water security in Kazakhstan.

1.4 Data and methodology

The exploratory sequential mixed research design was applied to understand water security perceptions in Central Asia. The research methodology consisted of four stages and integrated qualitative and quantitative data collection and analysis. At first, the bibliometric analysis of water security issues in Central Asia was conducted using qualitative content analysis and the NVivo software to explore water security trends in academic literature. Then the Delphi method was applied to conduct two rounds of the survey among regional and international experts to find consensus on water security priorities in each Central Asia country and compare water security trends in academic debate with the policy perspectives. The multinomial logistic regression (hereafter MNL) was employed using the SPSS program to test whether the demographic profile of experts affects framing water security priorities. Lastly, the DPSIR (drivers- pressures- state-impact- response) framework and semi-structured interviews were applied to explore the role of river basin management in strengthening water security in Kazakhstan. Table 1.2 presents a new methodology for understanding water security perceptions and summarizes the four stages. Each part will be discussed in the following sub-sections.

Table 1.2 Summary of research methodology

Stage	Sub-research question	Methodology	Hypotheses
1	*How is water security in Central Asia interpreted in academic discourse?*	Bibliometric analysis • Three-layer Boolean search: peer-reviewed articles in the English language from 1991 to 2019; Scopus, Web of Science, NU Library • Sample: 151 articles • Content analysis with the NVivo software	H:1
2	*How is water security in Central Asia perceived by practitioners?*	Delphi method • Purposive sampling of experts/ practitioners • Sample: 416 international and regional experts • Two rounds of the survey in Qualtrics software • MNL regression using the SPSS program	H:2
3	*To what extent are water security trends in literature aligned with the policy discourse mentioned by practitioners?*	Research-Practice Gap • Compare results of 1&2 stages • Identify possible reasons for the research-practice gap and differences in perceptions of water security in Central Asia	H:3
4	*What is the role of river basin management in strengthening water security in Kazakhstan?*	DPSIR Framework • Semi-structured interviews • Sample: 17 stakeholders • Case study: Balkhash-Alakol river basin • Thematic coding and analysis using the NVivo software	H:4

Stage 1: Bibliometric analysis of water security

To understand water security interpretations in Central Asia, the systematic literature review was conducted following the methodology developed by Xenarios et al. (2019) and by adopting the Asian Water Development Outlook (hereafter AWDO) framework (2013, 2016) of water security assessment with some adjustments. The literature review consisted of a three-layer Boolean search of peer-reviewed articles from 1991 to 2019. This timeframe revealed the transformation of water security perceptions in the post-Soviet period in Central Asia. The data sample included academic literature, i.e., peer-reviewed articles in the English language, to avoid overlapping and duplication with other publications such as working reports, conference proceedings, policy briefs, and book chapters. Multilayer research was conducted through Scopus, the Web of Sciences, and the Nazarbayev University library databases. Three-layer Boolean search consisted of 1) the phrase 'water security in Central Asia'; 2) the country-specific context: 'water security Kazakhstan', and also for all Central Asia countries and Afghanistan; and 3) the context-specific search of the attributes related to each security dimension (urban & household, economic, environmental, and water-related hazards).

At this stage, hypothesis 1 was tested whether techno-economic aspects of water security prevail in Central Asia countries, meaning the dominance of technical and engineering practices in managing water resources mainly to foster economic growth. The articles were diagnosed with the content analysis on qualitative data analysis software – NVivo 12 and cross-tabulation tools. Water security dimensions and attributes were coded using query-based coding and manual coding techniques. A cross-tabulation analysis revealed whether articles discuss one or several characteristics. The quality of sources was analyzed in terms of the ranking of journals. However, one of the challenges was inclusion of articles, yet literature was traced from different sources and databases to cover articles as much as possible. One might argue that water security perceptions differ in Russian literature than in peer-reviewed English articles. Still, the scope of this research was peer-reviewed articles in English. This thesis applied the AWDO (2013, 2016) framework with some adjustments, and if scholars use other water security frameworks, they might identify different water security perceptions. However, articles were coded based on attributes related to each security dimension to cover various aspects of water security.

Stage 2: Experts' perceptions on water security

The aim of using Delphi was to explore whether and to what extent practitioners'/experts' understanding of water security is congruent/consistent with the view of scholars and test hypothesis 2. The analysis of experts’ views on water security in Central Asia and Afghanistan was conducted using the Delphi approach, which is a structured group communication technique through multi-round questionnaires to gather experts' opinions to forecast future trends, reach a shared understanding and consensus on areas with high uncertainties, lack of information, and causal links (Avella, 2016; Markmann et al., 2021; Normand et al., 1998; Okoli & Pawlowski, 2004). Critical features of Delphi are anonymity of respondents, controlled and iterative feedback, groupthink without the dominant person, no group pressure toward consensus, and statistical aggregation of responses (Belton et al., 2019; Birko et al., 2015; C. C. Hsu, 2007; Normand et al., 1998). Two sequential questionnaire rounds were conducted among regional and international experts in Russian and English. Expert selection in this study was based on externally available criteria such as job position, publication, past performance, and membership of specific organizations and institutions linked to water resources in Central Asia and Afghanistan. The first round gathered experts’ opinions on water security dimensions, attributes, priorities, and trends. Participants were also able to modify or introduce new aspects and characteristics. Experts were asked to consent or object to the results collected from the first round in round two. The surveys were arranged online through Qualtrics software. Delphi’s results were analyzed using descriptive statistics, inferential statistics, and thematic analysis. Descriptive statistics consisted of a comparison of agreement between two rounds on each aspect of water security. I also conducted a cross-tabulation analysis to evaluate the relationship between the demographic profile of experts and their assessment of water security dimensions and country priorities. The MNL regression was applied to test whether the demographic profile of experts affects setting water security priorities using the SPSS program. The suggestions and comments of experts were also reviewed with the thematic analysis.

Scholars may privilege one topic over another because of their own biases as well as experts and policymakers can have their preferences. External and internal validation of findings was conducted to minimize biases, considering the inherent subjectivity of scholars and experts. External validation implied the first step of Delphi by cross-validating whether respondents agreed with the literature findings. Internal validation infered to the second round of Delphi to reach a consensus among experts. The Delphi method has some limitations: the subjectivity of results, risks of low response rate, and the probability of homogeneous bias. Experts represented a heterogeneous group selected with purposive sampling from various sources such as web searches, professional organization listings, and referrals to minimize homogeneous and self-selection biases. One might question the subjectivity of experts and their professional experience in setting water security priorities. It was challenging to cover all experts in Central Asia and international experts with expertise in Central Asia, but as many as possible experts were invited. Personal invitations and two kind reminders were sent to minimize the low response rate.

Stage 3: Comparison of research-practice discourse in water security

At this stage, the results of scholarly literature and experts' opinion on water security aspects were compared to test hypotheses 2 and 3. The literature review consisted of 151 peer-reviewed articles from 1991 to 2019 on water security issues in Central Asia. The experts' views were based on two rounds of the Delphi survey, which identified water security priorities for each Central Asia country and ranking of water security dimensions. The background of scholars and practitioners was discussed, including employment and origin. I compared the literature review findings and experts' opinions on water security dimensions, attributes, historic water security trends, and the ranking of water security priorities for each Central Asia country and Afghanistan. The academic and policy discourses on water security issues were discussed using the cultural theory to analyze why the interest of experts and scholars are not aligned. Some possible reasons for the research-practice gap in the water sector in Central Asia were also addressed. Still, the analysis was brief and descriptive without additional empirical evidence of the research-practice gap in the water sector.

Stage 4: Analysis of river basin management in Kazakhstan

The last stage of the thesis attempted to explore whether improving river basin management and planning can strengthen water security in Kazakhstan (hypothesis 4) using the DPSIR framework and semi-structured interviews. Scholars in academic literature and international and regional experts who participated in the Delphi survey suggested improvement of river basin management in Kazakhstan. The DPSIR framework represents a logical flow of causal links starting from drivers through pressures to states and impacts that all together lead to responses (Tscherning et al., 2012). The European Environmental Agency widely uses this framework to analyze environmental issues. The framework begins with drivers, which are direct/ indirect or natural/human-forced factors that cause changes in human-environment meant interaction (Pinto et al., 2013; Vannevel, 2018). While pressures are more specific than drivers, they can be presented as indicators that affect the state of, for example, water resources. Further, the current state impacts other areas, which requires a response in policy actions and decisions. Responses could be in the form of changes in legislative procedures, education, planning, and others (Tscherning et al., 2012).

River basin management was introduced two decades ago in Kazakhstan. Semi-structured interviews with stakeholders were conducted to evaluate river basin management and planning in the Balkhash-Alakol river basin (hereafter BA) in Almaty and Almaty oblast, one of the densely populated transboundary river basins in the country. The analysis consisted of the drivers of change towards the river basin approach, national and local pressures on water resources, and the current river basin management and planning state. Interviewers also reflected on the impact of the river basin approach in Kazakhstan. Policy recommendations of interviewers were also discussed. One of the challenges was to reach relevant stakeholders and decision-makers to conduct interviews. One might question the choice of case study among eight river basins in Kazakhstan and whether the findings would be applicable for other river basins. The selection of the BA river basin was based on the criteria of the transboundary river basin, and it was widely acknowledged that this basin is 'the role model' for other river basins, even in neighboring countries. To minimize subjectivity bias and incomplete information, I conducted interviews with stakeholders involved in river basin management and planning and experts and international consultants engaged in implementing integrated water resources management (hereafter IWRM) reforms in Kazakhstan and Central Asia. The thesis was summarized by proposing a preliminary reflection on the role of river basin management in strengthening water security.

1.5 Structure of the thesis

The thesis consisted of eight chapters, excluding bibliography and annexes. Following the introduction, Chapter 2 described the history of the development of the water security concept, discussed various definitions of water security and frameworks assessing water security. This chapter also discussed conceptualization challenges, operationalization gaps, and context specificity of achieving water security. The thesis reconceptualized water security from a conventional interpretation of water security in terms of water availability to holistic framing of water security because of the complexity of water systems. Chapter 3 described the research methodology, including data collection and analysis of all four abovementioned stages. Chapter 4 presented the findings of the content analysis of scholarly literature on water security issues in Central Asia. Chapter 5 reported the results of the Delphi method about experts' consensus and disagreements on water security dimensions, water security trends, and priorities for each country. Descriptive statistics, cross-tabulation results, and MNL regression outputs were also presented. This chapter also compared the findings of water security priorities set by scholars and practitioners. Chapter 6 focused on the findings of semi-structured interviews using the DPSIR framework evaluating river basin management in Kazakhstan. Chapter 7 discussed findings relating them to scholarly debate and evaluated data and methodology. Chapter 8 synthesized findings, highlighted future research perspectives, and presented policy implications.

Chapter 2

Literature Review

2 LITERATURE REVIEW

2.1 Historical evolution of the water security concept

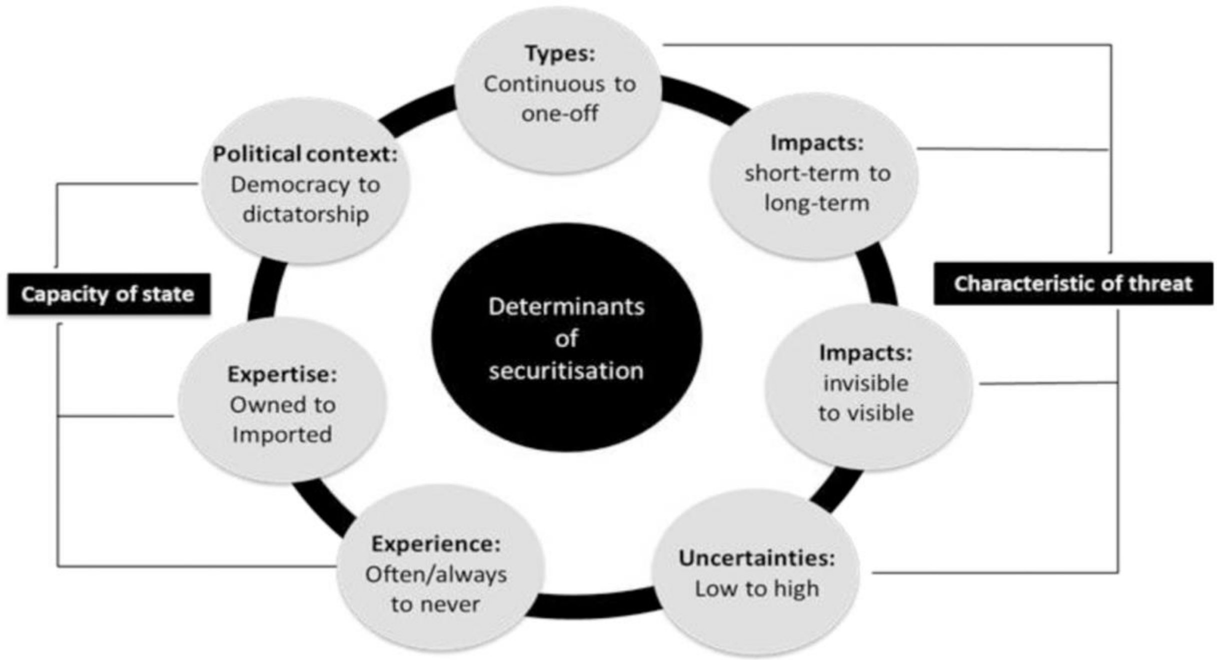
The water security concept has been widened and deepened in scholarly and policy discourses in the last two decades. Even though it is challenging to identify the origin of this concept, scholars link it with the water disputes in the Middle East in the 1990s (Cook & Bakker, 2012; Grey & Sadoff, 2007; Thapliyal, 2011). At the beginning of the 1990s, water security was associated with threats to food security, energy security, environmental security. For example, studies in the 1990s linked water security to geopolitical security in the Middle East and North Afrika because of water scarcity issues (Gerlak et al., 2018). Moreover, worldwide environmental degradation has raised attention towards water security and ecological security.

The water security concept has roots in the securitization theory, which studies the perceptions of threats (Octavianti, 2020; Thapliyal, 2011; Zeitoun et al., 2016). The securitization concept was first met in international relations and was developed during the Cold War, maintaining an inherent military focus (Charrett, 2009; Stritzel, 2014). The securitization theory states that national security policy does not appear independently; instead, it is carefully designed by policymaking dynamics. Security policies are formulated around 'dangerous,' 'threatening,' 'hazardous' issues (Stritzel, 2014; Zeitoun, 2011). In other words, external security threats negatively affect national security solved by the state-centric approach, where the state is the referent of security (Thapliyal, 2011). However, not all threats become securitization problems. According to the Multiple Streams Framework, social/economic/environmental issues getting the attention of policymakers become policy problems. Often, problems reach the attention of decision-makers due to crises or dramatic events, or negative feedback, which requires concentration and urgent action from the policymakers (Kingdon, 2001). The traditional approach of dealing with the securitization issue is built around military capabilities, power distribution, and resources. According to the securitization approach, safeguarding resources, including water resources, can be achieved using military measures.

The securitization concept has maintained an inherent military focus before the Copenhagen School, where scholars presented alternative interpretations of the security concept and emphasized the constructive nature of the security concept (Charrett, 2009; Leb & Wouters, 2013; Stritzel, 2014). The Copenhagen School discussed why some security issues receive more attention and relevant policy measures while others are overlooked. Securitization was defined by the Copenhagen School as "*the intersubjective and socially constructed process by which a threat to a particular referent object is acknowledged and deemed worth protecting*" (Charrett, 2009, p. 13). Hence, when a security issue is declared with the proper context and audience, it will get attention and mobilization of resources to handle it (Octavianti, 2020; Stritzel, 2014; Zeitoun, 2011). Understanding the nature of security issues and perceptions about security issues attempt to identify societal discourses. The Copenhagen School conceptualized security with economic, societal, environmental, and political sectors and highlighted that the role of security analyzers is to understand and interpret security issues.

The securitization theory attempts to address the questions such as "*what compromises the security, security for whom, and for what*" (Octavianti, 2020, p. 147). The securitization of water is linked with national security threats such as access to water, water availability, and human security against any bioterrorism, considered a geopolitical issue, and requires military measures (Cook & Bakker, 2012; Leb & Wouters, 2013; Mirumachi, 2013). For example, reducing the transboundary river flow or stopping it from upstream to downstream countries might provoke conflict, regional instability, and water insecurity. However, the idea for 'securitization' of water by national military-political institutes has not been developed (Leb & Wouters, 2013; Zeitoun, 2011). Octavianti (2020) proposed the framework of 'determinants of securitization' (Figure 2.1) consisting of the capacity of state (political context, expertise, experience) and characteristics of threat (impacts, types, and uncertainties). Different water-related dangers receive various policy measures. This framework might help understand why some water-related threats are securitized while others are not. According to Octavianti (2020), water-related treats with visible effects and higher uncertainties have high probability to be securitized than water-related treats with invisible effects and low delays. Indicatively, the threats excess of water (floods) is more likely to be securitized to protect society and economy from water than threats of shortage of water (droughts) because of invisible and delayed impacts.

Figure 2.1 The framework of 'determinants of securitization'



Source: Octavianti (2020)

The Ministerial Declaration on water security in XXI century was adopted at the World Water Forum in 2000, where water security was framed as meeting human needs in access and availability to water, sustaining environmental health, mitigating risks, and promoting good water governance and cooperation (Cook & Bakker, 2012; Gerlak et al., 2018; Zeitoun et al., 2016). Since then, water security has been extensively discussed by academic and policy communities and international organizations. Even a special journal of Water Security was initiated in 2017 by Elsevier's publisher. Water security is one of the future potential security risks linked with socioeconomic, environmental, and political areas. Moreover, international events highlighted the importance of water security, such as the Asia-Pacific Water Forum on Water Security: Leadership and Commitment in 2007, World Economic Forum of Global Agenda in 2008 and other. International organizations attempt to conceptualize and promote water security concepts internationally, such as the Global Water Partnership, UNESCO Institute for Water Education, ADB, etc. Scholars and development organizations have primarily started creating and elaborating on the water security concept.

2.2 Conceptualization of water security

The water security concept has become a dominant paradigm in water policy and management discourses (GWP, 2000; Norman et al., 2013; Woodhouse & Muller, 2017; Zeitoun et al., 2016). Water security has been conceptualized from different angles and perspectives (Cook & Bakker, 2012; Gerlak et al., 2018; Octavianti & Staddon, 2021; Zeitoun, 2011). Studies show that water security has been widely used across different disciplines: water resources, environmental studies, agriculture, engineering, public health, social science, and natural science. Consequently, framing water security also differs across disciplines. For example, agricultural studies specify water security as the availability of water resources for food production and the resilience to climatological variability; from a social perspective – access to good quality of water and sanitation & hygiene; from a legal standpoint – regulations and agreements on water allocation issues. Water availability, access to water, and conflict prevention also prevail in international conventions on transboundary watercourses to ensure water security (Albrecht et al., 2018; Leb & Wouters, 2013; Mirumachi, 2013). Environmentalists and ecologists interpret water security as healthy and sustainable ecosystems resilient to water-related disasters. Moreover, water security was studied from a political economy focusing on the politico-military point of view regarding safety and security issues beyond the water sector (Allan, 2003; Gerlak et al., 2018).

Table 2.1 presents the chronological development of the water security concept from the 1980s to 2020s. The shift from military security in the traditional securitization theory to the water security concept started in the 1980s when the Copenhagen School highlighted that issue becomes a security issue when someone identifies and labels it. Water security is frequently interpreted as the physical availability of freshwater resources from the hydrological and geophysical perspectives; hence, the primary unit of analysis of water security is water availability per capita. However, water availability does not ensure that river basins or countries are secure regarding water access, water quality, water allocation, and water risks. Since the 2000s, the water security term has been framed using complex and holistic approaches. Some definitions highlight human-ecosystem interlinkages, while some focus on managing risks. The water security concept also varies because of the scale from global to basin scales. Different dimensions were suggested to measure water security. Definitions of water security provided in Table 2.1 address both human and environmental needs in the water.

Gerlak et al. (2018) studied how water security is conceptualized in different contexts and scales by systematically reviewing 124 water security studies from 2010 to 2015. The analysis revealed that the water security term attempts to address the issues of quantity, quality, equality, safe access, and environmental protection. Recent studies revealed broader framing of securitization beyond militarization (Briscoe, 2009; Thapliyal, 2011). Water security can also be understood in terms of freedom of fear, adaptability, predictability, control, and reliability (Zeitoun et al., 2016). Water supply security focuses on threats linked with the shortage of water resources or the surplus of water resources that require policy measures, mainly formulated in climate-proofing infrastructure (Briscoe, 2009). This reveals that fear of water shortage is a dominant threat regarding water security. However, outdated large-scale water infrastructure could serve as another water security threats. Moreover, natural disasters, climatological variability, and environmental degradation can be considered as water security threats. Overall, the common understanding is that water security goes beyond water quantity or water-related hazards.

Table 2.1 Evolution of water security definitions

Time	Definition	Authors
Until the 1980s	*Traditional securitization theory: nations' safety and security*	
1980s-1990s	*Security is associated not only with the military sector but also with economic, societal, environmental, and political sectors*	The Copenhagen School (Buzan, Waever, and Wilde)
2000	*''Water Security, at any level from the household to the global, means that every person has access to enough safe water at an affordable cost to lead a clean, healthy, and productive life while ensuring that the natural environment is protected and enhanced."*	World Water Forum, (GWP, 2000, p.12)
2007	*Water security is one of the future potential security risks*	(United Nations Security Council, 2007)
2007	*"Availability of adequate quantity and quality of water for livelihoods, health, ecosystems, and production"*	(Grey & Sadoff, 2007)
2011	*The global 'web' of national water security: national security, water resources security, food security, energy security, climate security, human/community security*	(Zeitoun, 2011)
2012	*Operationalization of water security is context-specific*	(Cook & Bakker, 2012)
2013	*"A capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability"*	(UN Water, 2013, p.vi)
2013	*"Societies can enjoy water security when they successfully manage their water resources and services to satisfy household water and sanitation needs in all communities; support productive economies in agriculture, industry, and energy; develop vibrant, livable cities and towns; restore healthy rivers and ecosystems, and build resilient communities that can adapt to change"*	(AWDO, 2013, p.iv)
2013	*Water security is about managing water risks, including risks of excess, pollution, and risks of undermining the resilience of freshwater systems.*	(OECD, 2013)
2013	*"Water security constitutes the sustainable availability of adequate quantities and qualities of water for resilient societies and ecosystems in the face of uncertain global change."*	(Scott et al., 2013, p. 281)
2016	*Water security at a global scale is conceptualized as a function of 'availability,' 'accessibility to services,' 'safety and quality, and 'management.'*	(Gain et al., 2016)
2016	*National water security consists of five interdependent dimensions: household water security, urban water security, economical water security, environmental water security, and resilience to water-related hazards*	(AWDO, 2016)
2018	*Basin-scale water security framework consists of the following dimensions: water productivity, water availability, watershed health, water-related disasters, and water governance.*	(Babel & Shinde, 2018)
2020	*National water security consists of five interdependent dimensions: rural household water security, urban water security, economical water security, environmental water security, and water-related disaster security*	(AWDO, 2020)

Many studies highlight the importance of water security (AWDO, 2013, 2016, 2020; GWP, 2000; OECD, 2013). It was noticed that water security definitions and water security assessments are developed and suggested by international organizations and scholars but not by practitioners on the ground (Gerlak et al., 2018; Octavianti & Staddon, 2021). Another trend is that many studies mention water security without adequately defining it. There is no uniformly shared definition of water security that may also lead to misunderstanding the water security concept. At the same time, it is challenging to cover all context-specific water security challenges in one definition (Albrecht et al., 2018; Norman et al., 2013; Zeitoun, 2011). Water security studies have been criticized for broad and contested conceptualization (Cook & Bakker, 2012; Gerlak et al., 2018; Zeitoun, 2011). Yet, some scholars argued for comprehensive and holistic framing of water security because of the complexity of water systems (AWDO, 2016; GWP, 2000; Tortajada & Fernandez, 2018).

Framing water security is broad, complex, and multidimensional and requires a paradigmatic approach to analyzing water-related issues. There is still ongoing discussion whether water security and IWRM are complementary paradigms in water resources management (Cook & Bakker, 2012). Zeitoun et al. (2016) discussed several reasons for the conceptualization challenge of the water security concept. Firstly, water security research requires considering complex water-society interlinkages using the 'security through pluralism' approach. Secondly, the uncertainty about water availability and demand forecasts because of climate change. Growing human water demand challenges water reallocation from human necessities to ecological needs (Mirumachi, 2013). Thirdly, the application of water security in practice leads to simplification and context specificity. Hence, water security assessment depends on the conceptualization of water security. At the same time, studies mentioned water insecurity, as more broad and undeveloped term, simply stating the absence of water security and mentioning negative consequences to socioeconomic development, environment, and national security (Gerlak et al., 2018; Octavianti, 2020).

2.3 Operationalization of water security

Water security policies require initial assessment and regular monitoring of changes (Babel & Shinde, 2018; GWP, 2000; Octavianti & Staddon, 2021). "*We cannot manage what we cannot measure,*" says management guru Peter Drucker. Moreover. Risks cannot be mitigated if they have not been adequately understood and assessed (Zeitoun et al., 2016). Consequently, the operationalization of the water security concept is essential and urgent. If someone looks at only water quantity, some indices measure freshwater withdrawal as a proportion of available freshwater resources: water stress index and water shortage index, where water stress addresses demand-driven water scarcity and water shortage to population-driven water scarcity (Gain et al., 2016). However, these indices prioritize and assess only human needs in the water. Norman et al. (2013) mentioned limitations of these frameworks: data limitations, comparability challenges, limited interaction and application by practitioners. Moreover, understanding water security only in terms of threats from a water shortage might only ensure water supply hydraulic infrastructure, which represents a fragmented interpretation of water security (Briscoe, 2009; Dickson et al., 2016; Norman et al., 2013; Octavianti & Staddon, 2021; Thapliyal, 2011).

Scholars, practitioners, and international organizations suggested frameworks to measure water security at different scales using various disciplinary approaches (AWDO, 2013, 2016, 2020; Babel & Shinde, 2018; Dickson et al., 2016; Gaber et al., 2021; Gain et al., 2016; Holmatov et al., 2017; OECD, 2013; Scott et al., 2013; Stucki & Sojamo, 2012; Sun et al., 2016; Zeitoun, 2011). There are attempts in developing universal water security metrics, but they are difficult to operationalize because of local specificities and limited data (Gerlak et al., 2018; Norman et al., 2013; Octavianti & Staddon, 2021). Assessment of water security requires a holistic, interdisciplinary, and inclusive approach. Studies attempting to measure water security apply hydrological models, quantitative metrics, qualitative analysis, economic frameworks, etc. The analysis of Cook & Bakker (2012) reveals four broad categories of water security studies: empirical, modeling, conceptual, and lab based. Water security metrics are based on primary data (surveys, interviews) and secondary data from international and national databases. However, limited data availability might lead to a limited selection of indicators, leading to incorrect assessment and conclusions. Studies also suggested a participatory approach in understanding water security through surveys, scenarios development, and evaluation from local communities, stakeholders, experts, and public authorities. Some water security assessments apply a weighting method, which can also be criticized for subjective prioritization of specific water security dimensions.

Studies on water security differ in scale from macro to micro levels: community, national, regional, and transboundary. For example, hydrological studies focus on the basin level or watershed scale, while socioeconomic research – on a community level. The analysis of Gerlak et al. (2018) indicated that the focus of water security studies is national scale, followed by regional and city scales, while transboundary and community scales are in the minority. Publications about water security at the transboundary scale are lacking definition and assessment indicators due to socioeconomic, political, and geographic differences among countries sharing transboundary water resources. The study of Octavianti & Staddon (2021) revealed growing interest in water security on an urban level since 2015 and case-study research due to place and context specificities. Authors highlighted that case studies bring more insightful and meaningful assessments focusing on local, regional, and national scales, while transboundary basins were overlooked.

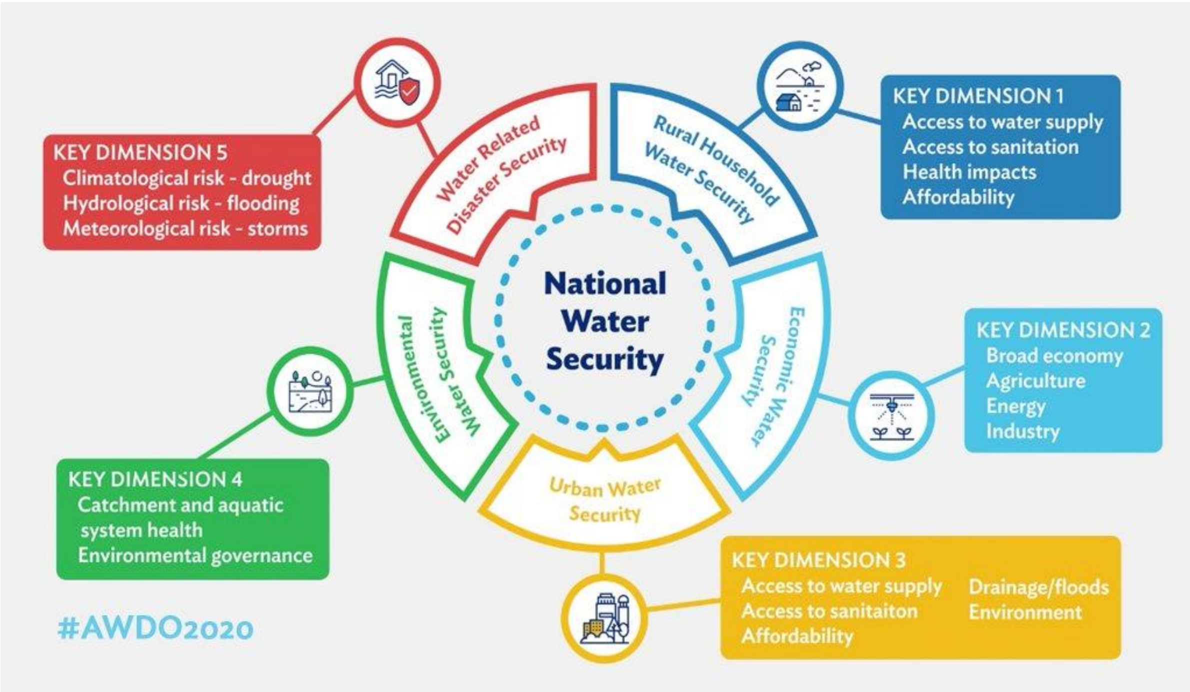
It is worth mentioning that many studies addressed water security for human systems and environment and human systems together, but not separately water security for the environment (Cook & Bakker, 2012; Gerlak et al., 2018). Studies highlighted different water security sources: surface water, groundwater, stormwater, rainwater, and reused water, depending on a region's aridity. Yet, most studies focused on surface water as the primary water source for ensuring water security (Gerlak et al., 2018; Octavianti & Staddon, 2021). Hence, water security research should develop 'beyond the river' and surface water runoffs (Zeitoun et al., 2016).

Academia and international organizations introduced various metrics, indicators, and indexes to assess water security. An overview of the most commonly used water security frameworks is discussed in the following sub-section. Indicatively, OECD (2013) highlighted achieving water security objectives means managing four water risks: the risk of excess, inadequate quality, shortage, and freshwater systems resilience. The ADB introduced a water security assessment framework (AWDO, 2013, 2016, 2020) consisting of five dimensions: household, urban, environmental, economic, and resilience to water-related disasters. Gain et al. (2016) discussed the usefulness of measuring global water security to achieve SDGs. Babel & Shinde (2018) developed a basin-scale water security framework and assessed water security in water productivity, water availability, watershed health, water-related disasters, and water governance. Most frameworks have indicators of water quantity, water quality, water accessibility, water supply to assess the risk of floods or droughts, climate indicators, while water governance indicators are underrepresented. Different metrics vary in scale (local or global assessments) and thematic focus. Still, indexes were criticized on four grounds: 1) for being biased on some aspects, 2) for not being adequately data-based or data-driven, 3) for oversimplifying the complex water-society interrelations, or 4) for focusing on surface water and little consideration of groundwater and atmospheric water.

2.3.1 Asian Water Development Outlook

The ABD suggested a water security assessment framework in 2013 published the Asian Water Development Outlook: Measuring Water Security in Asia and the Pacific. Later in 2016 AWDO framework was modified and presented in the Asian Water Development Outlook: Strengthening Water Security in Asia and the Pacific. Recently, the ADB presented the expanded framework with some adjustments focused on the policy-into-practice approach in Asian Water Development Outlook 2020: Advancing Water Security across Asia and the Pacific. The AWDO framework has kept tracking the water security status since 2013 for 49 countries in Asia and the Pacific. The AWDO framework represents a comprehensive water security assessment based on five interdependent equally important water security dimensions: rural household water security, economical water security, urban water security, environmental water security, and water-related disaster security (Figure 2.2). The definition of the AWDO was presented earlier (Table 2.1), which highlights that "*water security is more than just providing sufficient water for people and economic activities. It is also about having healthy aquatic ecosystems and protecting against water-related disasters*" (AWDO, 2016, p. xiv). Scholars have widely used the AWDO framework by scholars to assess water security in Southern Africa (Holmatov et al., 2017), China (Sun et al., 2016), Egypt (Gaber et al., 2021), and others.

Figure 2.2 National Water Security Index



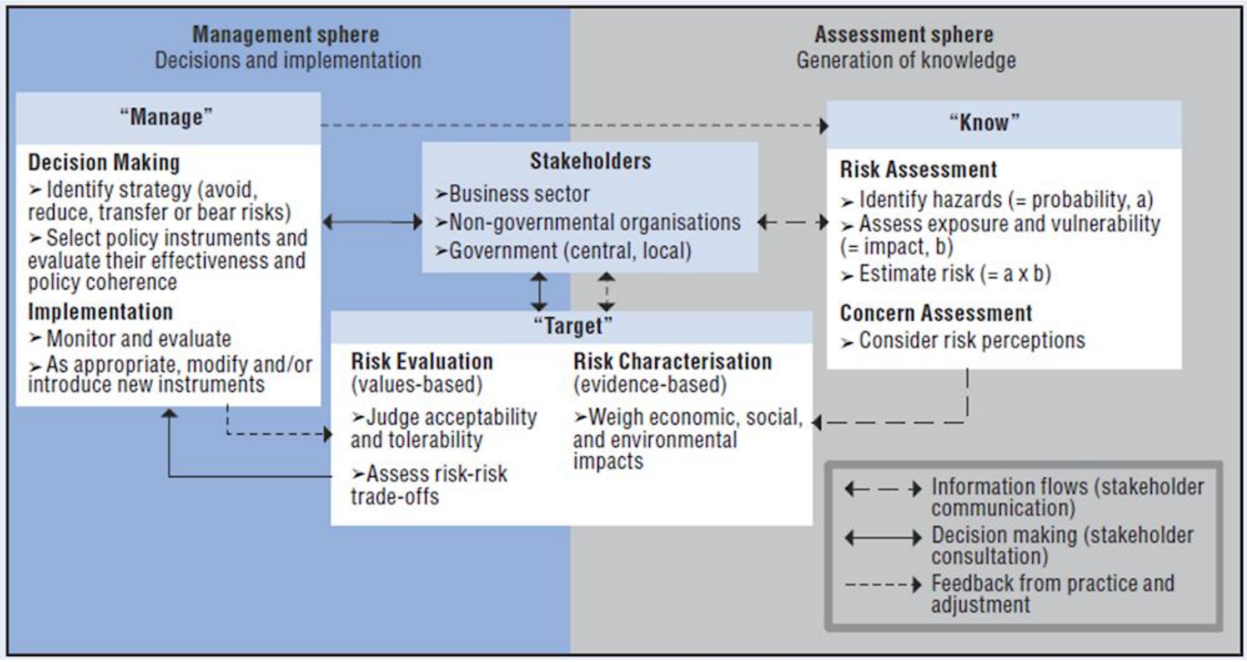
Source: AWDO (2020)

The AWDO framework measures the National Water Security score (0-100) for each ADB member country and divides countries into categories: model, effective, capable, engaged, and nascent. According to AWDO (2020), countries in Central Asia are grouped into different water security categories: capable - Kazakhstan (73.7), Kyrgyz Republic (72.6), Turkmenistan (67.6), Uzbekistan (62.1), engaged- Tajikistan (58.1), and nascent- Afghanistan (39.5). Capable category means that the country is improving access to drinking water and sanitation, economical water security and environmental governance are moderate, and there are some plans on reducing water-related risks. The difference between engaged and nascent categories is the proportion of access to drinking water and sanitation in urban and rural populations, assessment of economic water security and environmental water security (moderate/ poor), and measures to reduce disaster risks.

2.3.2 Risk-based assessment of water security

OECD (2013) suggested a risk-based approach to assess water security, presented in the report 'Water Security: Managing Risks and Trade-offs.' Improving water security requires risk management policies for four water-related risks: risk of shortage, risk of inadequate quality, risk of excess, and risk of freshwater systems resilience. The risk can be considered acceptable, tolerable, and intolerable. All these risks are interlinked and require water risk mitigation measures. A risk-based assessment of water security has some elements of technical risk assessment such as 'know,' 'target,' and 'manage' water-related risks (Figure 2.3). Knowing risk means identifying the drivers of water risks, understanding risk perceptions, and conducting a risk assessment. The next step is targeting water risks by identifying water risk characterization (evidence-based) conducting water risk evaluation (values-based) on whether water risk is acceptable, tolerable, or intolerable. Managing water risks includes developing a risk management strategy with relevant policy measures on whether water risks can be avoided, reduced, and transferred. Applying some elements of a risk-based framework for water security was discussed for several case studies for OECD countries: Australia, England, and Wales, France, the US. Market-based instruments for water security issues were discussed in the report. For example, improving water quality requires the introduction of emission taxes and emission permits. The interlinkages of food security, energy security, climate policy, and water security were also mentioned in the report.

Figure 2.3 Risk-based framework for water security



Source: OECD (2013)

2.3.3 Global water security index

Gain et al. (2016) used criteria of 'availability,' 'accessibility to services,' 'safety and quality,' and 'management' to develop the Global Water Security Index (hereafter GWS). Among the four categories of water security, the highest weight is assigned to availability (45%), while accessibility and safety and quality receive 20% and management -15%. The authors admitted that weighting is inherently subjective. Moreover, each security criteria consists of several indicators (Table 2.2). For example, the water availability dimension consists of three indicators: water scarcity index, drought index, and groundwater depletion. Authors discussed the demand-driven water scarcity and the supply-driven scarcity. The authors concluded that conventional assessments of water scarcity are poorly linked with the demands of policymakers and practitioners, giving insufficient attention to the human aspects such as social dimension and institutional capacities.

Authors compared the water scarcity index and water security estimation for selected seven countries to show the difference between blue water scarcity and the GWS index. Moreover, the authors emphasized that the GWS index can be used to monitor the progress of SDG 6. To improve the status of the GWS index, the authors gave recommendations to improve each indicator of water security. The assessment showed that Africa, South Asia, and the Middle East countries face inadequate water security. The GWS index for other case studies, such as some parts of the United States, Australia, and Southern Europe, revealed better estimation because of effective management, safety and quality, and accessibility indicators. The authors proposed for future research to study stakeholders engagement analysis and the role of water in societal and economic development.

Table 2.2 Components of the GWS index

Main components (weight)	Security criteria (weights)	Indicators (weights)
Global water security index	Availability (45%)	Water scarcity index (70%)
		Drought index (15%)
		Groundwater depletion (15%)
	Accessibility to water services (20%)	Access to sanitation (40%)
		Access to drinking water (60%)
	Safety and quality (20%)	Water quality index (50%)
		Global flood frequency (50%)
	Management (15%)	World governance index (70%)
		Transboundary legal framework (15%)
		Transboundary political tension (15%)

Ordered weights (indicators/criteria ordered in decreasing order): (i) aggregation of 2 indicators/criteria: 0.8; 0.2, (ii) aggregation of 3 indicators/criteria: 0.6; 0.2; 0.2; (iii) aggregation of 4 indicators/criteria: 0.55; 0.15; 0.15; 0.15.

Source: Gain et al. (2016)

2.3.4 Water security assessment at basin level

Babel & Shinde (2018) developed a water security framework at basin-scale composing of five dimensions: water availability, water productivity, water-related disasters, watershed health, and water governance, which address driving forces affecting water security (Table 2.3). The authors suggested approaches and sources measure indicators and variables. For example, the water governance dimension means the capacity of the government to manage water resources and adapt to changes. The authors highlighted that operationalization of water security enhancement would require a bottom-up approach. They applied the DPSIR framework to indicate the interconnection between environmental and human systems. The authors argued that it is essential to quantify variables to assess water security. The authors used the threshold from 1 to 5 for the water security index developed by AWDO (2013, 2016). An aggregation method was used where variables have equal weights. Table 2.4 presents the interpretation of the water security index. However, the authors admit that they did not apply this framework to a particular case.

Table 2.3 Water security assessment at basin scale

Dimension	*Indicator*	*Potential variables*	*Suggested ways to measure*
Water availability	Sustainable basin exploitation	1. Per capita water availability	Surface runoff/Population (Falkenmark, 1989)
		2. Water scarcity	Annual per capita water resources availability (Babel and Wahid, 2008)
		3. Water variation	The coefficient of variation of precipitation over the last 50 years (Babel and Wahid, 2008)
Water productivity	Economic value of water	1. Commercial/industrial revenue per drop	Non-agricultural GPP/Non-agricultural water use in the basin (ADB, 2013)
		2. Agricultural, aquaculture and livestock revenue per drop	Agricultural, aquaculture and livestock GPP/ Agricultural, aquaculture and livestock water use in the basin (ADB, 2013)
Water-related disasters	Drought factor	1. Drought damage	Economic damage caused by droughts
		2. Proportional area under drought	Drought area/Total area (Xiao, Li, Xiao, & Liu, 2007)
		3. Drought occurrence frequency	Number of drought occurrence per year (Koontanakulvong, Doungmanee, & Hoisungwan, 2013)
		4.Ratio of the area with water-saving irrigation to the total area of arable land	Area of irrigation/ Area of arable land (Xiao, Li, Xiao, & Liu, 2007)
	Flood factor	1. Flood damage	Economic damage caused by floods
		2. Proportional area of flooding	Flooding area/Total area (Xiao, Li, Xiao, & Liu, 2007)
		3. Flood occurrence frequency	Number of flood occurrence per year (Koontanakulvong, Doungmanee, & Hoisungwan, 2013)
		4. Percentage of population living in hazard-prone areas	Population living in hazard-prone areas/Total population (Mehr, 2011)
		5. Flood control capacity	Ratio of the water reserved in dams at the end of the year to the total water utilization (Xiao, Li, Xiao, & Liu, 2007)
Watershed health	Health of water bodies	1. Surface water quality factor	Dissolved oxygen concentration/Permissible limit
		2. Groundwater quality factor	Concentration of site-specific pollutants /Permissible limits of these pollutants
		3. Average class water quality rivers	Country-specific conditions (ADB, 2013)
		4. Biochemical oxygen demand (BOD) in water bodies	BOD 5-day values of river water samples. (Mehr, 2011)
	Vegetation cover	Natural vegetation factor	Natural vegetation area/Basin area
Water governance	Overall management of the water sector	Institution factor	Questionnaire
	Potential to adapt to future changes	Adaptability factor	Questionnaire

Source: Babel & Shinde (2018)

Table 2.4 Explanation of the water security index

Water Security Index Score	Water security condition	Description
1	Very poor	The basin is highly insecure with respect to most of the dimensions of water security. The basin is affected by severe water-related problems. Furthermore, the management and governance in the basin are inefficient.
2	Poor	The basin is insecure with respect to most of the dimensions of water security. The basin is affected by some water-related problems. The management and governance in the basin need improvement.
3	Average	The basin has mixed water security with respect to the dimensions of water security. There are patches of water-related problems in the basin. Governance and management instruments are in place but are still to yield the intended results.
4	Good	The basin is quite secure with respect to most of the dimensions of water security. There are hardly any water-related problems in the basin. The governance and management instruments are yielding most of the intended results.
5	Very good	The basin is highly secure with respect to all the dimensions of water security. There are no water-related problems in the basin. The governance and management instruments are yielding the intended results.

Source: Babel & Shinde (2018)

2.4 Context specific water security

The frameworks assessing water security mentioned earlier reveal the complexity of the concept and acknowledge the need for a cross-disciplinary approach to operationalizing such an elusive concept (Dickson et al., 2016; GWP, 2000; Norman et al., 2013; Octavianti & Staddon, 2021). Octavianti & Staddon (2021) reviewed about 80 water security assessment tools from publications, conceptual papers, and methodological papers and highlighted that many metrics are limited in application and usability by practitioners and decision-makers. On the one hand, it is difficult to include everything in one framework; on the other hand, the index can be biased towards specific water problems and interests. Water security assessment in practice is also challenging because it consists of several dimensions and multiple variables, which require data availability and regular monitoring. In addition to that, cross-country comparison of water security status is problematic because of the lack of a unified water security index. Another limitation of application of water security frameworks is an oversimplification of water-human-environment interlinkages (Cook & Bakker, 2012; Gerlak et al., 2018; Zeitoun et al., 2016). Therefore, operationalizing water security, including water security assessments, is still under discussion.

So, while it is understood that the idea of water security is broad and multi-disciplinary, during application and implementation stages, the concept of water security needs to be narrowed down and properly framed (Octavianti & Staddon, 2021; Scott et al., 2013; Stucki & Sojamo, 2012; Sun et al., 2016). Scholars and practitioners understood that inadequate metrics might derail policy interventions and the management of the problem. Implementing a broad water security concept at a national scale requires a context-sensitive water security assessment. Moreover, water security in practice includes implementation obstacles that require coordination, cooperation, and financial support makers (Dickson et al., 2016; Gaber et al., 2021; OECD, 2013). Consequently, robust water governance is critical in implementing a national water security strategy. Policy recommendations on strengthening water security are based on simplifying water-human-economy-environment links and risk analysis to define 'security through certainty' (Zeitoun et al., 2016). Maintaining water security depends on adaptive governance, including adaptive capacity, resilience, and capacity building (Akamani, 2016; Norman et al., 2013; UN Water, 2013).

Water security is framed, defined, and measured differently across geographical regions depending on the context (Cook & Bakker, 2012; Gaber et al., 2021; Gerlak et al., 2018; Holmatov et al., 2017; Norman et al., 2013; Sun et al., 2016). Most studies about water security are case-study research, and policy recommendations are context-specific. Since water security is context-specific, each country sets different water security priorities. For example, water security priorities differ among water-rich and water-scarce countries. Water security assessments vary because of hydrological characteristics, geographical and climate conditions, and water needs and demands.

Studies on water security in East Asia are associated with cities, in Australia with water quantity and availability because of an arid climate, in North Africa, and Middle East regions link water security with geopolitical issues at a national scale (Cook & Bakker, 2012; OECD, 2013; Zeitoun et al., 2016). The US Environmental Protection Agency prioritizes drinking water supply and infrastructure security. In the case of China, water availability and water pollution are critical dimensions of water security because of high population density and industrial development (Sun et al., 2016). According to the analysis of Octavianti & Staddon (2021), China is one of the most famous case studies because of growing concerns on water security at the country level. However, most of them are in the Chinese language. These examples show high variation in framing water security among different regions because of "*institutional agendas, programmatic objectives, disciplinary approaches, theoretical learning, political preferences, views of justice and equity, and geographical settings*" (Gerlak et al., 2018, p.86). However, the dominant formulation of water security remains in terms of *water scarcity in relation to water demand* in many regions. According to Octavianti & Staddon (2021), future studies on water security assessment might show the impact of water insecurity on other sectors and areas to show the importance of improving water security. They also suggested evaluating water security in specific locations to reveal and manage water security challenges in particular areas. Local understanding of water security perceptions might help conceptualize water security at the national level (Zeitoun et al., 2016).

Water has always been a critical driver for economic development and livelihood in Central Asia. The importance of water security issues in Central Asia involves political and economic aspects in terms of a common history as a part of the Soviet Union, then building independent states with interdependent water infrastructure. After the collapse of the USSR, Central Asia countries moved from regional development to national strategies (Abdullaev et al., 2019; Stucki & Sojamo, 2012; Wegerich, 2011). Several studies noted that in the post- Soviet time, Central Asia countries were restructuring national priorities, and water security has become an increasingly salient issue based on technical (engineering) solutions due to financial difficulties, social instability, and policy uncertainties (Abdullaev & Rakhmatullaev, 2016; Djanibekov et al., 2013; Granit et al., 2012; Guillaume et al., 2015). However, the engineering approach of water professionals for water allocation and discharges is still dominant in the region.

Water security in Central Asia is often interpreted as a sufficient quantity of water is available and accessible in inadequate supply. For example, scholars used water scarcity, the ratio between water withdrawal and water availability, as indicators in analyzing river basin vulnerability in Central Asia (Varis & Kummu, 2012). The analysis of physical water scarcity as a function of water shortage and water stress revealed water overuse and high-water consumption in the region (Porkka et al., 2012). The analysis of water security from the water management angle revealed the following problems: the existence of an inefficient agricultural sector, which is, indeed, the primary water user; the presence of industrial waste that may impact the level of pollution of transboundary rivers, and, finally, the poor governance and the politics of water policy in Central Asia (Amirova et al., 2019; Djanibekov et al., 2013; Karatayev et al., 2017; Krasznai, 2019; Stucki & Sojamo, 2012). In addition to unequal water distribution, institutional mechanisms to ensure water security in the region are weak. Studies also stated that Central Asia countries often meet and discuss water issues in various platforms promoted mainly by international donor organizations but fail to come up with agreements—which inevitably leads to problems of cooperation, implementation, and coordination (Zakhirova, 2013; Ziganshina & Janusz-Pawletta, 2020). As Mirumachi (2013) stated, the main challenge of transboundary water security is a political question about water allocation and reallocation; however, transboundary river basin organization and cooperation agreement do not necessarily lead to better water allocation.

Scholars discuss the obstacles in achieving water security in the region, such as poor water governance, lack of regional coordination, and weak institutions in the water sector (Himes, 2017; Krasznai, 2019; Sehring et al., 2019; Stucki & Sojamo, 2012). The aspect of water governance received the lowest attention from scholars in the context of water security in the Central Asia region and Afghanistan. Water management differs among Central Asia countries in administration and planning, complicating regional coordination on water issues (Abdullaev et al., 2019; Sehring et al., 2019, 2021). For example, the Committee of water resources is responsible for water policy in Kazakhstan, the Ministry of water resources in Uzbekistan, the Agency of water resources in Kyrgyzstan, and others. Water resources management also varies regarding hydraulic boundaries (river basins) in Kazakhstan, irrigation systems in Uzbekistan, and administrative boundaries in Kyrgyzstan. Water governance's path-dependency from the Soviet Union is reflected in national water legacies and centralized water bureaucracy (Abdolvand et al., 2015; Sehring et al., 2021; Wegerich, 2011). Hence, fragmented national water governance in countries complicates water resources management and achieving water security in Central Asia. Furthermore, regional organizations responsible for water cooperation were criticized for promoting the national water agenda where they are located (Allouche, 2007; Himes, 2017). Studies also stated that Central Asia countries often meet and discuss water issues in various platforms promoted mainly by international donor organizations but fail to come up with agreements—which inevitably leads to problems of cooperation, implementation, and coordination (Zakhirova, 2013; Ziganshina & Janusz-Pawletta, 2020). Moreover, many water management organizations in Central Asia share common challenges: limited funding, insufficient human capacity, aging water infrastructure, and others (Abdolvand et al., 2015; Abdullaev et al., 2019; Amirova et al., 2019). Moreover, the relevant literature emphasized brain drain, generational knowledge gap, lack of engineers and researchers in the water sector (Abdolvand et al., 2015; Sehring, 2020).

While policymakers and scholars alike have been aware of the saliency of water security issues, little progress has been made as to how such a question could be addressed. Worse, policymakers' decisions (or lack thereof) do not seem to reflect the lessons learned in the scholarly literature adequately. To some extent, this suboptimal communication between politicians and scholars demonstrates that water security is a broad phenomenon with several different aspects and subdimensions. Despite the many metrics and indexes devised to measure water security, there is not yet much consensus on how water security should be measured or the best way to do so in the context of Central Asia. Assessment of water security perceptions and their understanding in the Central Asia context remains a relatively understudied area of scholarly inquiry. In addition to that, the interpretation of water security in transboundary basins is overlooked because of the difficulty of achieving a common water security strategy (Albrecht et al., 2018; Mirumachi, 2013; Tortajada & Fernandez, 2018). The case of Central Asia could be a case of transboundary river basins.

Chapter 3

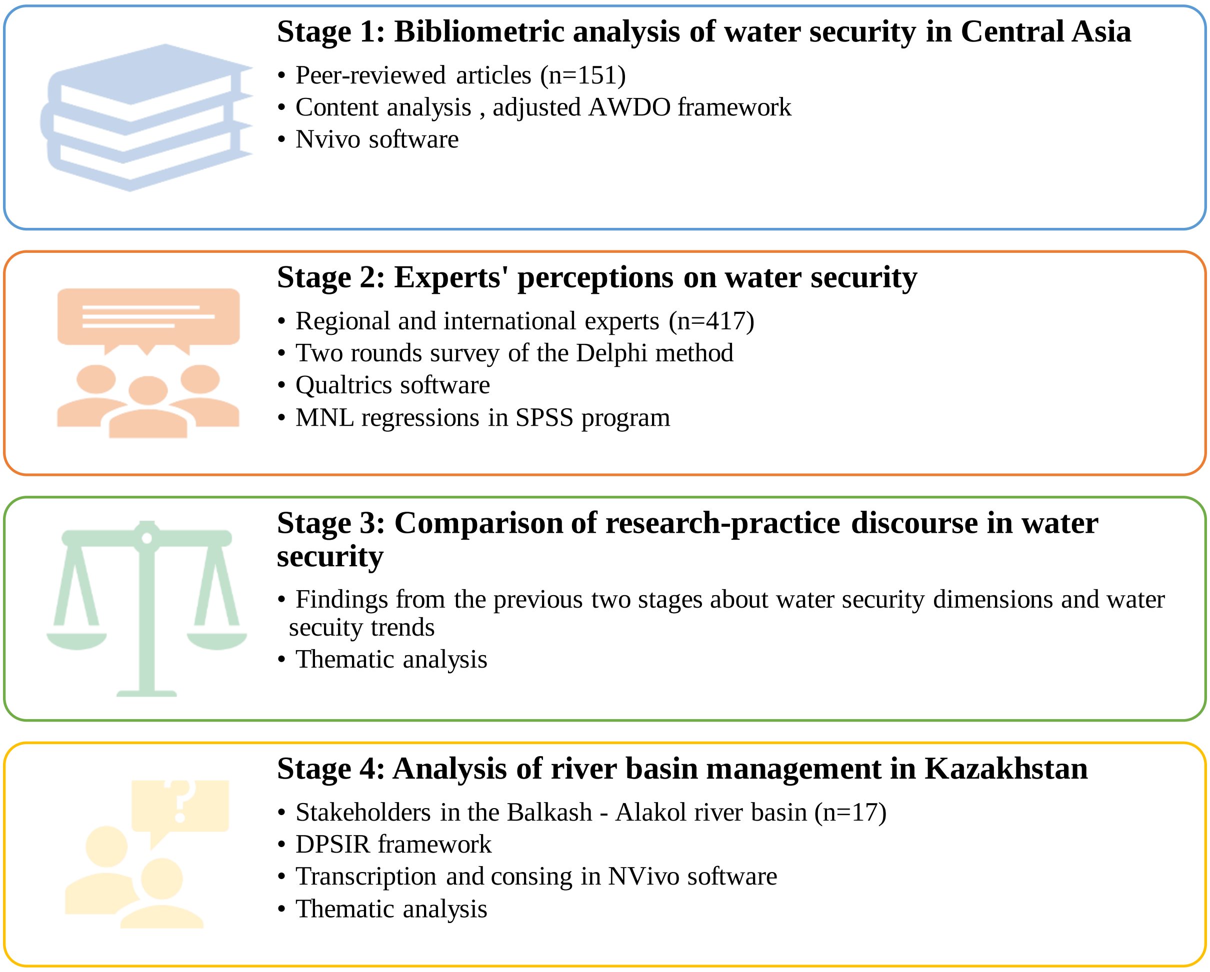
Data and Methodology

3 DATA AND METHODOLOGY

Mixed method research design helps to explore the research inquiry by combining quantitative and qualitative research methods. Since the 1980s, mixed methods have gained popularity among scholars studying social and human sciences (Bowen et al., 2017; Bryman, 2016; Creswell, 2014; Ivankova et al., 2006). Mixed methods are based on a pragmatic paradigm by synthesizing the quantitative and qualitative methods and triangulating findings. This thesis applied the exploratory sequential mixed method, meaning data collection and analysis are conducted in phases, including quantitative and qualitative research methods.

Four stages of the thesis's exploratory sequential mixed method design are illustrated in Figure 3.1. In the first phase, peer-reviewed journal articles discussing water security aspects in Central Asia were collected, then coded using the NVivo qualitative software and analyzed with content analysis to identify water security trends. The second stage included a survey with two rounds of the Delphi method to explore perceptions and opinions about water security among regional and international experts and practitioners using the Qualtrics software. Additionally, descriptive and inferential statistics were conducted using the MNL regression in the SPSS program. In the third phase, I compared findings of the previous two stages about water security trends and ranking of water security dimensions suggested by scholars and practitioners. Finally, the last stage consisted of qualitative semi-structured interviews with relevant stakeholders about river basin management in Kazakhstan. The thematic analysis of semi-structured interviews was transcribed and coded using the NVivo software. Four stages were conducted separately in sequence, but all stages were interconnected. Each part of the research methodology, including data collection, sampling, and data analysis, is discussed in detail in the following sub-sections.

Figure 3.1 Exploratory sequential research design



3.1 Stage 1: Bibliometric analysis of water security in Central Asia

This dissertation synthesized academic literature about water security to reveal water security interpretations in Central Asia. The methodology of the first stage is the continuation of the bibliometric review developed by Xenarios et al. (2019) and elaborated by Xenarios et al. (2020). The bibliometric analysis represents a systematic analysis of scholarly literature when the scope of research is broad and the dataset is large (Donthu et al., 2021). The bibliometric study aimed to investigate widely discussed aspects of water security and overlooked dimensions of water security in the transboundary basin of Central Asia. The qualitative content analysis represents the analysis of the text and documents coded systematically using the predefined categories (Bryman, 2016; Creswell, 2014). The content analysis's systematic coding allows conducting accurate inferences about overstudied or understudied topics.

The coding categories were based on the adjusted AWDO (2016) framework. According to AWDO (2013, 2016, 2020), the national water security index consists of five interconnected dimensions (discussed in 0). In the thesis, household & urban water security dimensions were merged due to the high concurrence of common aspects, for example, water supply systems, drinking water, and other indicators. The dimension 'resilience to water-related disasters' refers to natural hazards: floods, droughts, avalanches, and landslides. Overall, four dimensions of water security consisted of essential factors, i.e., attributes or indicators, which were formulated based on the AWDO framework, communication with scholars, and the NVivo word frequency assessment.

Three layers of the literature search are summarized in Table 3.1. The first layer of the Boolean search aimed to collect papers by phasing 'water security in Central Asia.' The next layer focused on countries individually, for example, 'water security Kazakhstan' and for each country accordingly. Articles from the second layer were double-checked with the previous layer to prevent double counting. The third layer was the country and topic specific. Overall, sixteen keywords, four factors for each dimension, were traced to all six countries. The household & urban water security dimension included the following attributes: sanitation, SDG-6, drinking water, and wastewater outlined for each country, for instance, 'Sanitation Kyrgyzstan,' 'SDG- 6 Afghanistan,' and so on for other Central Asia countries. Important factors influencing economic water security were irrigation, hydropower, industry, and WEF nexus, which were also traced for six countries individually. The environmental dimension included lakes, ecosystems, rivers, and mountains. The attributes of the hazards dimension were discussed in the previous paragraph. Articles were traced with a multilayer search in the Scopus and the Web of Sciences Databases. Articles were also verified with additional sources, such as the Nazarbayev University Library Search Database linked with worldwide publications on various subjects, including literature about water resources.

Table 3.1 Boolean search of water security literature

First layer	*Second layer*	*Third layer*
Context specific	**Country specific**	**Country specific and topic specific**
Water security in Central Asia	Water security in Afghanistan Water security in Kazakhstan Water security in Kyrgyzstan Water security in Tajikistan Water security in Turkmenistan Water security in Uzbekistan	Household & urban dimension: sanitation, drinking water, SDG6, wastewater Economic dimension: irrigation, hydropower, industry, WEF nexus Environmental dimension: rivers, lakes, ecosystems, mountains Water-related hazards: droughts, floods, landslides, avalanches **for each country*

The Russian language is more dominant than English in Central Asia; however, few articles in the Russian language are published in peer-reviewed journals. Moreover, it was noticed that some studies were also published in English in international peer-reviewed journals due to higher accreditation, wider dissemination, and readability. Therefore, papers only in the English language published in peer-reviewed journals were considered in this study. The academic literature in peer-reviewed journals was traced to avoid unnecessary duplication with book chapters, reports, conference papers, and media articles. Temporal restriction from 1991 to 2020 was imposed, revealing the evolution of water security perceptions in Central Asia after the USSR's dissolution. Another criterion in the search was the geographical one, which includes five Central Asia countries and Afghanistan, which shares transboundary rivers with Turkmenistan, Uzbekistan, and Tajikistan.

Papers were systematically coded and explored with NVivo data analysis software, which has helped researchers since 1999 to sort, analyze, evaluate, and visualize data in various formats (text, audio, images, and others). NVivo software offers advanced data management techniques to process information, understand key concepts, and find patterns and trends than other qualitative software. Coding sources to various themes/categories in NVivo software can be done with theme nodes and case nodes. A collection of references about a specific theme is presented as a node. In this thesis, theme nodes represent different dimensions of water security. Consequently, sixteen coding nodes, four attributes for each dimension, were created. Each paper can be coded several times in different subcategories (attributes). There are several ways to code data to a node, such as manually reading each article and creating nodes, auto coding, and query-based coding by uploading node classification into dimensions and keywords and sorting articles to this classification. This thesis coded dimensions and attributes with query-based and manual coding.

Coding helped identify the number of sources (articles) and word frequency for each dimension and individually for each subcategory (attributes). Coding in the reference list of each article was omitted. Another NVivo tool called matrix coding query was applied to cross-tabulate the coded content, identify which themes were underrepresented and find research gaps. Also, cross-tabulation tools were used to assess whether the same literature discussed more than one dimension. The contextual analysis was conducted regarding how water security dimensions and attributes were discussed in the literature. Articles were also classified into organizations, countries, and disciplines of the published journals based on information about the lead author. The SCImago Journal & Country Rank was used to define each journal's fields and group them into physical science, social science, life, and applied science to estimate the distribution of each group. The most frequently published journals among the relevant literature were identified. The analysis provided an overview of researchers' background discussing water security issues in Central Asia.

3.2 Stage 2: Experts' perceptions on water security

3.2.1 Description of the Delphi method

The Delphi method was applied to identify how regional and international water experts and practitioners perceive water security in the region after conducting the content analysis of academic literature about water security in Central Asia. The Delphi method is a group communication technique aiming to achieve a consensus among experts on specific issues (Belton et al., 2019; Okoli & Pawlowski, 2004). The Rand Corporation initiated the Delphi method to study the sensitive problems in the military sector. Since then, the Delphi approach has been widely used as an experts' communication tool to find a consensus on specific topics in medicine (Beattie & Mackway-Jones, 2004; Macdonald et al., 2000; Normand et al., 1998), education (Calabor et al., 2019; Green, 2014; Urias et al., 2020), environmental sciences including water resources (Ameyaw & Chan, 2015; Birko et al., 2015; Martínez-Paz et al., 2016), marketing (Jolson & Rossow, 1971; Larreche & Montgomery, 1977) and other.

Scholars classified studies applying the Delphi method into several groups. Avella (2016) categorized the Delphi method into policy Delphi for policy analysis and policy formulation, classical Delphi for predicting and estimating future trends, and decision-making Delphi for developing scenarios for better decision making. Researchers also differentiate the application of the Delphi method according to the design into Delphi (traditional or conventional Delphi) and modified (or fuzzy) Delphi (Gnatzy et al., 2011). Conventional Delphi starts with open questions where panelists offer their suggestions, while in modified Delphi, facilitators provide initial options on research questions based on literature review or previous study. Consequently, conventional Delphi collects all possible responses and provides the most frequent one on the next round to gain agreement among panel members. In the case of modified Delphi, researchers suggest a list of alternatives derived from the literature or previous study and ask participants to rate these alternatives based on the specific criterion and add others according to their expertise and experience. Hence, in modified Delphi, the first round begins with experts' assessment of pre-selected topics. The choice among different Delphi types is based on study's objectives, design, and implementation (Avella, 2016; Belton et al., 2019; Markmann et al., 2021; Okoli & Pawlowski, 2004).

Delphi was conducted through postal mail in the past. Nowadays, researchers use email distribution and online survey platforms for the Delphi study administration. Moreover, specific online platforms were created for conducting Delphi: eDelphi, Welphi, Mesydel, and others. Online platforms could speed up the process, gather more information, increase the response rate, and help with data analysis (Belton et al., 2019; Markmann et al., 2021). However, using software should ensure the anonymity and confidentiality of panelists (Avella, 2016). Online platforms and online questionnaires should be user-friendly and allow respondents with any computer skills to participate in the study (Belton et al., 2019). There are also online real-time Delphi and conventional round-based Delphi. Panelists respond to the questionnaire during the online real-time, facilitators immediately receive interim results, and then questions about a reassessment of the initial response follow. Comparing conventional round-based Delphi and online real-time Delphi reveals that panelists spend less time participating in the Delphi study. Researchers might receive a high response rate and increase efficiency in questionnaire administration in online real-time Delphi (Gnatzy et al., 2011). Conducting a Delphi study can take several months since, after each round, researchers/facilitators should analyze data and develop the next round of the questionnaire.

As with other group communication methods such as surveys, interviews, and focus groups, the Delphi approach relies on respondents' opinions. There are certain advantages of the Delphi method, which differ from other methods. The Delphi study is created as an anonymous questionnaire as a traditional survey. The sample size plays an important role; however, experts' knowledge and expertise play a more critical role in the Delphi method than sample representativeness. Moreover, the traditional survey can be criticized for subjective judgments, low validity, and sample representativeness. Participants' opinion in surveys is an aggregation of knowledge based on evidence and experience and speculation by guessing (Avella, 2016). The Delphi method usually consists of several rounds to minimize subjective results and homogenous or professional bias (Gnatzy et al., 2011; Hsu, 2007; Yousuf, 2007). Moreover, the Delphi study offers feedback after each round of surveys and anonymous iteration between participants. Hence, the Delphi study differs from traditional surveys regarding several rounds of the questionnaire, sample representativeness, and group judgment rather than relying on individual responses. Delphi differs from focus groups in terms of the absence of group pressure towards consensus, groupthink in specific directions, bandwagon effect, and dominance of certain individuals, allowing participants to answer independently, openly, and critically.

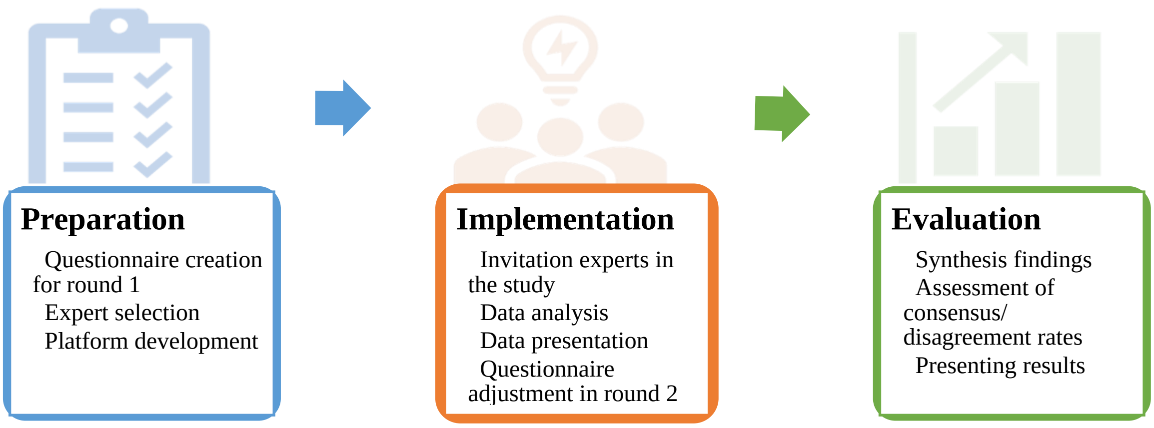
Even though interviews provide in-depth and valuable information, interviews are time-consuming to find interviewees, organize discussions, and analyze data. The Delphi method is also a time-demanding method to run several rounds of the questionnaire; however, this approach offers an agreement among experts without time and space limitations. Moreover, facilitators invite many experts with the Delphi rather than contacting each expert to conduct interviews. The Delphi method was chosen instead of a traditional survey, interviews, and focus group since the thesis aimed to explore the water security perceptions of experts and reach the agreement rate among regional and international experts of water security dimensions and priorities in Central Asia. The Delphi method was applied since it is a systematic, iterative forecasting method that relies on experts' opinions and expertise.

Based on a comparison of Delphi from other group communication methods, the following key features of Delphi can be highlighted such as anonymity of respondents, especially on sensitive issues, controlled and iterative feedback, independent responses without groupthink, heterogeneity of experts to elicit the opinion of various experts, and time and geographic flexibility for participants (Avella, 2016; Belton et al., 2019; Gnatzy et al., 2011; Okoli & Pawlowski, 2004). The Delphi approach has limitations, as do all research methods. Avella (2016) discussed researcher bias in formulating questions and selecting panel members, especially Delphi's modified design. Okoli & Pawlowski (2004) mentioned that anonymity could lead to irresponsible responses and professional bias if experts are professionals from similar areas. On the other hand, a heterogeneous group of participants requires more rounds to reach a consensus. Hsu (2007) and well as Yousuf (2007) pointed out Delphi results' subjectivity and increased risks of low response rate. Therefore, the Delphi study's success depends on participants' expertise and the willingness to participate in several rounds (Gnatzy et al., 2011).

3.2.2 Delphi research design

Delphi design in this thesis consists of three phases: preparation, implementation, and evaluation. The preparation phase includes defining the criteria for panel member selection, establishing a Delphi panel, developing the questionnaire, choosing the platform, and piloting the questionnaire. The implementation or execution phase consists of several rounds of Delphi, aggregation and data analysis, and feedback provision before each round. Finally, researchers synthesize data, examine, and present the Delphi study results at the evaluation phase.

Figure 3.2 Delphi research design



Preparation phase

Panel members play a crucial role in the Delphi study. Panelists should be experts with the required qualifications, expertise, and interest in the investigated research question. Criterion should be specific and measurable for panel member inclusion and not based on researcher opinion (Avella, 2016). Mauksch et al. (2020) discussed the advantages and limitations of experts' identification methods for foresight studies such as peer nomination, selection based on specific criteria (past performance, verifiable knowledge, publication, job position), self-assessment of expertise, and knowledge tests, where experts' opinions play a crucial role. According to Belton et al. (2019), researchers should select expert inclusion benchmarks to use common sense. Expert selection in this study is based on externally available criteria such as job position, publication, past performance, and membership of specific organizations and institutions associated with water resources in Central Asia and Afghanistan. This approach allows including a wide range of experts because of information available on the internet and verifying information but might omit some experts in the field and retired experienced experts (Mauksch et al., 2020). Experts from the region and international experts with expertise and experience in the region's water sector were invited, giving panel members geographical dispersion.

The experts' optimal size depends on Delphi study type and goals and participants' homogeneity (Okoli & Pawlowski, 2004). There is still an ongoing discussion in the literature on the size of the panel. As Avella (2016) pointed out, there are no standards on small and large panel sizes. The panel members can be separated into several groups for comparing the consensus among different groups. Belton et al. (2019) recommended having a heterogeneous group to avoid homogeneous/ professional bias and represent opinion diversity. Most Delphi studies apply purposive, convenient, and snowball sampling rather than random sampling because studies are interested in the opinion of the targeted group of population.

The study's respondents represent a diverse and multidisciplinary group selected with purposive sampling based on their pertinence to water resources management in the region. In particular, the respondents originate from Central Asia, Afghanistan, and abroad. They have appropriate knowledge and experience in the following areas: water resources, agriculture, climate change, hazards management, economics, international relations, and public policy. The respondents were identified through various sources: web searches, media, research articles, social media, professional organization listings, and the lists of regional and international conferences, seminars, and round tables. Overall, 417 experts were invited to participate in the Delphi surveys.

Questionnaire design plays a crucial role in the Delphi study. The questions should be framed clearly and precisely and must be quantifiable (Calabor et al., 2019). The survey can consist of open and closed questions with panel members' options to comment and justify their opinion. Belton et al. (2019) recommended splitting the topic of the Delphi study into subtopics and asking questions in a logical order for better understanding. The types of response options can be divided into ordinal (including the rank-ordered responses, Likert- type scale), categorical (including Yes/No options), and interval scales. The number of response options varies from five to nine in the Delphi studies, depending on the questions. Markmann et al. (2021) suggested developing questions with examples where abstract concepts are applied. Notably, in the Delphi studies, the ideational language in formulating questions might cause various interpretations and, hence, a more significant respondents' variance. Consequently, concrete questions increase the reliability of responses or provide definitions for some abstract and complex concepts (Markmann et al., 2021).

The Delphi survey in this study consisted of two sequential rounds. Each questionnaire consisted of two parts: the central section - questions on water security and the supplementary section - demographic questions. The section of the main questions is divided into five subsections, including questions on (1) relevance of water security dimensions in Central Asia and Afghanistan, (2) factors of each water security dimension, (3) historic water security trends, (4) ranking of water security factors related with each Central Asia countries and Afghanistan, (5) assessment of existing organizations and mechanisms in connection with water security aspects in the region. The demographic section included questions about gender, age, education, citizenship, employment, and experience in the water sector. All questions had multiple choice answers, including internal, ordinal, or categorical scales. The questions in the central part had an in-text option where experts could comment and introduce new aspects or add some explanatory text. The proposed water security dimensions and attributes in Central Asia are obtained from the literature analysis and from Xenarios et al. (2020). Water security trends derived from the relevant literature were presented in two figures in the questionnaire. The demographic questions had multiple-choice answers to comment and add the missing information. Experts had a choice to answer the survey either in English or Russian in both rounds. The summary of questionnaires of the 1st and 2nd rounds is attached in Annex 1.

After the first round, the interim outcomes were developed and shared among experts in the next round of the questionnaire. In round two, a summary of experts and results of the first round were introduced. The main objective of the second round was to reach a consensus on the water security issues (1-5) mentioned earlier among experts either by consenting or objecting to the results collected from the first round. Indicatively, in the first round, participants were asked to rate the relevance of water security dimensions in the context of Central Asia and Afghanistan and rank them according to their expertise and experience. In the second round, experts were asked whether they agree/disagree with the previous round ranking based on the group opinion. Another example is ranking relevance of factors of water security dimensions. In the first round, experts were asked to rate the relevance of different factors (four factors for each dimension) in Central Asia. In the second round, the question was whether experts consent or oppose the findings from the first round.

The Qualtrics software was chosen to conduct the Delphi method, including two rounds and two languages. Qualtrics is a cloud-based software powered by artificial intelligence and machine learning. The software is widely used for marketing analysis, experience management, and academic research. Qualtrics offers diverse question types, the opportunity to collaborate and work on the same project simultaneously, a comfortable and user-friendly interface, and reporting and data analysis tools. I applied advanced distribution functions to disseminate the survey through email, social media, anonymous links, schedule reminders, and avoid duplicate invitations. Data and analysis options were also used to develop reports, download data in different forms, and present data using various visualization tools.

Implementation phase

Researchers conducting Delphi studies should be neutral facilitators. In this study, two facilitators (me and supervisor) were involved in developing the questionnaires, running the Delphi, and communicating with panel members. Complete anonymity and confidentiality of panel members were ensured. Panel members did not know about the participation of other respondents in the survey promoting individual and critical responses. Another crucial feature of Delphi studies is iterative feedback. Researchers/facilitators share the anonymous summary of the initial questionnaire with panel members. Researchers should develop a new questionnaire based on previous iterations called rounds until reaching an agreement among panel members on specific issues (Avella, 2016). It is crucial that after the initial questionnaire, researchers ask panelists whether they agree or oppose the results from the initial questionnaire. Iterative feedback after each round informs panel members and facilitates achieving agreement. Without iterative feedback, Delphi studies might become traditional surveys collecting individual opinions.

The number of rounds of the Delphi studies has been debated in the literature (Aichholzer, 2009; Calabor et al., 2019; Green, 2014; Markmann et al., 2021). Since the Delphi studies' primary goal is to reach a consensus among panel members, it may take several rounds. The number of rounds depends on the consensus rate, and the issue of consensus rate is not uniquely determined and is widely discussed among scholars. Belton et al. (2019) emphasized analyzing response stability on a round-by-round basis. With each additional round, the number of participants and hence diversity of opinions decrease. Therefore, two or three rounds of Delphi studies are frequently suggested.

After each round, researchers process the initial questionnaire and distribute a summary where panel members remain anonymous. At each round, panelists have a chance to comment, provide feedback, and justify their position. Sending individual invitations may increase the participation rate rather than sharing a link for a webpage/ survey (Belton et al., 2019; Urias et al., 2020). Statistical summary in the form of central tendency measures (mode, median, and means) and the dispersion level (standard deviation) are the most used for analyzing each stage's questionnaires. At the same time, any indicator of majority opinion may cause opinion change towards majority opinion. Hence, the numerical information on most panel members' responses should be limited and avoided (Belton et al., 2019; Martínez-Paz et al., 2016).

Two sequential rounds were conducted in June-October 2020. The questionnaire was developed in English and then translated to Russian, commonly used in Central Asia for negotiations, education, and trade. Individual email invitations were sent via Qualtrics Software. The first invitations to experts were disseminated in June 2020, followed by two reminders in the next two weeks. Experts were invited to the second round in September 2020, followed by two reminders. However, before the questionnaire distribution, each questionnaire was piloted with three experts in the English and Russian languages. The Graduate School of Public Policy Institutional Research Ethics Committee approval was received in February 2020 for conducting the research.

The evaluation phase has been discussed below, including synthesis findings, of consensus/ disagreement rates assessment, and statistical analysis of results.

3.2.3 Analysis of Delphi's findings

The Delphi approach assists in defining the likelihood of forecasting future events and trends. Delphi studies' main goal is to identify areas where panel members agreed. Scholars suggested some threshold for reaching an agreement. For example, Avella (2016) mentioned 70% as a standard for agreement rate, varying from 55% to 100%. Agreement aggregation is defined as the average value of all experts' opinions. There is still an ongoing discussion in the literature on whether each expert should have equal weight or some experts should have higher based on experience and knowledge. The agreement rate increases with each additional round, but there are growing risks on a low number of responses. Moreover, some studies might not reach a high consensus but help identify specific opinion trends and directions, such as in policy Delphi when various alternatives are evaluated by panelists (Belton et al., 2019; Okoli & Pawlowski, 2004). The Delphi results can be analyzed using descriptive statistics, inferential statistics, and content analysis (Belton et al., 2019; Green, 2014; Macdonald et al., 2000; Markmann et al., 2021). All three method were applied for data analysis.

Descriptive statistics

Delphi results are presented in a comparison table to reveal any changes and developments from the first and second rounds. Descriptive statistics about experts' backgrounds consisted of information about age, gender, education, occupation, residence, and working experience. A cross-tabulation analysis was conducted to evaluate the relationship between the demographic profile of panel members and their assessment of water security dimensions and country priorities. The cross-tabulation report represented a two-dimensional table showing the interrelation between two variables. The columns consisted of four water security dimensions with rankings (low, moderate, high). While the rows included the demographic profile of respondents: age, experience, education, employment, and residence. The row percentages were chosen to calculate the proportion of respondents in a column category from the total counts in the row. Hence, each dimension with three rankings constitutes 100% in each row. Even though the cross-tabulation is a descriptive analysis, it helps identify relationships and patterns in the data. The experts' comments on dimensions, factors, and priorities in both rounds are discussed in the Discussion part. Comments and suggestions of experts were analyzed using qualitative content analysis. Suggestions of experts in Russian were translated into English. Comments were collected and grouped into subcategories, which might give valuable insights into understanding water security perceptions among experts.

Inferential statistics

Multinomial logistic (MNL) regression was used to test whether the demographic profile of experts (independent variables) affects water security dimensions and priorities (dependent variables) with more than two categories. The dependent variable can be nominal and ordinal with several categories but not continuous variables. If the dependent variable is ordinal, then MNL regression omits the information about the ranking. MNL regression uses maximum likelihood (ML) estimation to define logit coefficients since the dependent variable is converted to a logit variable. Therefore, MNL regression assesses changes in the log-odds of the dependent variable rather than a linear change of the dependent variable as occurs in ordinary least squares (OLS) regression (Garson, 2019; Tabachnick et al., 2007). If the OLS estimator minimizes the sum of squared distances of data points along the regression line, then ML estimation maximizes the log-likelihood and determines how likely observed data in independent variables could predict dependent variables.

Some strict OLS assumptions are not required in logistic regression, such as the linear relationship between dependent and predictors, normal distribution of dependent variable and error terms, and homoscedasticity. However, several assumptions shall be held to run MNL regression and to calculate unbiased estimators (Garson, 2019; Tabachnick et al., 2007):

Assumption #1: the dependent variable should have a nominal or categorical data level with several categories. In this study, the dependent variables are water security dimensions and water security priorities for each Central Asia country, which are categorical variables and coded as 1- low, 2 – moderate, 3- high (details in Table 3.2).

Assumption #2: independent variables should be continuous, nominal, or categorical. This study's, five independent variables (age, education, experience, employment, and residence) are nominal with several categories.

Assumption #3: independent predictors and dependent variables require mutually exhaustive and exclusive categories. In the survey of this study, respondents might choose only one answer per question. If the respondent determined the highest ranking among answers, other answers are omitted.

Assumption #4: the absence of high or perfect multicollinearity. In this study, none of the predictors are a linear function of another predictor in the model, and there is no perfect correlation between independent variables, which were detected with high standard errors of logit parameters. Multicollinearity was tested with the variance inflation factor analysis, which was about four, meaning low multicollinearity if the variance inflation factor is greater than or equal to 4 in social science research (Garson, 2019).

Assumption #5: no outliers. The standardized residuals analysis was conducted to detect outliers, removed, or modeled separately.

Assumption #6: low error in the independent variables and no missing variables. This assumption is partially violated in this study since experts choose to skip questions; therefore, missing values exist in the dataset, and they were replaced by 999 in the SPSS. Moreover, SPSS computes the listwise deletion of cases with missing values uses only a complete dataset for logistic regression.

Assumption #7: the linear relationship between the independents' and the dependent's logit odds (logit). To satisfy this assumption, Garson (2019) suggested dividing independent variables into categories to calculate parameter estimates for each level of variables. In this study, independent variables are categorical (details in Table 3.2).

Assumption #8: large sample size. ML estimation depends on large-sample asymptotic normality, which implies low reliability of parameter estimates with decreased observed data in predictors. High standard errors may signal it. About 112 experts participated in the first round, which gives a good sample size.

The following logistic regression model is applied in this study:

$$z^{1} = b_0 + b_1 X_1 + b_2 X_2 + ... + b_k X_k$$

[1] where z is the log odds of the dependent variable = ln (odds(event)). Several dependent variables were tested separately, such as four water security dimensions and three different water security priorities for each Central Asia country;

where b_0 is the constant and b terms are the logistic regression coefficients (parameter estimates),

where k(s) are independent (X) variables. The following independent variables were tested: age, education, experience, employment, and residence (Garson, 2019; Tabachnick et al., 2007).

The impact of the predictor can be explained by logit coefficients, which are analogous to the beta coefficient in OLS in terms of odds ratios that measure the effect size. However, it is crucial to consider that logistic regression does not predict the dependent as the OLS regression. Standardized logit coefficients in MNL regression assess the independent variables' relative strength as in OLS, but interpretation differs. The standardized logit coefficients compare the relative significance of the predictors regarding the effect on the dependent variable's logged odds (Garson, 2020; Tabachnick et al., 2007). Therefore, odds ratios are preferred and may interpret: the constant effect of independent variables on the likelihood that one outcome will occur (Garson, 2020). Parameter estimates consist of information about the estimated MNL regression coefficients (B), the standard errors of the individual regression coefficients (Std. Error), the Wald chi-square test (testing the null hypothesis that the estimate equals zero), the degrees of freedom for each of the variables that are equal to 1, the *P*-values of the coefficients that were used to reject or accept the null hypothesis at $P<.10$, and the odds ratio (Exp (B)).

It is important to differentiate the values and the meaning of the MNL regression coefficients (B) and the odds ratios for the predictors (Exp (B)). Since OLS regression has a linear function, the change in the coefficient of independent variables is interpreted. However, logistic regressions have a logit function, and therefore changes in the log-odds should be considered. The odds ratio of the explanatory variables is the natural log base of the MNL regression coefficients. The values of the odds ratio have the following interpretations: if Exp (B)>1: predictor increases the logit and probability of odds (event); if Exp (B)=1: predictor has no effect; and if Exp (B)<1: predictor decreases the logit and probability of odds (event).

Several pseudo-R-square statistics in MNL regression attempt to evaluate the strength of the relationship between predictors and dependent variables as R-squared in OLS. The R-square in MNL regression increases with each additional independent variable as in multiple linear regression. Hence, R-square in MNL does not measure the percentage of variance explained, but the variance of the categorical dependent variable depends on the frequency distribution of that variable (Garson, 2020; Tabachnick et al., 2007). Therefore, R-square does not have the same explanation and power in MNL regression as in OLS. However, several pseudo-R-square attempts to measure only the strength of association, such as Cox and Snell, Nagelkerke, and McFadden in the ‘Pseudo R Square’ table. The values of these variables vary from 0 to 1 and should be interpreted with caution.

The likelihood ratio test can be used as a goodness-of-fit to test model appropriateness. The significant value can define the likelihood ratio test of the overall model in the Model Fitting Information. In this study, a P=.10 level or lower was chosen to define the well-fitting model meaning that the model is significantly better with independent variables than constant. The null hypothesis can be rejected if the predictors have zero effect on the dependent variable. If the likelihood test is significant, at least one of the independent variables is significantly related to the dependent variable. Still, it does not provide information on whether some independent variables are more important than others. SPSS presents the Goodness-of-Fit table with the Pearson statistic, similar to Chi-square and the Deviance, the likelihood ratio chi-square. Both tests give identical results on estimates of the overall model fit tests.

In MNL regression, reference categories in dependent and independent variables shall be accurately chosen since each category in the dependent variable will be compared with the reference category (Garson, 2019). The lowest (first) category in the dependent variable is chosen as the reference category in this analysis. MNL regression requires meaningful coding, i.e., the category of most significant interest shall have the highest/last category (Garson, 2019, 2020). For example, 1-low, 2-moderate, 3-high. Table 3.2 presents the initial values of variables and their coding in SPSS for running regressions. Each water security dimension (urban & household, economic, environmental, and hazards) was initially assessed by respondents from 1 to 10 (with ascending order) in terms of relevance in the regional context. Recoding was made to help the identification of potential effects of the independent variables through clustering; thus, they were grouped into low (1-4), moderate (5-7), and high (8-10) categories. Experts ranked water security priorities for each country. Initial values of water security priorities (1-4 with descending order) were transformed into low (3-4), moderate (2), and high (1). The demographic profile of experts consists of information about age, education, experience, employment, and residence. The age category was clustered into 18-34, 35-54, and 55 or older. The education category was transformed into experts with up to a master's degree and experts with Ph.D. The experience category was modified into beginners, experienced, and professionals. The employment category consists of two broad groups: university/ research institute and other. Experts were divided according to their residence into regional experts (five Central Asia countries and Afghanistan) and international experts (all other countries).

Table 3.2 Coding of variables

Variable	Initial Value	Coding
Water security dimensions		
Urban & Household	1-10 (ascending order)	1-4 => 1- low 5-7 => 2- moderate 8-10 => 3-high
Economic	1-10 (ascending order)	1-4 => 1- low 5-7 => 2- moderate 8-10 => 3-high
Environmental	1-10 (ascending order)	1-4 => 1- low 5-7 => 2- moderate 8-10 => 3-high
Hazards	1-10 (ascending order)	1-4 => 1- low 5-7 => 2- moderate 8-10 => 3-high
Water security priorities		
<u>Afghanistan</u> Mountain Conservation Hydropower Drinking Water Other	1-4 (descending order)	3-4 => 1-low 2 => 2-moderate 1=> 3- high
<u>Kazakhstan</u> River Basin Planning	1-4 (descending order)	3-4 => 1-low 2 => 2-moderate

Drinking Water Irrigation Other		1=> 3- high
Kyrgyzstan Hazards Plans for Landslides Drinking Water River Basin Planning Other	1-4 (descending order)	3-4 => 1-low 2 => 2-moderate 1=> 3- high
Tajikistan Irrigation River Basin Planning Droughts Management Plans Other	1-4 (descending order)	3-4 => 1-low 2 => 2-moderate 1=> 3- high
Turkmenistan Drinking Water River Basin Planning Droughts Management Plans Other	1-4 (descending order)	3-4 => 1-low 2 => 2-moderate 1=> 3- high
Uzbekistan Irrigation River Basin Planning Droughts Management Plans Other	1-4 (descending order)	3-4 => 1-low 2 => 2-moderate 1=> 3- high
Demographic profile		
Age	18 - 24 25 - 34 35 - 44 45 - 54 55 - 64 65 or older	18-34 => 1 35-54 => 2 55 and older=> 3
Education	College Bachelor’s degree Master’s degree Doctorate	Up to master’s degree => 1 Ph.D. => 2
Experience	1-2 years 3-5 years	1-5 years=> 1: beginners 6-15 years => 2: experienced

	6-10 years 11-15 years More than 15 years	more than 15 years => 3: senior professionals
Employment	University/Research Institute Government Agency International Organization Non-Governmental Organization Consultancy Firm Self-Employed Other	University/Research Institute => 1 All other => 2-Other
Residence	24 countries	Central Asia and Afghanistan => 1-regional Non-Central Asia and Afghanistan => 2 - international

3.3 Stage 3: Comparison of research-practice discourse in water security

The water security concept is broad and, consequently, people have different understandings of water security. In this regard, I compared the findings of the scholarly debate (stage 1) and practitioners' knowledge (stage 2) to reveal any research-practice gaps and similarities regarding understanding water security in the context of Central Asia. The bibliometric analysis of 151 peer-reviewed articles represented scholarly debate about water security dimensions and water security attributes. At the same time, findings of water security trends and country priorities were borrowed from the publications of Xenarios et al. (2020). The results of the two-round survey of the Delphi method presented the position of practitioners regarding the above-mentioned water security parameters.

Comparison of the backgrounds of scholars and practitioners was conducted; however, the analysis is limited regarding employment and regional distribution of scholars and practitioners. The employment category consisted of three broad groups: university & research institutes, associations/ networks/organizations, and companies/ consultancies. The comparison of regional distribution presented the country of origin of practitioners, which they mentioned in the survey. While the origin of scholars was based on information about the location of the university/ institute of the first author because information about the origin of authors is difficult to find and validate. This information could be misleading since several authors could write articles, and the location of the university/ institute does not provide information about the origin of scholars. The regional distribution category was divided into several groups: Centra Asia, Europe, USA, China, East Asia, Southeast Asia, and Afrika.

The findings on scholars' and practitioners' prioritization of water security dimensions were compared. The ranking of the literature review findings was based on coding, namely numbers of sources (articles), in the NVivo program. Respectively experts' opinions were based on results from the first and second rounds. Findings of water security attributes were based on coding results of the relevant literature. In contrast, results of the first round of the Delphi method in ranking water security attributes were applied. The historic water security trends and Central Asia country priorities in the relevant literature were borrowed from our publication on a bibliometric review where machine learning techniques were applied to identify trends (Xenarios et al., 2020). In comparison, practitioners' opinions about historic water security trends at the policy level and country priorities were taken from the first round of the survey. The comparison of academic and practice/ policy discourse might help to reveal similarities and research-policy gaps related to water security in Central Asia. The comparison of academic and practice/ policy discourse might be helpful to test hypotheses 2 and 3 of this thesis. However, the comparative analysis of academic and policy discourses was descriptive without additional empirical analysis of policy documents, reports, and briefs.

3.4 Stage 4: Analysis of river basin management in Kazakhstan

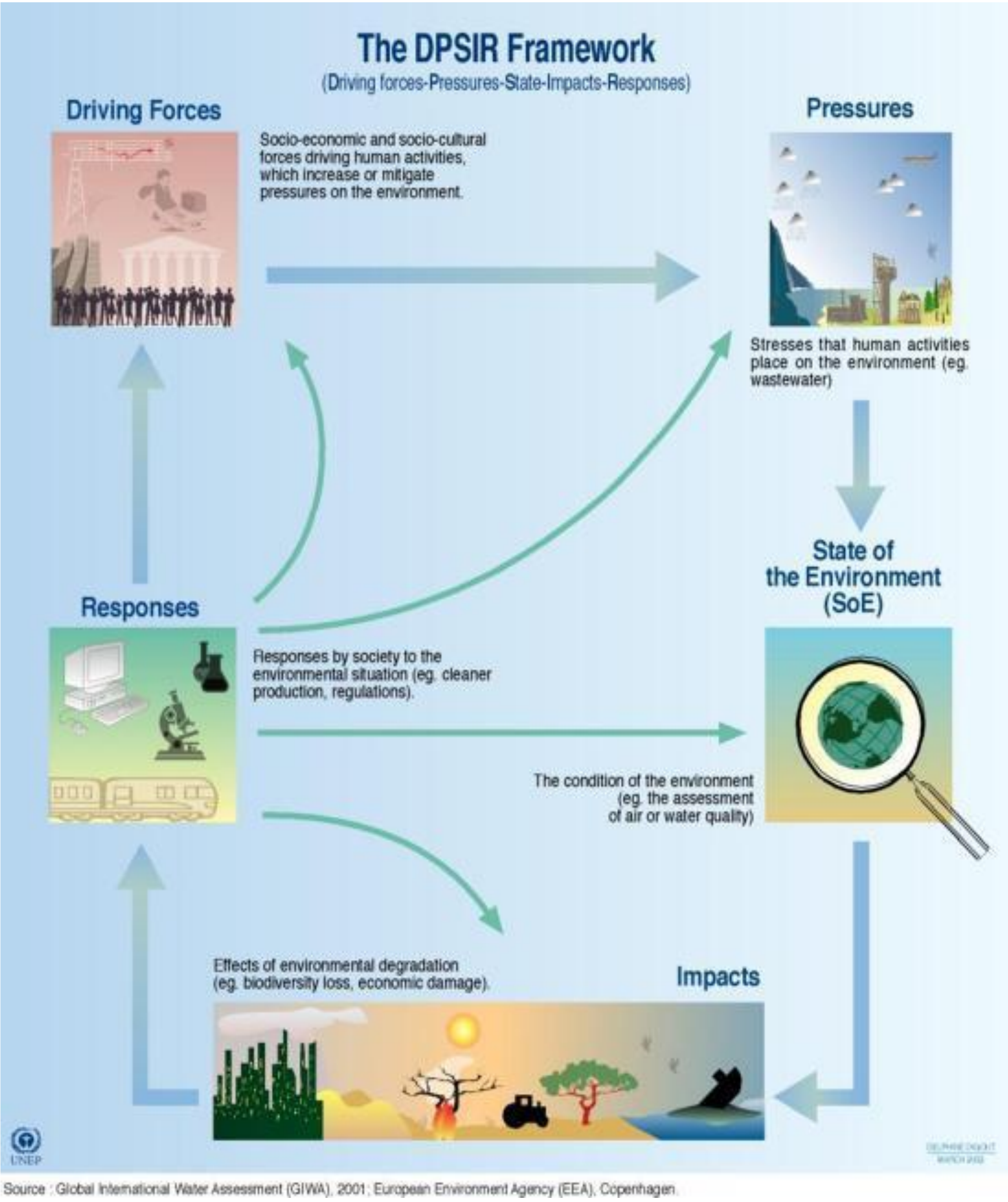
The content analysis of academic literature about water security issues in Central Asia and the Delphi survey with regional and international experts helped identify water security perceptions in the region and water security priorities for each Central Asia county. As a pilot study, I chose Kazakhstan, namely how identified water security priorities suggested by scholars and practitioners might help to strengthen water security in the country. I conducted semi-structured interviews using the DPSIR framework with relevant stakeholders in the BA river basin to explore to what extent river basin management can strengthen water security in Kazakhstan.

DPSIR framework

Semi-structured interviews were conducted using the DPSIR framework. The European Environment Agency, namely Smeets & Weterings (1999), suggested the DPSIR framework to understand the origin of environmental changes. The DPSIR framework helps define and analyze comprehensive causal interlinkages between the social and ecological systems. Since then, the framework has been widely used as an effective environmental policy communication, evaluation, and formulation tool (Tscherning et al., 2012). The DPSIR framework has been commonly used in various areas: water resources management (Pinto et al., 2013; Vannevel, 2018), the impact of the Water Framework Directive on European Union members (Borja et al., 2006), urbanization and environmental issues in Asian cities (Jago-on et al., 2009), evaluation of land degradation (Gessesew, 2017; Khajuria & Ravindranath, 2012), climate change and vulnerability assessment (Khajuria & Ravindranath, 2012), and biodiversity crisis (Omann et al., 2009).

The system analysis using the DPSIR framework consists of five interlinked elements: driving forces, pressures, state, impact, and response (Figure 3.3**Error! Reference source not found.**). These elements will be further discussed in the context of water resources. Driving forces include causes changes in water quality or quantity such as population increase, economic expansion, technological development, and lifestyle changes, including changes in consumption and production of goods and services. The central pressures in water resources consider urbanization, industrialization, and any activities that increase natural resources, emissions, waste, and urban, industrial, and agricultural pollution. Consequently, the state of water resources and the overall aquatic ecosystem will be changed to the quantity and quality of water resources. The impact of human activities on water resources goes beyond water availability and assesses the effect on society, economy, and environment. Responses consist of any reaction of government and society to reduce pressures, the influence of the state of water resources, and mitigate impacts. Responses represent regulations, policy changes, monitoring, and government interventions (i.e., taxes, subsidies). Most of the studies employing the DPSIR framework are case studies, which integrate knowledge and analysis, engage stakeholders, and provide alternatives rather than simple solutions (Omann et al., 2009; Tscherning et al., 2012; Vannevel, 2018).

Figure 3.3 DPSIR Framework



Source: https://www.grida.no

Many research projects funded by the European Union have extensively used this framework to support policy analysis, policy formulation, and evaluation as a reliable scientific tool (Borja et al., 2006; Pinto et al., 2013; Tscherning et al., 2012). The DPSIR helps structure information, develop interdisciplinary indicators, and present causal links between socioeconomic and environmental factors in terms of measurable indicators. The DPSIR can be applied as a starting point for scenario analysis and scenario formulation. According to the experience of Tscherning et al. (2012), decision-makers were interested in cause-effect analysis and several scenarios rather than dictated solutions suggested by researchers. The DPSIR is a helpful framework to support decision-making. It presents evidence, a complex picture of the situation, and several scenarios with presentive and adaptive measures instead of solutions (Borja et al., 2006; Gessesew, 2017; Khajuria & Ravindranath, 2012; Tscherning et al., 2012). Applying the DPSIR framework for decision-making requires a multidisciplinary approach, including specialists from different areas (Omann et al., 2009; Pinto et al., 2013).

The DPSIR framework is criticized for its implicit hierarchical structure (Gessesew, 2017; Tscherning et al., 2012). In other words, the framework structure implies hierarchical, causal, and unidirectional relations instead of complex interdependence. Other limitations of the DPSIR framework are the lack of dynamic trends, links between different scales and areas (Vannevel, 2018). The DPSIR analysis is descriptive and helpful to see the causal connections of environmental problems but lacks practical application and implementation (Jago-on et al., 2009; Omann et al., 2009; Tscherning et al., 2012). Moreover, the framework was criticized for simplifying reality and human environment interlinks and limited description of DPSIR elements. Indeed, indicators attempt to streamline and measure complex reality, and each DPSIR element is context specific. Initially, the DPSIR framework was suggested as a conceptual view rather than a practical application (Smeets & Weterings, 1999). Moreover, the application of DPSIR for large-scale analysis may give a narrow perspective, and the comparison of DPSIR studies is limited (Tscherning et al., 2012). To strengthen the assessment using DPSIR, choosing relevant indicators and exploring multiple causal communication between indicators (Smeets & Weterings, 1999). Applying DPSIR in small (local) scale analysis was also recommended to present more realistic regional developments, problems, interests, and specific responses (Tscherning et al., 2012). This also considers different interests and values at the local scale, which may be underestimated in extensive scale assessment.

Interview design

Interview as a research method was chosen to study to what extent improvement of river basin management proposed by scholars and experts might improve water security in Kazakhstan. Interviews are a face-to-face discussion between researcher and individual to collect in-depth information and investigate specific issues (Bryman, 2016; Creswell, 2014). The interview is a qualitative research method to gather opinions, attitudes, beliefs, values, perspectives, behavioral patterns, and stories. Interviews help collect background information on specific topics or events when experts' knowledge and expertise are vital.

Interviews differ from other research methods such as focus groups and surveys in design and interaction. Interviews help to discuss sensitive and conflicting topics because of the anonymity of interviewees. In comparison with surveys, interviews are time-consuming because of personal discussions. Qualitative interviews can be criticized for biased information and external validity of findings (Bryman, 2016). The results of interviews challenge the generalizability of findings. However, interviews provide in-depth subjective details with specific examples, stories, and experiences (Horton et al., 2004; Kvale & Brinkmann, 2009; Meuser & Nagel, 2009). Interviews are classified into structured, semi-structured, and unstructured. Structured interviews follow strict interview protocol to investigate a specific topic. Semi-structured interviews are guided conversations between researcher and individual. While unstructured or narrative interviews are a formless dialogue for conducting elite interviews, oral histories, narrative storytelling, discussion on sensitive topics, or studying new issues, establishing rapport is extremely important. The choice between different types of interviews depends on research design and research questions (Kvale & Brinkmann, 2009). The organization of interviews is time demanding because researchers should contact, agree with time and place, and meet with participants to conduct interviews in person, via phone, social media or online communication tools. Moreover, researchers should transcribe recordings, code data, and analyze it systematically.

Interview questions consisted of five parts of the DPSIR framework to explore the development of river basin management. The interviews were semi-structured, and the same questions were asked to interviewees. However, there were flexibility in asking additional questions depending on the background and experience of the interviewee. The DPSIR framework, namely the state element, aimed to evaluate river basin management rather than water quantity and quality parameters. The interviews consisted of questions about the driving forces of introducing and implementing river basin management in Kazakhstan, pressures on water resources, the current state and challenges of River Basin Inspectorate (hereafter RBI) and River Basin Council (RBC), the impact of river basin management on society, economy, and environment, and responses in the form of policy recommendations to improve river basin management to strengthen water security in Kazakhstan. However, before going into the main questions, the introducing questions were asked to build rapport with the interviewee. The interview questions were piloted and edited before conducting interviews. The interviews were conducted in English and Russian languages according to the convenience of interviewees. The interview questions are attached in Annex 2.

Interviewees were selected using purposive and snowball sampling based on their knowledge and expertise in river basin management in Kazakhstan. The list of potential respondents was formed based on their expertise, working experience, and workplace. Personal invitations were sent by email, followed by official invitations from the school. I conducted 17 interviews with relevant stakeholders in the BA river basin, namely Almaty city and Almaty oblast, face-to-face and online interviews depending on the COVID-19 situation in the county. I also conducted online interviews with international experts involved in these issues via Zoom.

All interviews were recorded with the permission of interviewers. The recordings were transcribed using the transcription tool in Microsoft Word. Transcriptions were coded in the NVivo software. Qualitative coding of interviews was conducted using the deductive and inductive approaches. The deducting coding means coding based on prescribed nodes. In this study, defined nodes are based on the five dimensions of the DPSIR framework. Inductive coding implies coding based on new topics raised by interviewees. The coding structure in the NVivo consists of parent nodes and child nodes. For example, parent nodes could be responses, and child nodes would be various recommendations categories. Each transcription was anonymous and has case classifications such as occupation, gender, and other relevant characteristics. Case classification helped to identify some patterns and gaps. The NVivo software was used for thematic analysis. After coding all transcripts, I analyzed each code using the thematic analysis by discussing codes.

Chapter 4

Results of academic discourse

4 RESULTS OF ACADEMIC DISCOURSE

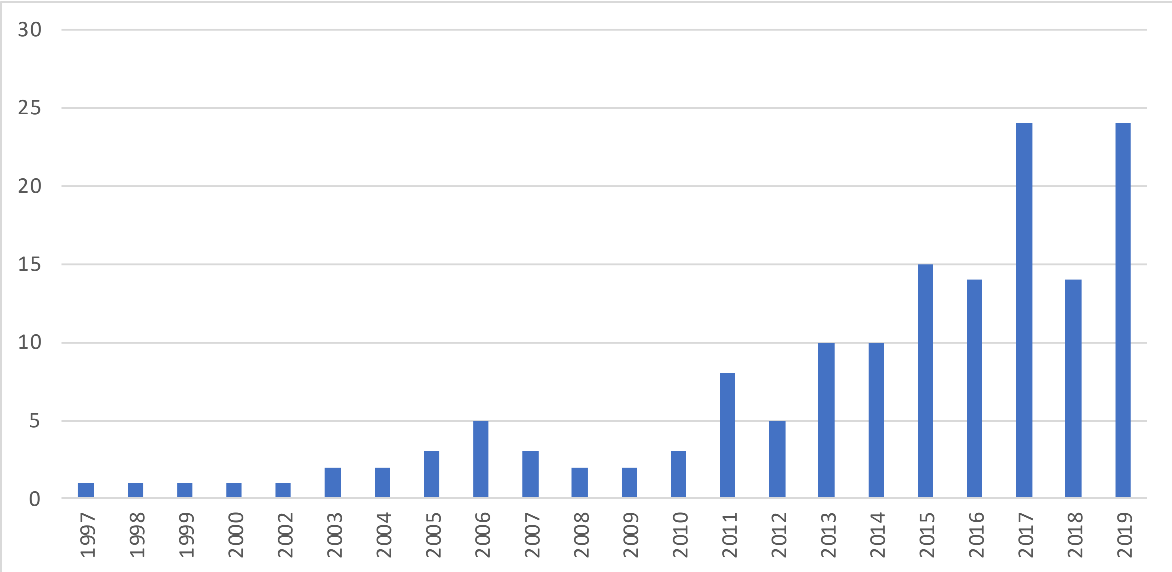
4.1 Findings of bibliometric analysis

The systematic analysis of academic literature on water security aspects in Central Asia (151 peer-reviewed articles) demonstrated the growing interest of scholars in transboundary water resources of the region, especially since 2010. Even though the search timeframe was 1991-2019, the first article in the sample was dated 1997. The content analysis of the literature revealed the predominance of environmental water security aspects, followed by economic water security and water-related hazards. In contrast, the urban & household dimension of water security has become salient in the scholarly debate after the 2000s. Scholars addressed the importance of environmental water security because of growing pressures regarding the impact of the climate crisis on water resources, the increase in water demand, and the ecosystem needs for water. Economic water security was discussed from the perspective of conflicting interests in water between upstream countries with the need to develop hydropower potential and downstream countries with large-scale irrigated agriculture. The cross-tabulation analysis illustrated interlinkages of water security dimensions and water security attributes. The analysis of the background of authors showed the widespread distribution of authors, not only scholars and researchers from Central Asia study water security issues in the region. Articles about water security aspects in Central Asia were published in journals with various subject areas revealing the interdisciplinary nature of the water security concept.

Comprehensive analysis of literature on water security in Central Asia using machine learning techniques and statistical regressions were published with colleagues as a book chapter in Water Insecurity and Sanitation in Asia book (Xenarios et al., 2019) and the journal Environmental Research Letters (Xenarios et al., 2020). In the thesis, I present the bibliometric and content analysis not included in my previous publications. About 151 articles were collected through three levels of Boolean search. Even though the timeframe was 1991-2019, the earliest article dated 1997. Figure 4.1 represents the number of publications on water security issues in

Central Asia per year. The diagram starts in 1997 since there were no studies until 1997 in the sample. Figure 4.1 reveals a few studies until 2011, followed by a sudden increase in publications. For example, 24 papers linked with water security aspects in Central Asia were published in 2017 and 2019. This finding reveals that the academic community's interest in water resources in Central Asia is growing dramatically.

Figure 4.1 Number of articles on water security in Central Asia



Coding results are presented in Table 4.1, where sources mean the number of papers found and references shows the keyword found. As discussed in the Methodology chapter, the coding strategy is based on dimensions and keywords of the AWDO framework (2016) with some modifications. Table 4.1 shows sources and references for each water security dimension and attribute. Each attribute was coded separately with the auto-code and manual coding tools in NVivo. Then attributes were grouped into dimensions; therefore, the number of sources of each dimension is a sum of sources of relevant attributes. However, it could be the case that the same article discusses several attributes of one dimension. As a result, the number of sources of each dimension excludes double counting of papers if they discuss several attributes in one dimension. For instance, 65 sources discuss the urban & household dimension, which is about half of the 121 sources presented in the four attributes (sanitation - 39, SDG 6 - 8, wastewater - 20, drinking - 54). This occurs because there are many instances where the same sources may be used to describe different perspectives of a particular water security dimension, as will be shown in more detail in cross-tabulation analysis. At the same time, references of each dimension are a sum of references of all coded attributes.

Table 4.1 Coding of water security dimensions and attributes

Name	Sources	References
Urban & Household dimension	**65**	**2126**
Sanitation	39	934
SDG 6	8	531
Wastewater	20	113
Drinking	54	548
Economic dimension	**127**	**4801**
Irrigation	114	3623
Hydropower	55	701
Industry	73	456
WEF	12	21
Environmental dimension	**148**	**6712**
Lakes	68	2344
Ecosystems	70	616
Mountains	130	1194
Rivers	123	2558
Hazards dimension	**96**	**3406**
Floods	33	146
Droughts	*73*	*1458*
Avalanches	14	44
Landslides	20	1758

Research papers might discuss several aspects of water security; hence, water security dimensions are not mutually exclusive. For example, almost all studies cover the environmental dimension (148 out of 151), many the economic dimension (127 studies), and some aspects of the hazard dimension (96). In contrast, the urban & household dimension presents minor sources (65). The most important attributes among all dimensions are the keywords mountains (130) and rivers (123), while irrigation (114) is also widely mentioned. Less frequently, the attribute of droughts (73), industry (73), and ecosystems (70) are discussed. The least mentioned attributes are avalanches (14), WEF (12), and SDG 6 (8).

Table 4.2 presents the cross-tabulation findings of four dimensions. Each table consists of information about the number of sources, percentage of studies discussing four attributes of a particular dimension, percentage of studies covering three attributes, and percentage of studies covering two out four attributes. It appears that 23% of studies cover all four attributes of the environmental dimension, about 7% of papers discuss four attributes of the economic dimension, and only 3% of studies mention all categories of the urban & household dimension. In contrast, no papers discuss all attributes of the water-related hazards dimension. The cross-tabulation analysis also includes exploring cases where three out of four attributes were used in the same source (study). In nearly 1 out of 4 cases, the same study discusses all three attributes of the economic dimension. In comparison, a ratio of around one out of 5 cases stands for the environmental dimension and approximately 1 out of 6 for the urban & household dimension. The option of the same source appearing in 2 out of 4 attributes is also explored. The sanitation and drinking attributes presented the highest overlap (28%) without showing excessive resemblance trends. Interestingly, a considerable number of studies (15%) refer to irrigation and industrial aspects, while an equal number of studies are used as a shared pool for the drought and flood attributes.

Table 4.2 Cross-tabulation of the sources used in each dimension

Urban & household dimension	
Total number of articles	***65***
All categories	3%
Three out of four categories	
Case 3 out of 4 (out sanitation)	0%
Case 3 out of 4 (out SDG 6)	14%
Case 3 out of 4 (out wastewater)	3%
Case 3 out of 4 (out drinking)	0%
Two out of four categories	
Case 2 out of 4 (sanitation + SDG 6)	2%
Case 2 out of 4 (sanitation + wastewater)	0%
Case 2 out of 4 (sanitation + drinking)	28%
Case 2 out of 4 (SDG 6 + wastewater)	0%
Case 2 out of 4 (SDG 6 + drinking)	0%
Case 2 out of 4 (wastewater + drinking)	11%

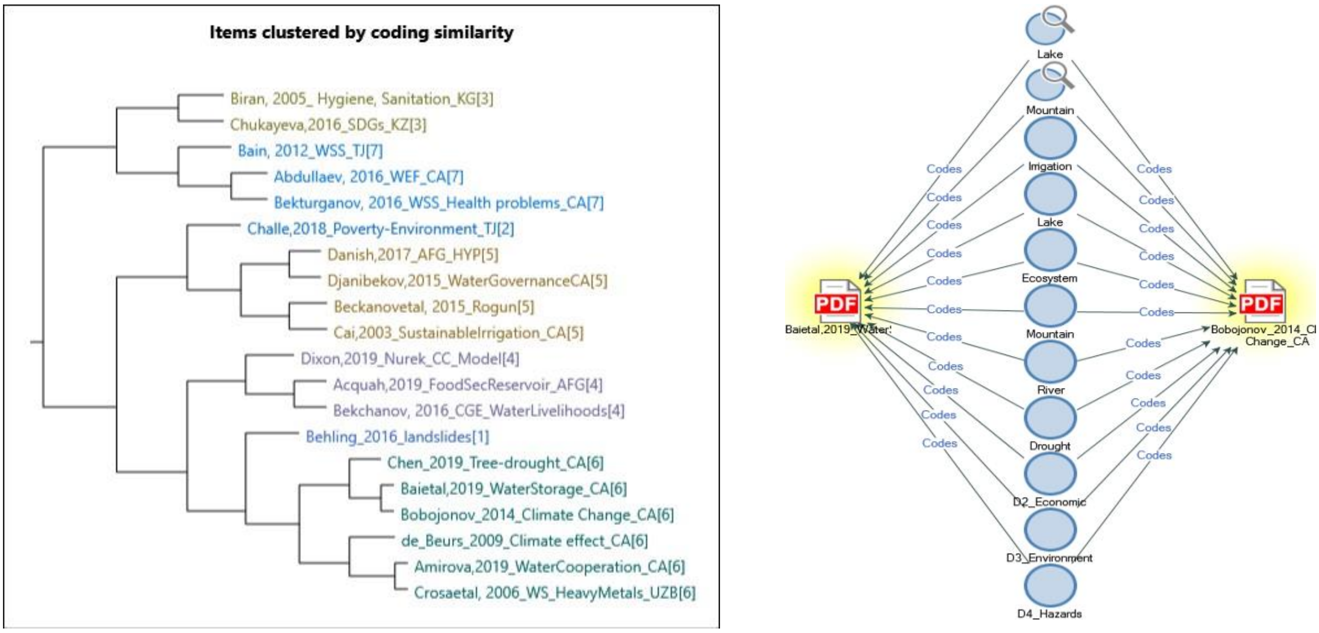
Economic dimension	
Total number of articles	***127***
All categories	7%
Three out of four categories	
Case 3 out of 4 (out irrigation)	0%
Case 3 out of 4 (out hydropower)	0%
Case 3 out of 4 (out industry)	1%
Case 3 out of 4 (out WEF)	26%
Two out of four categories	
Case 2 out of 4 (irrigation + hydropower)	6%
Case 2 out of 4 (hydropower + industry)	0%
Case 2 out of 4 (industry + WEF)	1%
Case 2 out of 4 (irrigation + industry)	15%
Case 2 out of 4 (hydropower + WEF)	0%
Case 2 out of 4 (irrigation + WEF)	0%

Environmental dimension	
Total number of articles	***148***
All categories	23%
Three out of four categories	
Case 3 out of 4 (out lakes)	18%
Case 3 out of 4 (out ecosystems)	11%
Case 3 out of 4 (out mountains)	3%
Case 3 out of 4 (out rivers)	0%
Two out of four categories	
Case 2 out of 4 (lakes + ecosystems)	1%
Case 2 out of 4 (lakes + mountains)	1%
Case 2 out of 4 (lakes + rivers)	7%
Case 2 out of 4 (ecosystems + mountains)	2%
Case 2 out of 4 (ecosystems + rivers)	1%
Case 2 out of 4 (mountains + rivers)	8%

Hazards dimension	
Total number of articles	***96***
All categories	0%
Three out of four categories	
Case 3 out of 4 (out floods)	1%
Case 3 out of 4 (out drought)	3%
Case 3 out of 4 (out avalanches)	2%
Case 3 out of 4 (out landslides)	2%
Two out of four categories	
Case 2 out of 4 (floods + drought)	15%
Case 2 out of 4 (floods + avalanches)	0%
Case 2 out of 4 (floods + landslides)	1%
Case 2 out of 4 (drought + avalanches)	1%
Case 2 out of 4 (drought + landslides)	3%
Case 2 out of 4 (avalanches + landslides)	5%

The NVivo software also helps conduct clustering analysis and create a comparison diagram. Clustering analysis groups articles into clusters based on coding similarity. Figure 4.2 shows the dendrogram with 20 randomly chosen papers grouped into 7 clusters based on coding similarity. Different colors mean different sets and each cluster has a similarity index. According to Jaccard's coefficient, cluster 6 (in green), especially Bobojonov & Aw-Hassan (2014) and Bain et al. (2012), have the highest similarity index. A comparison diagram allows identifying common coding between these articles. Indicatively, Figure 4.2 illustrates a comparison diagram for two articles with common coding in eight attributes and three water security dimensions.

Figure 4.2 Clustering analysis (left) and comparison diagram (right)



The background of the authors was also investigated. Many papers have several co-authors, but information about the leading author was considered. According to approximate information about the organization where the leading author belongs, most authors work at universities (54%), research institutes (35%), associations/ organizations/ networks (10%), and consultancies/companies (1%). Based on information where these organizations are located, authors are from 24 countries. Figure 4.3 illustrates the regional distribution and number of publications. For example, authors with the highest publications about water security issues in Central Asia are from Germany (28), the US (26), Central Asia (Kazakhstan -10, Uzbekistan -10, Kyrgyz Republic -3), China (23), UK (15), and Finland (7). However, regional distribution does not say about the origin or nationality of authors; this information is only about the location of organizations that authors indicated in publications.

Figure 4.3 Regional distribution of authors and number of publications

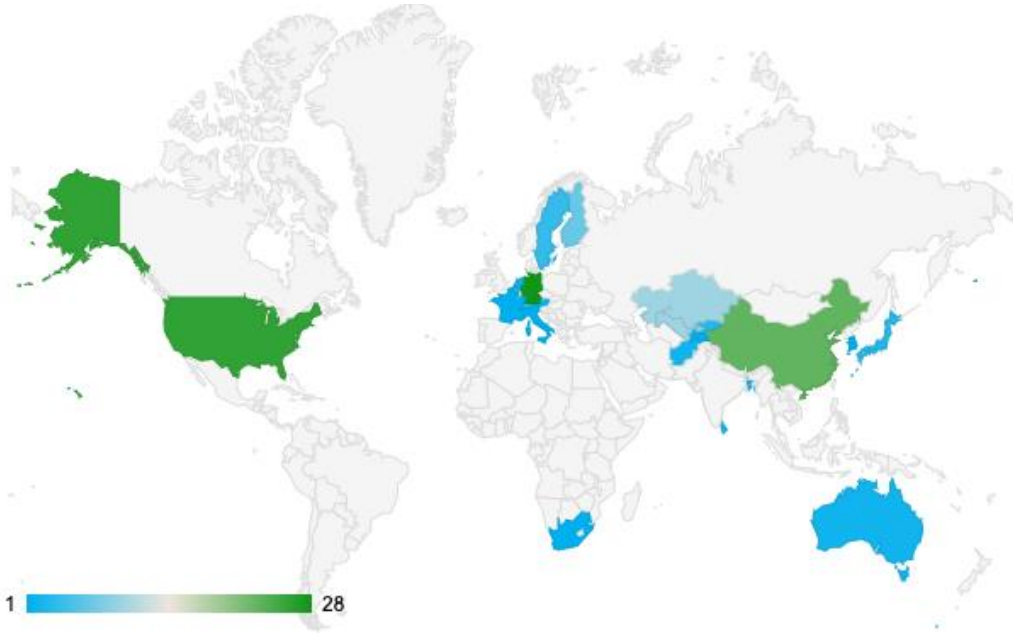
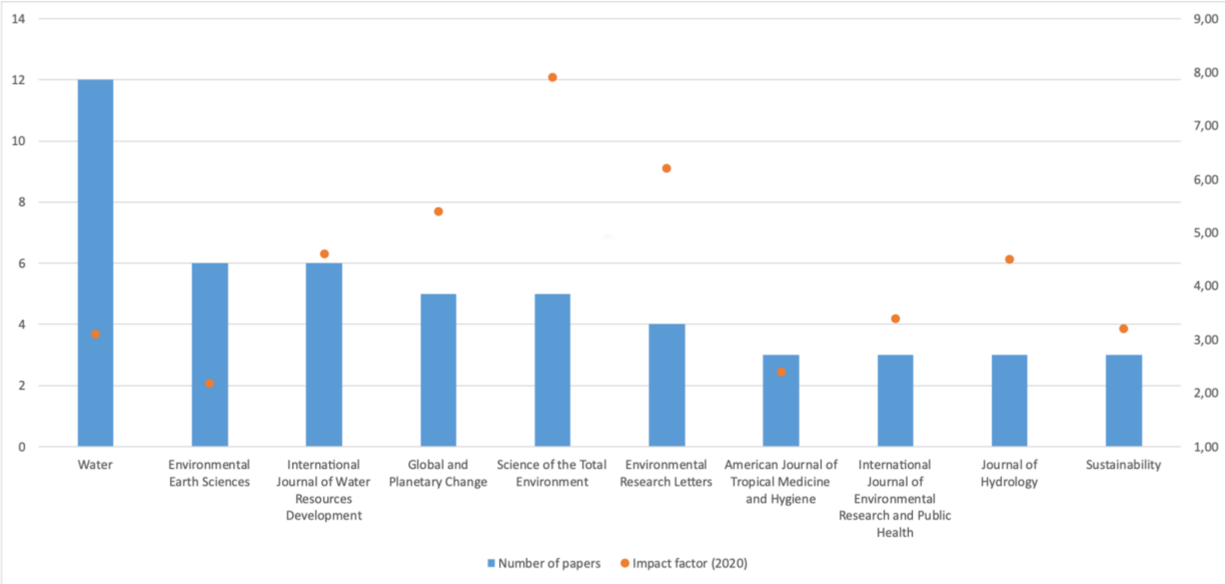


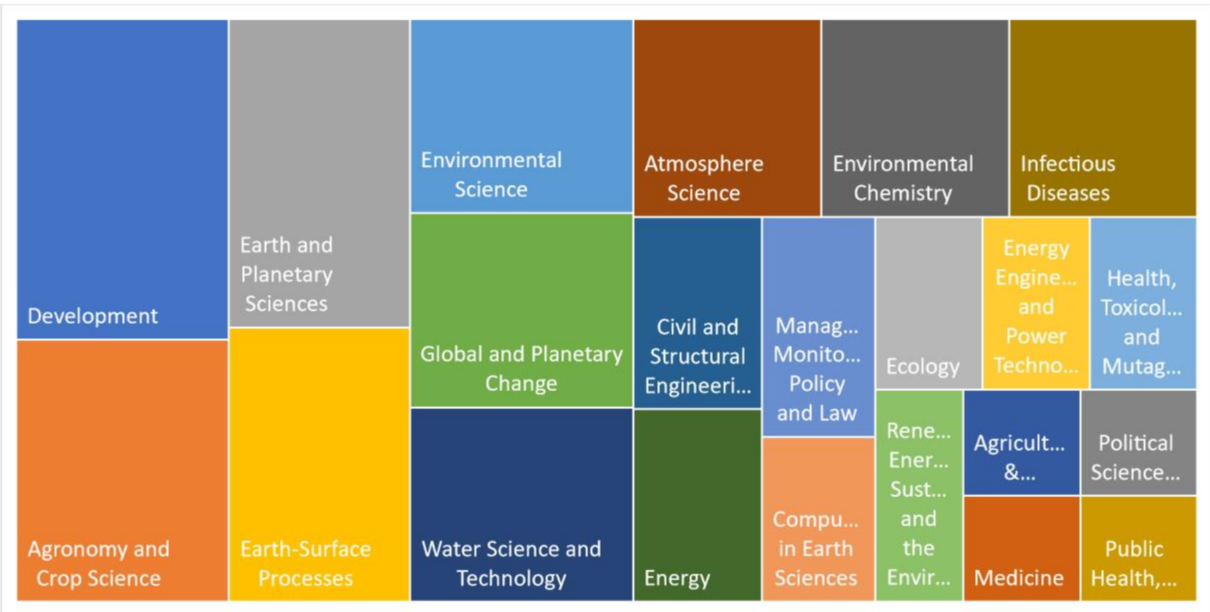
Figure 4.4 presents the list of journals where authors discussing water security aspects in Central Asia are the most often published. About one-third of papers are published in: Water (14), Environmental Earth Sciences (6), International Journal of Water Resources Development (6), Global and Planetary Change (5), Science of the Total Environment (5), and Environmental Research Letters (4). Figure 4.4 also reports the impact factor (2020) of these journals. The journals with the highest impact factor are Science of the Total Environment (7.9), Environmental Research Letters (6.2), and Global and Planetary Change (5.4). Overall, selected 151 articles were published in 95 journals. Figure 4.4 presents only journals with more than three publications. It could be the case that among 95 journals could be journals with a higher impact factor than in Figure 4.4, but I was not interested in journal ranking of individual publications.

Figure 4.4 Journals most frequently published



I also looked at subject areas of journals at the Scimago Journal Rank, which assigned journals into subject areas (thematic categories) based on Scopus Classification. About 95 journals have about 36 subject areas. For example, Figure 4.5 presents the most popular subject areas: development, agronomy and crop science, earth and planetary sciences, earth- surface processes, environmental science, global and planetary change, water science and technology, etc. The subject areas of publications on water security issues relating to Central Asia reveal the complex and interdisciplinary nature of water security concept.

Figure 4.5 Subject areas of journals



4.2 Contextual analysis of articles

4.2.1 Urban & household water security dimension

Sanitation attribute

Water quality in terms of access to improved sanitation and water sources was considered one of the estimators in assessing water security in Central Asia (Groll et al., 2015; Hayat & Baba, 2017; Karatayev et al., 2017; Stucki & Sojamo, 2012). Population in rural areas in Central Asia has inadequate access to safe water supply, i.e., limited access to indoor running water and sanitation (Gungoren et al., 2007; McKee et al., 2006; Tussupova et al., 2016). Poor water quality and unsafe hygiene and sanitation have caused many health issues in the countryside. Some studies use water and sanitation access as predictors of child mortality, especially among rural populations (Franz & Fitzroy, 2006; Jensen et al., 1997; Matthys et al., 2011).

Various projects on sanitation and hygiene were implemented in the Aral Sea basin by international organizations. Scholars conducted a study on hygiene promotion in northern Kyrgyzstan in rural areas (Biran et al., 2005). Sutherland & Aitmurzaeva (2006) described how participatory hygiene was promoted through the Rural Hygiene and Sanitation Project in Kyrgyzstan. Gungoren et al. (2007) experimented on how hygiene behaviors such as handwashing with soap, safe feces disposal, and boiling drinking water removal among children in rural Uzbekistan decreased water-related diseases. Herbst et al. (2008) investigated how water supply, sanitation, and hygiene impact diarrhea cases in Khorezm, Uzbekistan. Gon et al. (2014) analyzed how socioeconomic factors and infection-prone environments, including water and sanitation facilities, impact Afghanistan's maternal deaths.

Water supply and sanitation investment is a ‘powerful preventive medicine’ to address infectious diseases (Veluswami Subramanian et al., 2018). O’Hara et al. (2008) discussed the meaning of ‘access,’ ‘improved sanitation,’ and ‘improved source’ and argued that water supply and sanitation improvement in rural and urban areas needs different policies and approaches. In addition to engineering solutions for better water supply and sanitation, environmental hygiene policies were suggested (Veluswami Subramanian et al., 2018). Semenza et al. (1998) especially stressed a need for safe water access and sanitation for girls and women. Omarova et al. (2019) suggested organizing hygienic water use training among the population, including children. Bekturganov et al. (2016) suggested developing a small-scale water supply and sanitation system with efficient public funding.

Drinking attribute

Proper access to safe drinking water was an agenda in the Millenium Development Goals and continues to be in the SDGs 2030 Agenda. In the 1990s, Central Asia countries had better access and water supply and sanitation coverage than other Asian countries (Abdullaev & Rakhmatullaev, 2016). Sadly, access to potable water decreased from 57% in the 1990s to 50% in 2013 in the region. Safe drinking water is unavailable in many parts of rural areas (Bekturganov et al., 2016; Ellis & Schoenberger, 2017; Tussupova et al., 2016). Insufficient drinking water supply across Central Asia, especially in rural areas, causes households to use water for drinking and household facilities from unimproved sources such as irrigational canals, rivers, and lakes (Klümper et al., 2017; Stewart raf, 2014). Improper water storage and old water pipes may lead to infectious diseases and gastrointestinal illnesses such as typhoid, diarrhea, cholera, and dysentery (Bain et al., 2012; Bekturganov et al., 2016). Consequently, the rate of health diseases caused by poor drinking water quality is high in rural areas.

Drinking water sources in Central Asia have various challenges. For example, in Kyrgyzstan, nuclear tailing dumps are a problem; in Turkmenistan, drainage networks and surface water are polluted (Bekturganov et al., 2016). A reduction of access to safe drinking water by seven percent in 2008 compared to 1995 was noticed in Tajikistan (Bain et al., 2012). High mineral content is widespread close to the Aral Sea, especially in Karakalpakstan (Small et al., 2003). Groundwater and water desalinization are the primary drinking water sources in western Kazakhstan (Karatayev et al., 2017). Groundwater is the primary source of drinking water throughout the country contaminated by fluoride and arsenic in some parts of Afghanistan (Hayat

& Baba, 2017). In addition to this, agricultural fertilizers and residential and industrial wastes cause further groundwater pollution. Unsafe drinking water causes health problems and even child mortality in rural areas (Hayat & Baba, 2017).

Access to water is directly linked with socioeconomic features, i.e., people with higher incomes are more probable to have access to water indoors (McKee et al., 2006). Deterioration of water supply systems was affected by underinvestment in the renovation of water pipeline networks. The USAID programs invested in developing safe drinking water access, improving irrigation infrastructure, and protecting environmental ecosystems in Afghanistan (Danish et al., 2017; Himes, 2017). Central Asia countries attempt to mobilize extensive credits from international banks to improve drinking water infrastructure, which is still insufficient to solve drinking water issues in the region (Abdullaev & Rakhmatullaev, 2016).

Wastewater attribute

Before the USSR's dissolution, almost 70% of all big cities and 20% of courtside used their sewage systems with mechanical and biological treatments (Bekturganov et al., 2016). After the collapse of the USSR, many wastewater treatment plants shut down because of high operation and maintenance costs. Furthermore, even existing sewage and wastewater facilities, mainly with mechanical treatment and chlorine disinfection, poorly operate due to outdated technology and equipment, lack of investment, and trained staff (Bekturganov et al., 2016; Karatayev et al., 2017). More significant parts of existing water treatment plants in Centra Asia were constructed in the Soviet era in 1950-1980, requiring high operational costs and modernization (Bekturganov et al., 2016). The release of industrial wastewater and sewage into surface water resources such as rivers and lakes without treatment is customary in the region (Karatayev et al., 2017). For example, in Kazakhstan, only seven percent of wastewater is fully treated before dumping into waterways (Karatayev et al., 2017). More than half of the sewage in Kabul discharges to groundwater due to a lack of sewage treatment facilities (Hayat & Baba, 2017).

Rural wastewater collection and treatment vary from one village to another. The rural population in Central Asia and even urban dwellers in Afghanistan widely use wastewater septic tanks at their homes because of a lack of connection to the central sewage system, which causes groundwater contamination (Ahmadzai & McKinna, 2018). Currently, there is no reliable information countrywide in Kazakhstan about how wastewater is collected and treated in rural areas (Tussupova et al., 2016). Limited investment in wastewater treatment systems in Central Asia can be an outcome of weak environmental regulations and control, lack of funding and awareness about the consequences of wastewater discharge.

SDG 6 attribute

SDG 6 is one of the 17 SDGs of the Agenda 2030 for sustainable development aiming to ensure clean water and sanitation for all and addressing sustainability and availability of water resources. Huan et al. (2019) presented an alternative methodological assessment for SDGs and analysis in Kazakhstan and Kyrgyzstan from socioeconomic and environmental angles from 2000 to 2017. So, scholars included SDG 6 evaluation in environmental SDG performance, where Kazakhstan performed better than Kyrgyzstan; however, Kyrgyzstan has a volatile upward trend, and Kazakhstan has a volatile fluctuation.

Despite some good indicators of SDG 6, Omarova et al. (2019) argued that Kazakhstan still faces challenges in providing a safe water supply in rural areas. Chukayeva & Akzharov (2016) discussed the progress on the MDGs in Kazakhstan that was redefined to be SDGs and pointed out the role of the European Union in promoting and assisting in achieving MDGs. Lozano et al. (2018) assessed health-related SDGs, including SDG 6, for 195 countries, including the Aral Sea Basin states, and highlighted substantial problems in health-related SDGs in Afghanistan, including poor sanitation and hygiene. Achieving SDGs depends on policy measures (Challe et al., 2018). The role of multi-stakeholder initiatives in promoting SDGs in the case of Kyrgyzstan was also explored (Fowler & Biekart, 2017).

4.2.2 Economic water security dimension

Irrigation attribute

Irrigation plays a vital role in Central Asia due to fertile soil and arid /semiarid area (Guillaume et al., 2015). Irrigated cotton cultivation is a driver of employment and income for the rural population and, at the same time, is a cause of environmental degradation in the region (Rudenko et al., 2013). Irrigation water withdrawal increased almost twice from 1960 to 1990 when annual runoff increased by 30% from the 1960s to 1990 in the Syrdaraya river basin (Cai et al., 2003). Extensive irrigation areas led to soil degradation when fertile, and humus-rich soil became sandy-desert. Stucki & Sojamo (2012) described how the cotton industry negatively affects the quantity and quality of water resources in the region. Moreover, the following risks further put stress on irrigation systems in part because of water losses due to aging infrastructure, plans of upstream countries to expand the irrigated area, and groundwater degradation due to water use from groundwater for irrigated agriculture in summer (Karimov et al., 2018; Zakhirova, 2013).

Water infrastructure is another risk to water security in Central Asia. Water infrastructure, including irrigation and drainage networks, was intensively constructed in the 1960s -1970s, and most of the irrigation systems did not modernize since then (Granit et al., 2012; Rudenko et al., 2013; Small et al., 2003; Wegerich, 2011). Karatayev et al. (2017) mentioned that in Kazakhstan, water infrastructure, which is about 52% of water canals and 84% of water collectors, should be replaced and modernized. They also suggested pricing mechanisms for irrigation water and raised concerns about the sustainability of pump irrigation infrastructure constrained by low operation and maintenance finance and aging and ineffective pumping stations. According to Ward et al. (2013), more than 36% of Afghanistan's irrigation systems do not operate.

Uzbekistan has the largest irrigation area; consequently, water withdrawal is high compared to other countries in the region. Uzbekistan's water security can be improved if the irrigated area for cotton is reduced (Wegerich, 2011). Scholars also discussed economic costs associated with reduced water supply for irrigated agriculture in Uzbekistan and pointed out that water scarcity would be a challenge, especially in the vegetation seasons (Bekchanov & Lamers, 2016). Irrigation water security at the household level was assessed from hydrological and governance aspects for Tajikistan, where investing in irrigation infrastructure and drainage networks may improve irrigation water security at the household level (Klümper et al., 2017).

The cornerstone of sustainable irrigation water management is maintaining irrigated agriculture for food production and protecting environmental ecosystems (Cai et al., 2003). Inadequate and ineffective water management in the region has shown how large-scale irrigated agriculture may cause an ecological disaster. The situation in the Aral Sea basin may worsen in the upcoming 30 years due to population growth, urbanization, and extensive irrigation to ensure food security and self-sufficiency issues if Central Asia countries continue 'business as usual' water management (Abdullaev & Rakhmatullaev, 2016; Cai et al., 2003; Wegerich, 2011). Water use for agriculture could be reduced if irrigation networks are modernized and water-saving technologies are practiced (Rudenko et al., 2013). The introduction of drip irrigation technologies would minimize water withdrawal and improve cotton productivity by 40% and fruits, grapes, and vegetables by 60% (Duan et al., 2019). By improving economic efficiency and productivity of irrigation water use, Central Asia countries might improve water security and economic development (Cai et al., 2003; Guillaume et al., 2015). The importance of developing effective water irrigation institutions was also highlighted (Bekchanov & Lamers, 2016; Klümper et al., 2017).

Hydropower attribute

The hydropower attribute has also been touched upon in the above references related to the irrigation attribute. Hydropower infrastructure plays a vital role in the region utilized to generate electricity and river flow regulation, water storage, and irrigation (Reyer et al., 2017; Wegerich et al., 2015). The development and construction of large hydropower plants are sources of disputes among countries. Tajikistan has hydropower potential (8^{th} in the world) but has a problem finding investors to develop energy capacity (Laldjebaev et al., 2018; Stucki & Sojamo, 2012). Scenarios of the impact of different modes, cost-benefit analysis of the construction of the Rogun hydropower plant in the southeast of the country, and Uzbekistan's position about the negative impact on irrigated agriculture were described by several studies in the literature (Bekchanov & Lamers, 2016; Eshchanov et al., 2011; Jalilov et al., 2016, 2018). Scholars also discussed the impact and difference between small-scale and large-scale hydropower plants in the case of Tajikistan (Laldjebaev et al., 2018).

Some of the studies emphasized the need for more hydro-technical facilities in Kyrgyzstan and Tajikistan to address the significant needs for energy sufficiency (Laldjebaev et al., 2018; Mergili et al., 2013; Stucki & Sojamo, 2012; Wegerich et al., 2015). Without downgrading the potential effects of upstream hydropower use to downstream countries, it was pointed out that the conflicting interests do not arise from the increased water withdrawal by hydropower reservoirs but from the amount and time of water releases (Eshchanov et al., 2011; Jalilov et al., 2018; Zhang et al., 2018). It is also well documented that new transboundary issues may emerge due to Kyrgyzstan and Tajikistan's ambition to double or triple their hydropower capacity and the interest of China to invest in such projects (Chan, 2010; Klümper et al., 2017). The absence of transboundary water-sharing agreements of Afghanistan with other Central Asia countries remains a significant obstacle for its potential hydropower utilization by threatening the country's national water security (Ahmadzai & McKinna, 2018). Danish et al. (2017) as well Ahmadzai & McKinna (2018) discussed Afghanistan as an upstream country that does not use its hydropower potential and highly depends on importing energy.

Hydropower energy is one of the cleanest, most efficient sources, according to the literature. Still, it may also negatively influence the environment, for example, limitations of fish migration, changes in hydro morphology, evaporation from reservoirs, and variations of river flow (Zhang et al., 2018). Several studies discussed the potential impact of global warming on hydropower production due to the seasonality of water availability and changes in river runoffs that would constrain hydropower generation and other energy supply chains (Abdullaev & Rakhmatullaev, 2016; Reyer et al., 2017; Zhang et al., 2018).

Industry attribute

The studies related to the industry attribute mainly refer to water quality problems in riverine ecosystems. Population growth, industrialization, and urbanization in the region further press competition over water among the industrial sector, urban and domestic use, and agriculture (Djanibekov et al., 2013). Poor or lack of treatment from industrial waste, namely chemicals, hydrocarbons, metallurgy, and manufacturing, adversely impacts water quality, biodiversity, fishery, and generally the ecosystem (Bekturganov et al., 2016; Karatayev et al., 2017). Lee & Jung (2018) noted that water use per capita (including domestic, industrial, and agricultural use) is higher in Turkmenistan than in other countries in the region. However, water use for industrial purposes is high in Kazakhstan compared to other areas due to the mining and production of hydrocarbons (Rivotti et al., 2019; Stucki & Sojamo, 2012). Simultaneously, the industrial sector's contribution is higher in Kazakhstan's government than in other Central Asia republics.

Several studies analyzed water pollution in Central Asia, namely water pollution in Kazakhstan (Karatayev et al., 2017; Rivotti et al., 2019), breakdown of transboundary Ili river (Stewart raf, 2014), water quality in Tashkent province in Uzbekistan (Veluswami Subramanian et al., 2018), and water pollution in the Zaravshan river (Groll et al., 2015). Also agricultural and industrial pollutions affect downstream regions of the Amudarya and the Syrdarya rivers (Bekturganov et al., 2016; Jensen et al., 1997). The industrial sector is energy-intensive; therefore, sustainable energy supply has become a significant challenge in Afghanistan and Tajikistan. Scholars also discussed the possibility of using water for energy generation to meet domestic and industrial electrical needs (Ahmadzai & McKinna, 2018; Karimov et al., 2018; Klümper et al., 2017; Laldjebaev et al., 2018).

Water-Energy-Food Nexus attribute

The Water-Energy-Food (hereafter WEF) nexus attribute is partly the aftermath of irrigation, hydropower, and rivers attributes. The WEF nexus and water security concepts are relevant to Central Asia as the region faces population growth, economic progress, climate change, and management of transboundary rivers (Abdullaev & Rakhmatullaev, 2016; Guillaume et al., 2015; Keskinen et al., 2016). Water, food, energy, and security angles create a complex nexus of national and regional interests in Central Asia (Stucki & Sojamo, 2012; Wegerich et al., 2015). The need to develop a mutually beneficial scheme of water–energy–agriculture was suggested with robust governance (Abdullaev & Rakhmatullaev, 2016; Granit et al., 2012; Soliev et al., 2015). However, the boundaries and completeness of the WEF nexus and security concepts are also set in question for the region (Guillaume et al., 2015).

The WEF nexus in the region is complicated due to misallocation of water resources, competition, and conflicts of interests between downstream and upstream countries on transboundary rivers such as Amudarya and Syrdarya, tradeoffs between water use for hydropower and irrigation, and between environment protection and economic growth (Guillaume et al., 2015; Jalilov et al., 2016, 2018; Stewart raf, 2014). Keskinen et al. (2016) mentioned that the number of nexus-related publications has significantly increased, but there is no universal definition for the nexus. Even though the WEF nexus is actively promoted and discussed in Central Asia, there is still an implementation gap (Abdullaev & Rakhmatullaev, 2016). Researchers highlighted the role of the WEF nexus approach; however, practitioners mainly consider either water-food or water-energy nexuses (Keskinen et al., 2016).

4.2.3 Environmental water security

Lake attribute

The Aral Sea is placed in the desert area, where climate variabilities negatively impact (Cai et al., 2003). The main economic activity in the basin is agriculture, particularly water-intense crops in the desert lands such as cotton, wheat, and rice. In the 1950s-60s, the USSR implemented large-scale irrigation projects on cotton production in Central Asia that later led to disaster in the

Aral Sea. In addition to river diversions for irrigated agriculture, Jalilov et al. (2018) added that water supply through rainfall also decreased due to climate change (evaporation losses). Many factors caused the rapid shrinkage of the Aral Sea, mainly water mismanagement, extensive water use, and underinvestment in irrigation systems (Cai et al., 2003; Granit et al., 2012; Small et al., 2003). The International Fund for the Aral Sea was criticized in the literature, responsible for managing and protecting water resources in the Aral Sea Basin (Granit et al., 2012; Krasznai, 2019; Sehring et al., 2019).

The increase in cotton production damaged the Aral Sea ecosystems and, hence, the broader human-environmental system causing loss of livelihoods and negative health consequences (Guillaume et al., 2015). As Herbst et al. (2008) noted, most of the population in the basin live in rural areas; therefore, water salinization and soil degradation and poor water quality, inadequate sanitation, and hygiene have caused health problems for the population living in these areas. Scholars also studied environmental pollution and child health in the Aral Sea region and found out that the blood lipid concentration of the [beta]-isomer of the hexachlorocyclohexanes and DDT-compounds was too high in children mainly because of industrial pollutants (PCB-compounds, heavy metals) and large quantities of pesticides in water and soil (Jensen et al., 1997).

Guillaume et al. (2015) discussed how Kazakhstan maintained artificial barriers to keep the North Aral Sea level by building the Kokaral dam, investing in water-saving technologies, and decreasing cotton and rice production. Stewart raf (2014) discussed that the Aral Sea story could be repeated with Lake Balkhash and also noted pollution on the Irtysh river due to limited communication and negotiation on the geopolitical level between China, Kazakhstan, and Russia.

Scholars studied glacial lakes with remotely sensed data and noted that glacial lakes' expansion is linked with glacier retreat and decay and suggested further exploring the link between lake evolution and glacier retreat (Mergili et al., 2013). Some papers also discussed the glacier lake in the case of the western Teskey Range, Kyrgyzstan, where the growth of glacial lakes requires monitoring glacial lakes to prevent hazards associated with lake outbursts (Narama et al., 2018). The trend of glacial mountain lakes in the Tianshan mountains from 1990 to 2010 using Landsat Thematic Mapper was also explored, which shows that expansion of glacial lakes formation might lead to hazards in the form of lakes outburst. They also identified hazardous glacial lakes and the probability of their outbreak (Wang et al., 2013).

Ecosystem attribute

The broader concept of ecosystems is also related to the environmental dimension. The UN Agenda 2030 emphasizes SDG 15, which aims to protect and restore ecosystems and mitigate and adapt to climate changes. Especially, ecosystems in the Aral Sea Basin, where arid and semiarid areas are dominant, are vulnerable to climatic and human influence. Indeed, there is a difficulty in the tradeoff between human and environmental water uses in the Aral Sea basin (Guillaume et al., 2015; Schlüter et al., 2013).

Scholars discussed the importance of the availability of environmental water required for aquatic ecosystems (Guillaume et al., 2015). For example, Graham et al. (2017) highlighted the importance of aquaculture and fish in the ecosystem of Lake Balkhash. Schlüter et al. (2013) analyzed how climate change influences wetland ecosystems in the Amudarya river and noted that the vulnerability of wetland ecosystems depends on location and hydrological features. Guo et al. (2018) suggested studying the impact of droughts on vegetation ecosystems in Central Asia.

The lack of environmental sustainability and an ecosystem-service approach in economic development programs of Central Asia were considered a hurdle for the sustainable management of natural resources (Chukayeva & Akzharov, 2016; Thevs et al., 2019). Infrastructure projects may have resulted in less competing water uses in Central Asia in the past but overlooking the environmental flows and relevant ecosystems services (Guillaume et al., 2015; Karimov et al., 2018). For example, Graham et al. (2017) addressed fish and aquaculture problems as essential parts of the ecosystem but ignored or overlooked in the region. The disturbance and degradation of biodiversity in Central Asia and the vulnerability of wetland ecosystems are also perceived as significant threats to water security (Schlüter et al., 2013).

Environmental codices and regulations in Central Asia countries are weak and need further development and implementation, especially the polluter pay principle needs to be introduced and legislated (Bekturganov et al., 2016; Karatayev et al., 2017). Isobaev (2007) noted the lack of water quality information, i.e., the absence of a database, monitoring systems, and united water data collection. Scholars also recommended introducing policies and measures to rehabilitate degraded ecosystems (Granit et al., 2012).

Mountain attribute

Afghanistan, Kyrgyzstan, and Tajikistan are mountainous and landlocked countries, where agricultural land is limited, however in the last decade frequency of floods in mountainous areas has been rising (Bobojonov & Aw-Hassan, 2014). The mountainous attribute is associated with the lakes attribute due to the recent creation of glacial lakes in the high altitude of Tianshan mountains because of the glaciers' retreat (Mergili et al., 2013; Narama et al., 2018; Wang et al., 2013; Zheng et al., 2019). The Tianshan mountains are essential to water sources in the Aral Sea basin because two main transboundary rivers, the Syrdarya and Amudarya, are fed by glaciers and snow melting (Lee & Jung, 2018).

The recent enlargements of proglacial lakes in the Tien Shan mountains for 2002-2014 further stress the danger from the recession of glaciers to downhill populations (Mergili et al., 2013; Narama et al., 2018; Zheng et al., 2019). Scholars conducted a complex glacier monitoring in the Uzbek and Kyrgyz Tianshan and Pamir mountains (Hoelzle et al., 2017), risks assessment of lakes outbursts and the emerging potential mountain lakes in the Djungarsky Alatau (Kapitsa et al., 2017), study on the construction of small reservoirs in the plain fields for storing water originated from highlands in the winter season (Conrad et al., 2016).

River attribute

The river attribute is mainly comprehended by national water interests and the risk of disputes in transboundary rivers (Ahmadzai & McKinna, 2018; Chan, 2010; Karatayev et al., 2017). The threat of the runoff reduction because of the growing water demand, and global warning influence on downstream and in upstream countries (Bernauer & Siegfried, 2012; Reyer et al., 2017; Sorg et al., 2012) Also, the limited effectiveness of WEF nexus in transboundary basins is addressed due to excessive transnational water competition within each Central Asia country (Jalilov et al., 2018; Keskinen et al., 2016; Lee & Jung, 2018; Pueppke et al., 2018).

The classification of cooperative benefits was discussed, such as gains from the river, benefits to the rives, cost-cutting due to the river, and benefits beyond the river (Jalilov et al., 2016). Most studies discussed transboundary rivers from the perspective of benefits from the river, such as the Ili river, the Irtysh river, the Amudarya river, the Syrdarya river, and also tributaries of these rivers as the Vakhsh river and the Zeravshan river in Tajikistan, the Pyandj river and the Kunduz river in Afghanistan, the Aksu river and the Naryn river in Kyrgyzstan. Scholars emphasized the pollution of transboundary rivers from sewage, industrial and agricultural waste (Jalilov et al., 2016; Keskinen et al., 2016; Krysanova et al., 2015; Pueppke et al., 2018; Schlüter et al., 2013). The main rivers in Afghanistan are transboundary; however, due to prolonged political instability, Afghanistan does not have agreements and treaties with neighboring countries regarding water sharing and water allocation (Ahmadzai & McKinna, 2018; Danish et al., 2017).

4.2.4 Water-related hazards security

Drought attribute

The drought attribute is one of the water-related threats to water security. The Aral Sea basin with an arid climate and poor water resources management is vulnerable to precipitation deficits that also raise drought frequencies, especially rural population living and working in dry and semiarid areas, where the annual harvest and income of farmers varies according to weather conditions (Bobojonov & Aw-Hassan, 2014; Lioubimtseva, 2014). The frequency of weather-related disasters and major droughts is considered a significant risk to industrial and agricultural development and society in Central Asia (Abdullaev & Rakhmatullaev, 2016; Bobojonov & Aw-Hassan, 2014; Reyer et al., 2017; Small et al., 2003; Ta et al., 2018).

Drought characteristics in Central Asia might vary considerably between the southeastern parts, which are suffering from frequent short-term occurrences, and the northeastern territories, which experience fewer droughts but longer duration and severity (Guo et al., 2018). For example, droughts could be divided into climate drought, hydrological drought, and agricultural drought (Zhang et al., 2018). Some researchers studied the temporal and spatial variation of droughts in the region using different drought indexes (Ta et al., 2018; Wang et al., 2013; Xu et al., 2016). Severe droughts occurred in the 1930s, 1960s, 1970s, 1990s, especially in desert areas in Turkmenistan and Uzbekistan, and climate changes led to a rise in drought risks in the region (Reyer et al., 2017). Therefore, scholars suggested improving drought forecasting and monitoring tools in Central Asia, considering hydrological processes, temperature, and glacier melting (Bobojonov & Aw-Hassan, 2014; Guo et al., 2018; Xu et al., 2016).

Flood attribute

The incidents of floods as an inverse situation of the droughts attribute mentioned earlier in the collected studies by stressing such occurrences. It is noted that the release of massive water volumes in the winter season from reservoirs in highlands can cause enormous flooding problems in plains with fatalities in human lives and livestock as well as the destruction of housing properties (Chan, 2010; Narama et al., 2018; Reyer et al., 2017). Energy self-sufficiency plans of upstream countries cause water shortage in summer and flood risks in winter for downstream countries (Danish et al., 2017; Jalilov et al., 2016; Zhang et al., 2018). Significant challenges on flooding control are also recorded in Afghanistan by mentioning the need to create multipurpose dams for hydropower and irrigation services (Ahmadzai & McKinna, 2018; Danish et al., 2017; Hayat & Baba, 2017). There are currently ongoing plans to build small cascading reservoirs in Kazakhstan and Uzbekistan for flood protection and store excessive flows in the winter season (Guillaume et al., 2015; Wegerich et al., 2015). Researchers also discussed how glacier lakes might cause flood outbursts in the Amudarya river basin (Mergili et al., 2013) and the Aksu river basin (Krysanova et al., 2015).

Avalanche attribute

Large landslides accompanied by rock avalanches in the Tianshan (Central Asia) were described (Havenith et al., 2015). The avalanches mainly were referred to the mountainous regions of Tajikistan and Kyrgyzstan in relevance to the risks posed from possible bursts of avalanche-blocked dams that might reduce or affect the timing of water discharge in a river basin (Narama et al., 2018; Saponaro et al., 2015). Snow avalanches were not considered capable of causing lake outbursts (Kapitsa et al., 2017). However, it was noted that avalanches could lead to a reservoir overflow, mechanical rupture, and hydrostatic failure with severe effects on downstream inhabitants (Mergili et al., 2013). Some studies pointed out that Tajikistan's energy system is vulnerable to natural hazards as glaciers melting, more frequent avalanches, landslides, and floods (Laldjebaev et al., 2018).

Landslide attribute

Researchers conducted a spatiotemporal analysis of landslides activity in southern Kyrgyzstan using GIS and remote sensing techniques that may help to understand and assess landslide risks that endanger human lives and infrastructure in Kyrgyzstan (Roessner et al., 2005; Saponaro et al., 2015a, 2015b). The landslide attribute mainly was mentioned in the context of Kyrgyzstan as one of the most exposed countries in the world to such hazard (Behling et al., 2016; Havenith et al., 2015; Motagh et al., 2013; Roessner et al., 2005; Saponaro et al., 2015; Schlögel et al., 2011). The need to construct landside preventive barriers was suggested, while other studies encouraged more research assessments on landslide effects on hydropower schemes and infrastructure (Havenith et al., 2015; Mergili et al., 2013; Schlögel et al., 2011). Scholars also discussed a link between earthquakes and landslide frequency relationships that requires the spatial and temporal complex assessment of earthquake and landslide occurrence probabilities (Havenith et al., 2015).

Chapter 5

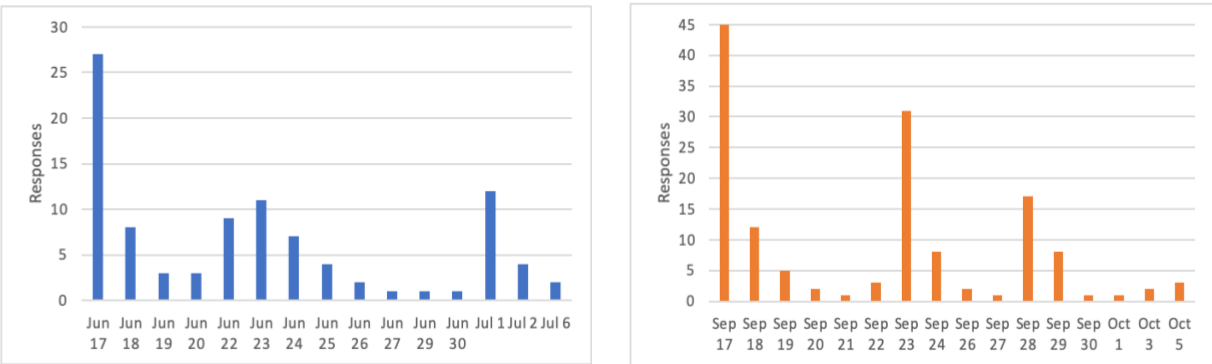
Results of policy discourse

5 RESULTS OF POLICY DISCOURSE

5.1 Delphi findings

The two rounds of Delphi were conducted in June - October 2020. The questionnaires were distributed among 417 experts in both rounds. Figure 5.1 shows that most experts participated in the surveys immediately when they received email invitations or reminders. To differentiate between experts in the Delphi study and scholars & researchers who are also experts in the literature review, I call participants from the Delphi study as experts/practitioners, while the authors of articles about water security issues as academics/ scholars. Some findings of the Delphi study were published in 2021 in the Central Asia Journal of Water Resources, and I cite it accordingly as Assubayeva (2021).

Figure 5.1 Distribution of responses



Note: Delphi 1st round (left), Delphi 2nd Round (right)

5.1.1 Background of participants

The socio-demographic background of respondents is summarized in Table 5.1. The same respondents were invited in both rounds; however, 156 out of 417 experts started the survey in the first round, and 164 experts out of 417 initiated the questionnaire in the second round but not all completed the survey. 112 and 118 respondents completed the survey in the first and second rounds, respectively. The interest among respondents in this study increased from 156 to 164 experts, and the number of completed responses increased slightly from 112 to 118 by the end of the second round, probably due to some reasons such as the period of conducting the survey and the length of the survey (Assubayeva, 2021). The invitation to the survey of the first round was distributed in the summer when some respondents had vacation and limited access to the email. Moreover, the length of the survey of the second survey was much shorter than the survey of the first round. Most likely that the main factor of a slight increase in response rate is the presentation of the first round results in the second round that increased attention among respondents.

Table 5.1 Background of participants of the Delphi study

		1st round	2nd round
Period		June - July 2020	September- October 2020
Number of invited experts		417	417
Number of experts starting survey		156	164
Number of completed responses		**112**	**118**
Socio-demographic profile			
Gender	Male	60%	65.6%
	Female	40%	34.4%
Age	18-34	24.5%	19%
	35-54	54%	49%
	55 and older	21.5%	32%
Education	Up to master’s degree	43%	38.2%
	Ph.D.	57%	61.8%
Employment	University/ Research Institute	63.7%	63%
	Other	36.3%	37%
Experience in water sector	1-5 years	30%	23.5%
	6-15 years	37.8%	36.3%
	More than 15 years	32.2%	40.2%
Language	Russian	35.7%	44%
	English	64.3%	56%
Citizenship	Regional*	58%	59.4%
	International	26.8%	33%
	n/a*	15.2%	7.6%
Residence	Regional*	44.7%	47.5%
	International	41%	39.8%
	n/a*	14.3%	12.7%

*Note: Regional- Central Asia and Afghanistan; n/a- not available, Source: adapted from Assubayeva (2021)

About two-thirds of respondents were male in both rounds. Almost half of the experts belonged to the age category 35-54 in both rounds. However, as it can be noticed that the proportion of experienced respondents aged 55 and older raised by 10% by the end of the second round, this can also be justified by the growth of the percentage of experts with more than15 years of experience from 32.2% in the first round to 40.2% in the second round. Overall, experts with different work experience were presented in the study: beginners – 1-5 years, professionals- 6-15 years, and experienced – more than 15 years of experience. About 40% of experts had a college and bachelor's degree and other master's and Doctorates. Some experts indicated 'aspirant' and 'candidate degree' according to the Soviet educational system. About two-third of experts were employed at universities and research institutes. About 30% of experts worked in other organizations: state agencies, global organizations, non-governmental organizations, consultancy firms, and others.

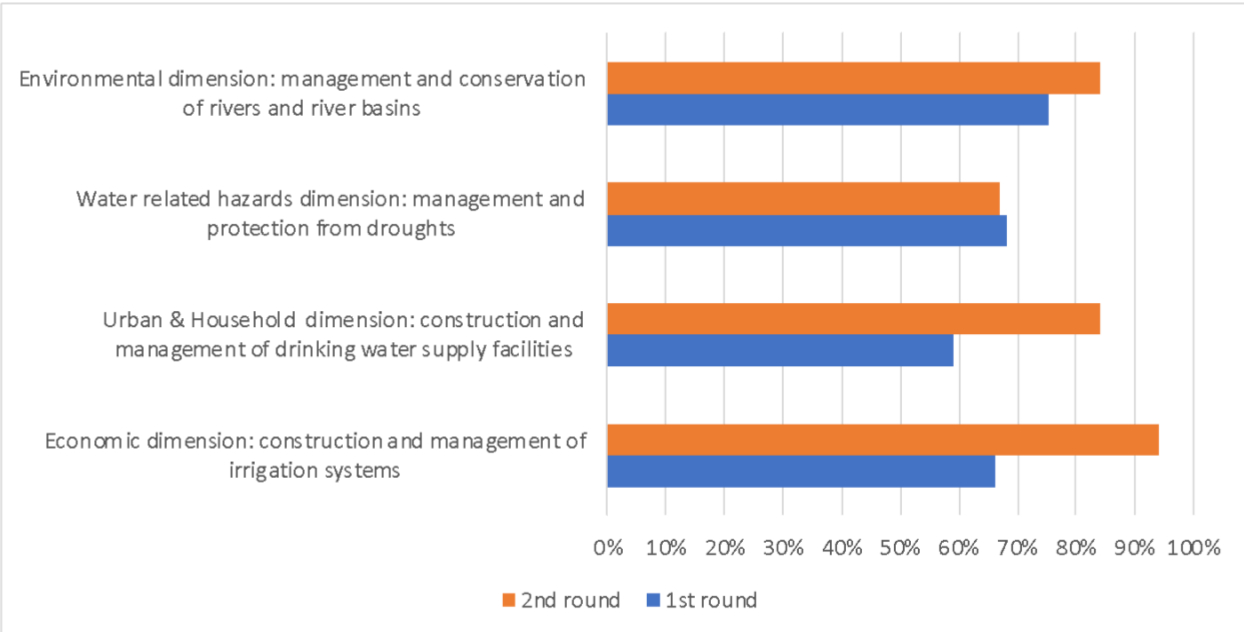
Respondents had a choice to answer questions either in English or in Russian. Most of the experts filled in the survey in English. However, the proportion of responses in Russian increased from 35.7% to 44% by the end of the second round. Overall, experts from 24 countries took part in both rounds, where most respondents were from Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, Afghanistan, Germany, Switzerland, the Netherlands, the U.S., and China. About 60% of participants are from Central Asia and Afghanistan; however, only about 45% live in the region. About 40% of experts resided abroad. Table 5.1 also presents the percentage of experts who did not indicate their residence and citizenship as unavailable (n/a).

5.1.2 Water security perceptions and priorities

Experts ranked the relevance of the water security dimensions in the context of Central Asia according to their experience. The first-round experts set the following ranking: 1st economic activities, 2nd urban & household facilities, 3rd natural hazards, and 4th environmental aspects. In the second round, about 80% of experts reached an agreement with this ranking by highlighting the prevalence of economic dimension and urban & household dimension of water security. In other words, experts emphasized the importance of socioeconomic aspects of water security, while the natural hazards dimension and environmental dimension are in the lower priority.

Figure 5.2 presents the essential factors that may affect each water security dimension in Central Asia according to the experience and opinion of experts. Experts emphasized the construction and management of irrigation systems as an essential factor of the economic dimension in Central Asia, which reached about 94% of the agreement rate among experts by the end of the second round. Experts selected investment in drinking water supply and sanitation for urban & household dimension that gained the consensus rate from 59% in the first round to 84% in the second round. In the environmental dimension, experts focused on managing and conserving rivers and river basins with the agreement rate of 75% and 84% in the first and second rounds, respectively. More than half of the experts pointed out the relevance of management and protection from drought for hazards dimension; however, about 26% of experts still disagreed with this factor in the second round, probably because this is related mainly with downstream countries in Central Asia.

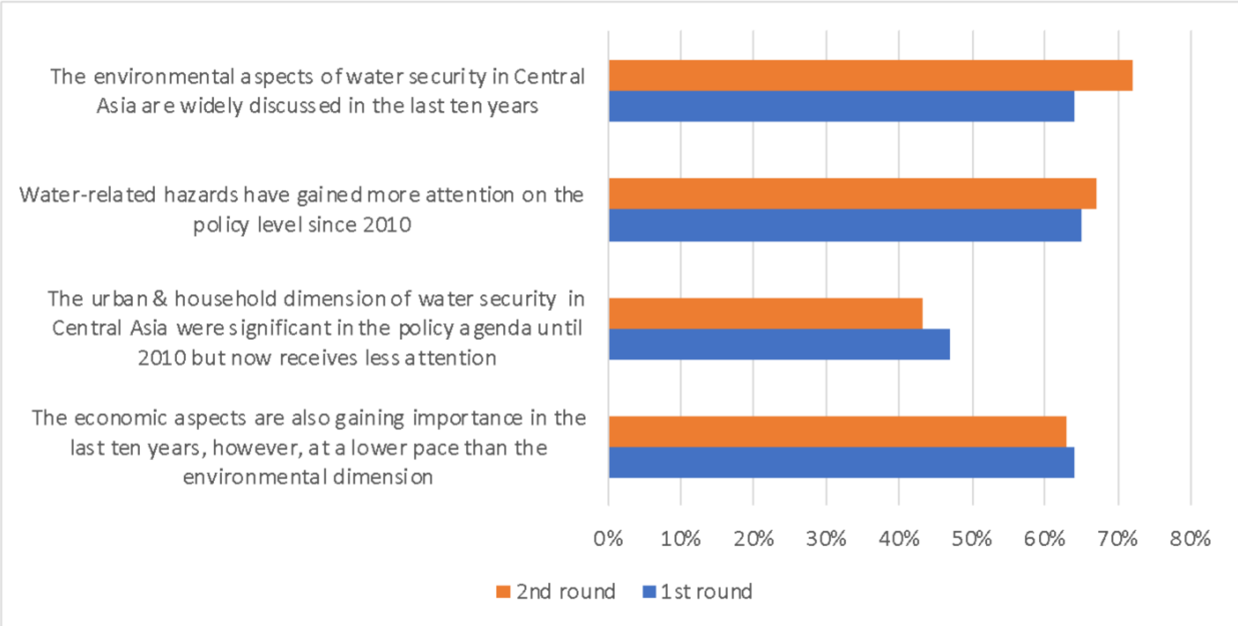
Figure 5.2 Important factors of water security dimensions



Source: adapted from Assubayeva (2021)

Experts acknowledged that water security is gaining more attention at the policy level, as in the relevant literature of the last twenty years. Experts also agreed that the environmental dimension of water security is somehow reflected at the policy level, including state initiatives, laws, programs. More than half of the experts confirmed that the hazards dimension had gained more attention since 2010 because of the growing frequency and scale of water-related hazards. Figure 5.3 reveals the consensus rate slightly decreased regarding the trends of economic dimension and urban & household dimension at policy level compared to literature. About two-third of experts disagreed that since 2010 there is the trend of decreasing significance of urban & household dimension in the literature is somehow reflected at the policy level in Central Asia. Lastly, only two-thirds of experts agreed with the trend of economic dimension. Namely, that economic dimension is drawing attention but not similar to the environmental dimension.

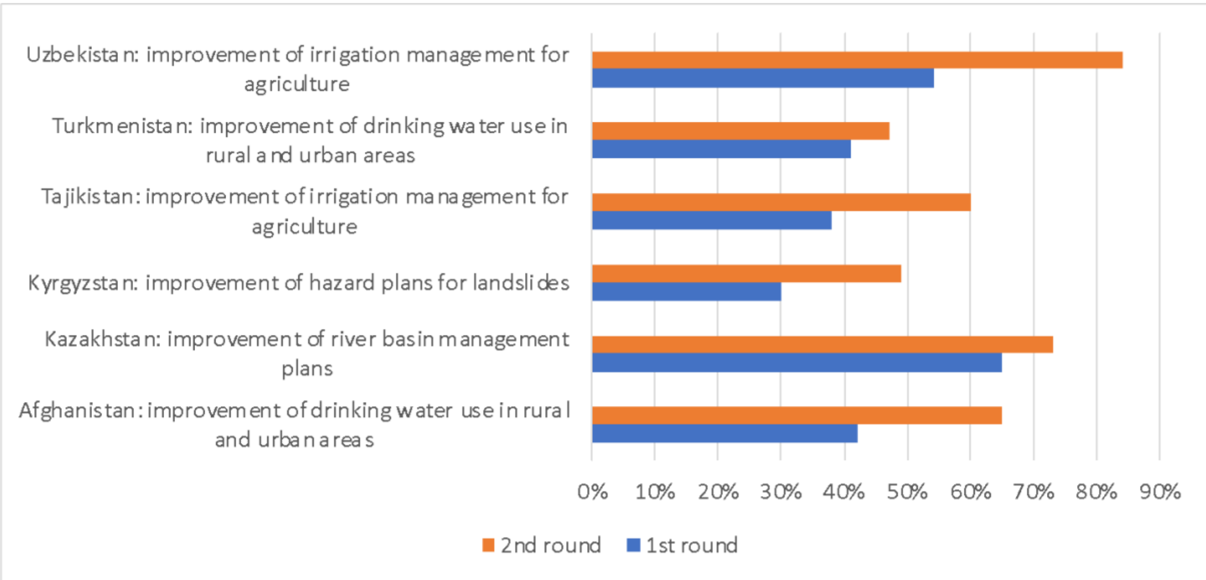
Figure 5.3 Trends of water security dimensions at the policy level



Source: adapted from Assubayeva (2021)

Experts also reached an agreement on water security priorities for some countries in Central Asia. Figure 5.4 presents a higher agreement rate in the second round because, in the first round, participants set ranking in water security priorities for each country. In contrast, in the second round, experts voted whether they agreed/disagreed with the water security priority suggested by the majority from the first round. The highest agreement rate (84%) among experts was reached in the case of Uzbekistan, that the country should improve irrigation management to achieve water security in the country. Kazakhstan also received a high consensus rate (73%) among experts on improving river basin plans to strengthen water security. Experts highlighted improving drinking water systems in rural and urban areas in Afghanistan and about 60% of experts suggested improving irrigation management in Tajikistan. Figure 5.4 also shows a low agreement rate in the case of Turkmenistan and Kyrgyzstan. Nearly half of the experts agreed that improving drinking water use in Turkmenistan and improving hazard plans from landslides in the Kyrgyz Republic might strengthen water security in these countries. Moreover, experts criticized current institutions and mechanisms and suggested establishing new mechanisms and institutions for solving water security issues in Central Asia.

Figure 5.4 Consensus on water security priorities



Source: adapted from Assubayeva (2021)

5.1.3 Cross-tabulation results

The results of cross-tabulation analysis of the first round of the Delphi survey are presented in Table 5.2. Horizontal lines represent the socio-demographic features of experts, and vertical columns represent four water security dimensions, where each dimension consists of three assessments (low, moderate, high). Since the number of responses varies among dimensions and demographic questions, the number of responses was transformed into percentages; hence, each row per dimension equals 100%. Experts with different demographic features highly ranked the relevance of economic dimension in the Central Asia context. However, some experts with 1-5 years of experience underestimated the environmental dimension. Some experienced experts undervalued the urban & household dimension, and some experts aged 55 or older underrated the hazards dimension.

The high importance of urban & household dimension was given by experts with 6-15 years of experience and employed in other sectors than university & research institutes. Whereas respondents with 1-5 years of experience in the water sector, or aged 35-54, or with a Ph.D. degree, or employed at university/ research institutes, or from abroad gave moderate relevance of urban & household dimension. Panelists aged 55 and older, or with more than 15 years of experience, or from the region underestimated this dimension in the context of Centra Asia.

Most experts highlighted the importance of the economic water security dimension. As mentioned earlier, respondents among different demographic categories highly ranked the relevance of economic dimension in the Central Asia context. The moderate assessment was given by respondents employed in other sectors or aged 55 and older, or with a Ph.D. degree, or from the region. About 22% of panelists with 1-5 years of experience and about 15.2% of experts employed at university & research institutes gave low weights to this dimension.

Table 5.2 reveals diverse assessments of the environmental dimension among experts. For example, around 30-40% of respondents among different categories except for respondents with 1-5 years of experience highly ranked the environmental dimension. The same proportion of respondents except for Ph.D. holders gave a moderate assessment. Meanwhile, respondents with 1-5 years of experience (37.5%) or with a Ph.D. degree (32.8%) or aged 35-54 (32.1%) underrated the environmental dimension. Finally, a moderate assessment was given by most experts except for those aged 55 and older (38.1%) who underestimated the hazards dimension

Table 5.2 Cross-tabulation of water security dimensions (%)

	Urban & Household dimension			***Economic dimension***			***Environmental dimension***			***Hazards dimension***		
	low	*moderate*	*high*	*low*	*moderate*	*high*	*low*	*moderate*	*high*	*low*	*moderate*	*high*
Age												
18-34	30.8	30.8	38.5	12.0	28.0	60	24	36.0	40.0	11.5	53.8	34.6
35-54	20.5	47.7	31.8	10.9	23.6	65.5	32.1	30.2	37.7	29.1	41.8	29.1
55 and older	33.3	39.8	34.1	14.3	38.1	47.6	22.2	44.4	33.3	38.1	23.8	38.1
Experience												
1-5 years	11.1	66.7	22.2	22.2	11.1	66.7	37.5	37.5	25.0	22.2	44.4	33.3
6-15 years	16.1	38.7	45.2	10.5	28.9	60.5	28.2	38.5	33.3	20.5	48.7	30.8
more than 15 years	34.6	34.6	34.8	10.3	31.0	58.6	25.5	30.9	43.6	28.8	39.0	32.2
Education												
Up to master's degree	30.8	30.8	38.5	7.3	22	70.7	19.5	43.9	36.6	21.4	42.9	35.7
Ph.D.	22.6	45.3	32.1	14.1	32.8	53.1	32.8	27.9	39.3	27.7	43.1	29.2
Employment												
University/ Research Institute	23.7	47.5	28.8	15.2	18.2	66.7	30.2	31.7	38.1	25.8	42.4	31.8
Other	30.0	24.2	45.5	5.1	46.2	48.7	23.1	38.5	38.2	24.4	43.9	31.7
Residence												
Regional	32.5	32.5	35	10.2	32.7	57.1	26.7	37.8	35.6	20.0	44.0	36.0
International	21.2	44.2	34.6	12.5	25.0	62.5	28.1	31.6	40.4	29.8	42.1	28.1

The cross-tabulation results of water security priorities in Afghanistan are presented in Table 5.3. The development of mountainous conservation for water storage and hazard protection (e.g., floods, droughts) was underestimated by experts, mainly aged 18-34, or with 1-5 years of experience, or working at university/research institutes. Experts' assessments vary widely on the development of hydropower plants for electricity and agricultural use. Participants aged 35-54, or with 6-15 years of experience, or employed in sectors other than university/ research institutes, or from abroad gave a low assessment. Experts with 1-5 years of experience, or with a Ph.D. degree, or from the region think that developing hydropower plants for electricity and agricultural use should be prioritized in Afghanistan. Most of the experts highly ranked improving drinking water use in rural and urban areas to strengthen water security in the country.

Table 5.3 Cross-tabulation of water security priorities in Afghanistan (%)

	Mountainous conservation			***Hydropower development***			***Drinking water***		
	low	***moderate***	***high***	***low***	***moderate***	***high***	***low***	***moderate***	***high***
Age									
18-34	50	30	20	35	35	30	25	35	40
35-54	29.3	41.5	29.3	46.3	31.7	22	29.3	26.8	43.9
55 or older	28.6	50	21.4	28.6	37.5	35.7	42.9	14.3	42.8
Experience									
1-5 years	57.1	28.6	14.3	28.6	28.6	42.8	28.6	42.9	28.6
6-15 years	34.6	26.9	38.5	42.3	38.5	19.2	26.9	34.6	38.5
more than 15 years	31.8	47.7	20.5	38.6	31.8	29.5	34.1	27.3	41.6
Education									
Up to master's degree	44.8	37.9	17.3	30.4	34.8	34.8	13.0	30.4	56.5
Ph.D.	29.2	39.6	31.3	25.8	32.3	41.9	22.6	38.7	38.7
Employment									
University/ Research Institute	54.5	27.3	18.2	27.6	34.5	37.9	34	26.4	39.6
Other	42.9	28.6	28.6	45.8	33.3	20.9	25	29.2	45.8
Residence									
Regional	35.3	35.3	29.4	23.5	38.2	38.3	41.2	26.5	32.3
International	34.9	41.9	23.2	51.2	30.2	18.6	23.3	27.9	48.8

The literature review revealed the following water security priorities in Kazakhstan: improving river basin management plans, improving drinking water use in rural and urban areas, and improving irrigation management for agriculture. Table 5.4 presents the cross-tabulation results of these priorities, where most of the experts, except those aged 18-34 or from region, emphasized the importance of river basin management and gave a high assessment. Only 22.6% of international experts and about 16% of experts with 1-5 years of experience ranked high the drinking water priority. While, about 50% of experts aged 35-54, with 6-15 years of experience, and from abroad gave the lowest ranking to improving drinking water use in rural and urban areas. Many respondents highlighted the low relevance of prioritizing irrigation management for agriculture in Kazakhstan.

Table 5.4 Cross-tabulation of water security priorities in Kazakhstan (%)

	River basin planning			***Drinking water***			***Irrigation management***		
	low	***moderate***	***high***	***low***	***moderate***	***high***	***low***	***moderate***	***high***
Age									
18-34	41.2	23.5	35.3	11.8	52.9	35.3	58.8	23.5	17.6
35-54	14.8	29.6	55.6	51.9	22.2	25.9	40.7	40.7	18.5
55 or older	12.5	25.0	62.5	37.5	37.5	25.0	50.0	37.5	12.5
Experience									
1-5 years	16.7	16.7	66.6	33.3	50.0	16.7	66.7	33.3	-
6-15 years	21.1	26.3	52.6	52.6	21.1	26.3	36.8	47.4	15.8
more than 15 years	24.1	31.0	44.8	31.0	37.9	31.0	48.3	27.6	24.1
Education									
Up to master's degree	21.7	30.5	47.8	34.8	34.8	30.4	56.5	30.4	13.0
Ph.D.	22.6	25.8	51.6	41.9	32.3	25.8	38.7	38.7	22.6
Employment									
University/ Research Institute	18.2	27.3	54.5	42.4	30.3	27.3	45.5	39.4	15.2
Other	28.6	28.6	42.9	33.3	38.1	28.6	47.6	28.6	23.8
Residence									
Regional	34.8	21.7	43.5	26.1	39.1	34.8	47.8	34.8	17.4
International	12.9	32.3	54.8	48.4	29.0	22.6	45.2	35.5	19.4

Table 5.5 presents the cross-tabulation results of water security priorities in Tajikistan, such as improving irrigation management, improving river basin planning, and developing drought plans. Improvement of irrigation management for agriculture received either moderate or high assessment from most experts. The importance of enhancing river basin management plans was emphasized by senior experts from the region or with more than 15 years of experience. In comparison, many experts evaluated the low relevance of improving drought management plans as a critical factor in achieving water security in Tajikistan.

Table 5.5 Cross-tabulation of water security priorities in Tajikistan (%)

	Irrigation management			***River basin planning***			***Drought management***		
	low	***moderate***	***high***	***low***	***moderate***	***high***	***low***	***moderate***	***high***
Age									
18-34	12.5	43.8	43.7	43.8	25	31.2	75	25	-
35-54	6.7	50	43.3	30	33.3	36.7	76.7	16.7	6.7
55 or older	27.3	63.6	9.1	-	18.2	81.8	80.7	15.8	3.5
Experience									
1-5 years	25	50	25	25	50	25	75	-	25
6-15 years	4.8	52.4	42.8	33.3	33.3	33.3	85.7	14.3	-
more than 15 years	15.2	48.5	36.3	24.2	24.2	51.6	78.8	18.2	3
Education									
Up to master's degree	10.5	57.9	31.6	26.3	26.3	47.4	84.2	10.5	5.3
Ph.D.	12.8	46.2	41	28.2	30.8	41	79.5	17.9	2.6
Employment									
University/ Research Institute	15.8	42.1	42.1	21.1	36.8	42.1	81.6	15.8	2.6
Other	5	65.6	29.5	40	15	45	80	15	5
Residence									
Regional	19.2	42.3	38.5	19.2	30.8	50	84.6	15.4	-
International	6.3	56.3	37.4	34.4	28.1	37.5	78.1	15.6	6.3

Table 5.6 reveals that experts gave diverse assessments to waters security priorities for Kyrgyzstan, which were suggested from the literature. Most experts underestimated the improvement of drinking water use in rural and urban areas. The low assessment was also given to improve hazard plans for landslides, especially by senior experts, experts with 1-5 years of experience, and holding up to master's degree. The opinion of experts on the improvement of river basin management plans in Kyrgyzstan is varied. For example, young experts from the region with a Ph.D. employed in other sectors gave a low assessment of this priority. At the same time, experts with 1-5 years of experience in the water sector and senior experts emphasized improving river basin management plans in Kyrgyzstan.

Table 5.6 Cross-tabulation of water security priorities in Kyrgyzstan (%)

	Hazards plans			***Drinking water***			***River basin planning***		
	low	***moderate***	***high***	***low***	***moderate***	***high***	***low***	***moderate***	***high***
Age									
18-34	35.3	47.1	17.6	41.2	23.5	35.3	52.9	17.6	29.5
35-54	25	42.5	32.5	45	27.5	27.5	37.5	27.5	35
55 or older	45.5	27.3	27.2	45.5	45.5	9	27.3	18.2	54.5
Experience									
1-5 years	62.5	25	12.5	37.5	37.5	25	12.5	37.5	50
6-15 years	24	44	32	44	28	28	52	16	32
more than 15 years	27	40.5	32.4	43.2	32.4	24.4	40.5	24.3	35.2
Education									
Up to master's degree	46.2	30.8	23	34.6	34.6	30.8	34.6	26.9	38.5
Ph.D.	20.5	45.5	34	47.7	29.5	22.8	45.5	20.5	34
Employment									
University/ Research Institute	31.8	43.2	25	43.2	27.3	29.5	34.1	27.3	38.6
Other	26.9	34.6	38.5	42.3	38.5	19.2	53.8	15.4	30.8
Residence									
Regional	39.4	33.3	27.3	30.3	42.4	27.3	45.5	18.2	36.4
International	21.6	45.9	32.4	54.1	21.6	24.3	37.8	27	35.2

The literature review revealed the following water security priorities for Turkmenistan: improving river basin management plans, improving drinking water use in rural and urban areas, and improving drought management plans (Table 5.7). Assessment of experts varied a lot on improving of river basin management plans, especially among different age groups. Most experts gave either low or moderate assessments to advancing of drought management plans. Additionally, improvement of drinking water use in rural and urban areas was prioritized by experts, primarily aged 18-34 (61.1%) or with 6-15 years of experience (52.9%) or employed in other sectors than university/research institute (50%).

Table 5.7 Cross-tabulation of water security priorities in Turkmenistan (%)

	River basin planning			***Drinking water***			***Drought management***		
	low	***moderate***	***high***	***low***	***moderate***	***high***	***low***	***moderate***	***high***
Age									
18-34	50	38.9	11.1	27.8	11.1	61.1	38.9	44.4	16.7
35-54	34.5	37.9	27.6	37.9	31	31.1	41.4	20.7	37.9
55 or older	25	-	75	25	50	25	41.2	31.4	27.4
Experience									
1-5 years	16.7	66.7	16.6	50	16.7	33.3	50	16.7	33.3
6-15 years	41.2	47.1	11.7	41.2	5.9	52.9	29.4	41.2	29.4
more than 15 years	42.9	21.4	35.7	25	39.3	35.7	46.4	28.6	25
Education									
Up to master's degree	28.6	47.6	23.8	28.6	28.6	42.8	52.4	23.8	23.8
Ph.D.	46.7	26.7	26.6	36.7	23.3	40	33.3	36.7	30
Employment									
University/ Research Institute	39.4	36.4	24.2	39.4	24.2	36.4	36.4	33.3	30.3
Other	38.9	33.3	27.8	22.2	27.8	50	50	27.8	22.2
Residence									
Regional	39.1	30.4	30.5	26.1	34.8	39.1	39.1	34.8	26.1
International	39.2	39.4	21.5	39.3	17.9	42.8	42.9	28.6	28.5

Most experts highly ranked the importance of improving irrigation management for agriculture for achieving water security in Uzbekistan. At the same time, experts underrated the improvement of river basin management plans and drought management plans. According to Table 5.8, many experts highlighted the importance of improving irrigation management for agriculture, especially experts aged 18-34 (64.7%) or employed in other sectors (63.1%). Improvement of river basin planning was rated low among experts, especially those aged 18-34, 6-15 years of experience, or employed in other sectors. Overall, most experts gave a low or moderate assessment to improving drought management plans in Uzbekistan.

Table 5.8 Cross-tabulation of water security priorities in Uzbekistan (%)

	Irrigation management			***River basin planning***			***Drought management***		
	low	***moderate***	***high***	***low***	***moderate***	***high***	***low***	***moderate***	***high***
Age									
18-34	17.6	17.6	64.7	58.8	23.5	17.6	41.2	52.9	5.9
35-54	7.4	51.9	40.7	48.1	14.8	37.1	51.9	29.6	18.5
55 or older	8.3	33.3	58.4	41.7	33.3	25	66.7	33.3	-
Experience									
1-5 years	33.3	33.3	33.3	-	50	50	83.3	16.7	-
6-15 years	5.3	36.8	57.9	73.7	10.5	15.8	31.6	47.4	21
more than 15 years	9.1	36.4	54.5	45.5	24.2	30.3	60.6	33.3	6.1
Education									
Up to master's degree	5	45	50	40	25	35	70	25	5
Ph.D.	13.2	31.6	55.3	55.3	21.1	23.6	44.7	42.1	13.2
Employment									
University/ Research Institute	12.8	38.5	48.7	41	25.6	33.4	53.8	35.9	10.3
Other	5.3	31.6	63.1	68.4	15.8	15.8	52.6	36.8	10.6
Residence									
Regional	12	32	56	44	28	28	60	32	8
International	9.1	39.4	51.5	54.5	12.8	27.3	48.5	39.4	12.1

5.2 Multinomial logistic regression results

MNL regression was applied to test whether the demographic profile of experts affects assessing water security dimensions and priorities with more than two categories. Separate MNL regressions were run for each water security dimension and priority as the dependent variable. Table 5.9 presents the frequency distribution of dependent and independent variables, including the number of responses (N), coded values with frequencies and percentages, mean, and Std. Deviation. The number of observations varies among variables since experts might skip or prefer not answering questions. Overall, 88 experts answered the demographic questions in the first round. The most frequent categories among independent variables are 35-54, employment at university/research institutes, and professionals with more than 15 years of experience. Education and residence categories have almost equal distribution among subcategories. Water security dimensions received the most significant responses ranging from 88 to 102. According to Table 5.9, the most frequent categories among water security dimensions are the moderate assessment of urban& household dimension (39.8%), the high assessment of economic dimension (60.4%), the high assessment of environmental dimension (37.5%), and the moderate assessment of hazards dimension (41.2%).

MNL regressions were also run with water security priorities for each country, i.e., 18 priorities - three per country. Table 5.9 reveals a high assessment of improvement of drinking water use for urban and rural areas (42.7%) as the most frequent category for Afghanistan. The most frequent category for Kazakhstan was the high assessment of improvement of river basin management plans (50%). The low estimation of the advancement of drinking water use in rural and urban areas was the most frequent answer for Kyrgyzstan and Turkmenistan. Many experts highlighted the low relevance of improving drought management plans in Tajikistan (80.7%). The most frequent categories in Uzbekistan were the high relevance of improvement of irrigation management (51.8%) and the low relevance of improvement of drought management plans (51.8%). The number of responses regarding water security priorities varied from 51 to 77, with the weakest response rate in the case of Turkmenistan.

Table 5.9 Frequency distribution of dependent and independent variables

	N	Values	Frequency	%	Mean	Std. Deviation
Independent variables						
Age	88	1= 18-34	26	29.5%	1.951	.673
		2= 35-54	44	50.0%		
		3= 54 and older	18	20.5%		
Education	88	1= up to master's degree	38	43.2%	1.628	.485
		2= Ph.D.	50	56.8%		
Experience	88	1= beginners	9	10.2%	1.407	.493
		2= experienced	28	31.8%		
		3= professionals	51	58.0%		
Employment	88	1= university/ research institutes	58	65.9%	2.460	.641
		2= other	30	34.1%		
Residence	88	1= regional	39	44.3%	1.557	.498
		2= international	49	55.7%		
Dependent variables						
Water security dimensions						
Urban & household	88	1= low	23	26.1%	2.087	.779
		2= moderate	35	39.8%		
		3= high	30	34.1%		
Economic	101	1= low	12	11.9%	2.485	.694
		2= moderate	28	27.7%		
		3= high	61	60.4%		
Environmental	96	1= low	27	28.1%	2.107	.807
		2= moderate	33	34.4%		
		3= high	36	37.5%		
Hazards	102	1= low	27	26.5%	2.065	.755

		2= moderate	42	41.2%		
		3= high	33	32.4%		
Water security priorities						
AF_Mountains	77	1= low	26	34.7%	1.909	.781
		2= moderate	30	40%		
		3= high	19	25.3%		
AF_Hydropower	77	1= low	30	39.0%	1.883	.810
		2= moderate	26	33.8%		
		3= high	21	27.3%		
AF_Drinking	77	1= low	23	30.7%	2.103	.852
		2= moderate	20	26.7%		
		3= high	32	42.7%		
KZ_Drinking	54	1= low	19	36.5%	1.888	.816
		2= moderate	18	34.6%		
		3= high	15	28.8%		
KZ_Irrigation	54	1= low	25	46.3%	1.722	.762
		2= moderate	19	35.2%		
		3= high	10	18.5%		
KZ_Basin Planning	54	1= low	12	23.1%	2.277	.810
		2= moderate	14	26.9%		
		3= high	16	50%		
KG_Hazards	70	1= low	21	30.9%	2.000	.780
		2= moderate	28	41.2%		
		3= high	19	27.9%		
KG_Drinking	70	1= low	30	42.9%	1.828	.815
		2= moderate	22	31.4%		
		3= high	18	25.7%		
KG_Basin Planning	70	1= low	27	39.7%	1.942	.882
		2= moderate	16	23.5%		
		3= high	25	36.8%		
TJ_Irrigation	58	1= low	7	12.3%	2.258	.663
		2= moderate	29	50.9%		
		3= high	21	36.8%		
TJ_Basin Planning	58	1= low	16	28.1%	2.155	.833

		2= moderate	16	28.1%		
		3= high	25	43.9%		
TJ_Drought	58	1= low	46	80.7%	1.224	.497
		2= moderate	9	15.8%		
		3= high	2	3.5%		
UZ_Irrigation	58	1= low	6	10.7%	2.431	.678
		2= moderate	21	37.5%		
		3= high	29	51.8%		
UZ_Basin Planning	58	1= low	28	50%	1.775	.859
		2= moderate	12	21.4%		
		3= high	16	28.6%		
UZ_Drought	58	1= low	29	51.8%	1.569	.678
		2= moderate	21	37.5%		
		3= high	6	10.7%		
TM_Basin Planning	51	1= low	20	39.2%	1.862	.800
		2= moderate	18	35.3%		
		3= high	13	25.5%		
TM_Drinking	51	1= low	17	33.3%	2.078	.868
		2= moderate	13	25.5%		
		3= high	21	42.1%		
TM_Drought	51	1= low	21	41.2%	1.862	.825
		2= moderate	16	31.4%		
		3= high	14	27.5%		

Note: AF- Afghanistan, KZ- Kazakhstan, KG- Kyrgyzstan, TJ- Tajikistan, TM- Turkmenistan, UZ- Uzbekistan

5.2.1 Regression analysis results of water security dimensions

Separate MNL regressions were run for each water security dimension. Only the regression analysis of the urban & household dimension and the economic dimension were presented because the likelihood ratio tests revealed that the models with the environmental and hazards dimensions showed statistically insignificant and poor results. The reference category in all models was low assessment (i.e., low relevance of water security dimensions or low relevance of water security priorities). The table with MNL regression results consisted of information on model fitting, Pseudo R-Square, and parameter estimates. The model fitting report showed the Likelihood Ratio Chi-Square test of the final model with specified predictor variables, which tested that at least one of the coefficients in the final model was not equal to zero in the model. The degrees of freedom (df) showed the number of predictors. To test the null hypothesis, the *P*-values (Sig.) must be *P*<.01 (i.e., the willingness to compare a type I error). The value of pseudo-R-Square, namely Cox and Snell, was presented without interpretation since R-Square does not have the same meaning as in OLS regression and only attempted to measure the strength of association. The description of parameter estimates was described in Chapter 3- Methodology.

Among MNL regressions with five predictors, the regression model on urban & household dimension with three predictors (education, experience, employment) better fitted the model and gave statistically significant outputs. The reference category in this model was the low relevance of the urban & household dimension in the context of Central Asia. According to Table 5.10, there was a high probability that experts with up to 5 years of experience, relative to professionals with 15 years of experience, gave a higher assessment to moderate relevance of urban & household dimension than low relevance (Exp (B)=8.854, *P*=.068). Moreover, the probability of a higher assessment of the urban & household dimension was higher for experts with 6-15 years of experience than professionals with 15 years of experience (Exp (B)=3.640, *P*=.046).

Table 5.10 Regression results of the urban & household dimension

Model Fitting Information (Likelihood Ratio Tests)			
Model	Chi-Square	df	Sig.
Intercept Only			
Final	14.742	8	0.064
Pseudo R-Square			
Cox and Snell	0.148		

Parameter Estimates							
UH[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
moderate	Intercept	-0.001	0.581	0.000	1	0.998	
	Education= master's degree	-0.982	0.605	2.631	1	0.105	0.375
	Education= Ph.D.	0[b]			0		
	Experience= 1-5 years	2.181	1.195	3.328	1	0.068	8.854
	Experience= 6-15 years	0.867	0.656	1.747	1	0.186	2.379
	Experience = more15 years	0[b]			0		
	Employment= Univ/Research Institute	0.530	0.616	0.741	1	0.389	1.699
	Employment= other	0[b]			0		
high	Intercept	0.286	0.544	0.277	1	0.599	
	Education= master's degree	-0.344	0.582	0.349	1	0.555	0.709
	Education= Ph.D.	0[b]			0		
	Experience= 1-5 years	1.065	1.313	0.658	1	0.417	2.900
	Experience= 6-15 years	1.292	0.649	3.966	1	0.046	3.640
	Experience= more 15 years	0[b]			0		
	Employment= Univ/Research Institute	-0.533	0.591	0.814	1	0.367	0.587
	Employment= other	0[b]			0		

a. The reference category: low; b. This parameter is set to zero because it is redundant.

Table 5.11 presents the significance level (*P*=.036) of the likelihood ratio chi-square test of the regression model on the economic dimension with three predictors (education, experience, employment) signaling that this model fitted better and gave statistically significant outputs. The reference category in this model was the low relevance of the economic dimension in the context of Central Asia. The intercept (with *P*=.032) was MNL estimate for high assessment of economic dimension relative to low assessment when the independent variables in the model were assessed at zero. Moreover, there was a high tendency that experts employed at universities & research centers were more likely to give a lower evaluation to moderate relevance of economic dimension than low relevance (Exp (B)=0.145, *P*=.029). Experts with a Ph.D. degree or more than 15 years of experience in the water sector or employed in other sectors than university & research institutes were more likely to give high relevance of economic dimension in Central Asia.

Table 5.11 Regression results of the economic dimension

Model Fitting Information (Likelihood Ratio Tests)							
Model	Chi-Square	df	Sig.				
Intercept Only							
Final	16.502	8	0.036				
Pseudo R-Square							
Cox and Snell	0.145						
Parameter Estimates							
ECON[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
moderate	Intercept	2.195	0.847	6.714	1	0.010	
	Education= master's degree	0.180	0.883	0.042	1	0.838	1.198
	Education= Ph.D.	0[b]			0		
	Experience= 1-5 years	-1.585	1.424	1.239	1	0.266	0.205
	Experience= 6-15 years	0.087	0.780	0.012	1	0.911	1.091
	Experience = more 15 years	0[b]			0		
	Employment= Univ/Research Institute	-1.928	0.883	4.761	1	0.029	0.145
	Employment= other	0[b]			0		
high	Intercept	1.797	0.836	4.617	1	0.032	
	Education= master's degree	1.105	0.794	1.938	1	0.164	3.021
	Education= Ph.D.	0[b]			0		
	Experience= 1-5 years	-1.081	1.037	1.086	1	0.297	0.339
	Experience= 6-15 years	0.013	0.713	0.000	1	0.985	1.013
	Experience = more15 years	0[b]			0		
	Employment= Univ/Research Institute	-0.503	0.848	0.352	1	0.553	0.605
	Employment= other	0[b]			0		

a. The reference category: low; b. This parameter is set to zero because it is redundant.

5.2.2 Regression analysis results of water security priorities

Experts ranked the water security priorities for each country. Separate MNL regressions were run for each water security priority. The likelihood ratio tests revealed that the models with water security priorities in Turkmenistan showed statistically insignificant and poor results; therefore, the regression results were not presented. The MNL regression model of the development of hydropower plants gave some statistically significant results in the case of Afghanistan. Table 5.12 presents the significance level (*P*=.031) of the likelihood ratio chi-square signaling that the model with one predictor (residence) fitted better than the model with no predictors. The reference category in this model was the low relevance of the development of hydropower plants in Afghanistan. There was a high tendency that experts from the Central Asia region relative to international experts were more likely to give a higher assessment of the moderate and high relevance of hydropower development in Afghanistan than low relevance (Exp (B)=2.750, *P*=.076 and Exp (B)=4.469, *P*=.014).

Table 5.12 Regression results of water security priority in Afghanistan

Model Fitting Information (Likelihood Ratio Tests)							
Model	Chi-Square	df	Sig.				
Intercept Only							
Final	6.942	2	0.031				
Pseudo R-Square							
Cox and Snell	0.086						
Parameter Estimates							
AF_Hydropower[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
moderate	Intercept	-0.526	0.350	2.262	1	0.133	
	Residence= Regional	1.012	0.569	3.156	1	0.076	2.750
	Residence= International	0[b]			0		
high	Intercept	-1.012	0.413	6.004	1	0.014	
	Residence= Regional	1.497	0.610	6.019	1	0.014	4.469

	Residence= International	0[b]			0		

a. The reference category is low; b. This parameter is set to zero because it is redundant.

In the case of Kazakhstan, only MNL regression on improving drinking water use in rural and urban areas with two predictors (age and experience) gave statistically significant results. According to Table 5.13, the significance level (*P*=.038) of this regression model's likelihood ratio chi-square test signaling that the model fitted significantly better. The reference category in this model was the low relevance of improvement of drinking water usage in rural and urban areas. Table 5.13 reveals that there was a high probability that experts in the age category 18-34 relative to senior experts were more likely to give higher importance to moderate and high assessment of drinking water usage in rural and urban areas than low assessment (Exp (B)=23.841, *P*=.032 and Exp (B)=17.013, *P*=.055). It is interesting to note that experts with 6-15 years of experience in the water sector were less likely to assess moderate relevance than low relevance of improving drinking water usage in rural and urban areas in Kazakhstan (Exp (B)=0.076, *P*=.026).

Table 5.13 Regression results of water security priority in Kazakhstan

Model Fitting Information (Likelihood Ratio Tests)							
Model	Chi-Square	df	Sig.				
Intercept Only							
Final	16.340	8	0.038				
Pseudo R-Square							
Cox and Snell	0.269						
Parameter Estimates							
KZ_Drinking[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
moderate	Intercept	0.281	0.864	0.106	1	0.745	
	Age= 18-34	3.171	1.480	4.593	1	0.032	23.841
	Age= 35-54	-0.499	1.016	0.241	1	0.624	0.607

	Age= 55 and older	0[b]			0		
	Experience= 1-5 years	-1.605	1.492	1.157	1	0.282	0.201
	Experience= 6-15 years	-2.573	1.157	4.946	1	0.026	0.076
	Experience= more 15 years	0[b]			0		
high	Intercept	-0.162	0.947	0.029	1	0.864	
	Age= 18-34	2.834	1.477	3.679	1	0.055	17.013
	Age= 35-54	0.032	1.071	0.001	1	0.976	1.033
	Age= 55 and older	0[b]			0		
	Experience= 1-5 years	-2.034	1.623	1.571	1	0.210	0.131
	Experience= 6-15 years	-1.692	1.009	2.811	1	0.094	0.184
	Experience = more15 years	0[b]			0		

a. The reference category is low; b. This parameter is set to zero because it is redundant.

Among water security priorities in Kyrgyzstan, only MNL regression model for improving drinking water use gave some statistically significant results. The reference category in this model was the low relevance of improvement of drinking water use in Kyrgyzstan. There was a high probability that experts from Central Asia relative to international experts were more likely to give a moderate assessment to improve drinking water use than low assessment (Exp (B)=3.500, *P*=.033). Table 5.14 presents the significance level (P=.090) of the likelihood ratio chi-square indicating that the model with one predictor (residence) fitted significantly better than the model with no predictors. The statistically significant intercepts revealed that international experts were more likely to emphasize moderate and high relevance of improving drinking water use in Kyrgyzstan higher than low relevance.

Table 5.14 Regression results of water security priority in Kyrgyzstan

Model Fitting Information (Likelihood Ratio Tests)			
Model	Chi-Square	df	Sig.
Intercept Only			

Final	4.827	2	0.090				
Pseudo R-Square							
Cox and Snell	0.067						
Parameter Estimates							
KG_Drinking[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
moderate	Intercept	-0.916	0.418	4.798	1	0.028	
	Residence= Regional	1.253	0.589	4.530	1	0.033	3.500
	Residence= International	0[b]			0		
high	Intercept	-0.799	0.401	3.958	1	0.047	
	Residence= Regional	0.693	0.610	1.291	1	0.256	2.000
	Residence= International	0[b]			0		

a. The reference category is low; b. This parameter is set to zero because it is redundant.

The MNL regression of irrigation management for agriculture in Tajikistan reported statistically significant outputs. The regression model with four predictors (age, employment, education, and residence) showed that the model fits significantly better since the significance level (*P*=.038) of the likelihood ratio chi-square. The reference category in this model was the low relevance of improvement of irrigation management for agriculture in Tajikistan. Table 5.15 presents a high tendency that experts aged 35-54 were less likely than senior experts to give a moderate assessment of irrigation management for agriculture compared to a low assessment. Moreover, there was a high probability that experts employed at universities & research institute relative to experts in other sectors were less likely to give a high assessment of irrigation management for agriculture in Tajikistan than low assessment ((Exp (B)=0.292, *P*=.092). In comparison, there was a high tendency that experts with master's degrees relative to experts with Ph.D. were more likely to emphasize the importance of improving irrigation management for agriculture in Tajikistan (Exp (B)=5.137, *P*=.075). Overall, there was a high probability that senior international experts with a Ph.D. degree or employed in other sectors than university & research institutes were more likely to prioritize irrigation management for agriculture in Tajikistan.

Table 5.15 Regression results of water security priority in Tajikistan

Model Fitting Information (Likelihood Ratio Tests)							
Model	Chi-Square	df	Sig.				
Intercept Only							
Final	19.186	10	0.038				
Pseudo R-Square							
Cox and Snell	0.286						
Parameter Estimates							
TJ_Irrigation[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
moderate	Intercept	-0.697	1.798	0.150	1	0.698	
	Age= 18-34	-2.093	1.667	1.577	1	0.209	0.123
	Age= 35-54	-3.212	1.473	4.753	1	0.029	0.040
	Age= 55 and older	0[b]			0		
	Employment= Univ/Research Institute	1.644	1.430	1.321	1	0.250	5.175
	Employment= other	0[b]			0		
	Education= master's degree	-0.514	1.410	0.133	1	0.716	0.598
	Education= Ph.D.	0b			0		
	Residence= Regional	1.061	1.107	0.919	1	0.338	2.890
	Residence= International	0[b]			0		
high	Intercept	2.945	1.252	5.535	1	0.019	
	Age= 18-34	-2.944	1.383	4.533	1	0.033	0.053
	Age= 35-54	-1.787	1.193	2.242	1	0.134	0.167
	Age= 55 and older	0[b]			0		
	Employment= Univ/Research Institute	-1.232	0.730	2.846	1	0.092	0.292
	Employment= other	0[b]			0		
	Education= master's degree	1.636	0.920	3.160	1	0.075	5.137
	Education= Ph.D.	0[b]			0		
	Residence= Regional	-1.056	0.703	2.255	1	0.133	0.348
	Residence= International	0[b]			0		

a. The reference category: low; b. This parameter is set to zero because it is redundant.

In the case of Uzbekistan, the MNL regression on the improvement of irrigation management with three predictors (age, education, employment) gave statistically significant results. According to Table 5.16, the likelihood ratio chi-square test of this regression model (*P*=.055) signaled the model fitted significantly better. The reference category in this model was the low relevance of improvement of irrigation management. There was a high probability that experts aged 18-34 relative to senior experts were less likely to give a moderate assessment higher value than to low evaluation of improvement of irrigation management (Exp (B)=0.036, *P*=.052). It is interesting to note that there was a high tendency that experts with master's degrees relative to experts with a Ph.D. were more likely to assess moderate relevance higher than low relevance of improvement of irrigation management (Exp (B)=45. 028, *P*=.018). Moreover, senior experts with a Ph.D. degree employed in other sectors than university & research institutes were more likely to prioritize irrigation management for agriculture in Uzbekistan.

Table 5.16 Regression results of water security priority in Uzbekistan

Model Fitting Information (Likelihood Ratio Tests)							
Model	Chi-Square	df	Sig.				
Intercept Only							
Final	15.217	8	0.055				
Pseudo R-Square							
Cox and Snell	0.238						
Parameter Estimates							
UZ_Irrigation[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
moderate	Intercept	1.657	1.564	1.122	1	0.289	
	Age= 18-34	-3.326	1.709	3.789	1	0.052	0.036
	Age= 35-54	1.052	1.433	0.539	1	0.463	2.864
	Age= 55 and older	0[b]			0		
	Employment= Univ/Research Institute	-1.368	1.331	1.057	1	0.304	0.255
	Employment= other	0[b]			0		

	Education= master's degree	3.807	1.613	5.569	1	0.018	45.028
	Education= Ph.D.	0^b			0		
high	Intercept	2.657	1.453	3.345	1	0.067	
	Age= 18-34	-1.570	1.416	1.229	1	0.268	0.208
	Age= 35-54	0.005	1.341	0.000	1	0.997	1.005
	Age= 55 and older	0^b			0		
	Employment= Univ/Research Institute	-1.237	1.237	1.000	1	0.317	0.290
	Employment= other	0^b			0		
	Education= master's degree	2.032	1.394	2.125	1	0.145	7.631
	Education= Ph.D.	0^b			0		

a. The reference category: low; b. This parameter is set to zero because it is redundant.

Table 5.17 summarized the MNL regression results on national water security priorities and demonstrates that the clustering of experts into five categories is appropriate. In other words, the demographic characteristics of experts affect the setting of water security priorities.

Table 5.17 Summary of MNL regressions

	Age	**Education**	**Experience**	**Employment**	**Residence**
Development of hydropower plants for electricity and agricultural use in Afghanistan					CA and Afghanistan
Improvement of drinking water use in rural and urban areas in Kazakhstan	18-34		1-5 years		
Improvement of drinking water use in rural and urban areas in Kyrgyzstan					CA and Afghanistan
Improvement of irrigation management in Tajikistan	18-34 35-54	Master's degree		University/ Research Institute	
Improvement of irrigation management in Uzbekistan	18-34	Master's degree			

5.3 Thematic analysis of practitioners' suggestions

Some experts mentioned their suggestions regarding water security dimensions and priorities. The comments from the first round of Delphi were collected, and comments in Russian were translated to English. Experts suggested including transboundary complexity, strengthening legislative and institutional aspects, analyzing interstate and domestic politics, and improving water education. Experts added factors that might contribute to the urban & household dimension of water security in Central Asia in addition to literature findings. They mentioned continuous monitoring of water supply and drainage systems, transparency on data quality and quantity, improvements of rural wastewater systems, individual behavioral changes, and improvement of personal hygiene. Experts supplemented the economic dimension with the following factors: changing water status as a product, controlling and monitoring groundwater resources, changing the water pricing, and adopting water-efficient irrigation methods. They contributed with the following factors for the hazards dimension: mitigation of technological disasters, spatial planning to infrastructure and settlements, and management and protection against mudflows in the foothills. They also complemented attributes of environmental dimension by the following factors: land conservation, regulation of groundwater use, biodiversity conservation, reduction of water losses, and climate change adaptation and mitigation measures.

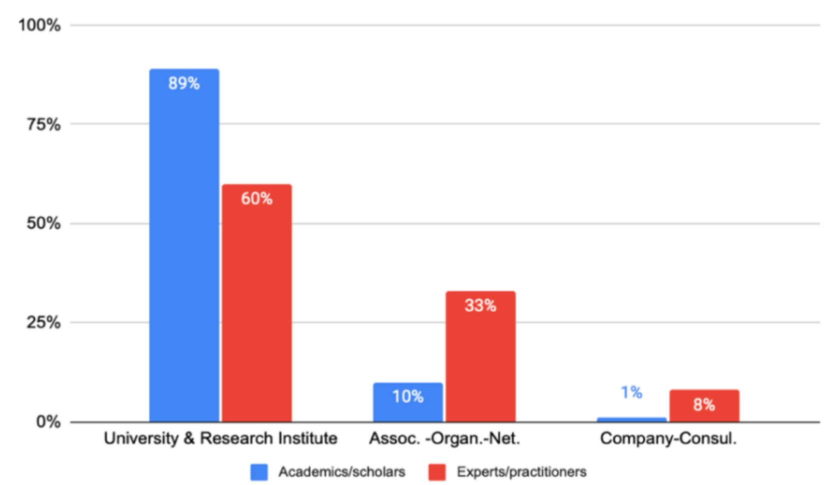
Experts also suggested additional water security priorities. In the case of Afghanistan, experts added improvement of water monitoring systems, developing transboundary water cooperation with downstream countries, development of river basin planning, and modernization of irrigation systems. However, some experts did not answer this question since they mentioned a lack of information and expertise in water management in Afghanistan. Water security priorities in Kazakhstan were complemented with water infrastructure improvement, land restoration, monitoring and control over lakes and lake systems, and training of water experts. Regarding Kyrgyzstan, experts highlighted glaciers monitoring, investment in hydropower projects, improvement of irrigation management, negotiation and cooperation with downstream countries, and training of water experts. Respondents noted improving drinking water quality, improving the monitoring system of glaciers and natural hazards, and developing hydropower projects should also be prioritized in Tajikistan. In the case of Uzbekistan, experts emphasized the improvement of wastewater systems, the improvement of drinking water quality, and the conservation of the Aral Sea. According to experts' opinion, improvement of irrigation systems, development of water-saving technologies, and improvement of inefficient water infrastructure should be considered in Turkmenistan.

5.4 Comparison academic literature's findings and practitioners' views

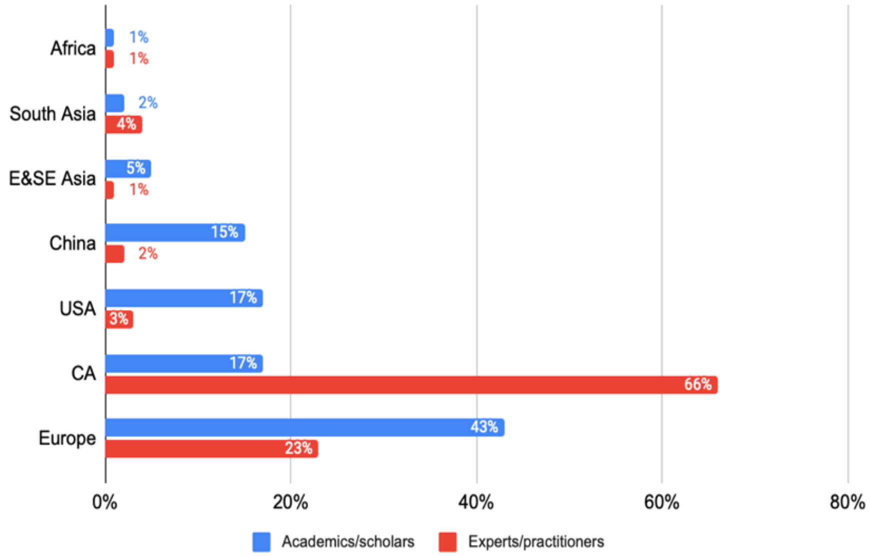
This section compares the results of scholarly literature and practitioners' perceptions on water security aspects in Central Asia. The literature review consisted of 151 peer-reviewed articles from 1991 to 2019 on water security issues in Central Asia. The experts' opinions were gathered with two rounds of the survey. Invitations to the survey were sent to 417 experts, where 112 and 118 experts participated in the first- round and the second round of the survey, respectively.

Table 5.18 presents the background of scholars and practitioners/experts. Several scholars could be authors of the peer-reviewed articles; hence, the first author's affiliations (organization and country of origin) were considered for analysis. Most scholars, namely 89%, were employed at universities and research institutes. About 10% of scholars were occupied in associations and networks, and only 1% work at companies and consultancy agencies. The employment of practitioners who participated in the surveys represented as an average from two survey rounds. On average, about 60% of experts worked at universities and research institutes. One-third of practitioners were employed at government agencies, international organizations, associations, networks, and 8% in company-consultancy agencies. The comparison of employment revealed that articles were written by scholars and researchers, while experts' opinion in this study consisted of researchers, practitioners, consultants, and public servants. As was mentioned earlier, I present a literature review finding as academics/ scholars' findings and the opinion of researchers/ experts as practitioners' views.

Table 5.18 Comparison of the background of scholars and practitioners

	Academics/scholars	Experts/practitioners
Sample	151 articles	112 experts (1st round) / 118 experts (2nd round)
Employment/ occupation		

Regional distribution



Source: adapted from Assubayeva (2021), Xenarios et al. (2020)

The regional distribution of scholars and practitioners gave interesting insights. Half of the articles on water security issues in Central Asia were written by scholars from Europe, 17% from the USA, and only 17% by regional experts, namely from Central Asia countries and Afghanistan. One-fourth of articles were produced by scholars from China, East &South-East Asia, and South Asia. The regional distribution of practitioners was different from scholars. Two-thirds of practitioners were from the region and about 23% of experts were from Europe. The analysis of regional distribution showed that about half of the articles on water security aspects in Central Asia were written by scholars from Europe. At the same time, experts' opinions represented the position of regional experts.

Table 5.19 presents the literature review findings and experts' opinions on water security dimensions in Central Asia. The hierarchy of water security dimensions in Central Asia differs from the literature from practitioners' opinions. Scholars widely discussed the importance of environmental aspects, followed by economic activities, natural hazards, and urban & household facilities. In comparison, practitioners emphasized the importance of economic dimension and urban & household dimensions of water security in the region.

Table 5.19 Ranking of water security dimensions by scholars and practitioners

Ranking	***Academics/ scholars***	***Experts/ practitioners***
1	Environmental aspects	Economic activities
2	Economic activities	Urban & household facilities
3	Natural hazards	Natural hazards
4	Urban & household facilities	Environmental aspects

Comparing literature review findings and experts' opinions revealed academic and policy discourses in ranking water security dimensions. Moreover, widespread water supply infrastructure decay, poor quality of drinking water and sanitation facilities, and lack of wastewater regulation treatment are common challenges of all Central Asia countries (Abdolvand et al., 2015; Abdullaev et al., 2019; Stucki & Sojamo, 2012; Wegerich, 2011). According to the Sustainable Development Report (2020), Central Asia countries face major and significant difficulties in achieving SDG 6 - clean water and sanitation (Sachs et al., 2021). Practitioners prioritized the importance of economic and household & urban dimensions of water security in the context of Central Asia. Indeed, the economies of Central Asia countries highly depend on water resources availability: upstream countries for electricity generation and hydropower plants operation, and downstream countries for irrigation and agricultural production. In contrast, scholars discussed environmental aspects of water security regarding surface runoff changes in transboundary rivers and the impact of climate change on water resources in the region (Xenarios et al., 2020). As a result, scholars focused on future scenarios and raised awareness about the potential impact of global warming on water resources and the overall ecosystem in the region. At the same time, practitioners highlighted current water policy challenges and water needs.

The literature review also revealed attributes (important factors) of each water security dimension. Table 5.20 shows that experts highlighted strengthening urban & household dimensions by improving operation and administration of drinking water supply systems, sanitation, hygiene facilities, and wastewater treatment facilities. Scholars and practitioners also agreed on enhancing the economic dimension of water security via investing in the operation and governance of irrigation and hydropower systems. Regarding environmental aspects of water security, practitioners ranked 1st management and protection of river basins, 2nd broader management and preservation of the natural environment, and 3rd protection of mountains and wider mountainous regions. Moreover, scholars and practitioners noted strengthening the natural hazards dimension by developing conservation and management plans from droughts, floods, and landslides.

Table 5.20 Comparison of ranking of water security attributes

Academics/scholars	**Experts/practitioners**
Urban & Household dimension	
Drinking water supply facilities	1st
Sanitation and hygiene facilities	2nd
Wastewater treatment facilities	3rd
Economic dimension	
Irrigation systems	1st
Hydroelectric systems	2nd
Industrial water use	3rd
Environmental dimension	
Protection and management of river basins	1st
Conservation of ecosystems	2nd

Protection of mountainous regions	3rd
Natural hazards dimension	
Control and protection from droughts	1st
Flood defense and management	2nd
Management and protection from landslides	3rd

Source: adapted from Assubayeva (2021), Xenarios et al. (2020)

The Delphi surveys helped identify current policy discourse in Central Asia and rank the attributes of water security and water security priorities for each country suggested from the literature review. Experts highlighted the improvement of operation and administration of drinking water supply systems as an essential factor of household & urban dimensions. According to WASH data, access to basic drinking water services has grown in the region since the 2000s; however, drinking water quality needs improvements. Since the area equipped for irrigation is enormous in Central Asia despite the arid and semi-arid climate, especially in Uzbekistan, maintenance, and management of irrigation systems, which were built in the 1960s-1970s, need huge investments (Bekchanov & Lamers, 2016; Djanibekov et al., 2013; Groll et al., 2015; Rudenko et al., 2013). Population growth and economic development in the region have led to increased water use. However, Central Asia countries share transboundary rivers, where water allocation is still under discussion. Hence, management and preservation of river basins were prioritized by experts to strengthen the environmental water security dimension. Climate change in terms of temperature rise in arid-semiarid areas will cause frequent and more prolonged droughts in the region (Guo et al., 2018; Li et al., 2017; Xu et al., 2016). Therefore, experts suggested developing management and protection plans from droughts for hazard dimensions.

The next section of this study compares historic water security trends in the literature and policy levels (e.g., state initiatives, laws, by-laws, etc.). The number of studies on water security in Central Asia significantly increased from 1997 to 2019, primarily since 2011. About two-third of experts confirmed that in the last 20 years, higher importance was also given to the water security concept in Central Asia at a policy level. The historical trend of each water security dimension was borrowed from the machine learning analysis of relative word frequency (Xenarios et al., 2020). The household & urban aspects are widely discussed in the literature until 2012, but there is a steady decreasing trend. Whereas half of the experts disagreed that there was a similar situation on the policy level. There has been a growing discussion on the environmental aspects of water security and water-related hazards in Central Asia in the last ten years. Most experts acknowledged that similar trends could be observed on the policy level. The historical trend of the economic dimension of water security was receiving less recognition than the hazard and environmental dimensions. About two-thirds of experts agreed that there was a similar situation on the policy level in Central Asia.

Table 5.21 Comparison of historic water security trends

Academics/scholars	***Experts/practitioners***
The number of studies discussing water security has been growing exponentially since 2010.	Two-thirds of experts confirmed growing interest in water security in Central Asia at a policy level.
The household & urban aspects have been discussed in the literature until 2012; then, there is a steady decreasing trend.	Two-thirds of experts opposed the relevance of this trend on the policy level in Central Asia.
Water-related hazards have been discussed more frequently since 2012 as one of the significant water parameters of security in Central Asia.	Two-thirds of experts agreed with the relevance of a similar trend on the policy level in Central Asia.
There has been a growing discussion on the environmental aspects of water security in Central Asia last ten years.	About 72% of experts confirmed a similar trend on the policy level in Central Asia.
Economic factors received less recognition than the hazard and the environmental dimensions.	One-third of experts disagreed that there is a similar situation on the policy level in Central Asia.

Source: adapted from Assubayeva (2021), Xenarios et al. (2020)

Historic water security trends in the literature and experts' opinions on similar trends on policy level revealed the potential research-practice gap on water security issues in Central Asia.

The growing number of publications demonstrated that a discussion over water security in Central Asia has been gaining more attention, especially over environmental and hazards dimensions. The global agenda promotes climate adaptation and mitigation initiatives, particularly the vulnerability of arid and semi-arid regions such as Central Asia, where temperature rise might impact the loss of glaciers, declining precipitation, variability in surface water runoff, and result in periodic floods and droughts (Didovets et al., 2021; Mitchell et al., 2017; Reyer et al., 2017). In contrast, practitioners emphasized the importance of socioeconomic aspects of water security policy in Central Asia, gaining less attention among scholars. Experts' opinions can be supported by the fact that the economies of Central Asia countries highly rely on the availability of water resources since agriculture remains the primary water user. In 2019, the highest contribution of agriculture to gross domestic product (hereafter GDP) in the region was in Afghanistan (25.8% of GDP) and Uzbekistan (25.5% of GDP). Moreover, employment in agriculture is also high in the region: 45% in Tajikistan, 43% in Afghanistan, and 26% in Uzbekistan (World Bank, 2021). Consequently, water scarcity is one of the region’s pressures of sustainable socioeconomic progress. However, the discrepancy between scholarly research and experts' opinions on policy agenda on household and economic dimensions of water security revealed the potential gap between the demand for relevant water policy recommendations and the supply of scholarly knowledge.

A bibliometric review using machine learning techniques revealed water security priorities discussed in the literature for each Central Asia country (Xenarios et al., 2020). Experts ranked these priorities for each country in the first round of the Delphi method. Table 5.22presents water security priorities for each country and the ranking of these priorities. Practitioners highlighted the importance of enhancing drinking water facilities in Afghanistan and Turkmenistan. For Kazakhstan, experts prioritized the importance of improving river basin management plans.

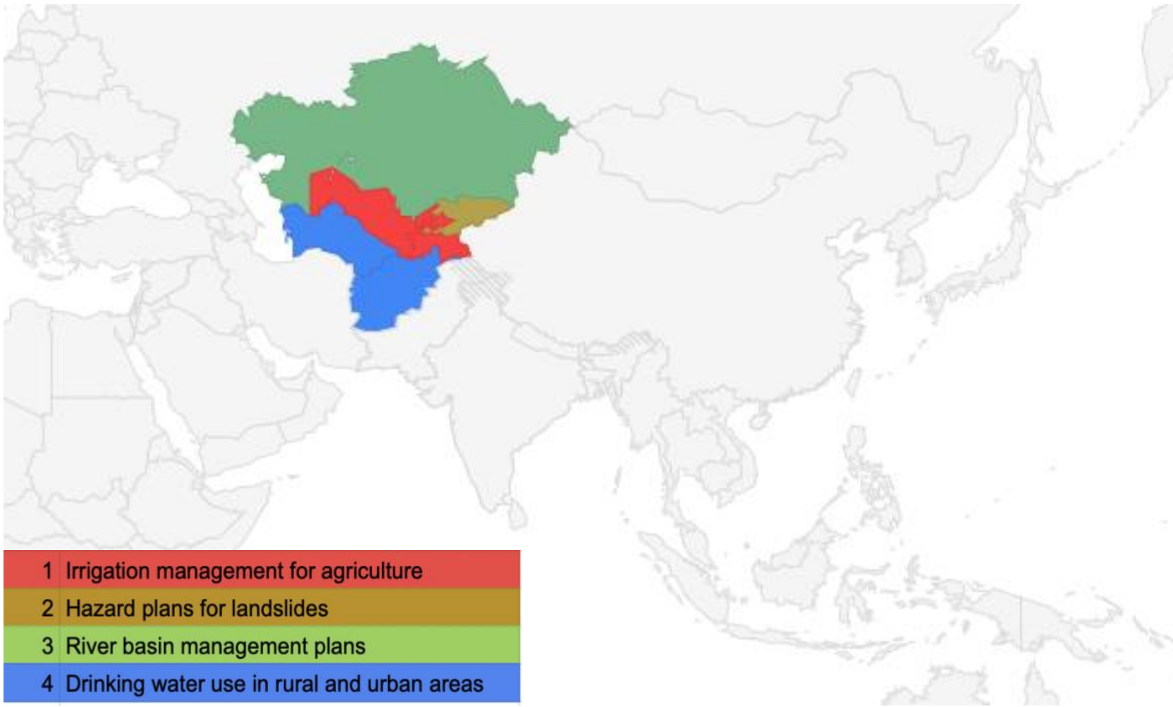
Development of hazards plans for landslides was suggested for Kyrgyzstan. Experts emphasized the importance of enhancing irrigation management in Tajikistan and Uzbekistan. **Error! Reference source not found.** illustrates the map of water security priorities for each country.

Table 5.22 Comparison of ranking water security priorities for Central Asia countries

Academics/scholars	**Experts/practitioners**
Afghanistan	
Drinking water use in rural and urban areas	1st
Mountainous conservation for water storage and hazard protection	2nd
Hydropower plants for electricity and agricultural use	3rd
Kazakhstan	
River basin management plans	*1st*
Drinking water use in rural and urban areas	2nd
Irrigation management for agriculture	3rd
Kyrgyzstan	
Hazard plans for landslides	1st
River basin management plans	2nd
Drinking water use in rural and urban areas	3rd
Tajikistan	
Irrigation management for agriculture	1st
River basin management plans	2nd
Drought management plans	3rd
Turkmenistan	
Drinking water use in rural and urban areas	1st
River basin management plans	2nd
Drought management plans	3rd
Uzbekistan	
Irrigation management for agriculture	1st
River basin management plans	2nd
Drought management plans	3rd

Source: adapted from Assubayeva (2021), Xenarios et al. (2020)

Figure 5.5 Water security priorities in Central Asia



Source: adapted from Assubayeva (2021), Xenarios et al. (2020)

In the next chapter, I presented the results of interviews about the role of river basin management in strengthening water security. I took as a pilot study the case of Kazakhstan, where both scholars and practitioners suggested achieving water security by improving river basin management. In Chapter 7, I synthesized all findings and discussed policy implications. Finally, in Chapter 8, I concluded by answering research questions.

Chapter 6

River Basin Management in Kazakhstan

6 RIVER BASIN MANAGEMENT IN KAZAKHSTAN

6.1 Overview of river basin approach

This chapter explores whether improving river basin management and planning can strengthen water security in Kazakhstan using the DPSIR framework and semi-structured interviews. Scholars in academic literature and international and regional experts participating in the Delphi survey suggested improvement of river basin management in Kazakhstan. This chapter analyzes the drivers of change towards the river basin approach, national and local pressures on water resources, and the current state of river basin management. Interview participants also reflected on the impact of the river basin approach on water security and environmental sustainability. Policy recommendations on strengthening institutional mechanists of river basin management in Kazakhstan were also discussed.

Before discussing the findings from interviews, the concept of river basin management is briefly described as one of the key principles of IWRM, promoting a holistic approach to water policy. The principles of IWRM (equity, efficiency, environmental sustainability) were developed in the 1980s-1990s by water professionals, engineers, economists, and environmental scientists as a response to negative outcomes of past water mismanagement policies (Allan, 2003; Molle, 2008; P. P. Mollinga, 2008). IWRM was officially presented in 1992 at the World Summit on sustainable development in Rio to manage competing demands for water among sectors and upstream and downstream water users by planning and managing on the basin level. Since then, IWRM has been widely promoted as a universal and influential water management approach in policymaking.

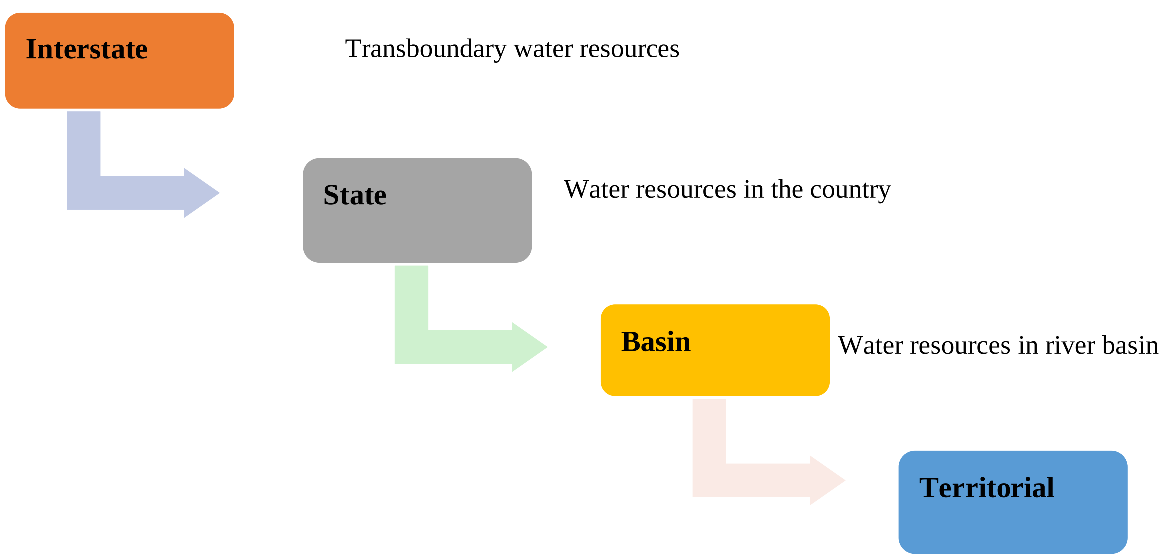
However, the idea of managing water at the basin level has deep roots. Coordinating water needs in the basin level was suggested by W. Wilcocks in the 1890s in the case of regulation plans in the Nile river (Barrow, 1998). The primary purpose was to manage conflicting water demands between different users in the river rather than on the basin/ catchment level. Then the idea of control of the hydrological regime supported by the 'hydraulic mission' with massive dam contractions in the 1930s-1960s had dominated and remains still defeating in developing countries (Allan, 2003; Molle, 2008; P. P. Mollinga, 2008). Later, after environmental degradation linked with water engineering projects, the IWRM paradigm shifted focus to watershed and ecosystem management. Basin management was promoted as an integrated, interdisciplinary, and holistic approach that prioritizes environmental protection and sustainability in the territory of the relevant basin ((Barrow, 1998; Molle, 2009). Experts, international donors, and organizations supported this management model and promoted experience of successful example of comprehensive and multi-purpose river basin planning such as the US Tennessee Valley Authority, the Australian Murray-Darling Basin Commission, the French Water Agencies (Agencies de l'Eau), and other (Molle, 2008; Mukhtarov & Gerlak, 2013). However, scholars argued that IWRM and river basin approaches were not merely scientific or not emerged by chance but were promoted by complex webs of interests and lobbying (Molle, 2009; P. P. Mollinga, 2008; Mukhtarov & Gerlak, 2013).

Water resources in the catchment are managed by a single organization- a river basin organization (hereafter RBO). RBOs were created to address water challenges such as water pollution, environmental degradation, coordination water uses and users. RBO should consider the interest and participation of different governmental agencies, local communities, NGOs, water users. The responsibilities of RBOs might include coordination of water uses in shared basins (between regions/interstate), integration of land and water management, promotion of sustainable development and regional development, provision of decentralized planning and management, prevention of pollution and degradation, and others (Barrow, 1998). Over the last decades, the role of RBOs shifted from integrated planning and nature conservation to stakeholder engagement and sustainable development (Molle, 2009; Santos Coelho et al., 2018; Woodhouse & Muller, 2017).

6.2 Water governance in Kazakhstan

The structure of water resources management in Kazakhstan consists of several levels: interstate, state, basin, and territorial (Figure 6.1). On the interstate level, mainly the Ministry of Foreign Affairs and the Ministry of Ecology, Geology, and Environment are responsible for negotiations on transboundary water resources. The Ministry of Ecology, Geology, and Environment, namely the Committee of Water Resources, works on water policy formulation and implementation at the state level. Eight basin inspections are responsible for water management on the basin level. Finally, local administration in the oblast/ city is responsible for water management at the territorial level.

Figure 6.1 Water governance in Kazakhstan

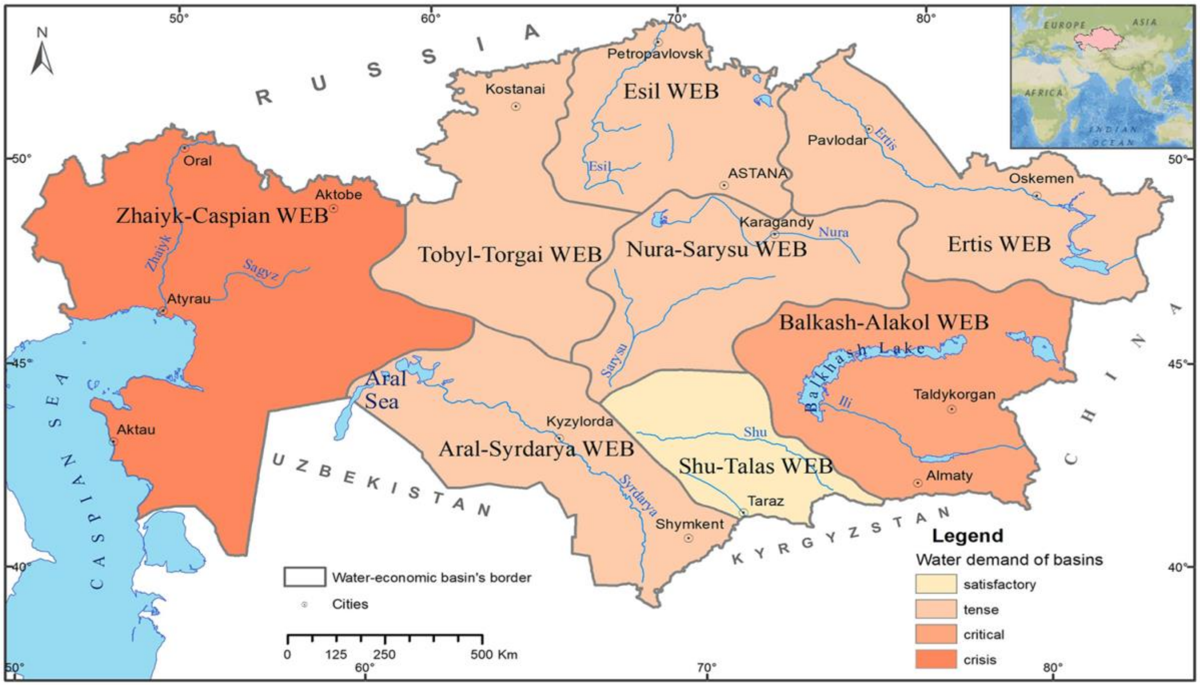


About 44% of surface runoff in Kazakhstan comes from neighboring countries, namely China, Russia, and Kyrgyzstan; however, there are limited agreements on water allocation and water quality in transboundary rivers. Kazakhstan is a downstream country in a transboundary Syrdarya river shared with Tajikistan, Kyrgyzstan, and Uzbekistan. Central Asia countries signed 1992 the Almaty agreement and the 1998 Syrdarya agreement on water allocation in the Syrdarya river, but water allocation remained according to the criteria and volumes from the Soviet time, which are still under dispute (Abdullaev et al., 2019; Djumaboev et al., 2019; Krasznai, 2019; Wegerich, 2011; Ziganshina, 2009). Moreover, Kazakhstan is a downstream country in the Talas river and the Shu river shared with the Kyrgyz Republic, where the bilateral agreement was signed in 2000 on sharing costs of transboundary water infrastructure, yet water allocation is vaguely addressed (Sutherland et al., 2011; Wegerich, 2011). Regarding the Ili river, there is an agreement signed with China in 2001 and updated in 2011, where the agreement on water quality and quantity has not yet concluded (Pueppke et al., 2018; Thevs et al., 2017). To solve the ecological crisis with the shallow Jaiyk (Ural) river, Kazakhstan and Russia had signed an agreement in 2016, but actions to solve the problem are limited.

In 2003, river basin organizations on the basin level were introduced. Chapter 7 (Articles 40-43) of the Water Code of the Republic of Kazakhstan (2003) describes the functions of river basin inspectorates for regulation of use and protection of water resources (RBIs). RBIs fall into line with the Committee on Water Resources of the Ministry of Ecology, Geology, and Environment. RBIs are located mainly in big cities: Almaty, Atyrau, Karagandy, Kostanay, Kyzylorda, Nur-Sultan, Semei, and Taraz. According to Article 40, RBIs are responsible for water resources use and protection in the territory of the basin, development and implementation of basin agreements, control and monitoring of water resources, issuance and renewal of permits for water use, protection of water resources in the territory of the relevant basin and other (Water Code, 2003). Moreover, River Basin Councils (RBCs) were introduced to coordinate the activities of different organizations working with water resources management in the relevant basin. Article 43 says that RBC is an advisory body within the framework of the basin agreement. RBCs include the representatives of local, territorial administration (akimats), water users, water utilities, NGOs, and RBIs. RBCs discuss water resources management and water allocation issues and make recommendations to RBIs, akimats, and other organizations if it is required.

The country's territory is divided into eight basins based on hydrological characteristics: Aral-Syrdaya, Balkhash-Alakol, Ishym, Irtysh, Jaiyk-Caspian, Nura-Sarysu, Tobol-Turgai, and Shu-Talas. Each river basin represents an area of land drained by a significant river and its tributaries. Figure 6.2 illustrates that all river basins are transboundary according to geographic characteristics except the Nura-Sarysu basin. Each basin differs in terms of hydrological, climatic, geographical, and geological features. Hence water resources are unevenly distributed in Kazakhstan. Moreover, socioeconomic situations differ a lot among basins. For example, the Jaiyk-Caspian basin, located in the western part of the country with an oil and gas industrial zone, relies on groundwater for drinking water and irrigation because of shallowing the Jaiyk (Ural) river. Agriculture relies mainly on surface water resources in the south (Aral-Syrdarya, Shu-Talas, and Balkhash-Alakol basins).

Figure 6.2 River basins in Kazakhstan



Source: Issanova et al. (2018), Note:WEB: Water-Economic Basins

6.3 Pilot study: Balkhash- Alakol river basin

The Balkhash- Alakol (BA) basin is strategically vital for Kazakhstan because of its unique location, economy, and environment. The BA basin is located in the country's southeast part, including four regions: Almaty oblast, Zhambyl oblast, Karaganda oblast, and East-Kazakhstan oblast, with a total area of 353 thousand km^2. Population in the BA basin is more than 3 million, where most of the population live in Almaty city and Almaty oblast. The basin has rich mineral resources: non-ferrous metallurgy, raw materials to produce building materials, and brown coal reserves. The BA river basin shares the transboundary Ili river with China.

The river basin has a unique hydrological network consisting of about 45 000 small rivers, about 24000 lakes, and reservoirs. The largest river is the Ili river constitutes about 75% of the basin catchment area. The length is 1439 km, with 815 km of river in the territory of Kazakhstan. The basin has rich groundwater reserves. The river basin consists of large hydraulic engineering structures such as the Kapshagai reservoir on the Ili river, the Bartogai reservoir with the Big Almaty Canal on the Chilik river, rice irrigation systems on the Akdala massif, Shingeldinsky irrigation array, and others. Lake Balkhash is the third largest closed water body in Kazakhstan. Lake Balkhash depends on the Ili river, particularly about 80% of surface water in the lake coming from the river. About 18 small rivers also discharge to the lake, including Karatal, Aksu, Charyn, Lepsy, and Ayaguz.

The water-related challenges are growing in scale in the river basin (Pueppke et al., 2018; Thevs et al., 2017). The reduction of glaciers has caused climate aridity, increasing the scale of desertification, and reduction of surface runoff in rivers. Moreover, the ecological situation in Lake Balkhash is worsening due to changes in the hydrological regime of the lake due to extensive water use in the region, water pollution by agricultural, industrial pollutants, and wastewater, and extensive water use by the upstream country for irrigation development and construction of hydropower plants (Thevs et al., 2017). There is an ongoing discussion between Kazakhstan and China about water quantity allocation and water quality issues in the Ili river.

6.4 Interview findings

Seventeen semi-structured interviews were conducted in August - October 2021, mostly face-to-face in Almaty and Almaty oblast and online interviews via Zoom. Table 6.1 presents the occupation of interviewers, including representatives of RBI in the BA river basin, local executive body (akimat), representative of primary water users in the basin (agricultural, municipal, industrial), representatives of NGO and independent ecologists, consultants from international organizations, and researchers from local and foreign universities and research institutions. About one-third of interview participants were female. Five interviewees were members of RBC in the BA basin. Furthermore, seven interviewees were actively engaged and worked in the international projects, which introduced reforms on the river basin approach in Kazakhstan and Central Asia. The interviews were conducted in Russian and English and took about one hour each. The confidentiality and anonymity of interview participants are ensured.

Table 6.1 Occupation of interview particpants

Organization	*Description*	*Number of interviewers*
River Basin Inspectorate	Balkhash-Alakol river basin	1
Local executive body	Akimat of Zhambyl oblast, Department of Natural Resources Management	1
Industrial water use	Kazakhmys Group	1
Agricultural water use	Big Almaty Canal	2
	Kazvodhoz in Almaty oblast	1
Municipal drinking water use	"Almaty Su" public utility company	1
University & Research Institute	Local	1
	Foreign	1
International organizations	Experts involved in developing basin approach in Kazakhstan and CA	6
NGO & Independent ecologist	In water sector and ecology	2

All interviews were recorded (except for one but notes were taken), transcribed, and coded in the NVivo software. Figure 6.3 presents the thematic analysis of interviews. I applied deductive coding (research-driven) in terms of critical dimensions of the DPSIR framework (drivers, pressures, state, impact, responses) and inductive coding (data-driven) based on information from interviewers (water security in Kazakhstan, water governance, river basin management in Central Asia). Coding results revealed that most interviewers discussed the current state of river basin management in Kazakhstan (red color) followed by water governance issues in Kazakhstan and the main drivers of the river basin management approach. Some parent nodes also have child nodes. For example, Figure 6.4 reports that the parent node of water governance (in brown) has the following child nodes: water policy, water legislation, water administration, and water diplomacy. In comparison, the parent node of the state (in red) has also additional nodes for each child node (RBI, RBC, river basin planning, and water users). The summary of the codebook is attached in Annex 3.

Figure 6.3 Hierarchy coding of parent nodes

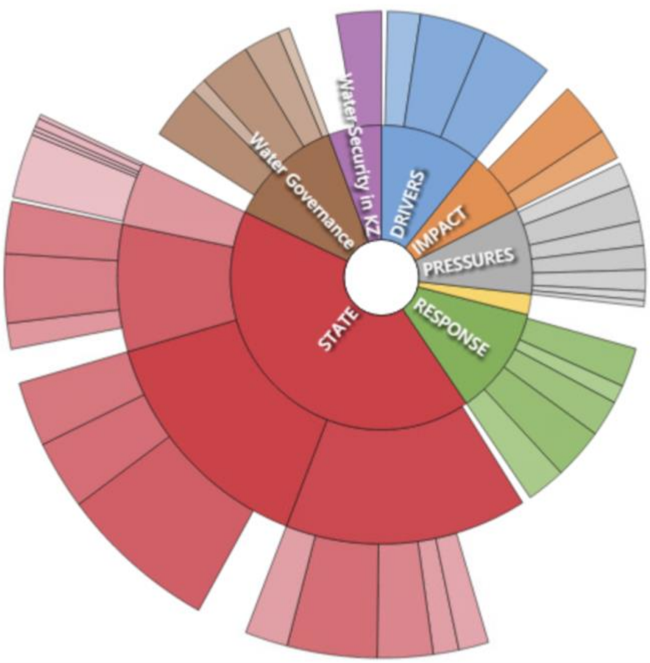
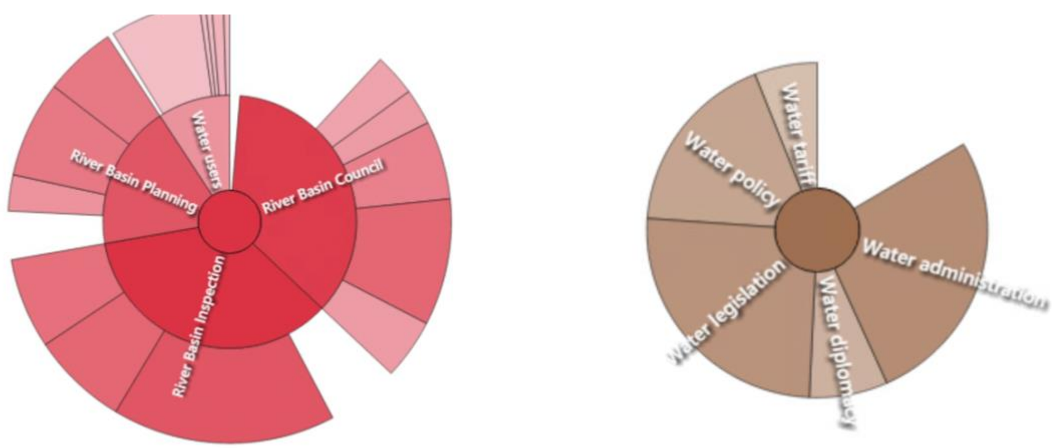


Figure 6.4 Hierarchy coding of child nodes



Note: Child nodes of STATE parent node in red; child nodes of WATER GOVERNANCE parent node in brown

6.4.1 DRIVERS: development of river basin management

According to the DPSIR framework, driving forces influence specific policies or reforms. According to interview participants, drivers of introducing the river basin approach in Kazakhstan can be divided into three broad categories: path dependency from the USSR; the role of international organizations and projects; and the global agenda on IWRM, sustainable development, and climate change. About twelve participants mentioned that the river basin approach was not new for Kazakhstan since some elements of river basin management existed in the Soviet time, such as complex schemes of water use in main rivers, RBI, however, on administrative boundaries. Moreover, the bottom-up approach in terms of consultations and involvement in the decision-making process of stakeholders was not part of Soviet water management. Interview participants also highlighted the role of international projects and donors that assisted in implementing IWRM principles. Lastly, the global agenda on sustainable development and the dominant paradigm on IWRM also influenced water reforms in Kazakhstan. Representative of the international organization summarized that there was internal demand for water reforms and also external influence from international donors in promoting IWRM principles led to introducing the river basin approach in Kazakhstan.

Path Dependency from the Soviet Union

In the Soviet time, water resources management was based on administrative-territorial boundaries. The river basin organizations existed in the Kazakh Soviet Socialist Republic, namely in each region (oblast), and were responsible for monitoring, controlling, and protecting water resources. However, river basin organizations were called basin associations (*obedinenie*) then basin management (*upravlenie*) and remained as RBIs. In the case of the BA basin, one basin inspectorate included two regions and was called ‘*Semirechinskoe*’ because seven rivers flow to Lake Balkhash.

The water balance was entirely regulated in the USSR and used mainly for agriculture Water management in Soviet times was top-down; the government decided what and where to grow, how much water to give. According to interview participants, in the 1980s, economic and political disputes over water have started increasing among different water users and countries on transboundary rivers. There was a need for an institution/ organization to distribute water more evenly but did not obey the administrative boundaries. Consequently, the Amudarya River Basin Organization and the Syrdarya River Basin Organization were established in the 1980s to manage water resources on the basin level. Basin plans in the form of complex schemes of water use in the Syrdarya river and Amudarya river were developed, which included only technical solutions on the basin scale. The water management in these two basins was mixed, including basin and territorial. Member of RBC argued that some elements of RBC existed in the past when the Ministry of water resources discussed water needs among different water users: agriculture, industry, fishery, municipality, etc., but these discussions had only a consultative and advisory role.

The Ministry of water resources in the Soviet times was responsible for massive hydraulic infrastructure construction; however, because of the economic crisis in the 1990s, the Ministry then was responsible for water resources management. At that time, the dominant paradigm was managing water resources within the hydrological boundaries because the traditional water management based on administrative and territorial boundaries led to negative externalities and environmental degradation. Interview participant from a local university mentioned that Kazakhstan chose the French model of water resources management. The country's territory was divided into eight basins in concordance with the main river with its tributaries and lake or sea where the river flows. For example, the Jayik (Ural) river flows to the Caspian Sea, the Syrdarya river to the Aral Sea, the Ili river to Lake Balkhash. RBIs were established in each river basin responsible for interregional water administration and water policy implementation.

International Projects and Funding

In the Soviet Union, water organizations were financed well; however, after the collapse of the USSR, water organizations reduced staff and stayed with limited budgets from the newly established governments. Moreover, widespread economic collapse in the 1990s led to a lack of attention to the water sector. According to interview participant from an international project:

> *"...water management organizations faced a financing deficit, and to receive additional funding from international donors, some projects and reforms were proposed, which influenced water policy…"*

Indeed, scholars discussed the role of the transnational policy entrepreneurs in promoting and developing the concept of river basin organizations worldwide that can be divided into four broad groups: intergovernmental donor/aid organizations, international non-governmental organizations, global knowledge networks, and private sector (Molle, 2008; Mukhtarov & Gerlak, 2013). Transnational policy entrepreneurs applied various strategies to promote the idea of the river basin approach, such as material incentives (loans, grants, projects), nonmaterial incentives (trips, conferences, reputation, international status), best practice model, and a matter of prestige (Molle, 2009; Mukhtarov & Gerlak, 2013). In the case of Central Asia countries, intergovernmental donor/aid organizations promoted IWRM reforms.

Kazakhstan is a pioneer in implementing IWRM principles in Central Asia, including implementing the river basin principle, establishing RBCs, and updating water legislation (Water

Code). All these reforms were implemented with support and consultations from some international projects. For example, the UNDP project in the 2000s assisted in establishing basin councils in each basin, where the BA basin council was the first. Interview participant from an international project also mentioned that in 2004 the UN recommended developing IWRM plans and asked developed countries to help developing countries. The global agenda was to create IWRMand water efficiency plans by 2005 with assistance from developed countries in the World Summit in 2002 (Molle, 2008). Specifically, the Government of Norway helped Kazakhstan develop IWRM plans by funding the project in 2004. However, there were also other donors promoting the implementation of IWRM principles in Kazakhstan.

Global Agenda on IWRM, sustainable development, and climate change

The 1992 Dublin Statement on water and sustainable development announced a novel integrated approach to managing freshwater resources and declared social equity, economic efficiency, and environmental sustainability principles. Principles of IWRM and river basin management were popularized and promoted by international non-governmental organizations such as Global Water Partnership and donor organizations. They encourage governments to apply the principles of IWRM and river basin management in water policy, water legislation, and water administration. The international agenda towards MDGs and then SDGs plays an essential role in implementing reforms and financing projects. Moreover, the impact of the climate crisis on water resources has been widely discussed among scholars and international organizations. As interview participant from the research institute noted:

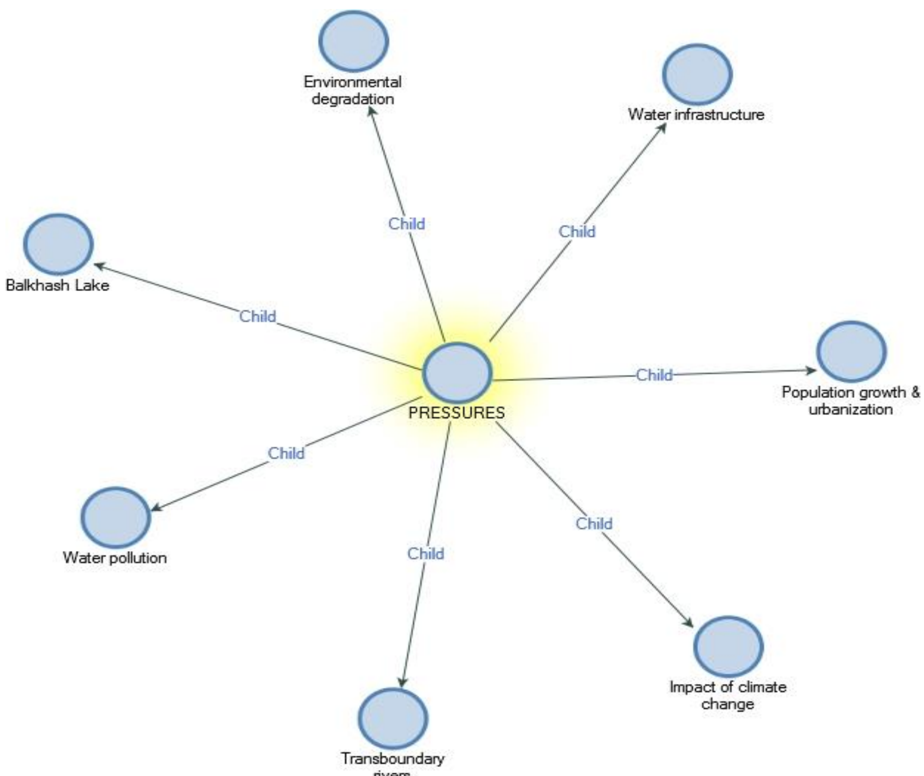
"... Kazakhstan cares about status and prestige and invests in best practices...."

Consequently, the global agenda on sustainable development, climate change, and IWRM also influenced implementing the river basin approach in Kazakhstan to attract additional funding, gain greater international acceptance, and politically rewarding projects.

6.4.2 PRESSURES: water challenges in the BA river basin

Different river basins have different pressures because of socioeconomic development, geography, hydrology, climate, and infrastructure. Figure 6.5 presents a summary of the thematic coding of pressures. Interview participants mentioned some common pressures in all basins, such as environmental degradation, aging water infrastructure, high dependency on surface runoff from transboundary rivers, and urbanization. Some specific pressures in the BA river basin were grouped into water pollution, limited agreement on transboundary Ili river with China, and the growing environmental crisis in Lake Balkhash.

Figure 6.5 Thematic coding of pressure node



Severe water crisis as the catastrophe in the Aral Sea and environmental degradation caused water reforms in terms of river basin approach to distribute water resources fair and equally. Only after the problem in the Aral Sea did water managers start thinking about ecosystem needs in water. It is essential to note that about 44% of surface runoff in Kazakhstan comes from neighboring countries. There is still limited agreement on water quantity and quality issues. Climate change in glacier melting has influenced the shift in the peak of water flow from summer to spring, putting additional pressure on water resources management. Population increase, economic growth, and rapid urbanization reveal growing competing and conflicting demands on water. Moreover, water-related hazards such as floods and droughts are increasing in scale and frequency. At the same time, the aging water infrastructure constructed in the 1960s-1970s led to high water losses.

Interview participants also mentioned some specific pressures related to the BA river basin. About 70% of the surface flow of the Ili river is formed in China, where massive irrigation construction projects have been implemented in Northwest China. Water quality problems are caused by industrial, agricultural, and wastewater pollution. As a result, any changes in water quantity and quality in the Ili river directly influence Lake Balkhash. The Balkhash ecosystem, especially the Balkhash delta, is vulnerable today. The population of Almaty increased twice last 20 years; however, the local municipal water provider has certain limits on surface water discharge and uses groundwater reserves. Indeed, the BA river basin is rich in groundwater reserves. However, widespread groundwater extraction and lack of regulations on groundwater use might cause depletion of these reserves.

6.4.3 STATE: river basin management at present

The state dimension of the DPSIR framework focuses on institutional mechanisms of river basin management in Kazakhstan, including the performance and challenges of RBIs, RBCs, and river basin planning. About 20 years ago, the river basin approach was introduced in Kazakhstan; despite many critics, it is crucial to explore what works and what challenges exist.

River Basin Inspectorate (RBI)

RBIs are subordinate to the Water Resources Committee. RBIs are responsible for maintaining water balance in the river basin and dividing water resources among water users. Moreover, RBIs are in charge for water policy implementation, including but not limited to controlling, monitoring, issuing water permits, setting water limits, and preserving water protection zones. RBIs are financed from the state budget, and employees are civil servants. RBI in the BA river basin consists of several departments: state control department, water protection department, and monitoring department. There are several inspectors responsible for water resources monitoring the basin.

Article 66 of the Water Code (2003) states that all water users in the basin must receive a special permit for water use from RBIs, including using hydraulic structures to use, withdraw, divert, and store surface water or groundwater for any purposes and discharge any wastewater to water sources. RBI is also responsible for approving new projects planning to use water resources in the basin and preventing construction in water protection zones. All their services (issuing permits) are state services that are filled in and approved electronically. According to the Water Code, there are about 25 functions of RBIs, including management, coordination, control, inspection, cadaster, monitoring, issuance of permits, and many others. However, the question is whether RBIs have the capacity and resources to perform all their duties. According to interview participant from local NGO, in the 2000s, when RBIs were established at each river basin, RBIs had enough human resources, transport, techniques, laboratories. In 2021 the BA RBI had only 19 staff, one car, and no laboratory.

Many interview participants mentioned RBIs have limited human and financial resources. The salary of inspectors is low. For example, interview participant from the agricultural sector said that an inspector with five years of experience responsible for water protection receives about 120 thousand tenge per month (~ 280 USD). Moreover, interview participants mentioned low inspectors' qualifications, high staff turnover, and lack of water specialists. This is a dilemma: RBIs are not attractive for experienced professional water specialists. As a result, the requirements for inspectors are low; inspectors are highly overloaded mainly with paperwork rather than monitoring and protecting water resources (interview participant from RBI).

Regarding data and monitoring, RBIs do not have resources and laboratories to collect data and cross-check data that they receive from different organizations and, importantly, spot polluters and violations. For example, RBIs receive data about surface water in rivers from Kazgyromet, drinking water quality - Sanitary and Epidemiological Station, groundwater - hydrogeological expeditions, water distribution for irrigation – Kazvodkhoz. Another paradox: how can inspectors perform their primary function as monitoring and controlling with lack of transport and data in the basin with 415 000 km^2, about 736 rivers, and several large lakes?

Coordination is one of the critical responsibilities of RBIs. Indeed, RBIs work with various state organizations, water users, and stakeholders. Several interview participants mentioned horizontal communication and consultation in data sharing with organizations: Kazvodhoz, akimats, Kazhydromet, etc. Even though the river basin might consist of several regions (oblast), RBIs should be a coordinator among akimats from different areas. In reality, akimats have more political and decision-making power than RBIs. As was mentioned by interview participant from a local NGO, there is pressure on RBIs in terms of top-down decisions from government, ministry, and akimats, even in issuing water permits and water use limits. There is limited coordination and cooperation among state agencies involved in managing and using water resources because of fragmented and complex water governance and public administration in Kazakhstan.

River basin council (RBC)

RBCs were introduced in the Water Code in 2003. International organizations (namely UNDP project ‘IWRM National Plan and water saving in Kazakhstan’) helped organize and establish RBCs in each basin from 2004 to 2007. RBCs have advisory and consultative roles. The idea behind RBCs is to introduce elements of democracy in water management, where all stakeholders can discuss and participate in decision-making. Two meetings of RBCs per year were financed from the government budget, which is an additional responsibility of RBIs. Interview participants from international organizations highlighted that “*it is a positive sign that the government supports stakeholders meeting and discussion*.”

The members of RBCs might vary among river basins because of differences in water use and economic activities in basins. For example, in one basin, the participation of representatives from industry is critically important, while in some basins - farmers. RBCs usually consist of representatives of RBIs, akimats, and various water users. Interview participant from international project mentioned that the participation of representatives in upstream and downstream water users is not always considered, which is critically essential in water resources management. Other interviewees suggested including environmental NGOs, journalists, youth, and researchers. RBCs provide recommendations since they have only an advisory role. Interview participant from a local NGO shared those decisions of RBCs remain on paper, often ignored because they are not legally binding, and raised concerns about the role of RBCs since they do not have power and their decisions are only recommendations. However, members of the BA RBC provided contra arguments. For example, the RBC specifically indicates the organizations to whom suggestions are addressed and ask for actions. The BA RBC attempts to apply administrative and legal measures to enforce their recommendations.

Members of the BA RBC also provided several examples when recommendations of the BA RBC were practical and were implemented. For example, the BA RBC organized an urgent meeting in February 2021 when they received Kazhydromet's forecast and recommended all water users in the basin prepare and adapt for the dry year. Another example was the prevention of geological explorations in the delta of Lake Balkhash. The BA RBC also discussed water division concerns between upstream and downstream water users, implementation of water protection activities of the basin agreement of various water users (Kazakhmys corporation), and others. Indeed, several interview participants (non-members of the BA RBC) mentioned that the BA RBC is one of the most active and engaged RBCs in Kazakhstan because of its active members.

International and regional organizations (CAREC, USAID, others) introduced small RBCs in transboundary basins to discuss transboundary aspects. Small RBCs differ in terms of structure and membership. For example, the head of small basins is elected by members, including aksakals, representatives of religious organizations if there is a religious community, and border troops that oversee the territory. Most interview participants are unaware of small basin councils because they exist only in Chu-Talas and Aral-Syrdarya basins. Interview participants also mentioned that there is no capacity and resources for small basins councils and that they exist only because of donors' support, which is temporary and not sustainable.

River Basin Planning

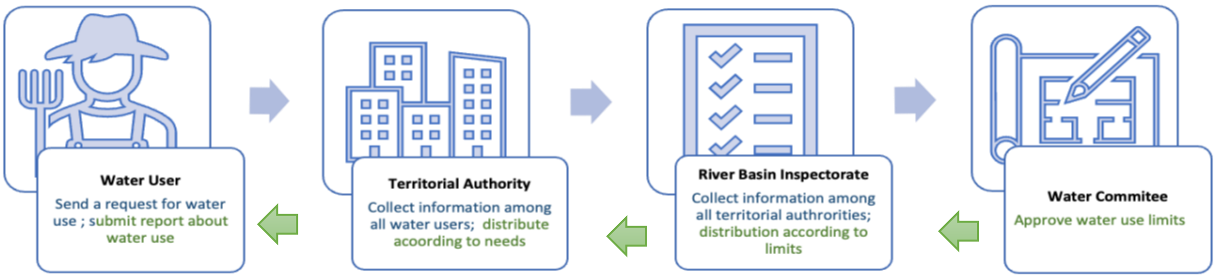
River basin planning is insufficient and based on water balances and the general scheme of integrated use and protection of water resources (scheme). The latest scheme was approved in

2016, where different water uses scenarios at each river basin until the year 2040 were described. Several interview participants mentioned that schemes existed in the USSR but not on a basin-scale but rather for major rivers, for example, a complex scheme of the Syrdarya river. Currently, river basin plans are designed only for BA and AS basins within the donor's project 'Promoting IWRM and transboundary dialogue in Central Asia.' However, several interview participants criticized both documents because they are not legally binding and consequently are not considered when some infrastructure projects are planned and implemented.

According to interview participants, river basin agreements for the protection of water resources were signed in the past among three parties: water user, RBI, and local authority (akimat). Usually, the basin agreements were signed by large water users to outline the measures of protection, use, and conservation of water resources for a certain period. Then water users report on the meetings of RBCs. Often the basin agreements were initiated by RBC when they notice water problems and start initiating bilateral or multilateral agreements to solve water problems.

RBI is responsible for issuing water-use limits and controlling these limits. Interview participants described that at the end of each year, all water users (including farmers, industry, public utility company, other water users) send requests for water use based on norms per unit of production and norms of water consumption to akimats. Figure 6.6 illustrates that then akimats compile the water needs in the region and send a request to RBI, which is then submitted to the Committee of Water Resources. Based on Kazhydromet's forecasts, the Committee approves the water limits for each basin. Then this process goes in reverse order: Water Committee=> RBI=> Regional (local) akimats=> water users. Overall, the role of RBIs is to monitor water use according to specified limits and penalize violations.

Figure 6.6 Process of issuing water use limits



6.4.4 IMPACT: hydrological or administrative boundaries?

The river basin approach is a dominant paradigm in water management. To understand the impact and importance of the river basin approach in the context of Kazakhstan, I asked interview participants about the influence of the river basin approach on society, economy, and ecology. River basins vary in terms of availability of water resources, geographic conditions, and different economic priorities. Moreover, river basins have transboundary rivers with foreign countries. Interview participants mentioned that effective water management in the country on a basin-scale might help quickly adapt to climate changes, mitigate water pollution, solve local water issues with local people and local knowledge, especially under the present fragmented government system.

Most respondents mentioned that the river basin approach promotes holistic and integrative management especially when competing water demands are growing, water balance consists of different sources, and when water resources should be allocated without prioritizing some water users and ignoring the environmental needs. Some interview participants highlighted the role of river basin management:

"…river system can be compared with the blood vessels where everything is interconnected…" (interview participant from agricultural sector)

"… it is useless to solve water problems in downstream when water pollution and high-water losses take place in upstream…river basin management is about the consolidated and coordinated response with involvement of stakeholders…" (interview participant from a local NGO)

Some interview participants mentioned the challenges of implementing river basin management in Kazakhstan. River basin management requires a strong RBO with relevant institutional functions and resources, while in Kazakhstan, the role of RBO is limited to regulation of water use limits and protection of water resources and even called inspectorates. As a result, the role of RBI is only in terms of a 'local watchdog' that needs to monitor water use limits and save water protection zones. The role of RBCs is a platform of discussion and participation of stakeholders in the basin rather than holistic basin planning, management, and consolidated decision-making.

Interview participants also highlighted the impact on society, economy, and ecology if water resources would be managed on administrative-territorial boundaries in Kazakhstan. Most interview participants provided the example of the Aral Sea crisis when ecosystem needs in water were neglected, and water use was prioritized for socioeconomic activities. Several interview participants mentioned a potential competition and conflict in water distribution among regions when each administrative unit will attempt to satisfy its own water needs, especially when sustainable ecological culture is underdeveloped. However, interview participant from a research institute raised concern about the debate on the scale (hydrographic or administrative boundaries) because good water governance and sound water policy matter in water resources management.

6.4.5 RESPONSE: improving institutional mechanisms

The response dimension of the DPSIR framework presents a set of recommendations to reduce pressures, influence the state of water resources management, and reflect on drivers and impacts. Most interview participants suggested improving river basin management by mobilizing funding of RBIs, strengthening RBCs, and developing riven basin planning. Water resources management should be accompanied by investing in water infrastructure and water-saving technologies to increase water use efficiency. Interview participants also highlighted supporting capacity building and strengthening collaboration in transboundary rivers.

Most interview participants mentioned developing RBIs and increasing financial resources, including salaries, transport, staff, laboratory, data monitoring systems, because RBIs play a critical role in adaptive water governance due to climate change and transboundary complexity in Kazakhstan. However, the role and functions of RBIs are still vague and not clearly defined, which leads to a conflict of power and responsibilities. For example, RBIs are responsible for controlling and monitoring water resources in the relevant basin, Kazvodhoz – for water infrastructure and water distribution, departments of the natural department, ecology, and agriculture at each oblast are also responsible for monitoring and control. There are some elements of communication and consultation between organizations, but there is still a lack of horizontal coordination and collaboration. For example, in mitigation and adaptation to droughts, RBIs will prepare their calculations, akimats prepare their plans. There is the perception that RBIs only have control, administrative, and monitoring roles but not planning, formulating water policies and decision-making at the basin level.

Interview participants also highlighted that RBCs in Kazakhstan are emerging as an inclusive platform for dialogue of different water users, discussion of water problems, and shared responsibility in the basin. The low number of inspectors with limited logistics face challenges in conducting regular monitoring in the basin. Therefore, local water users can raise many water issues in the RBC meetings since they know the local situation and problems better. According to interview participants, RBC is a platform of water information exchange between water users, akimats, and RBIs. Members of RBCs suggested increasing financing the meetings of RBCs and creating a secretariat for RBCs since there is limited monitoring of the implementation of their recommendations. Non-members of RBCs raised the concern of top-down, centralized water resources management and planning at the national level where bottom-up RBC requests are not considered. Interview participant from a local NGO suggested the following structure: RBCs will be responsible for developing water policy in the basin, and RBIs will be implementors of this policy because, at present, recommendations of RBCs are not obligatory for RBIs.

River basin planning is weak because of short-term fragmented water policy. Water resources management in Kazakhstan is problem-based management rather than solution-based management. River basin planning should include a strategic long-term development plan of the basin and measures for the protection and distribution of water resources. There is another dilemma: RBIs have limited capacity to develop such plans, but river basin planning is critical for water management in the basin. Overall, the river basin plan should be based on the national development plan and be legally binding.

Chapter 7

Discussion

7 DISCUSSION

7.1 Unpacking academic discourse

This thesis aimed to understand the scholarly discourse on water security issues in Central Asia, namely peer-reviewed articles in English published by regional and international researchers. The systematic analysis of scholarly literature on water security issues in Central Asia indicated the growing interest of scholars in transboundary water resources of the region, especially since 2010, not only among scholars from Central Asia but worldwide. The first article in the sample was dated from 1997, even though the search timeframe was 1991-2019. Most probably, this finding might reflect the low interest in water resources management after the break of the USSR because of financial 'drought,' social instability, and policy uncertainties in Central Asia countries (Abdolvand et al., 2015; Abdullaev & Rakhmatullaev, 2016; Wegerich et al., 2015). Moreover, the increase of publications on water security issues in Central Asia since 2010 aligns with the expanding research on water security globally (Gerlak et al., 2018; Octavianti & Staddon, 2021; Zeitoun, 2011). The literature review results indicated the predominance of publications addressing environmental water security, followed by economic water security and water-related hazards. In contrast, the urban & household dimension of water security has become salient in the scholarly debate after the 2000s. This finding partially supports hypothesis 1 about the prevalence of techno-economic aspects of water security in Central Asia in the academic literature because coding results revealed a discourse on the environmental dimension of water security, but the improvement of water infrastructure was widely recognized in the relevant literature.

The content analysis demonstrated a clear dominance of the environmental water security dimension in the scholarly literature by addressing the growing pressures because of climate crisis and anthropogenic activities to promote social welfare and boost economic growth using hydraulic infrastructure in mountainous regions and transboundary rivers that impact environmental ecosystems and water catchments in Central Asia. The disaster of the Aral Sea illustrates how economic activities may end up when the environmental aspect is neglected because any variation in water consumption will cause changes in the hydrological cycle and ecosystem services. The prevalence of the river attribute in the environmental dimension can be elucidated by the water allocation disputes of transboundary rivers in the region, such as the Syrdarya and the Amudarya rivers. Furthermore, numerous articles discussed how global warming affects the glaciers in the Pamirs and Tianshan mountains and the hydrological processes in the region (Bernauer & Siegfried, 2012; Didovets et al., 2021; Hagg et al., 2018; Hu et al., 2016; Reyer et al., 2017). The finding of a high relevance of environmental water security in Central Asia in the academic literature is also consistent with the global scholarly and policy discourses on climate crisis reflected in the recent IPCC (2021) report addressing challenges of restoration of aquatic ecosystems, depletion of groundwater, and water pollution. The analysis of the subject area of publications demonstrated the prevalence of environmental science, engineering, and development subject areas.

Economic water security also extensively addressed in the relevant literature given the fact of water needs for large-scale irrigated agriculture of water-intensive crops in the downstream republics and for the development of hydropower and electrification projects to ensure energy security in the upstream republics (Bobojonov & Aw-Hassan, 2014; Conrad et al., 2016; Djanibekov et al., 2013; Keskinen et al., 2016; Zhang et al., 2018). Thus, the conflict of competing water demands mainly for irrigation in the plains of Uzbekistan, Kazakhstan, and Turkmenistan and hydropower generation in mountainous Kyrgyzstan, Tajikistan, and Afghanistan was discussed as a hotbed for water insecurity in Central Asia that might intensify because of the impact of global heating on the spatial and temporal uneven water distribution in the region. The economic aspect of water security centers on better water management in agriculture, energy, and industry (AWDO, 2013, 2016, 2020). Nevertheless, water challenges in Central Asia are still overlooked and underfinanced, including the inefficient and degraded irrigation systems that were constructed in the 1950s-1970s, the mismanagement of water withdrawal, low water tariffs, lack of water-saving technologies, limited industrial wastewater treatment (Abdullaev & Rakhmatullaev, 2016; Challe et al., 2018; Karatayev et al., 2017; Karimov et al., 2018). Existing water use practices and water disputes within and between countries are the outcomes of poor water resources management (Wegerich et al., 2015). The water-energy-food nexus attribute received low coding results even though the debate over water-food-energy interlinkages has gained popularity in the last decade in the literature, primarily in transboundary river basins (Guillaume et al., 2015; Jalilov et al., 2016; Stucki & Sojamo, 2012).

Water-related hazards have increased in scale and frequency in Central Asia, which is vulnerable to the unforeseeable climate crisis. Extreme weather events and water-related disasters vary in the region: high risks of landslides in the mountainous regions of Kyrgyzstan (Havenith et al., 2015; Sanhueza-Pino et al., 2011; Schlögel et al., 2011); droughts in arid and semiarid regions of Central Asia (Guo et al., 2018; Li et al., 2017; Xu et al., 2016); floods in downstream countries because of massive water discharge from reservoirs and flood outbursts because of glacier lakes in upstream countries (Mergili et al., 2013; Narama et al., 2018; Tijssen et al., 2017). Studies noted low capacity to monitor and forecast water-related cataclysms, insufficient climate adaptation and mitigation initiatives, lack of disaster risk assessment, and limited measures to build resilient communities acclimating to water-related disasters (Didovets et al., 2021; Lioubimtseva, 2014; Pollner et al., 2010; Sorg et al., 2012). Scholars highlighted that the Aral Sea basin is vulnerable to climate change impacts in more frequent and intense heat waves (Pollner et al., 2010; Yu et al., 2020). For example, severe droughts and heatwaves occurred in 2020 and 2021 in various parts of Central Asia, causing mass livestock die-offs in Kazakhstan, harvest losses in Uzbekistan, and low pasture yields in Turkmenistan. According to the forecast in Risk and Resilience portal (2021), average annual losses from droughts in Central Asia will cost about 5000 million USD, and annual adaptation costs to climate-related hazards are estimated at 1600 million USD. Water-related hazards are crucial drivers of water insecurity because of high economic costs, human lives risks, infrastructure damage, and the likelihood of climate migration (IPCC, 2021; Risk and Resilience portal, 2021).

The urban & household water security dimension received the lowest attention among scholars. As Wegerich et al. (2015) noted, the urban water supply is taken either for granted or overlooked in the literature. A cornerstone of water security is access to improved sanitation and hygiene, clean drinking water, and maintaining water supply and wastewater systems, which are reflected in SDG 6 (AWDO, 2013, 2016, 2020). As stated in the Sustainable Development Report 2020, more than 80% of the population has access to basic drinking water and sanitation services in Central Asia except for Afghanistan (Sachs et al., 2021). Yet, there is a high variation in water supply and sanitary facilities among households in urban and rural areas (Bekturganov et al., 2016; Karatayev et al., 2017; Tussupova et al., 2016). Even though all six countries declare to achieve SDG 6, challenges remain unsolved: insufficient funding in aging water supply infrastructure, data availability and analysis, outdated and inadequate monitoring systems (Challe et al., 2018; Chukayeva & Akzharov, 2016; Sachs et al., 2021). As Hutton et al. (2007) argued, investments of 1 USD in household water supply and sanitation lead to 5-10 USD savings on health expenditures.

It should be noted that the academic discourse discussed here is limited to the analysis of peer-reviewed articles, where sampling limitations might influence findings. Indeed, it is challenging to include all publications on water security aspects in Central Asia; still, the articles were searched in the leading databases and publishing houses such as Scopus, Web of Science, and cross-checked in the Nazarbayev University library, which has access to the enormous academic databases. There is a chance that water security dimensions would be addressed differently in academic literature in the Russian language. Thus, the findings require additional verification. It is acknowledged that the scope of analysis is based on the AWDO framework (2013, 2016, 2020). Other water security assessments and indices suggested by scholars and international organizations might differ in terms of water security dimensions and attributes. The AWDO framework was chosen since it represents a comprehensive vision of water security, especially for Asia and the Pacific, developed by leading water research institutes and researchers and followed by consecutive updates in 2013, 2016, and 2020.

7.2 Appraising practitioners' consensus

The Delphi method was applied to elicit experts' views on water security in Central Asia and collect pragmatic knowledge of experts and practitioners constructed by the experience and expertise in the field. The findings of the Delphi study presented the positions of experts and practitioners, who are often either consultants or lobbyists or policy entrepreneurs in the water policy agenda-setting and policy formulation. Experts prioritized socioeconomic dimensions of water security in the region by ranking economic and urban & household dimensions higher than water-related hazards and environmental dimensions. This finding does not support hypothesis 2 about similar water security prioritizations by experts and practitioners with the relevant literature recommendations.

The Delphi findings are in line with the common perception about water resources in the region as input for the economic growth of independent republics, particularly in irrigated agriculture and hydropower generation (Abdullaev & Rakhmatullaev, 2016; Allouche, 2007; Varis & Kummu, 2012; WB, 2020; Xenarios et al., 2019, 2020). Indeed, employment in agriculture (% of total employment) is high in the region, varying from 40% in Tajikistan and Afghanistan to 15% in Kazakhstan, while the contribution of agriculture to GDP ranges from 5% in Kazakhstan to 26% in Uzbekistan (World Bank, 2021). Experts suggested strengthening water security in Central Asia by investing in economic and urban & household dimensions: upgrading water infrastructure including drinking water supply systems, irrigation systems, wastewater treatment facilities, etc.

Achieving water security is context-specific; hence, experts set different priorities for Central Asia countries because of socioeconomic and political situations, institutional settings, and geographical features. This finding confirms the distinction among countries regarding water security challenges and the segregation of countries by not treating all countries as the same in the Central Asia region (Assubayeva, 2021; Stucki & Sojamo, 2012; Zakhirova, 2013). The highest agreement rate among experts was reached on investing in irrigation systems in Uzbekistan that inherited the massive irrigation canals for cotton production. Experts also reached a consensus in improving river basin management in Kazakhstan, a pioneer in the region in implementing the river basin approach. Unexpected findings on water security priorities for upstream countries in Central Asia contradict the common perception of the importance of water for hydropower generation. For instance, experts highlighted the importance of investing in the drinking water supply in Afghanistan and enhancing irrigation management in Tajikistan. In comparison, a low agreement rate was reached in developing hazard plans from landslides in Kyrgyzstan. Conflict of interests in water needs between upstream and downstream riparian countries and different interpretations of water security among Central Asia countries discourage joint initiatives in water allocation. Even the preliminary assessment of costs of inaction for upstream and downstream republics was conducted to promote limited transboundary cooperation (Adelphi and CAREC, 2017).

Quantitative analysis, including cross-tabulation reports and MNL regressions, demonstrated the diversity of views in assessing national water security priorities among experts of different ages, employment, and residence. In the case of Afghanistan, experts from the Central Asia region are more likely to give a higher rating of hydropower development in the country than international experts. MNL results of drinking water use improvement in Kazakhstan and Kyrgyzstan displayed interesting insights. Indicatively, international experts are more likely to emphasize the importance of improving drinking water use than experts from the region. Moreover, young experts relative to senior experts are more likely to rank higher improvement of water usage in rural and urban areas. Regressions on enhancing irrigation management in Tajikistan and Uzbekistan suggested that experts with Ph.D. degree are more likely to stress improving irrigation infrastructure than experts with bachelor's and master's degrees. Experts working at university/ research institutes relative to experts employed in other sectors tended to give a high assessment of improving irrigation systems. The difference can be explained by a different school of thought and paradigms of water resources management: the Soviet school – 'hydraulic mission' and engineering solutions to ensure water security vs. post-Soviet era school - IWRM paradigm and water governance to improve water security; or water security priorities set by regional experts vs. international experts. Additionally, experts mentioned transboundary river complexity, weak legislative and institutional aspects, complex interstate and domestic politics, inadequate data monitoring and forecasting tools, and inadequate water education are contemporary water security challenges in the region.

The application of the Delphi method has increased substantially in the last decade because the Delphi method is efficient in terms of anonymous participation and unaffected consensus from group pressure, authority, status, position (Aichholzer, 2009; Avella, 2016; Belton et al., 2019; Okoli & Pawlowski, 2004). Another advantage of the Delphi approach is cross-validation of the literature review findings and reaching a consensus among aggregated groups rather than individual viewpoints. Yet, the Delphi method, as any research method, has some limitations: biased selection of experts, the low response rate with additional rounds of the survey, and experts' biases (Birko et al., 2015; C. C. Hsu, 2007; Larreche & Montgomery, 1977; Urias et al., 2020). To diminish selection bias, specific criteria for expert selection were identified: job position, publication, past performance, and membership of specific organizations and institutions linked with water resources in Central Asia and Afghanistan (Assubayeva, 2021). Since the concept of water security is multidimensional, experts from different areas of competence were invited. Still, this study is missing questions about the disciplinary background of participants that might influence the setting priorities in water security dimensions and country priorities. It might be the case that participants in this study would have economic, social science, or international development backgrounds, which will influence to prioritizing socioeconomic aspect of water security. There is no agreement in the literature about the optimum size of experts and the number of rounds. Usually, the number of experts declines with each additional survey round. However, in this study, the number of participants slightly increased from 112 to 118 from the first to the second round, probably because of motivating experts to get acquainted with results from the first round.

The water security concept is complex by nature, and there are indeed different perceptions and understandings of water security that might also impact the results since the working definition of water security was not provided to experts to avoid any pressure towards the specific interpretation of water security. Language barriers might also influence the findings. The surveys were conducted in English and Russian; however, each Central Asia country and Afghanistan have a national language, and specific concepts might have context-specific subjective explanations. Some studies criticize the tendency towards conformity and consensus increase of the Delphi method (Aichholzer, 2009; Dalkey & Helmer, 1963). However, this study revealed the conscious participation of experts because they did not reach an agreement on specific aspects of water security, such as water security priorities for some countries and water security trends.

7.3 Mapping science and practice

The literature review findings presented the academic debate/ knowledge, while the Delphi method revealed the pragmatic perspective of experts' knowledge by concentrating on the local context. The shift from social problems into policy problems does not emerge by chance or in a vacuum but instead promoted by policy networks, international institutions, and epistemic communities (Colebatch, 2006; Kingdon & Stano, 1984; Molle, 2008). Practitioners as part of policy networks and scholars as part of epistemic communities might influence agenda setting, policy formulation, and decision making. As Kingdon (2001) stated, social/economic/ environmental issues become policy problems when they get the attention of policymakers. Often, problems reach the attention of decision-makers due to crises or dramatic events or negative feedback, which requires concentration and urgent action from the policymakers. And here is the role of policy entrepreneurs (experts, scholars, consultants, etc.) that might use the windows of opportunities for potential policy change. Thus, understanding the perceptions of scholars and experts/ practitioners on water security issues in the region is advantageous.

Comparing academic debate and experts' practical-technical knowledge illustrated the difference in prioritizing water security dimension and trends for Central Asia and Afghanistan. Scholars explored the mismanagement of water resources on aquatic ecosystems in Central Asia by also forecasting the potential impact of global heating on water resources and complex environmental change, raising awareness about climate change adaptation and mitigation measures in vulnerable arid and semiarid areas. In contrast, experts noted higher relevance of economic dimension and urban & household dimension of water security in the region by reflecting current water challenges and water needs in investing in the reconstruction of infrastructure for agricultural productivity enhancement, hydropower production, and urban water systems. The comparison of academic debate and practitioners' perspectives does not support hypothesis 2 about similar water security prioritizations among scholars and practitioners. The perspectives of academics and practitioners also vary in historic water security trends. About half of the experts opposed the downward trend of the urban & household aspects of water security at policy levels (e.g., state initiatives, laws, by-laws, etc.) since 2012 as per the literature. Some experts also disagreed that the economic dimension of water security is gaining less attention at the policy level than the hazard and environmental dimensions as in the relevant literature. The dissimilarity of academic knowledge and practical knowledge of experts could be the outcome of different perceptions and priorities on various aspects of water security.

Risk perceptions vary among people, and in social sciences, different theories attempt to explain the differences in public perception of risk and dangers (Hoekstra, 2000; Mamadouh, 1999; Wildavsky & Dake, 1990). Wildavsky & Dake (1990) suggested better prediction of threats perception by cultural theory because of the worldview of perceiver than knowledge, personality, and political orientation. Cultural theory (or the theory of sociocultural viability) is based on the anthropological research of a group-grid typology of cultures by Mary Douglas, where group dimension indicates the level of belonging to the group and the grid dimension represents the degree of influence of external rules and regulations on individual behavior. According to the classification (high/ low) in two dimensions, four types of cultural biases were identified: hierarchist, egalitarian, individualist, and fatalist. The hierarchist cultural bias belongs to bureaucrats promoting institutional sovereignty in decision-making, procedurals, and rules and giving higher rates for threats of social deviance. Egalitarians advocate for greater equality and shared responsibility represent civil movements and NGOs prioritizing environmental risks because of overexploitation. The individualist cultural bias is shared among entrepreneurs believing in competition and equality of opportunity and perceiving higher threats from war and economic failure. Fatalists are marginal members of society sharing 'stoic' and 'opportunistic' attitudes and perceiving risks as pervasive. High variation within each culture can also be observed (Koehlet et al. 2018). Overall, the cultural theory explains how differences in values, beliefs, expectations, and attitudes influence sociocultural behavior and public perceptions (fear or not to fear) towards dangers (Wildavsky & Dake, 1990).

The cultural theory was applied in the water sector to understand controversies in water management (Hoekstra, 2000), to explain the role of actors in water policy (Allan, 2005), to evaluate different water risks by the four cultures (Koehler et al., 2018). Hoekstra (2000) discussed perspectives of different water challenges shared among four cultures (Table 7.1). For example, the water scarcity problem is defined by hierarchists as a supply problem, while egalitarians consider it as a growing water demand problem. Consequently, suggestions for water scarcity problem will vary among different groups: hierarchists emphasize the increasing supply to meet water demands through the construction of large scale reservoirs, dams, artificial groundwater recharge; while egalitarians highlight the importance of managing water needs to ensure the sustainability of water environments through policy incentives but not massive dam constructions because of ecological damages; and individualists see the solution in market pricing. Allan (2005) emphasized the influence of four cultures in water management paradigms. Indicatively, industrial modernity or hydraulic mission was promoted by hierarchists, while reflexive modernity or green paradigm was advocated by egalitarians (environmental activists and green civil movements).

Table 7.1 Four perspectives on water challenges

	Hierarchist	Egalitarian	Individualist	Fatalist
Water demand	a given need	a manageable desire	price-driven	an unmanageable desire
Water-conserving technology	large-scale technology push	small-scale technology push	price-driven	no policy
Water price policy	incremental price increase	water taxing	market pricing	no policy
Water availability	stable runoff	stable runoff in inhabited areas	total runoff or no limits	irrelevant to individuals
Water scarcity	supply problem	demand problem	market problem	problem of individuals
Groundwater use	inevitable	below sustainable level	desirable if cost-effective	profitable to a few
Artificial groundw. recharge	solution to water scarcity	should not be necessary	desirable if cost-effective	no policy
Artificial surface reservoirs	solution to water scarcity	undesirable	desirable if cost-effective	no policy
Water trade	controlled trade	no water trade	free trade	trade is for the rich
Food security policy	food self-reliance	food self-sufficiency	free trade	no policy
Hydrological cycle	robust within limits	vulnerable to perturbations	robust	unpredictable
Sensitivity of sea level	moderately sensitive	highly sensitive	insensitive	unknown
Public water supply	incremental improvements	basic supply to everyone	driven by economic growth	given to the rich
Water quality evaluation	functional quality standards	pristine quality as reference	economic value	no reference
Wastewater policy	treatment to meet standards	treatment, decrease production	'polluters pay' principle	no policy
Flooding risks	divergent risk levels	equal risk principle	economic trade-off	risk acceptance

Source: Hoekstra (2000)

Cultural theory can also be applied to explore differences in prioritizing water security dimensions in Central Asia among scholars and practitioners. The academic debate on water security aspects represents the position of egalitarian cultural bias. In contrast, experts' opinions reflect on current water policy challenges and hence can be considered as a position of hierarchist. The literature analysis revealed that scholars discuss the impact of mismanagement of water resources, climate change, and growing water demands on aquatic and environmental ecosystems.

Scholars share the egalitarian cultural bias in depleting resources, overexploitation of resources, risk and responsibility sharing, and preventive management (Hoekstra, 2000); and consequently, prioritizing environmental dimension of water security in Central Asia to raise ecological awareness. Practitioners represent the hierarchist perspective in ranking higher economic dimension and urban & household dimension of water security to ensure water availability among competing water needs by investment in irrigation and water supply infrastructure to prevent social conflicts and promote economic growth and welfare. The contradiction in ranking water security aspects among scholars and practitioners reveals differences in cultural preferences, including water risks perceptions, values, lenses, and beliefs in prioritizing and managing water challenges. This finding supports hypothesis 3 about equivocal water security perceptions among scholars and practitioners.

The research-practice gap on water issues in Central Asia can result from differences in the demand for appropriate water policy recommendations and the supply of scholarly water knowledge, imperfect communicating science, and indifference or ignorance of policymakers in scientific research findings. Evidence-based policy is a mantra in public policy. Yet not all knowledge is usable and applicable; hence, knowledge usability depends on the knowledge production process, communication mechanisms, and institutional arrangements (Dilling & Lemos, 2011; Lemos, 2015). For example, scholars with egalitarian cultural bias might focus on perceived water risks, while policymakers with the hierarchist perspective reflect on observed water risks (Koehler et al., 2018). Scholars publish in international journals, while experts and policymakers in Central Asia may have language barriers, access barriers, and understanding barriers. The primary audience of scientific publications is the international scientific community rather than local experts and policymakers. Policymakers and practitioners might be interested in simple-fix and short-term solutions rather than complex scientific problem conceptualization and overgeneralization in water studies, especially in engineering and economic sciences (P. Mollinga & Gondhalekar, 2014). It could be the case that scientific research about water resources in the region is theoretical, shallow, and general, while policymakers need a practical application, local knowledge, and expertise. Scholars mentioned that national politics on water resources in Central Asia is understudied in the literature (Sehring, 2020; Sehring et al., 2019). This also shows scholars' and policymakers' different interests and priorities in knowledge perception and usability.

Some cultural theorists recommend "clumsy solutions" or pluralist policies for complex problems considering perspectives of four types of cultural biases: the authority of hierarchists, equality and cooperation of egalitarians, entrepreneurship of individualists, and stoicism of fatalists (Allan, 2005; Koehler et al., 2018; Mamadouh, 1999). The clumsy approach can also be applied towards water security progress in Central Asia by integrating different perspectives into water policy and planning, sharing water risks among water users, setting market regulations, and promoting dialogue and collaboration among stakeholders. The bridging gap between scholars' knowledge supply and knowledge demand of policymakers by creating a platform and coordinating a dialogue might produce policy-relevant recommendations, co-producing of scientific research, and effective science communication (Colebatch, 2006; Lemos, 2015; Molle, 2008). For example, policymakers and experts might consider scholarly knowledge in agenda-setting and policy formulation rather than relying on common knowledge about best practices and models that are not updated or modified (Molle, 2008), while academics might raise debates about real-world problems. The publicly funded science should support in understanding, formulating, and implementing policy solutions to societal problems (Dilling & Lemos, 2011; Lemos, 2015).

The argument research-practice gap is based on comparing scholarly literature and experts' views and does not include the analysis of policy documents, policy briefs, and reports. Moreover, there is a high chance of overlap between scholars and practitioners because about two-thirds of practitioners are employed at universities and research institutes. The authors of some publications might relate to water security issues in Central Asia, and hence, practical/technical knowledge might be underrepresented. Future studies can analyze the sources of the research funding of the water resources in Central Asia and how it influences transboundary cooperation.

7.4 Advancing river basin management

Strengthening water security by improving river basin management in Kazakhstan was proposed in scholarly literature and by practitioners from the Delphi method. The river basin management and planning evaluation in Kazakhstan was conducted using the DPSIR framework by interviewing stakeholders in the BA river basin. The analysis revealed that introducing the river basin approach two decades ago was a response to water challenges, Soviet experience with water management, the influence of the global agenda on IWRM and sustainable development, and the role of international donor organizations and projects. Scholars discussed several reasons for the widespread replication of successful examples of RBO. One of the potential explanations is the snowball effect when the idea of the river basin approach was dominant among academic literature, policy networks and supported by successful examples (Molle, 2008; P. P. Mollinga, 2008). Even Global Water Partnership was established as an epistemic community promoting IWRM (Molle, 2008). In Kazakhstan, Global Water Partnership was one of the most active advocators of IWRM. Another potential driver could be the incentives of decision-makers and experts involved in implementing IWRM (Molle, 2009; Mukhtarov & Gerlak, 2013). Indicatively, for water bureaucrats, it is an opportunity to attract international and multilateral donors and loans to cope with ‘fiscal drought’; for national policymakers, it is a credit for international acceptance and visibility, for national experts – the opportunity for publications, global conferences, workshops, and career reputation (Molle, 2009; Mukhtarov & Gerlak, 2013).

Implementation of the river basin approach usually attempts to solve specific water problems. The most well-known river basin organization models (the US Tennessee Valley Authority, Agencies de l’Eau, the Australian Murray-Darling Basin Commission) were introduced to address specific water challenges. For example, the US Tennessee Valley Authority was established to control the river system through a set of dams and reservoirs, accompanied by substantial state-led investments in technology and infrastructure; while the French Water Agencies (Agencies de l’Eau) aimed to solve water quality problems by introducing the ‘polluter pays principle to internalize negative externalities and costs that influenced the development of the European Water Framework Directive (Molle, 2009). In the case of the Australian Murray-Darling Basin Commission, the objective was to enhance water use efficiency by developing water-sharing agreements and creating water markets (Molle, 2008, 2009). These examples reveal that even though these organizations are named under the umbrella of ‘river basin organizations,’ the goals and contexts vary among these models.

The results demonstrated that the role of RBI in Kazakhstan is in the implementation of top-down water policy in the relevant river basin, issuing water permits and limits, monitoring, and protecting water resources. Indeed, different RBOs have different functions and power. RBOs can differ based on their functions: *authorities* (can formulate and implement changes), *entities* (are intermediaries with some power), and *committees* (have advisory and observer roles) (Barrow, 1998). Initially, the idea behind river basin organizations was to be a vehicle of bottom-up planning and decentralized water management. In the case of Kazakhstan, water management remains top-down, centralized planning and management. Table 7.2 compares the critical elements of the river basin approach in Kazakhstan with the water resources management in the Soviet time and IWRM guidelines. It seems that water resources management and planning are still top-down but just administered on the basin scale and labeled with some elements of IWRM (RBOs, RBCs). Even the river basin planning is implemented according to the Soviet complex schemes of using and protecting water resources, while the key principle of bottom-up planning is overlooked.

Table 7.2 Comparison of river basin management in the USSR and Kazakhstan

	USSR	**IWRM**	**KAZAKHSTAN**
River Basin Organization	River Basin Inspectorate	River Basin Organization	River Basin Inspectorate
River Basin Plan	Complex schemes	River Basin Plan	Complex schemes
Basin Councils	No	Yes	Yes
Decision making	Top-down, technical solutions	Bottom-up, participatory	Mix, mainly top-down
Boundaries	Administrative-Territorial (only in Amudarya and Syrdarya rivers)	Hydrological	Hydrological/ mixed

RBCs are developing as a platform and dialogue for water users and stakeholders to meet and discuss water security challenges in the basin, but their recommendations are not legally binding. This finding is supported by the data in IWRM Data Portal (2021), where Kazakhstan received the highest score in participation and instrument dimension, especially in public participation and private sector participation, because of the existence of basin councils in all river basins. Nevertheless, interviewers suggested strengthening the role and defining functions of RBCs and RBIs and increasing financing, which is also reflected in the report of IWRM Data Portal (2021).

Fragmented water governance was mentioned by interviews and the relevant literature (Karatayev et al., 2017; Thevs et al., 2017; Zhupankhan et al., 2018). Improvement of national water policy, capacity building of water administrators, and better legislation are also addressed in the IWRM report. Namely, improvement of the enabling environment was highlighted, including national water policy, laws, basin plans, and transboundary arrangements. Indeed, complex national water legislation is formulated on the Constitution of the Republic of Kazakhstan and consists of the Water Code and other regulations, including 28 international treaties, 11 Codes, 37 Laws, 21 Decree of the President, and 115 Government decrees, affecting the issues of water resources management (IWRM Data Portal, 2021). The results demonstrated coexistence and communication of state agencies about data and information sharing but limited cooperation and cross-sectoral coordination in planning and implementation.

River basin management was assessed in this study since practitioners prioritized it in the Delphi surveys. However, scholars and practitioners also proposed improving drinking water supply systems, advancing irrigation management, land restoration, updating monitoring and control systems, training water experts, and promoting transboundary agreements on water allocation in Kazakhstan. The impact of these priorities on water security can be explored in future studies. The credibility of findings is subject to a single case study, inherent subjectivity bias of interviewees, and researcher bias in analysis and interpretation. The findings were cross-checked with recent publications and reports. To minimize subjectivity bias and incomplete information, interviews were conducted with local stakeholders and international consultants with substantial experience in river basin management in Kazakhstan and Central Asia, which gave credibility to their responses.

7.5 Towards water security

I propose a preliminary reflection on the role of river basin management in strengthening water security for countries primarily relying on transboundary rivers built on findings from the case study of Kazakhstan. Water security is fundamental for achieving sustainable development and promoting economic well-being, especially in countries sharing transboundary rivers as Kazakhstan. Transboundary water security depends on complex socio-economic-political factors and national capacities to allocate, regulate, and reallocate water resources among stakeholders and users (Albrecht et al., 2018; Mirumachi, 2013). Scholars and practitioners also highlighted that improvement of water governance is critical to solving water insecurity in developing countries (Araral & Wang, 2013, 2015; Gerlak et al., 2018). Countries' water security in the context of transboundary rivers, as in Kazakhstan, generally depends on internal and external factors. I refer to water governance, water resources management, institutional capacity, and water policy as internal factors. While arrangements in transboundary rivers, socioeconomic development and political situation in neighbor countries, uneven temporal, and spatial hydrological distribution to external factors.

The narrative of water insecurity among water bureaucrats and policymakers in downstream countries is mainly about the high dependence on transboundary rivers. Indeed, the socioeconomic development and wellbeing of 3 billion people rely on 310 international transboundary aquifers. Yet nearly 60% of these basins lack agreements on water allocation, water pollution, and governing disputes (UNEP-DHI and UNEP, 2016). This confirms the challenges, obstacles, and conflicts of interest in the development and implementation of agreements and treaties on transboundary water cooperation: asymmetries in water governance and infrastructure, promotion of national interests and values, imbalance in institutional capacity, information, and power asymmetries (Albrecht et al., 2018; Mirumachi, 2013; Wolf, 2007). About 44% of surface runoff in Kazakhstan comes from neighboring countries, namely China, Russia, and Kyrgyzstan; however, there are limited agreements on water allocation and water quality in transboundary rivers (discussed in detail in 6.2). Consequently, in Kazakhstan and other downstream countries sharing transboundary aquifers, the water security term might refer to water supply security because of dependency on transboundary rivers. However, shifting the responsibility on water insecurity because of high dependence on transboundary watercourses and limited agreement might lead to limited actions on the national level regarding water governance and water resources management. This is especially relevant for downstream countries with external uncontrollable factors, such as socioeconomic development in upstream countries, uneven spatial and temporal water distribution, and the uncertain impact of the climate crisis.

This study emphasizes the role of internal factors in strengthening water security: water governance, water management, institutional capacity, and water allocation at the national level. It was widely acknowledged that water stress is a crisis of governance (OECD, 2011). Scholars empathized the role of river basin authorities in water governance at the basin level as a bottom-up approach to manage water resource uses and users and stakeholder participation (Barrow, 1998; Gerlak et al., 2018; Santos Coelho et al., 2018). The river basin approach is one of the principles of IRWM and adaptive water governance. The river basin management practices were introduced across the globe, but implementation showed mixed results because of contextual, institutional, and physical settings (Allan, 2003; Molle, 2008, 2009; P. Mollinga & Gondhalekar, 2014). Countries share similar challenges in the implementation of the river basin approach such as lack of coordination and cooperation in the basin, lack of data, poor databases, limited financial and human resources, poor jurisdiction to control and manage the basin, insufficient funding for monitoring (Barrow, 1998; Molle, 2009; Mukhtarov & Gerlak, 2013). Scholars provided counterarguments that despite implementation failure of the river basin approach, this is a pathway towards decentralization of water resources management and democratization of policymaking (Meublat & le Lourd, 2001; Molle, 2008). Public participation helps communicate and address the growing pressures on water ecosystems and assess the impact of water security challenges on societal, economic, and environmental systems. Especially when water-related disasters are increasing in scale because of climate change, prompt decision-making in basin-scale is crucial to increase resilience and diminish the vulnerability of water users and communities. Hence, strong RBOs (or RBIs in Kazakhstan) are vital in ensuring long-term sustainable water security at the local and river basin scales.

The river basin approach can be considered as an operational tool to ensure water security by achieving water resources' good ecological and chemical status and promoting trust and cooperation among stakeholders in the basin. The river basin management also enables and regulates sustainable and efficient use of water by creating a polycentric water governance platform for coordinating stakeholders and state agencies and engaging water users in the discussion of complex and interconnected water security dimensions. In the case of Kazakhstan, RBCs showed an example of how local knowledge, increasing public awareness, and stakeholder engagement might help coordinate and resolve water disputes, adapt to climate changes, and build resilience faster. Moreover, RBCs encourage bottom-up the river basin planning and ensure accountability of river basin organizations. Water security issues often require quick local actions because ambitious national climate adaptation and mitigation plans might not be relevant at the basin level because of differences in hydrological, geographical, and economic settings. Moreover, competing demands in water under the conditions of scarcity, vulnerability, and complexity of water resources because transboundary rivers ask for responsive institutions flexible for change (Albrecht et al., 2018). This finding partially supports hypothesis 4 about strengthening water security by improving institutional mechanisms of river basin management. However, the river basin approach is not the only key variable in internal factors that influence water security but also sound water policy, water legislation, and strong water administration. Good water governance, including river basin management and planning, might strengthen water security by achieving a sustainable balance between the social, economic, and environmental needs for water.

This thesis did not claim that water security can be achieved in countries with high dependency on transboundary rivers only with river basin management at the domestic level but instead proposed an alternative perspective to the dominant narrative of water insecurity in downstream riparian countries, which relies mainly on the dependence on transboundary rivers and aquifers. High uncertainties in socioeconomic development and water resources use in upstream countries and unpredictable risks associated with climate change require efficient management, allocation, coordination, and use of water resources and strengthening water governance. Contemporaneously, transboundary water cooperation should be promoted by connecting water resources with other sectors (trade, services, etc.). The abovementioned policy recommendations depend on political will to achieve water security, promote transboundary cooperation, invest in water infrastructure, institutions, and capacity building that will meet and address current and future water security threats.

Chapter 8

Conclusion

8 CONCLUSION

8.1 Synthesis

The concept of water security has gained increasing importance under the high uncertainties of the climate crisis and rising water demand. Water security underpins practically all sustainable development goals that either enable or depend on the securitization of water resources. The concept of water security emerging from the securitization theory changed the focus from defined national security threats to constructed threats developed by the Copenhagen School. Scholars and practitioners have scrutinized water security from different angles by highlighting the complex interconnected socio-economic-environmental systems and diverting from fragment understanding of water security in terms of only water availability. Different metrics and frameworks were developed to assess water security from various perspectives and scales. This thesis discussed the main challenges of the water security concept: conceptualization challenge, operationalization gaps, and context specificity. Interpretation of water security depends on "*institutional agendas, objectives, disciplinary approaches, theoretical leanings, political preferences, views of justice and equity and geographic settings*" (Gerlak et al., 2018, p.86). Instead of developing another water security framework, this thesis explored perceptions of water security in Central Asia, as a case study of complex transboundary river basin, among scholars and practitioners by taking the baseline of the AWDO framework (2013, 2016, 2020). Following the suggestions of scholars and practitioners, this thesis also investigated to the role of river basin management in strengthening water security in the case of Kazakhstan.

Water security was always important for Central Asia countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan) sharing one of the complex transboundary river basins because of interconnected water infrastructure in the Aral Sea basin constructed in the Soviet era when water resources were used mainly for cotton production causing the Aral Sea crisis. Former water-energy-agriculture tradeoffs collapsed after the break of the USSR when hydropower reservoirs in water-abundant upstream republics operated to release water in vegetation period for downstream riparian republics in exchange for cheap fossil fuels in winter. Water security challenges escalated after the dissolution of the USSR because of regional fragmentation in terms of water-rich upstream countries interested in expanding hydropower electricity generation and energy-rich downstream countries in water needs for irrigated agriculture in arid areas causing disputes on water allocation in the Syrdarya and the Amudarya rivers. Unequal distribution of water resources in Central Asia, limited transboundary cooperation and mismanagement of water resources at all levels cause water insecurity in the region. This thesis also included Afghanistan in the analysis since the country shares the Amudarya River with other Central Asia republics. Water security was ensured in Central Asia by large-scale engineering water infrastructure in the USSR. Still, regional disputes on water allocation to meet national water needs represent a fragmented interpretation of water security that might cause negative externalities to socioeconomic development and environmental flows.

This thesis demonstrated exploratory and interdisciplinary study synthesizing heterogeneous knowledge, including the academic publications on water security in the region, pragmatic understanding of practitioners gained from the two rounds of the Delphi method, and local knowledge about river basin management collected from stakeholders. The section below presents answers for research questions stated in Chapter 1.

Research question 1: How is water security interpreted in academic discourse in Central Asia?

Insights from the academic literature help to understand how water security threats in the context of Central Asia are formulated and constructed through scholarly debate and justifications. To answer this research question, a comprehensive assessment of water security interpretations in academic literature in Central Asia, including Afghanistan, was conducted for the post-Soviet era: from 1991 to 2019. The peer-reviewed articles in English were traced in the leading research databases through the three-layer Boolean search of keywords of water security dimensions and attributes adjusted from the AWDO water security assessment framework (2013, 2016). Chapter 4 presented the coding results of 151 articles, followed by the content analysis of each water security dimension. The dramatic increase of publications since 2010 revealed the strong interest of the scientific community in complex transboundary river systems in Central Asia and the increasing popularity of the water security term. Among four broad water security dimensions, environmental water security aspects prevailed in the scholarly literature by highlighting the impact of the climate crisis on water catchments and environmental ecosystems, raising awareness of the past, present, and future negative externalities associated with anthropogenic activities to environmental flow (for example, the Aral Sea), and promoting of nature-based solutions to achieve water security in Central Asia.

The coding results revealed the importance of the economic dimension of water security concerning inefficiency and aging water infrastructure of irrigated agriculture, expansion of hydropower projects in upstream countries, and complexness of water-energy-food nexus in Central Asia. Scholars also discussed the vulnerability of the region to the potential impact of global heating and increase in frequency and scale of water-related disasters: droughts and floods. Meanwhile, about one-third of the articles covered the urban and the household dimension of water security by noting limited wastewater treatment, insufficient drinking water supply systems, and sanitation in rural areas of Central Asia. The thesis demonstrated the dominance of the environmental water security dimension in academic discourse in the context of Central Asia.

Research question 2: How is water security in Central Asia perceived by practitioners?

Experts and practitioners play a paramount role in problem statements and agenda-setting framing water security. Two rounds of the Delphi method were organized to identify water security perceptions of local and international experts with a background in Central Asia's water sector. By the end of the second round of the survey, practitioners reached a consensus on ranking the relevance of water security dimensions in Central Asia and Afghanistan by highlighting economic and urban & household aspects of water security. The findings suggested that practitioners perceive achieving water security in the region by improving and investing in water infrastructure to increase water use efficiency in irrigated agriculture and hydroelectric power plants and drinking water supply facilities. The prevalence of socioeconomic aspects of water security might negatively affect environmental flows and aquatic catchments as it happened with the Aral Sea. Over and above, experts reached an agreement on setting water security priorities for some Central Asia countries: upgrading irrigation systems in Uzbekistan, enhancing river basin management in Kazakhstan, and improving drinking water supply systems in Afghanistan. Overall, experts identified different water security priorities for Central Asia countries by confirming regional fragmentation in the interpretation of waters security among countries sharing transboundary rivers that might cause insufficient initiatives for transboundary water resources management. Chapter 5 presented MNL regression results and cross-tabulation analysis by indicating some behavioral patterns (difference in age, education, and origin) among experts in prioritizing water security dimensions and country priorities. Indicatively, practitioners of the Soviet engineering school are more likely to advocate for a 'hydraulic mission' in ensuring water security, compared to experts educated by contemporary paradigms in water resources management, who are more likely to promote IWRM principles and water governance in achieving water security in Central Asia.

Research question 3: To what extent are water security trends in literature aligned with the policy discourse mentioned by practitioners?

Historically, decision-making in water resources management in the world relies on scientific knowledge and evidence. Mapping the academic debate and pragmatic perspective of experts about water security in Central Asia helps to understand water security perceptions in the region among individuals involved in agenda-setting, lobbying, and policy formulation. The comparison of literature review findings and experts' opinions on water security issues illustrated different interpretations of water security. The cultural theory was applied to explain the difference in water security interpretation among scholars and practitioners because of differences in water risk perceptions. The academic debate on water security reflected the egalitarian cultural bias by prioritizing environmental risks because of overexploitation and mismanagement of water resources and emphasizing shared responsibility and greater equality in water allocation. Practitioners' opinions were considered hierarchist cultural bias by highlighting the socioeconomic aspect of water security to ensure water availability among competing water needs, prevent social conflicts, and improve institutional mechanisms to enhance transboundary cooperation in Central Asia. The contradiction in ranking water security aspects among scholars and practitioners revealed differences in cultural preferences, including water risks perceptions, values, lenses, and beliefs in managing water challenges. Hence, water security strategy should integrate different perspectives into water policy and planning and promote dialogue and collaboration among stakeholders.

Historic water security trends in the academic literature were not fully reflected in policy discourse in Central Asia, revealing the gap between the demand for relevant water policy recommendations and the supply of scholarly knowledge. The research-practice gap could be the outcome of the socio-cultural aspect of knowledge production, lack of scientific knowledge communication, and limited application of scientific knowledge in the realm and capacity of the region. Central Asia is known for weak water governance and mismanagement of water resources. The bridging gap between scholars' knowledge supply and knowledge demand of policymakers by encouraging interaction and co-production might increase knowledge usability, communicate about the wicked complexity of water security, and create a dialogue for evidence-based policies.

Research question 4: What is the role of river basin management in strengthening water security in Kazakhstan?

The thesis examined the role of river basin management in strengthening water security in Kazakhstan suggested by scholars and practitioners. River basin management was introduced about two decades ago in Kazakhstan to respond to water challenges. Semi-structured interviews using the DPSIR framework explored the drivers of change towards the river basin approach: global agenda on IWRM and sustainable development, the influence of international organizations and projects, and past dependency on Soviet water management. Interviewers also mentioned that pressures on water resources are growing in scale because of the effects of global warming and the rapid increase in water demand. RBIs are responsible for implementing top-down, centralized water management and planning at the relevant basin by monitoring water use and issuing water permits and water limits. In contrast, RBCs demonstrated a platform for bottom-up problem solving and dialogue on water security challenges between water users and stakeholders. Interviewers also reflected on the vital role of the river basin approach on sustainable socioeconomic development and environmental conservation. Advancing river basin management in Kazakhstan was suggested by improving fragmented water governance, better water legislation, capacity building of water administrators, enhancing human, financial, and technical resources, and promoting intersectoral cooperation and collaboration of government agencies.

Building on findings of the case study in Kazakhstan, this thesis outlined strengthening internal factors of achieving water security and proposed an alternative perspective to the dominant narrative of water insecurity in downstream riparian countries because of dependence on transboundary rivers and aquifers. Since external factors (socio-economic-political development in upstream countries, uneven temporal, and spatial hydrological distribution) are unmanageable by downstream countries, improving internal factors (institutional capacity of water governance, cross-sectoral collaboration in water policy, water use, and water allocation) can influence in achieving water security. The river basin approach can be an operational tool to ensure water security by achieving water resources' good ecological and chemical status and promoting trust and cooperation among stakeholders in the basin. In the case of Kazakhstan, RBCs demonstrated an example of how ecological (local) knowledge and stakeholder engagement might help coordinate and resolve water disputes at local level, which can be a path to adapt to climate changes and build resilience faster at the local level. River basin management and planning can strengthen water security by contributing to a sustainable balance between the social, economic, and environmental needs for water.

8.2 Suggestions for further research

This thesis proposed an innovative analytical and methodological approach in understanding waters security perceptions in Central Asia - one of the most complex transboundary systems in the world. The thesis contributed to the current state of knowledge about the water security concept by bridging conceptualization, operationalization, and context specificity gaps that have been gaining importance in the virtue of the impact of the climate crisis on aquatic ecosystems and growing competing water demands. The thesis offered an in-depth analysis of water security perceptions in Central Asia among scholars and practitioners. Some behavioral patterns of practitioners in selecting water security dimensions and priorities were identified with MNL regressions and cross-tabulation analysis. The exercising of the Delphi approach in the context of complex water security presented an attempt to reach a consensus of certain aspects of water security priorities among practitioners. The comparison of scholarly debate and pragmatic knowledge of practitioners on water security issues illustrated the difference in water security perceptions because of cultural preferences, values, and lenses in managing water challenges. The case study of Kazakhstan contributed to the literature on river basin management by evaluating the drivers towards the river basin approach, pressures in the river basin, assessment of the role of river basin organization, river basin councils, and river basin planning, and outlining some policy recommendations. Finally, the thesis offered some insights into the role of river basin management in achieving water security.

Future research is recommended to analyze how water security threats are securitized because water challenges are growing in scale in developing and developed countries and not all water security threats become policy problems and national security threats. There are still limited studies on transboundary water security that are wickedly complex by nature but critically important because about 3 billion people rely on transboundary aquifers worldwide. Future studies might also contribute to understanding water security discourses in the Russian language or analyzing local social media (news, blogs, etc.) to reveal water security perceptions of the public shaped by journalists. There is a chance that water security dimensions would be addressed differently in academic literature in the Russian language. This thesis focused on the case study of Kazakhstan, but future studies might explore the perspective of water security priorities for other

Central Asia countries suggested by practitioners in the Delhi method. Further research is needed to explore the impact of unregulated groundwater extraction on the ecosystem in Central Asia in the virtue of global heating. On the national scale, cross basin analysis of river basin management can be conducted in Kazakhstan since this thesis focused only on one river basin.

8.3 Policy implications

This thesis validated that water security priorities and water security perceptions are sensitive to the context from the policy perspective. There is no standard water security strategy that fits all the needs. Understanding and forecasting water security threats might prevent negative externalities and high social and economic costs associated with water-related disasters that are increasing in scale because of global warming and widespread water demand rise. The thesis findings can be used by scholars from other fields, practitioners, and policymakers. This thesis attempted to bridge the interpretations of water security in Central Asia among scholars and practitioners to understand the securitization threats of water resources better. Academic debate on water security in Central Asia addressed environmental and resilience aspects of water security. At the same time, practitioners reflected on the current water security policy discourse, which focused on socioeconomic dimensions. Policymakers should be aware of different interpretations of water security and consider consultations and collaboration in agenda-setting and planning multipurpose water policy with relevant stakeholders from other sectors (energy, agriculture, environment, urban supply, etc.). Different water security priorities were suggested for Central Asia countries, which revealed different national water security challenges and the transboundary complexity of river basin systems that might be an obstacle for transboundary water security because of fragmented interpretation in terms of water allocation. The transboundary river system asks for interregional cooperation and interconnectedness of national water policies to achieve common environmental goals and prevent water disputes and negative consequences of water-related disasters. However, improving the institutional capacity of water governance should be addressed for better water allocation and efficient water use at the country level.

In conclusion, the analysis of the thesis confirmed the highly multidimensional and contextualized nature of the elusive water security concept. The long-standing interest in the water security concept can be explained by its impact on societal and economic developments. The water security concept represents the complexity of causality, including scarcity, governance, equity, and hazards. This thesis offered research methodology design to reveal water security perceptions. Water security assessment requires a complex and holistic approach; consequently, achieving water security needs cross-sectoral planning and management of water resources. As it is widely recognized, strengthening water security is context specific. Still, the operationalization of water security faces challenges; even in this study, bridging the role of river basin management in strengthening water security is still preliminary and needs further investigations. Achieving water security requires robust public policy accompanied by uncertainty, volatility, confronted paradoxes, and needs.

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Annexes

Annex 1

Delphi surveys

Summary of 1st round questionnaire:

- Rating relevance of water security dimensions in Central Asia
- Rating relevance of water security attributes in Central Asia
- Assessment of water security trends at policy level
- Ranking water security priorities for Central Asia countries and Afghanistan
- Assessment of current institutions and mechanisms in Central Asia dealing with water security aspects

- Demographic questions: age, gender, education, experience, employment, residence

Summary of 2nd round questionnaire

- Assessment of ranking water security dimensions from the 1st round
- Assessment of the most important attributes of water security dimensions identified from the 1st round
- Assessment of historic water security trends
- Assessment of water security priorities for Central Asia countries and Afghanistan
- Assessment of current institutions and mechanisms in Central Asia dealing with water security aspects

- Demographic questions: age, gender, education, experience, employment, residence

Annex 2

Interview questions

Evaluation of river basin management in Kazakhstan

DRIVING FORCES

- What contributed to the change for river basin approach?
- What were the driving factors?
- What problems did river basin management attempt to solve?

PRESSURE

What pressures do you think contributed to the development of river basin management?

STATE

RBI

- What is the current state of RBIs?
- What challenges does RBI face?
- How is RBI interdependent from other agencies in solving the water issues?
- How would you assess how RBI copes with the functions specified in the mandates?

RBC

- What is the role of RBCs? Who are current and potential?
- What is the impact/value of recommendations of the basin council? Please provide example
- What is the progress of subbasin councils in small rivers?

River basin planning/agreement

- What is the status of the general water use schemes on basin level?
- What is the current state of the basin agreement/plan?
- Who is responsible for the development/implementation/evaluation of this agreement/plan?

IMPACT

- How does river basin management impact society, economy, ecosystem of the region?
- How does administrative-territorial water resources management impact society, economy, ecosystem of the region?

RESPONSES

- How river basin management can be improved in terms of capacity, distribution of functions and mandates of different bodies, management and coordination, etc.?

- How water security in Kazakhstan should be improved? What is the role of river basin management in strengthening water security in Kazakhstan?

Annex 3

Coding of interviews about river basin management in Kazakhstan

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