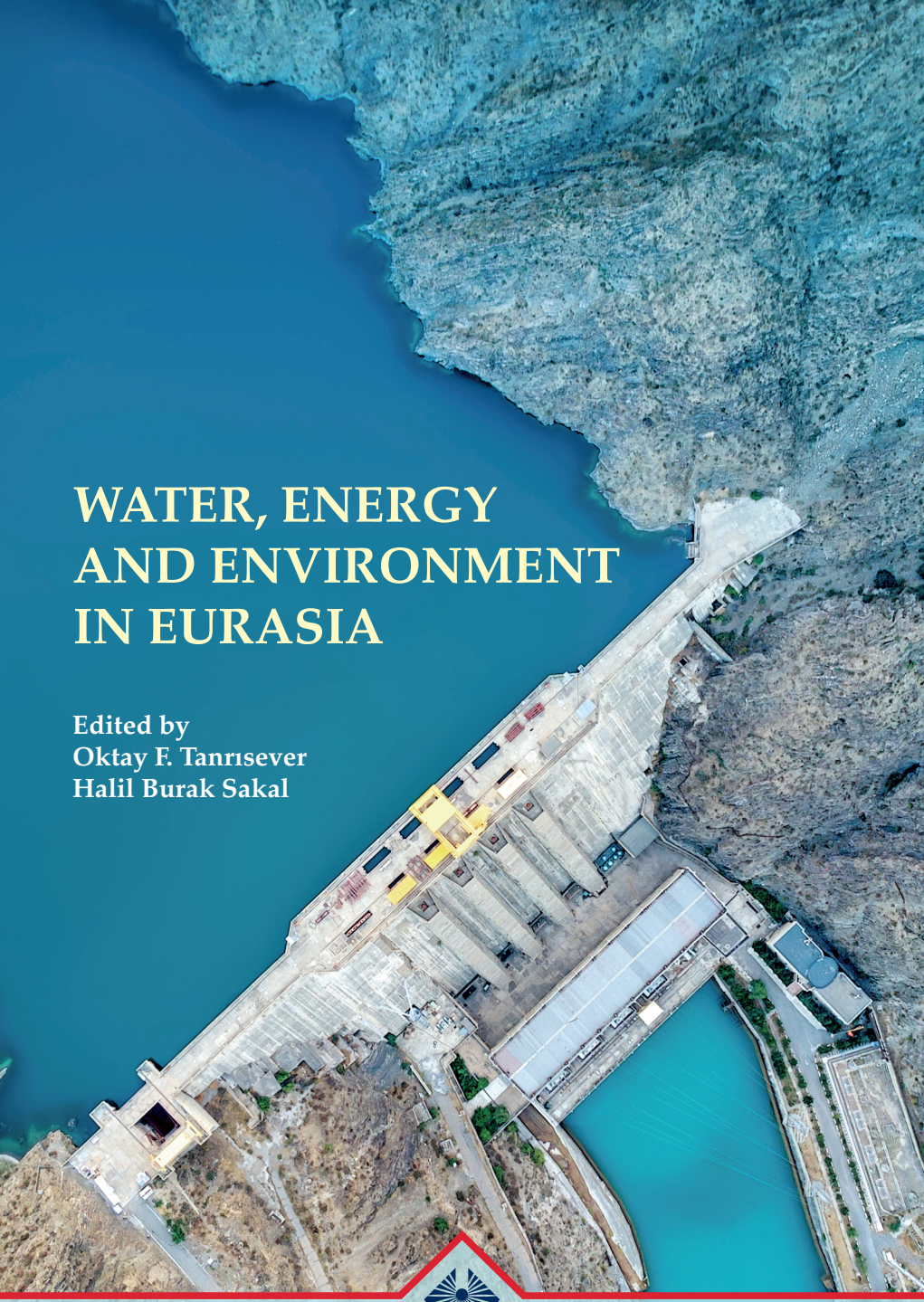
WATER, ENERGY AND ENVIRONMENT IN EURASIA

Edited by
Oktay F. Tanrısever
Halil Burak Sakal



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yayinevi@kapadokya.edu.tr
kapadokyayayinlari.kapadokya.edu.tr
+90-384-3535009
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Part 3. Regional Level of Analysis

List of Abbreviations

ADB	The Asian Development Bank
BCU	Basin country unit
BO	Build-own
BOT	Build-operate-transfer
CA	Central Asia
CAREC	The Regional Environmental Centre for Central Asia
CIS	Commonwealth of Independent States
DSİ	State Hydraulic Works of Turkey *(Devlet Su İşleri)*
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GWh	Gigawatt-hours
GWP	Global Water Partnership
ha	Hectares
HEP	Hydroelectric power
HPP	Hydropower plant
ICPR	International Commission for the Protection of the Rhine
IEA	International Energy Agency
IFAS	International Fund for Saving the Aral Sea
IJC	International Joint Commission
INWEB	International Network of Water-Environment Centres for the Balkans
IRENA	International Renewable Energy Agency
ISRBC	International Sava River Basin Commission
IUCN	International Union for the Conservation of Nature
IWRM	Integrated water resources management

JMP	Joint Management Programme
km	Kilometres
kW	Kilowatts
kWh	Kilowatt-hours
mm	Millimetres
Mtoe	Million tonnes of oil equivalent
MW	Megawatts
MWh	Megawatt-hours
NDC	Nationally determined contribution
OECD	Organization for Economic Co-operation and Development
OSCE	Organization for Security and Co-operation in Europe
SDG	Sustainable development goal
TFDD	Transboundary Freshwater Dispute Database
TGNA	Turkish Grand National Assembly
ToOR	Transfer of Operating Rights
TW	Terawatts
TWh	Terawatt-hours
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework on Climate Change Convention
UNICEF	United Nations Children's Fund
US	United States
US$	United States dollars
USSR	Union of Soviet Socialist Republics
WB	The World Bank
WEF	Water-energy-food (nexus)
WFD	Water Framework Directive (of the EU)
WHO	World Health Organization
WIS	Water Initiatives Support
WRI	World Resources Institute
WSS	Water supply and sanitation
WWAP	World Water Assessment Programme

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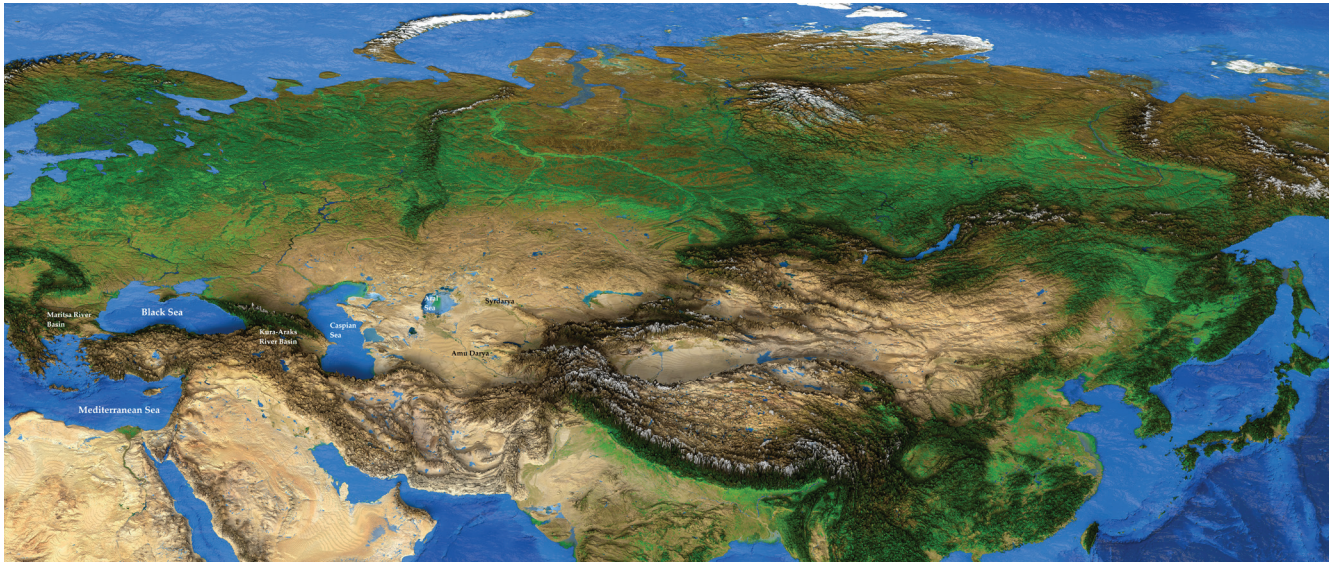

Map 1. Physical map of Eurasia

Map 2. Political map of Eurasia

Preface

This co-edited book is based on the contributions of the experts who participated in and presented their papers at the Water and Energy Nexus in Central Asia and the Caucasus Workshop. This workshop was held at the Cappadocia University in Ürgup-Turkey between 2 and 3 May 2019.

We would like to thank the Cappadocia University for agreeing to support this book project both at the workshop and publication stages. We are particularly thankful to Prof. Dr. Hasan Ali Karasar, the Rector of the Cappadocia University.

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Last but not least, we are so grateful to our families for their personal support and understanding throughout all stages of this book project.

List of Contributors

Iskandar Abdullaev is Assistant of Professor at the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan. Currently, he works as a Deputy Director of the Central Asian Regional Economic Cooperation (CAREC) Institute. Dr. Iskandar Abdullaev has over 25 years of experience in water management, water institutions, and environmental activities in Afghanistan and five Central Asian countries.
Email: iabdullaev68@gmail.com
ORCID: 0000-0002-9110-9268

Claire Franco is Erasmus Mundus IMCEERES student. She is affiliated with the University of Glasgow, the University of Tartu, and KIMEP University.
Email: claire_franco@gwu.edu

Mehmet Çağatay Güler is PhD student at the Department of International Relations, Bilkent University. His articles have been published in various academic journals, and he is the contributor to many books and articles related to Russian foreign policy, post-Soviet geography, and water and energy politics. His interviews and analyses have been published by national and international media agencies and organizations.
Email: cagatay.guler@bilkent.edu.tr
ORCID: 0000-0001-8604-0449

Batyr Kurbanov is Leading Specialist of the Secretariat of the Intergovernmental Commission on Sustainable Development of the International Fund for Saving the Aral Sea, Regional Basin Organization.

Previously, he worked for 15 years in the UN divisions as UNDO and WFP UN in Turkmenistan. He is engaged as a national expert under UN and EU projects in Central Asia. His areas of expertise include institutional strengthening, stakeholder engagement, project management, and capacity building at local, national, and regional levels.
Email: bkurbanov1962@gmail.com

Mayıs Kurt has been working as a Senior Environmental Engineer in the private sector for more than ten years. She has experience in water management, water and wastewater network design and treatment and sludge management. Currently, she is the national coordinator of the AFD Capacity Building Program for Municipalities and SKIs in terms of leak detection, GIS and geocoding, energy efficiency, and design training.
Email: mayiskurt@gmail.com
ORCID: 0000-0001-8316-848X

Aksulu Kushanova works as a Senior Energy Investment Specialist at the Regional Environmental Centre for Central Asia based in Almaty, Kazakhstan. She leads the analytical part and heads the implementation of the Nexus demonstration projects across Central Asian countries. Previously, she worked as Energy Consultant at the World Bank, independently developing specific sections in numerous research projects.
Email: akushanova@carececo.org

Ruslan Melian is Head of the Science and Development Department at the Aquaproject Institute in Moldova. His areas of expertise are water and environmental issues.
Email: rmelian@rambler.ru

Shavkat Rakhmatullaev is Visiting Lecturer at the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan. Currently, he works as Water Management Specialist at the World Bank Uzbekistan Country Office. He has over 15 years of professional experience in water management, hydrology and sustainable development in Central Asia.
Email: rakhmatullaev@rambler.ru
ORCID: 0000-0003-2814-5861

Tais Reznikova is Water Resources Management Specialist with an academic background in IWRM, environmental management and policy. She is leading the Water Initiatives Support Programme at the Regional Environmental Centre for Central Asia (CAREC) in Almaty, Kazakhstan. Her academic interest relates to the engagement of the private sector with sustainable water management and sustainability issues.
Email: treznikova@carececo.org

Halil Burak Sakal is Associate Professor of International Relations at Cappadocia University, Nevşehir, Turkey. His academic works and research interests include water, energy and environment; sustainable tourism development; and economic and political issues and historiography in Eurasia.
Email: burak.sakal@kapadokya.edu.tr
ORCID: 0000-0002-2054-5222

Shynar Sarikenova is Assistant of the Water Initiatives Support (WIS) Program at the Regional Environmental Center for Central Asia (CAREC), Almaty, Kazakhstan.
Email: shsarikenova@carececo.org

Oktay F. Tanrisever is Professor of International Relations and the Chairperson of the Center for Black Sea and Central Asia (KORA) at the Middle East Technical University (METU), Ankara-Turkey. He has specialized in energy, water and environmental diplomacy; transnational and regional security and peace-building in Eurasia.
Email: oktay@metu.edu.tr
ORCID: 0000-0003-0874-1324

Cemalettin Tüney is Country Coordinator at the Turkish Cooperation and Coordination Agency (TİKA), Tashkent Office, Uzbekistan. His research interests are renewable energy, hydroelectricity development of Turkey, and energy markets.
Email: c.tuney@tika.gov.tr

Introduction

Sustainability is a key challenge for all countries in all regions of the world. Climate change based on human activity makes the sustainable pursuit of water, energy and environmental policies even more challenging. In fact, the increased mobility of people and commodities, the increase in industrial and agricultural production as well as the growing volume of regional and international trade necessitate the greater uses of energy. Besides, the human beings have come up with many diverse and effective ways of generating energy for economic and daily life activities involving the exploitation of various types of fuels. The earth's energy resources are scarce, however, and energy generation activities are placing increasing pressure on the environment. Water lies between energy and the environment, being linked to them both as a crucial component of the environment and an important energy source.

To reduce the impact on the environment and to increase the level of livability on the planet, humans need to develop better and more sustainable ways of using water, energy and environmental resources. While the efficiency of traditional techniques is being continuously increased in energy generation, new and emerging technologies and innovations promise more significant energy production, requiring less effort and fewer investments. That said, engineering solutions and approaches to the resolution of the water, energy and environmental issues

the world is facing today are just one side of the coin, as political and economic approaches are also necessary if we are to gain a comprehensive and all-encompassing understanding of the situation. This book presents a political and economic approach to water, energy and environmental problems while taking into account the knowledge built on engineering solutions and methods.

The main subject of this volume is the inversely-related interdependencies of the Eurasian region's water, energy and environmental matters. The inversely-related interdependency between energy and the environment is more visible in water resources management since water is a central component of both the ecological system and hydropower production systems. In fact, increases in the use of energy and water resources tend to result in the intensification of environmental problems. The adoption of more effective environmental protection policies requires a reduction in energy production and consumption, and this inverse relationship makes achieving sustainability – a critical criterion in any long-term development strategy – an even more difficult target.

Eurasia is one of the regions that has been most affected by developments in the water, energy and environmental nexi. It is a vast region with tremendous variety in its geographic, climatic and environmental characteristics. While aridity and water scarcity are crucial problematic issues in some parts, floods and seasonal variances in precipitation are the bane of others, all of which are issues that can only be resolved through transboundary efforts and regional cooperation. Some parts of the region are rich in hydrocarbon reserves, while others lack such reserves, but are rich in water resources. The region can lay claim to one of the most devastating environmental disasters in history that resulted in the disappearance of the Aral Sea, recognized as one of the worst human activity-based problems

in the water, energy and environmental nexi in Eurasia. Needless to say, the effective management of environmental and water challenges of this region requires the development of a sustainable regional cooperation framework among the regional governments and peoples.

Throughout the Eurasian region, it is possible to observe growing interdependencies between the water, energy and environmental nexi in the post-Soviet period (Wegerich, 2009). The change in political boundaries since the collapse of the Soviet Union has increased the level and variety of intergovernmental relations, but also the intensity of political and economic tensions. Inherent problems and infrastructure issues pose increasing challenges to regional sustainability and development. The former Soviet-era interconnections and complex regional interdependencies related to various commodities, including oil, natural gas, electrical energy and food in Central Asia and the Caucasus, ceased to exist in the post-Soviet political setting. The growing economies, increasing populations and mounting regional conflicts intensified the search for energy and food security, placing stresses on water resources and the environment as a whole.

This book explores the challenges related to the growing linkages among the water, energy and environmental nexi in the mostly post-Soviet Eurasian region. The authors of this volume focus in particular on Central Asia, the Caucasus and the Balkans. While the Central Asian countries of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, and the Caucasian countries of Georgia, Armenia and Azerbaijan, are former Soviet republics, Turkey and Bulgaria both bordered the former Soviet Union, and so today share water resources and a common environment with the post-Soviet nations. For analytical purposes, therefore, this book considers Eastern Europe and Turkey to be adjacent to Eurasia, even though they

are more connected to Europe and the Middle East in terms of their water, energy and environmental relations.

All these countries have energy interconnections in the form of pipelines and electricity transmission lines that date back to the Soviet era. The water, energy and environment policies and relations among and between these countries entered a new era after the dissolution of the Soviet Union, with the inherent legal, institutional, infrastructural and physical connections in the presence of non-centrally-planned economies and new forms of political systems.

Although the nexus approach is widely recognized in international academic literature as a sound explanatory conceptual framework for studies of the relationships between water, energy and the environment in general, scholarly works on the nexi of water, energy and the environment in Eurasia are relatively rare, and those that have been penned cover only specific subregions of Eurasia, such as Central Asia (Kostianoy et al., 2018) rather than Eurasia as a whole. Scholarly analysis of this topic is critical since existing literature focuses either on the energy or environmental dimensions, or embraces engineering-based technical approaches and solutions. This book has a broader spatial coverage and takes a political-economic approach to the nexus issue, based on the understanding that Eurasia's water, energy and environmental problems are interrelated, notwithstanding their Soviet past and former or current political and economic dynamics.

Fortunately, there is a wealth of academic literature on water, energy and environmental issues in Eurasia, among which the major works can be categorized in terms of their focus on water, energy and the environment, or the geographical subregions of focus. That said, the geographical foci of these studies cannot be considered to be even among the sub-regions of Eurasia, as there is a clear majority of academic studies on

Central Asia's water, energy and environmental problems over those of the Caucasus and other parts of Eurasia.

As noted above, academic literature on the water, energy and environmental issues of adjacent parts of Eurasia, such as Eastern Europe and Turkey, is critical, as these studies partially employ the nexus perspective that is widely used in academic literature on water, energy and environmental issues in Europe. For example, one noteworthy publication, being Annika Kramer, Aysegul Kibaroglu and Waltina Scheumann's edited volume *Turkey's Water Policy: National Frameworks and International Cooperation* (Heidelberg: Springer, 2011) outlines the key issues in Turkey's water policy in which some chapters employ the nexus approach. Unfortunately, this publication falls short of identifying the linkages between the energy and environmental dimensions due to its primary focus on the water and environment relationship, with less emphasis on the energy issue.

The research paper of Campana et al. entitled "Science for Peace: Monitoring Water Quality and Quantity in the Kura-Araks Basin of the South Caucasus" focuses on the relationship between the quality and quantity of water, and the common problems related to quantity, quality and water allocation in the basin (Campana et al., 2008), but disregards Turkey in its analysis, as well as the linkages between the energy and environment dynamics, to a large extent. Similarly, Ghazaryan's chapter entitled "Resource Management Problems in South Caucasus Region" (2009) focuses on the governance aspect of water resources in the South Caucasus, but similarly, fails to establish or analyze the connections between water, energy and the environment from a systemic perspective. Dukhovny and Schutter's (2011) comprehensive book *Water in Central Asia* deals with all water problems in the region, but overlooks the linkages of energy and the environment and similar dynamics in

Central Asia, as well as in other parts of the post-Soviet Eurasian geography.

There are several other noteworthy publications on water, energy and the environment in Eurasia. For example, the article entitled "Dryland belt of Northern Eurasia: contemporary environmental changes and their consequences" by Groisman et al. focuses on part of Eurasia in its comparison of the drylands in the south and the forest lands in the north in terms of environmental changes and their impacts. This article, however, ignores the energy aspect of the problem (Groisman et al., 2018). In a similar vein, Stucki and Sojamo (2014) examine the water, energy and security nexus in Central Asia, emphasizing the security aspect of the local, national and international linkages between water and energy. The authors concentrate on water and energy security in Central Asia, although the environmental aspect remains largely overlooked in this very important study.

Although the body of related academic literature is rich in terms of scholarship quality and its coverage of sub-regions and countries, the new challenges related to the growing interconnections between water, energy and environment issues require a re-examination of the changing dynamics between them. This volume seeks to contribute to academic literature by emphasizing the importance of the nexus approach in explorations of water, energy and environment issues throughout the Eurasian region.

In general, the chapters in this book assume the presence of an evolving regional complex in Eurasia including the five Central Asian states of Kazakhstan, Kyrgyzstan, Turkmenistan, Uzbekistan and Tajikistan; the three Caucasian countries of Georgia, Armenia and Azerbaijan; and finally Turkey, as well as some of the neighboring countries with close connections to the water, energy and environmental resources of this region.

The nexus approach is often conceptualized as a more comprehensive response to the challenges encountered when covering the state, civil society, the private sector and those responsible for environmental sustainability and productivity in an inclusive analytical framework. Although water is the central nexus element, the nexus is not the same as Integrated Water Resources Management (IWRM). According to the Global Water Partnership, IWRM is "a process which promotes the coordinated development and management of water, land and related resources, to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership, 2011), and is a redefinition of a concept first suggested in the 1960s (Giordano & Shah, 2014). At an international level, it first entered the agenda of the World Summit on Sustainable Development in 2002 (Rogers & Hall, 2003). Some studies in literature have attempted to merge the nexus approach with the IWRM approach. Benson et al. argue that the primary concerns and goals of the IWRM and the nexus approach coincide, to a significant degree, although the IWRM has been more dominant as international bodies have adopted it as a direction for development (Benson et al., 2015).

Another approach to water and environmental problems is "water governance", being "a complex process that considers multi-level participation beyond the state, where decision making includes not only public institutions, but also the private sector, civil society and society in general" (Tortajada, 2010, p. 298). Similar to the nexus approach, water governance embraces political, economic and social processes and institutions, although the nexus approach is about compromise and trade-offs, as well as the cooperative frameworks of water, energy and environmental resources in a given region. The nexus approach embraced in this book, on the other hand,

takes into consideration the issues and problems of the environment, along with water use, pollution, energy generation, production and transfers.

At this point, it is important to note that there is no single "nexus", but rather a range of "nexi". There are various conceptualizations of the nexus approach in literature, in which it is used both as an analytical tool for academic research, and as a governance framework linked to sustainability issues. The nexus approach in governance often relies on multisectoral and multistakeholder processes on multistate or regional levels (Keskinen et al., 2016). Food systems are often included in nexus analyses, as agriculture is highly reliant on irrigation systems and the reservoirs created primarily for hydropower generation (Granit et al., 2014; Hamidov et al., 2022; Jalilov et al., 2018).

The water-energy nexus, which is central to our book, is another common topic of interest in academic literature (Ackerman & Fisher, 2013; Biswas, 2008; Gleick, 2014; Hussey & Pittock, 2012; Sovacool & Sovacool, 2009). This conceptualization emphasizes that water and energy depend on each other at a system level (Dodder, 2014). From this perspective, energy is required for such processes as the capturing, pumping, transfer and treatment of water, while water is consumed for mining, hydraulic fracturing, refining oil and gas, power plant cooling and hydroelectricity generation (Cooley & Donnelly, 2014; Hussey & Pittock, 2012). Many of the thermoelectric power plants built during the Soviet era use large volumes of water for cooling systems, while the more updated systems use water more efficiently (Dodder, 2014).

The nexus approach enables researchers to explore the relationships between the different dynamics that shape the complex relationship between water, energy and the environment. In fact, the large quantities of water used in the lifecycle of energy (oil, electricity, bio-energy) raises issues of sustainable

water and energy production, water degradation and pollution, as well as ecosystem damage (Wu et al., 2008). Agricultural activities also have a large water footprint (Hoekstra et al., 2011; Hoekstra & Mekonnen, 2012). Globally, agriculture uses 70 percent of all freshwater withdrawn in the world. As a general observation, it can be stated that the Central Asian republics of Uzbekistan, Turkmenistan, Kyrgyzstan and Tajikistan, and the South Caucasus nation Azerbaijan are serious water users. According to the World Bank's World Development Indicators, last updated in 2022, these countries withdraw over 90 percent of their freshwater resources for agricultural processes (World Bank, 2022).

Needless to say, water, energy and environmental policies are politically and economically interconnected, with policies aimed at developing one sector increasing the burden on others (Allan et al., 2015). Development strategies and market mechanisms, if left unregulated, may have considerable impacts on the environment. Researchers have reported on the significance of climate change in assessments of the nexus (Welsch et al., 2014). The adverse impacts of water shortages and climate change may be reversed through better water and environmental policies (World Bank, 2016).

The trade of electricity and the interconnections between regional electricity distribution networks have a strong influence on the international political economy of energy, as well as the nexi of water, energy and the environment. Hydroelectricity is a critical element in the water and energy nexus (Oud, 2002). In most Eurasian countries, hydroelectricity is seen having the potential to boost economic activity and ensure growth, especially in hydrocarbon-poor countries (Bartle, 2002). On the other hand, large dams and hydropower plants can have significant negative impacts on the environment in these regions (Berga et al., 2006). It is argued in literature that

environmental concerns must be taken into consideration when supplying people with energy and electricity (Egré & Milewski, 2002). After the environmental necessities are met during electricity generation, the benefits of integrating renewable power production can be considered, and the nexus approach can be seen as a key analytical tool for the identification of the factors necessary for the achievement of sustainable and equitable investments in water, energy and environmental resources. In this respect, the nexus approach allows political, administrative, economic and socio-economic dynamics to be conceptualized in a more meaningful and comprehensive way.

This book as a whole seeks to answer the following key questions: What are the major conceptual issues with regards to the water, energy and environment nexus? What are the key challenges and drawbacks faced by the countries in the Eurasian region in responding to the nexus issues? How can regional cooperation be developed so as to mitigate nexus-related sustainability problems? What are the future implications of the current challenges in the regional and global environment?

The book is presented in three parts that address these questions systematically in terms of the employed conceptual framework and levels of analysis. The first part focuses on the conceptual framework for exploring the key issues and theories on the water, energy and environment nexus. The second part concentrates on individual countries in Central Asia and the Caucasus and Turkey. In the third part, the book discusses the regional and international aspects of water, energy and environmental issues in Eurasia.

In the first chapter, Sakal and Tanrisever outline the book's conceptual framework by focusing on the academic literature on various aspects of the water, energy and environment nexus at a systemic level, suggesting that water, energy and environmental dynamics rely on each other. The first chapter, in this

respect, reviews the nexus approach and its impacts on policymaking in the Eurasian region. The authors argue that the nexus approach, as an analytical tool, supports scientific research and is being increasingly embraced not only as an analytical framework by researchers, but also as a governance framework by politicians and decision-makers in the Eurasian region.

In the second chapter, Kushanova, Kurbanov and Franco discuss the water, energy and food security nexus in Turkmenistan, arguing that Central Asian countries are particularly vulnerable to the risks of climate change, in a country like Turkmenistan, which is predominantly desert, water and arable land are scarce and valuable commodities. The authors focus on the reconstruction of the traditional sardob water reservoirs and their modernization with solar-powered pumping stations as a case study.

The third chapter focuses on the water and electricity nexus in Turkey, where hydropower is emphasized as a key target in Turkey's economic development plans, being considered as a possible solution to the rising electricity demand in Turkey's rapidly industrializing and urbanizing socio-economic system. Tüney argues that hydropower contributes to Turkey's efforts to reduce its energy dependency on other countries while being carbon-free, cheap and clean. In Turkey, as this chapter shows, the construction of large dams has been one of the focal points in the country's development strategy.

In the fourth chapter, Güler discusses the characteristics of water and energy security issues in Armenia. This chapter aims to clarify the role of hydropower in the energy security of Armenia. Armenia possesses significant water resources and considerable precipitation to feed those resources, but no fossil fuel resources like its Tajikistani and Kyrgyzstani counterparts in Central Asia, and so must depend on foreign resources. In this

context, hydropower stands as the most significant domestic resource for Armenia.

The fifth chapter analyzes the hydropolitical conflicts in Central Asia using Rogun Dam as a case study. Tanrisever and Sakal seek to identify the opportunity structures available to the conflicting parties of Tajikistan and Uzbekistan through a mixed methodology involving the use of quantitative and qualitative data about hydropower resources, as well as the water resources devoted to agricultural use. The chapter argues that Uzbekistan's change in position on this issue from being conflictual to more conciliatory can be understood from the hydropower resource data, as well as the water resources for agricultural use, and the relevant countries' policy options and peaceful settlement alternatives.

In the sixth chapter, Kurt analyzes the Maritsa River Basin and its beneficiary countries of Turkey, Greece and Bulgaria from three main perspectives: water quality, agricultural activity and energy benefit. The chapter also gives place to bilateral agreements and the flood problems faced by Turkey in the Maritsa region, and puts forward some possible solutions. The chapter argues that water supply and demand issues can be resolved through transboundary coordination and cooperation among the countries involved.

In the seventh chapter, Abdullaev and Rakhmatullaev discuss water security and climate change in Central Asia. Building the chapter on the understanding that there is a need for global recognition and acceptance of the importance of the interlinkages between water, energy, food and the environment for national development and prosperity. The economies of the arid Central Asian countries are growing and integrating with the global value chains, yet the transition from a centralized to more market-oriented economy is not yet complete. As the

authors discuss, these countries have declared their commitment to global climate change agreements and sustainable development goals. The main goal of this chapter is to provide a comprehensive assessment of the main issues and perspectives related to the irrigation, energy, agriculture and water sectors in the context of water-secure economies and risk management under potential climate change projections.

In the penultimate chapter, Reznikova, Sarikenova and Melian focus on water and the environment in the shared basins of Central Asia. The authors show that the Central Asian countries are continuing to develop legal frameworks for water resources management, including those related to water quality, since independence. The majority of water quality standards currently in use in Central Asia are based on the Soviet system. Besides, the characteristics and the classification system of these water quality standards fail to comprehensively demonstrate the status of the water quality in water bodies in an accessible way for all water users in Central Asia. Based on the comprehensive interviews with regional experts on water quality management, the chapter examines the main barriers to the implementation of legislation aimed at transitioning to a new classification system related to water quality in Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Finally, space in the chapter is spared for an analysis of the current water quality provisions and for the presentation of recommendations for the countries in the region.

The book closes with a concluding chapter in which the key findings of each chapter are identified and discussed in line with the overall perspective of the book.

References

Ackerman, F., & Fisher, J. (2013). Is There a Water-Energy Nexus in Electricity Generation? Long-term Scenarios for the Western United States. *Energy Policy*, *59*, 235–241. https://doi.org/10.1016/j.enpol.2013.03.027

Allan, T., Keulertz, M., & Woertz, E. (2015). The Water–Food–Energy Nexus: An Introduction to Nexus Concepts and Some Conceptual and Operational Problems. *International Journal of Water Resources Development*, *31*(3), 301–311. https://doi.org/10.1080/07900627.2015.1029118

Bartle, A. (2002). Hydropower Potential and Development Activities. *Energy Policy*, *30*, 1231–1239.

Benson, D., Gain, A. K., & Rouillard, J. J. (2015). Water Governance in a Comparative Perspective: From IWRM to a 'Nexus' Approach? *Water Alternatives*, *8*(1), 756–773.

Berga, L., Buil, J. M., Bofill, E., DeCea, J. C., GarciaPerez, J. A., Mañueco, G., Polimon, J., Soriano, A., & Yagüe, J. (2006). *Dams and reservoirs, societies and environment in the 21st century. 1–2.*

Biswas, A. K. (2008). Integrated Water Resources Management: Is It Working? *International Journal of Water Resources Development*, *24*(1), 5–22. https://doi.org/10.1080/07900620701871718

Campana, M. E., Vener, B. B., Kekelidze, N. P., Suleymanov, B., & Saghatelyan, A. (2008). Science for Peace: Monitoring Water Quality and Quantity in the Kura—Araks Basin of the South Caucasus. In J. E. Moerlins, M. K. Khankhasayev, S. F. Leitman, & E. J. Makhmudov (Eds.), *Transboundary Water Resources: A Foundation for Regional Stability in Central Asia* (pp. 153–170). Springer Netherlands. https://doi.org/10.1007/978-1-4020-6736-5_11

Cooley, H., & Donnelly, K. (2014). Hydraulic Fracturing and Water Resources. In *The World's Water* (Vol. 8). Pacific Institute.

Dodder, R. S. (2014). A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives. *Current Opinion in Chemical Engineering*, *5*, 7–14. https://doi.org/10.1016/j.coche.2014.03.004

Dukhovny, V. A., & Schutter, J. de. (2011). *Water in Central Asia* (1st ed.). CRC Press. https://doi.org/10.1201/9780429299926

Egré, D., & Milewski, J. C. (2002). The Diversity of Hydropower Projects. *Energy Policy*, *30*, 1225–1230.

Ghazaryan, M. (2009). Water Resource Management Problems in South Caucasus Region. In T. H. Illangasekare, K. Mahutova, & J. J. Barich (Eds.), *Decision Support for Natural Disasters and Intentional Threats to Water Security* (pp. 173–178). Springer Netherlands. https://doi.org/10.1007/978-90-481-2713-9_11

Giordano, M., & Shah, T. (2014). From IWRM back to Integrated Water Resources Management. *International Journal of Water Resources Development*, *30*(3), 364–376. https://doi.org/10.1080/07900627.2013.851521

Gleick, P. H. (Ed.). (2014). *The World's Water*. Island Press/Center for Resource Economics. https://doi.org/10.5822/978-1-61091-483-3

Global Water Partnership. (2011). *Integrated water resources management*. Global water partnership.

Granit, J., Jägerskog, A., Lindström, A., Björklund, G., Bullock, A., Löfgren, R., de Gooijer, G., & Pettigrew, S. (2014). Regional Options for Addressing the Water, Energy and Food Nexus in Central Asia and the Aral Sea Basin. In V. Stucki, K. Wegerich, M. M. Rahaman, & O. Varis (Eds.), *Water and Security in Central Asia: Solving a Rubik's Cube*. Routledge.

Groisman, P., Bulygina, O., Henebry, G., Speranskaya, N., Shiklomanov, A., Chen, Y., Tchebakova, N., Parfenova, E., Tilinina, N., Zolina, O., Dufour, A., Chen, J., John, R., Fan, P., Mátyás, C., Yesserkepova, I., & Kaipov, I. (2018). Dryland belt of Northern Eurasia: Contemporary environmental changes and their consequences. *Environmental Research Letters*, *13*(11), 115008. https://doi.org/10.1088/1748-9326/aae43c

Hamidov, A., Daedlow, K., Webber, H., Hussein, H., Abdurahmanov, I., Dolidudko, A., Seerat, A. Y., Solieva, U., Woldeyohanes, T., & Helming, K. (2022). Operationalizing water-energy-food nexus research for sustainable development in social-ecological systems: An interdisciplinary learning case in Central Asia. *Ecology and Society*, *27*(1), art12. https://doi.org/10.5751/ES-12891-270112

Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2011). *The Water Footprint Assessment Manual: Setting the Global Standard*. Earthscan.

Hoekstra, A. Y., & Mekonnen, M. M. (2012). The Water Footprint of Humanity. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(9), 3232–3237. https://doi.org/10.1073/pnas.1109936109

Hussey, K., & Pittock, J. (2012). The Energy–Water Nexus: Managing the Links between Energy and Water for a Sustainable Future. *Ecology and Society*, *17*(1), 31. https://doi.org/10.5751/ES-04641-170131

Jalilov, S.-M., Amer, S. A., & Ward, F. A. (2018). Managing the water-energy-food nexus: Opportunities in Central Asia. *Journal of Hydrology*, *557*, 407–425. https://doi.org/10.1016/j.jhydrol.2017.12.040

Keskinen, M., Guillaume, J., Kattelus, M., Porkka, M., Räsänen, T., & Varis, O. (2016). The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers. *Water*, *8*(5), 193. https://doi.org/10.3390/w8050193

Kibaroğlu, A., Kramer, A., & Scheumann, W. (Eds.). (2011). *Turkey's water policy: National frameworks and international cooperation*. Springer.

Kostianoy, A. G., Semenov, A. V., Zhiltsov, S. S., & Zonn, I. S. (Eds.). (2018). *Water Resources in Central Asia: International Context* (1st ed. 2018). Springer International Publishing : Imprint: Springer. https://doi.org/10.1007/978-3-030-11205-9

Oud, E. (2002). The Evolving Context for Hydropower Development. *Energy Policy*, *30*, 1215–1223.

Rogers, P., & Hall, A. W. (2003). *Effective Water Governance*. Global Water Partnership. http://dlc.dlib.indiana.edu/dlc/handle/10535/4995

Sovacool, B. K., & Sovacool, K. E. (2009). Identifying Future Electricity–Water Tradeoffs in the United States. *Energy Policy*, *37*(7), 2763–2773. https://doi.org/10.1016/j.enpol.2009.03.012

Stucki, V., & Sojamo, S. (2014). Nouns and numbers of the water-energy-security nexus in Central Asia. In V. Stucki, K. Wegerich, R. M. Mizanur, & O. Varia (Eds.), *Water and Security in Central Asia: Solving a Rubik's Cube*. Routledge.

Tortajada, C. (2010). Water Governance: Some Critical Issues. *International Journal of Water Resources Development*, *26*(2), 297–307. https://doi.org/10.1080/07900621003683298

Wegerich, K. (2009). The New Great Game: Water Allocation in Post-Soviet Central Asia. *Georgetown Journal of International Affairs*, *10*(2), 117–123.

Welsch, M., Hermann, S., Howells, M., Rogner, H. H., Young, C., Ramma, I., Bazilian, M., Fischer, G., Alfstad, T., Gielen, D., Blanc, D. L., Röhrl, A., Steduto, P., & Müller, A. (2014). Adding Value with CLEWS – Modelling the Energy System and its Interdependencies for Mauritius. *Applied Energy*, *113*, 1434–1445. https://doi.org/10.1016/j.apenergy.2013.08.083

World Bank. (2016). *High and Dry: Climate Change, Water, and the Economy*. License: Creative Commons Attribution CC BY 3.0 IGO.

World Bank. (2022). *World Development Indicators*. http://data.worldbank.org

Wu, M., Mintz, M., Wang, M., & Arora, S. (2008). *Consumptive Water Use in the Production of Bioethanol and Petroleum Gasoline*. Energy Systems Division, Argonne National Laboratory.

PART I

THE CONCEPTUAL FRAMEWORK

Chapter 1
Water, Energy and Environment Nexus

Halil Burak Sakal, Oktay F. Tanrisever

Introduction

Water issues and policies are often linked to other issues, such as the environment (World Bank, 2016), pollution (P. Kumar & Saroj, 2014), climate change (Beck & Walker, 2013; Welsch et al., 2014), agriculture (or food) (Bazilian et al., 2011; Cooley et al., 2014; Finley & Seiber, 2014; Keskinen et al., 2016; Lawford et al., 2013; Lele et al., 2013; Muller, 2015; Smajgl et al., 2016) or population (Chen et al., 2016), and these interconnected policies and issue-linkages form a system, a complex, or more simply, a nexus. While academicians have focused on various nexuses since the 1970s and 1980s (Allan et al., 2015; Cooley et al., 2014; Dodder, 2014; Muller, 2015), there is as yet no commonly agreed-upon definition for the term. The nexus as an analytical tool supports scientific research, and is embraced as a governance framework by politicians and decision-makers alike (Keskinen et al., 2016).[1] This approach of governance relies on the application of "multisectoral" and "multistakeholder processes" at multistate or regional levels (Keskinen et al., 2016, p. 14).

1 The authors have carried out a comparative analysis of the water-energy-food nexuses of Central Asia, South Asia and Southeast Asia (the Mekong).

The United Nations (UN) and other international organizations increase emphasis on sustainability issues. The Sustainable Development Goals (SDGs) set out within the UN 2030 Agenda for Sustainable Development have expanded the dimensions of sustainability and focused on stakeholder responsibilities. Most of the SDGs are closely linked to the water, energy and environment nexus, making sustainability a priority for public and private sectors. The 2021 UN Climate Change Conference in Glasgow showed the urgency of immediate action in environment, energy and water related problems of the planet.

Problems of energy, water, and the environment are often interconnected, and the solution to these problems needs a nexus-based approach. The nexus approach gained prominence during the UN Conference on Environment and Development in Rio de Janeiro in 1992 amid the debates on "development versus environment". This debate was based on the economic aspect of water and energy and their "social and cultural dimensions" were ignored (Muller, 2015, p. 675). Today, it is understood that this approach failed to resolve environmental problems, and so the nexus approach regained momentum in academic and policymaking circles focusing more on socio-economic sustainability and resilience.

The necessity of going beyond the resource management discourse made the nexus approach gain impetus in academia and decision-makers in the 2000s. According to Smajgl et al., a dynamic nexus approach balanced among the sectors is needed (Smajgl et al., 2016). In this chapter we present a framework for the *water*, *environment*, and *energy* nexus, as one of the most commonly analyzed linkages in literature (Ackerman & Fisher, 2013; Allen et al., 2014; Biswas et al., 2013; Hoekstra & Mekonnen, 2012; Holland et al., 2015; Hussey & Pittock, 2012; Liu et al., 2015; Siddiqi & Anadon, 2011; Sovacool & Sovacool,

2009; Walsh et al., 2015) from a social and political perspective (Allan et al., 2015, p. 309).

The water-energy-environment nexus

The water-energy-environment nexus focuses on the natural and technical phenomenon at a system level (Dodder, 2014, p. 7), suggesting that water, energy and environment rely on each other. This reliance has been reported to be asymmetrical, although the energy needed to capture (Cooley et al., 2014, p. 6), pump, transfer and treat water is relatively less significant than the amount of water used for mining, hydraulic fracturing (Cooley & Donnelly, 2014), refining oil and gas, power plant cooling and hydroelectricity generation (Hussey & Pittock, 2012). On the other hand, the impact of processes such as water withdrawal, irrigation, mining, energy generation and the final consumption of energy has an enormous impact on the environment (Tidwell & Pebbles, 2015). As the increasing global greenhouse gas emissions deteriorate the negative impacts of global warming, the interrelated systems of water, energy and environment need urgent focus of policymakers (Wan & Ni, 2021).

Blue water is often defined as the water available from such water bodies as lakes, seas and rivers; green water, on the other hand, is the water provided by rainfall that is held in the soil; and gray water refers to water pollution. Blue water is used in the production processes of nearly all commodities, while food and other agricultural productions around the globe rely heavily on green water. When blue water is used in agricultural production, "it competes with other water users in industry" (Allan et al., 2015, p. 305).

A remarkable peculiarity here is the difference between the concepts of withdrawal, use and consumption of water (Wu et al., 2008). Water withdrawal is defined as "any water

diverted from a surface or groundwater source" (US Department of Energy, 2014). Consumed water does not return to its source because of evaporation, transpiration, incorporation into products, transfer to a different basin, or stored in the dams (Hoekstra et al., 2011). Nearly 80 percent of the evaporation and transpiration associated with agricultural production comes from green water, and the remaining from blue water (Molden, 2007, pp. 5–7).

Withdrawn water, used or consumed during such economic processes as energy generation or agricultural activity, is "any water diverted from a surface or groundwater source" (Dodder, 2014, p. 8; Liu et al., 2015, p. 319; US Department of Energy, 2014, p. 1), and has impacts on the environment (Kumar & Yaashikaa, 2019). Both blue and green water can be consumed (US Department of Energy, 2014, p. 1), in that water consumption means the "loss of water from the available ground-surface water body in a catchment area" (Hoekstra et al., 2011, p. 2). This consumption alters the water cycle, has impacts on fragile ecosystems by changing the flow regime, temperature, and other chemical properties of water (Döll et al., 2012).

Industry is a significant user of water, with the main area of use in the industrial sector being for "heat transfer" in the form of heating or cooling, steam production, washing of products and factories, control of air pollution or incorporation into products (Green, 2003, p. 219). Power plants, especially thermoelectric plants, use vast amounts of water for cooling, for the production of steam to drive turbines and for the operation of "environmental control systems" (Dodder, 2014, p. 8). Some of the power plants built in the mid-20 century up until the 1970s used a technology called "once-through" or "open-loop" cooling, which withdraws water from the source and returns it to the source at a higher temperature after cooling.

More recent systems use a recirculating cooling approach in which the same water is used several times for cooling. During this process, evaporative consumption is higher, while water withdrawal is less than in once-through systems. Often, hybrid system installations that combine dry cooling and recirculation are preferred (Dodder, 2014, p. 8). In the production process of hydroelectricity, the consumptive use of water differs significantly. Large amounts of water are subject to evaporation from huge reservoirs. In the United States, calculations of the water lost to evaporation from reservoirs range from 0–68 cubic meters of water per MWh of produced hydroelectricity (Dodder, 2014, p. 11).

Water and climate change

The "water footprint" of a process or product is the amount of water consumed while completing the process, and includes fresh surface water withdrawals (blue water), rainwater intake (green water) and the degree of water pollution (gray water) during industrial and agricultural production processes, tourism activities or domestic use. (Hoekstra et al., 2011; Vanham, 2016, p. 2). There are two basic approaches to estimating the water footprint, being the volumetric approach (Hoekstra et al., 2011, p. 23),[2] and "life-cycle assessment". While the former is based on "water management", the latter focuses on production processes. The volumetric approach encompasses blue, green and gray water, while life-cycle assessment includes only blue water.

On a global scale, agricultural production generally has the highest water footprint (92 percent), while industry and domestic use account for 4.4 and 3.6 percent, respectively (Hoekstra

2 In this approach, water footprint is calculated as water volume per product or per time period.

& Mekonnen, 2012, p. 3233; Holland et al., 2015, p. E6708). Around 24 percent of domestic and industrial use is related directly to the energy sector, which globally accounts for 6.5 cubic kilometers of clean water consumption per year, while the petroleum and natural gas sectors consume 1.6 and 0.3 cubic kilometers, respectively (Holland et al., 2015, p. E6708). It should be kept in mind that bio-energy crops also consume water (Wu et al., 2008). The International Energy Agency estimates that between 2010 and 2035, an 85 percent increase in clean water consumption is likely to occur, driven largely by the increased demand for biofuel (Holland et al., 2015, p. E6713). The large amount of water used in the energy lifecycle (oil, electricity, bio-energy) raises the issues of sustainable water and energy production, water degradation and pollution, and ecosystem damage (Wu et al., 2008, p. 4).

The withdrawal of water for irrigation, and domestic and industrial use has been increasing since the beginning of the 20th century. According to estimates, agricultural withdrawals have increased more than five-fold, while domestic and industrial withdrawals have increased 18 times throughout the 20th century (Davies et al., 2013, p. 296), and whether these trends will continue is a subject of frequent discussion in the literature. There have been several attempts to calculate the future water demands for the production of electricity, with some authors concluding that by the end of the century the water withdrawals for electricity production will decrease, while general water consumption will increase as a result of population and economic growth. Any decrease in the withdrawal of water for electricity generation will be thanks to the development of cooling technologies in power plants, the increased awareness of climate change, the adoption of water-saving technologies, etc. (Davies et al., 2013; Liu et al., 2015). These decreases could be possible under different assumptions or scenarios,

such as through laws and regulations aimed at reducing water use, caps on carbon emissions, or water and carbon limits (Ackerman & Fisher, 2013).

Carbon footprint is used for measuring impacts of processes on the environment. Almost all processes of water use and energy production and consumption cause carbon footprint. Energy is used for the sourcing, treatment and distribution of water, while water is used in various phases of energy production. The energy required to deliver 1 cubic meter of water for human usage differs depending on the source of the water, with the cheapest source being water withdrawn from lakes or rivers, which has an average cost of 0.37 kWh energy per cubic meter. In contrast, drilling for groundwater costs 0.48 kWh; treating wastewater costs between 0.62 and 0.87 kWh; reusing wastewater costs 1–2.5 kWh; and treating seawater requires 2.58–8.5 kWh of energy per cubic meter of water supply (Walsh et al., 2015, p. 19). Globally, approximately 8 percent of all generated energy is used to pump, transport and treat water (The Climate Reality Project, 2016).

On the other side of the coin is the water used for energy generation. Nearly 90 percent of the global power generation is "water-dependent." A large proportion of global electricity is produced by boiling water to create steam to drive the turbines (The Climate Reality Project, 2016). Thermal power plants, which have the largest share of global energy production, are responsible for around 40 and 50 percent of the total clean water withdrawals in Europe and the United States, respectively (Liu et al., 2015, p. 319; The Climate Reality Project, 2016; US Department of Energy, 2014, p. 1). Furthermore, irrigation in the United States is responsible for 37 percent of total withdrawals (Liu et al., 2015, p. 318). Globally, according to International Energy Agency estimates, in 2010, nearly 15 percent of the total clean water withdrawals were linked to

energy production (Walsh et al., 2015, p. 20). There have been suggestions that internationally accepted standards such as the ISO14046 "Environmental Management: Water Footprint" and management practices increase efficiency in water management (Walsh et al., 2015, p. 27).

Water is also consumed in the lifecycle of energy. In secondary phase oil-recovery processes during hydraulic fracturing (Cooley & Donnelly, 2014), large amounts of water with chemical additives and "propping agents" (e.g. sand, ceramic beads, etc.) are injected into the earth to extract more oil through the creation of cracks in the rocks. During this process, much of the injected water and its additives remain underground (Cooley & Donnelly, 2014, p. 64). Although this amount depends on the well, in the United States, the net water use (water injection minus produced water) ranges from 2–5.5 gal per gal of extracted crude oil (Wu et al., 2008, p. 3). Refining oil also consumes water. In the United States, the amount of water ranges from 0.5 to 2.5 gallons per gallon of processed crude (Wu et al., 2008, p. 4).

The nexus approach and policy making in water, energy and environment

Academicians studying the water-energy-environment nexus advise policymakers to assess issues based on technical subjects such as "water footprint" and "virtual water flows" that complicate the already challenging water and energy policies.

Virtual water and its trade contribute to the scarcity of water and the political milieu surrounding water and is essential in terms of development policies (Warner & Wegerich, 2010, p. 5). Hussey and Pittock note that energy, environment and water policies are usually developed separately (Hussey & Pittock, 2012). Policies aimed at developing one sector or protecting the natural environment may place pressure on another

interrelated sector – either water- or energy-related sectors (Hussey & Pittock, 2012). This is especially true for developing countries. Considering the increasing pressure of fighting climate change on the developing countires, the Paris Agreement foresaw a US$ 100 billion of climate aid each year from the industrialized countries to the developing world.

On the other hand, the policymaking circles in the developed countries give rising importance to environmental issues and have already begun treating nexuses as a whole (US Department of Energy, 2014). In the United States, the energy sector uses the largest quantities of water, having an immense impact on the environment, and prominent international organizations such as the United Nations and the World Business Council for Sustainable Development are all well aware of the importance of this issue (Hussey & Pittock, 2012).

Allan, Keulertz and Woertz identified a link between the nexus and economy, suggesting that food and energy are both "emotional" inputs for society, and that water, food and energy policies, such as taxes and subsidies, have a direct effect on the "social contract" between political leaders and society (Allan et al., 2015, p. 302). Internationally, the agricultural policies of rich OECD countries have a determining effect on food prices, while energy prices, especially the price of oil, are determined by big oil corporations and governments. The nexus of food, water and energy is "dominated by market mechanisms" according to the authors, and these mechanisms have damaging impacts on the nexus that are often underreported (Allan et al., 2015, pp. 302–304).

Considering the environment as a whole when shaping water and energy policies is essential. Scott et al. suggest the application of two concepts in nexus-based decision-making, being "resource coupling" and "multi-tiered institutional arrangements". Resource coupling takes into account the regional and

basin-scale resources of water and energy required to meet human demands. It is argued in this regard that the global demand for resources has an impact on local levels. Multi-tiered institutional arrangements refer to "laws, policies and organizations that operate across jurisdictional levels for the management of resources" (Scott et al., 2011, p. 6623), and the authors suggest that institutions and decision-making practices should be integrated into the nexus approach (Scott et al., 2011, p. 6629).

The similarities and differences between water and energy play a decisive role in the nexus-based approach to environmental policymaking. In their utilization of both water and energy, people have an impact on the climate and environment. As national incomes have grown around the globe, the demand for energy and water has followed suit throughout history, yet, the quality and quantity of both vary significantly geographically. There is a dramatic difference between the relative costs of water and energy resources, and as a result, the energy sector is much larger than that of water. Consequently, the energy sector and business both influence and are being influenced by politics and policymaking. Furthermore, they are being impacted by environment-related international agreements, binding regulations such as the EU's Green Deal, and increasing social pressure. As the energy sector is relatively more developed than the water sector globally, there is greater availability of energy data than water data to be used in policymaking (Walsh et al., 2015). While energy is transferable and can travel long distances in various forms (such as electricity, hydrocarbons through pipelines), water is a "local or regional resource" (Scott et al., 2011, p. 6629), which means that energy policies can be on a global scale, while water policies remain at a local, regional or basin scale. This difference results in a situation where energy policies (such as use, reduction, efficiency)

are referred to as solving global environmental problems while water problems may be ignored based on their local scale.

A highly significant aspect noted in relevant literature and in policymaking is the recognition of the importance of climate change, its impacts on the global economy (Koch, 2002) and its relationship with water and energy issues. With a focus on the climate, land, energy and water nexus, Welsch et al. revealed the importance of climate change when assessing the linkages in the subject matter, and the increasing demand for hydroelectricity may further increase the importance of such a nexus (Hermann et al., 2011; Welsch et al., 2014, pp. 1443–1444). A World Bank study concluded that water scarcity, together with the accelerating impacts of climate change, may lead to a shrinkage in national incomes of to 6 percent by 2050, leading to mass migration and conflict around the globe. The fact that the negative impacts of water scarcity and climate change may be reversed through better water and environment policies (World Bank, 2016) increases the importance of resource management at a global level.

Criticizing the nexus approach from a Foucauldian perspective, Leese and Meisch argue that nexus approaches are dominated by the neoliberal discourse, and suggest that the current understanding of the water, energy and food nexus is highly "securitized". The agenda of nexus debates, they claim, has undergone a change of focus from "distributional justice" to the security of supply and economy, and suggest that the issue of sustainability is seen as an "imminent threat that legitimizes urgent action" (Leese & Meisch, 2015, p. 704).

Previous studies have sought to combine the nexus approach with the integrated water resources management (IWRM) approach. According to Benson et al., the "IWRM and nexus approaches appear closely related" (Benson et al., 2015, p. 757), claiming that the priorities and aims of both IWRM and nexus

approach overlap to a great degree, although the IWRM has been dominant since it was first embraced on international platforms as a guide to development (Benson et al., 2015).

The nexus of hydropower, water management and environment

The transfer of water and electricity has increasing impacts on the environment. Extensive irrigation systems often take the form of long networks of irrigation canals and large reservoirs, the length of which can have considerable impacts on the environment. First of all, the longer the network, the greater the surface area of the irrigation system, leading to increased evaporation in arid and temperate climates. Sometimes the water in a catchment area evaporates naturally in shallow and wide wetlands, such as the Sudd in the upstream Nile River Basin (Mohamed et al., 2005). The impact is further increased if the water is transported to agricultural regions outside the catchment area. Second, irrigation water that travels long distances and mixes with local waters, can lead to changes in the composition of the local water, such as in its hardness, temperature and flow regime, which may have a detrimental effect on some species that may even lead to total extinction. Third, newly established connections between water bodies may lead to the transfer of species from one region to another (Green, 2003, p. 294), with the potential to upset the local ecosystem.

Hydroelectricity production is often regarded as clean and renewable (Frey & Linke, 2002), although some studies challenge this claim (Gagnon & Van de Vate, 1997; A. Kumar & Sharma, 2012). As Orr et al. note, the construction of dams and reservoirs "always created conflicts between energy supply and related economic interests, versus their social and environmental impacts" (Orr et al., 2012, p. 926). As the global population growth and demand for greater economic and social wealth

continues, especially in developing economies, dams tend to continue to be the primary choice of policymakers in their efforts to bolster development (Chen et al., 2016).

Hydroelectricity production consumes considerable amounts of blue water, mainly through evaporation from the large surface areas of reservoirs. In a 2015 study, Zhao and Liu, summarizing the approaches to the assessment of the water footprint of hydroelectricity production, listed three main approaches. The first is the gross water consumption method, in which the gross amount of water that evaporates from the reservoir is evaluated; second is the net water consumption method, which considers the evaporation levels prior to the construction of the dam, and subtracting it from the gross water evaporation; and third is the water balance method, based on the difference between the annual inputs and outputs of the reservoir (Zhao & Liu, 2015, p. 41). The authors go on to suggest that a new method can be developed that distinguishes hydroelectricity production from the other uses of the dam – that is, considering the water consumption linked to the reservoir for its functions of flood control, recreation, navigation, water supply and agriculture, separately from its hydroelectricity production function, using an allocation coefficient based on the weight of the economic value of these individual functions (Zhao & Liu, 2015, pp. 42–45). The authors assume that reservoirs consume only blue water, and that no water pollution is caused during the production of hydroelectricity. However, other researchers showed the negative impacts of HPPs on water quality (Wei et al., 2009) and the environment (Pohl, 2004). The impact is high for large dams with large reservoirs, although moderately sized dams also have impacts (Brown et al., 2009; Pohl, 2004; Stanley, 2018; Tilt et al., 2009).

In their study of a reservoir in China, Wei et al. found that dams decrease the quality of water in the reservoirs over the

long term, although some improvements in quality may be experienced in the short term (Wei et al., 2009, pp. 1776–1777). Another study reported the water quality of rivers and streams to be severely affected by the construction of dams (Kurunc et al., 2006). The above studies generally refer to the contamination of the reservoir water, although other scholars have argued that the water quality in the lower part of a basin, downstream of a dam, generally remains unaffected (He et al., 2006, p. 24). In general, the impact of dams on river ecosystems, water quality, health (Lerer & Scudder, 1999) and other factors related to socio-economic and political outcomes are well documented, having been discussed at length in the relevant literature.

Another major impact of large dams is on fisheries, even in the presence of fish passages or fish ladders (Orr et al., 2012, p. 926; Rosegrant, 2015, p. 17), while the sediment accumulation or sedimentation associated with dams can be to the detriment of rivers (Morris & Fan, 1997), which can be a major issue in river basins where there is dense agricultural activity. Furthermore, most large dam projects necessitate the relocation of the local population, usually the poor, whose farmlands and pastures will be covered by the reservoir (Wang et al., 2013). As a general trend, dam removal has been touted as an important and viable alternative to decrease their negative effects (Stanley et al., 2002, pp. 172–173), with factors such as dam safety, the increasing costs of maintenance, environmental concerns and the reduced benefits from dams being put forward as justification. In the 20th century, 587 dams were decommissioned in the United States, gaining pace particularly between 1995 and 2000 when the number of dams removed reached 140 (Pritchard, 2001).

Small hydropower projects are generally considered to be more environment-friendly (Abbasi & Abbasi, 2011, pp. 2139–2140; Frey & Linke, 2002), there being no, or only a small

dam, with a small reservoir (Paish, 2002, p. 538). Due to their small size, the efficiency of small hydropower generators is usually lower than that of large turbines (Paish, 2002, p. 540). On the issue of cost efficiency, small high-head, i.e. higher than 50 meters, HPPs are more cost-effective than those with a lower head, and while small low-head HPPs are more common, most are usually not attractive as an investment choice (Paish, 2002, p. 548).

There is a strong link between climate change, energy and electricity production. The Paris Agreement, under the UN Framework Convention on Climate Change, was signed in April 2016 in New York and entered into effect in November 2016. As of 16 December 2016, 118 parties, accounting for 80 percent of all global emissions, had signed the text, with China and the United States – two major sources of greenhouse gasses globally that account for 20 and 18 percent of the total global emissions, respectively – ratified the agreement. Turkey ratified the agreement in late 2021.[3]

Perhaps the key to the Paris Agreement is energy production, being responsible for at least two-thirds of the global emissions of greenhouse gasses. Accordingly, as the International Energy Agency argues, "transformative change in the energy sector" is essential if the agreement is to reach its aims (IEA, 2016, p. 21). Renewable energy and electricity production is an important aspect of this transformation. As of 2015, the increases in the amount of greenhouse gasses resulting from energy generation have stopped (IEA, 2016, p. 21), although the Agency stresses that the water and energy nexus will intensify in the coming decades due to the rising energy demand related to the provision of water (IEA, 2016, p. 347),[4] irriga-

3 The member states that did not sign the Agreement are Nicaragua, Syria and Uzbekistan.

4 Water sector demanded 120 Mtoe of energy in 2014, principally in the form of electricity.

tion and energy production. The trend here, however, is also optimistic, as the development of more efficient cooling technologies will lead to a decrease in the amount of water withdrawn from reservoirs (IEA, 2016, p. 347).

As suggested by Burgos, integrated electricity systems and a pooling of resources can support environmental policies and renewable electricity production, leading to greater efficiency in electricity generation (Burgos, 2007, p. 2), although this requires coordinated energy policies, and strong institutions and regulations (Burgos, 2007, p. 11) in countries with various energy sources. For instance, coal-fueled generators in a country with low potential for hydro or solar power can be supported by renewables from neighboring countries at times of peak demand. That said, such integrations can also have adverse effects, especially in liberalized and non-regulated energy markets, where private generators may prefer lower cost power plants for the production of electricity, including coal- or gas-fired plants (Burgos, 2007, pp. 2–3). It should be kept in mind, however, that the steady decline in the cost of installed solar power will make photovoltaic cells a more sustainable and preferable source of electricity generation in the future, ahead of fossil-fuel generators (Barbose & Darghouth, 2016; Bolinger & Seel, 2016; Fehrenbacher, 2016; Shankleman & Martin, 2017).

Conclusion

This chapter has analyzed and explored theoretical studies of water, energy and environment along with the recent debates on socio-economic and developmental aspects. The multidisciplinary character of the subject necessitates the scrutiny of a wide range of studies from various disciplines including, but not limited to, political geography, environmental history, hydrology, ecology, earth sciences, engineering, politics and economics.

Influenced by a neo-Malthusian realism, some studies tend to link water, energy and environment with security issues, and evaluate nexus-related policy areas within a state-centric framework. On the other hand, the approaches focusing on institutions, regimes and regional cooperation have a more optimistic outlook framed by socio-economic and environmental sustainability. The scholars embracing the latter approach tend to maintain the view that the application of widely-recognized nexus analysis would support optimum sustainable outcomes in water management and energy production. Finally, critical approaches try to maintain a distance from state-centrism or the determinism of traditional theories.

Here, a more technical aspect of literature is the nexus approach, based on its embrace of theoretical and practical politics and economics. This chapter reviews the nexus approach from the perspective of its impact on policymaking, arguing that water development and management issues within the significant river basins, along with energy production and trade issues, should be evaluated as a whole considering their impact on the natural environment. In this respect, this chapter provides a framework for the book, in which the highly interrelated issues of water, energy and environment are discussed based on case studies selected from the Eurasia region.

References

Abbasi, T., & Abbasi, S. A. (2011). Small hydro and the environmental implications of its extensive utilization. *Renewable & Sustainable Energy Reviews*, *15*(4), 2134–2143.

Ackerman, F., & Fisher, J. (2013). Is There a Water-Energy Nexus in Electricity Generation? Long-term Scenarios for the Western United States. *Energy Policy*, *59*, 235–241. https://doi.org/10.1016/j.enpol.2013.03.027

Allan, T., Keulertz, M., & Woertz, E. (2015). The Water–Food–Energy Nexus: An Introduction to Nexus Concepts and Some Conceptual and Operational Problems. *International Journal of Water Resources Development*, *31*(3), 301–311. https://doi.org/10.1080/07900627.2015.1029118

Allen, L., Cohen, M. J., Abelson, D., & Miller, B. (2014). Fossil Fuels and Water Quality. In *The World's Water* (Vol. 8). Island Press.

Barbose, G., & Darghouth, N. (2016). *Tracking the Sun IX: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States*. Berkeley Lab.

Bazilian, M., Rogner, H., Howells, M., Hermann, S., Arent, D., Gielen, D., Steduto, P., Mueller, A., Komor, P., Tol, R. S. J., & Yumkella, K. K. (2011). Considering the Energy, Water, and Food Nexus: Towards an Integrated Modelling Approach. *Energy Policy*, *39*(12), 7896–7906.

Beck, M. B., & Walker, R. V. (2013). On Water Security, Sustainability, and the Water-Food-Energy-Climate Nexus. *Frontiers of Environmental Science & Engineering*, *7*(5), 626–639.

Benson, D., Gain, A. K., & Rouillard, J. J. (2015). Water Governance in a Comparative Perspective: From IWRM to a "Nexus" Approach? *Water Alternatives*, *8*(1), 756–773.

Biswas, A. K., Braga, B. P. F., Tortajada, C., & Palermo, M. (2013). *Integrated Water Resources Management in Latin America*. Taylor and Francis.

Bolinger, M., & Seel, J. (2016). *Utility-Scale Solar 2015: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*. Berkeley Lab.

Brown, P. H., Tullos, D. D., Tilt, B., Magee, D., & Wolf, A. T. (2009). Modeling the costs and benefits of dam construction from a multidisciplinary perspective. *Journal of Environmental Management*, *90*.

Burgos, F. J. (2007). *Regional electricity cooperation and integration in the Americas: Potential environmental, social and economic benefits*. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.562.2075&rep=rep1&type=pdf.

Chen, J., Shi, H., Sivakumar, B., & Peart, M. (2016). Population, water, food, energy and dams. *Renewable and Sustainable Energy Reviews*, *56*, 18–28.

Cooley, H., Ajami, N., Ha, M.-L., Srinivasan, V., Morrison, J., Donnelly, K., & Christian-Smith, J. (2014). Global Water Governance in the Twenty-First Century. In *The World's Water* (Vol. 8). Pacific Institute.

Cooley, H., & Donnelly, K. (2014). Hydraulic Fracturing and Water Resources. In *The World's Water* (Vol. 8). Pacific Institute.

Davies, E. G. R., Kyle, P., & Edmonds, J. A. (2013). An Integrated Assessment of Global and Regional Water Demands for Electricity Generation to 2095. *Advances in Water Resources*, *52*, 296–313. https://doi.org/10.1016/j.advwatres.2012.11.020.

Dodder, R. S. (2014). A Review of Water Use in the U.S. Electric Power Sector: Insights from Systems-Level Perspectives. *Current Opinion in Chemical Engineering*, *5*, 7–14. https://doi.org/10.1016/j.coche.2014.03.004

Fehrenbacher, K. (2016, June). *Solar Is Going to Get Ridiculously Cheap*. http://fortune.com/2016/06/13/solar-to-get-crazy-cheap/

Finley, J. W., & Seiber, J. N. (2014). The Nexus of Food, Energy, and Water. *Journal of Agricultural and Food Chemistry*, *62*, 6255-6262. dx-.doi.org/10.1021/jf501496r.

Frey, G. W., & Linke, D. M. (2002). Hydropower as a Renewable and Sustainable Energy Resource Meeting Global Energy Challenges in a Reasonable Way. *Energy Policy*, *30*, 1261–1265.

Gagnon, L., & van de Vate, J. F. (1997). Greenhouse gas emissions from hydropower: The state of research in 1996. *Energy Policy*, *25*(1), 7–13.

Green, C. H. (2003). *The handbook of water economics: Principles and practice*. Wiley.

He, D., Feng, Y., Gan, S., Magee, D., & You, W. (2006). Transboundary Hydrological Effects of Hydropower Dam Construction on the Lancang River. *Chinese Science Bulletin*, *51*(22), 16–24.

Hermann, S., Rogner, H. H., Howells, M., Young, C., Fischer, G., & Welsch, M. (2011). *The CLEW Model – Developing an integrated tool for modelling the interrelated effects of Climate, Land use, Energy, and*

Water (CLEW). http://kth.diva-portal.org/smash/record.jsf?pid=-diva2%3A502741&dswid=8805

Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2011). *The Water Footprint Assessment Manual: Setting the Global Standard*. Earthscan.

Hoekstra, A. Y., & Mekonnen, M. M. (2012). The Water Footprint of Humanity. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(9), 3232–3237. https://doi.org/10.1073/pnas.1109936109

Holland, R. A., Scott, K. A., Flörke, M., Brown, G., Ewers, R. M., Farmer, E., Kapos, V., Muggeridge, A., Scharlemanne, J. P. W., Taylor, G., Barrett, J., & Eigenbrod, F. (2015). Global Impacts of Energy Demand on the Freshwater Resources of Nations. *Proceedings of the National Academy of Sciences of the United States of America*, E6707–E6716. https://doi.org/10.1073/pnas.1507701112

Hussey, K., & Pittock, J. (2012). The Energy–Water Nexus: Managing the Links between Energy and Water for a Sustainable Future. *Ecology and Society*, *17*(1), 31. https://doi.org/10.5751/ES-04641-170131

IEA. (2016). *World Energy Outlook 2016*. IEA.

Keskinen, M., Guillaume, J. H. A., Kattelus, M., Porkka, M., Räsänen, T. A., & Varis, O. (2016). The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers. *Water*, *8*(5), 193. https://doi.org/10.3390/w8050193

Koch, F. (2002). Hydropower—The politics of water and energy: Introduction and overview. *Energy Policy*, *30*(14), 1207–1213.

Kumar, A., & Sharma, M. P. (2012). Greenhouse Gas Emissions from Hydropower Reservoirs. *Hydro Nepal: Journal of Water, Energy and Environment*, *11*, 37–42.

Kumar, P., & Saroj, D. P. (2014). Water–Energy–Pollution Nexus for Growing Cities. *Urban Climate*, *10*(5), 846–853. https://doi.org/10.1016/j.uclim.2014.07.004

Kurunc, A., Yurekli, K., & Okman, C. (2006). Effects of Kilickaya Dam on Concentration and Load Values of Water Quality Constituents in Kelkit Stream in Turkey. *Journal of Hydrology*, *317*, 17–30. https://doi.org/10.1016/j.jhydrol.2005.05.006

Lawford, R., Bogardi, J., Marx, S., Jain, S., Wostl, C. P., Knüppe, K., Ringler, C., Lansigan, F., & Meza, F. (2013). Basin perspectives on the Water–Energy–Food Security Nexus. *Current Opinion in Environmental Sustainability*, *5*(6), 607–616. https://doi.org/10.1016/j.cosust.2013.11.005

Leese, M., & Meisch, S. (2015). Securitising Sustainability? Questioning the "Water, Energy and Food-Security Nexus." *Water Alternatives*, *8*(1), 695–709.

Lele, U., Klousia-Marquis, M., & Goswami, S. (2013). Good Governance for Food, Water and Energy Security. *Aquatic Procedia*, *1*, 44–63. https://doi.org/10.1016/j.aqpro.2013.07.005

Lerer, L. B., & Scudder, T. (1999). Health impacts of large dams. *Environmental Impact Assessment Review*, *19*(2), 113–123.

Liu, L., Hejazi, M., Patel, P., Kyle, P., Davies, E., Zhou, Y., Clarke, L., & Edmonds, J. (2015). Water Demands for Electricity Generation in the U.S.: Modeling Different Scenarios for the Water–Energy Nexus. *Technological Forecasting and Social Change*, *94*, 318–334. https://doi.org/10.1016/j.techfore.2014.11.004

Mohamed, Y., van den Hurk, B. J. J. M., Savenije, H. H. G., & Bastiaanssen, W. G. M. (2005). Impact of the Sudd wetland on the Nile hydroclimatology. *Water Resources Research*, *41*(8).

Molden, D. (2007). *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. Earthscan, International Water Management Institute & Comprehensive Assessment of Water Management in Agriculture (Program).

Morris, G. L., & Fan, J. (1997). *Reservoir Sedimentation Handbook: Design and Management of Dams: Reservoirs, and Watersheds for Sustainable Use*. McGraw-Hill.

Muller, M. (2015). The "Nexus" As a Step Back towards a More Coherent Water Resource Management Paradigm. *Water Alternatives*, *8*(1), 675–694.

Orr, S., Pittock, J., Chapagain, A., & Dumaresq, D. (2012). Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources. *Global Environmental Change*, *22*(4), 925–932.

Paish, O. (2002). Small Hydro Power: Technology and Current Status. *Renewable and Sustainable Energy Reviews*, *6*, 537–556.

Pohl, M. (2004). Channel Bed Mobility Downstream from the Elwha Dams, Washington. *The Professional Geographer*, *56*(3), 422–431.

Pritchard, S. (2001, Ağustos). *It didn't start with Edwards*. http://www.waterpowermagazine.com/features/featureit-didn-t-start-with-edwards/

Rosegrant, M. W. (2015). Global Outlook for Water Scarcity, Food Security, and Hydropower. In K. Burnett, R. Howitt, J. A. Roumasset, & C. A. Wada (Eds.), *Routledge Handbook of Water Economics and Institutions*. Routledge.

Scott, C. A., Pierce, S. A., Pasqualetti, M. J., Jones, A. L., Montz, B. E., & Hoover, J. H. (2011). Policy and Institutional Dimensions of the Water-Energy Nexus. *Energy Policy*, *39*(10), 6622–6630. https://doi.org/10.1016/j.enpol.2011.08.013

Shankleman, J., & Martin, C. (2017, January). *Solar Could Beat Coal to Become the Cheapest Power on Earth*. https://www.bloomberg.com/news/articles/2017-01-03/for-cheapest-power-on-earth-look-skyward-as-coal-falls-to-solar

Siddiqi, A., & Anadon, L. D. (2011). The Water–Energy Nexus in Middle East and North Africa. *Energy Policy*, *39*(8), 4529–4540. https://doi.org/10.1016/j.enpol.2011.04.023

Smajgl, A., Ward, J., & Pluschke, L. (2016). The Water–Food–Energy Nexus – Realising a New Paradigm. *Journal of Hydrology*, *533*, 533-540. 10.1016/j.jhydrol.2015.12.033.

Sovacool, B. K., & Sovacool, K. E. (2009). Identifying Future Electricity–Water Tradeoffs in the United States. *Energy Policy*, *37*(7), 2763–2773. https://doi.org/10.1016/j.enpol.2009.03.012

Stanley, A. (2018). *Mapping the U.S.-Canada Energy Relationship* (CSIS Briefs) [Brief]. CSIS. https://www.csis.org/analysis/mapping-us-canada-energy-relationship

Stanley, E. H., Luebke, M. A., Doyle, M. W., & Marshall, D. W. (2002). Short-Term Changes in Channel Form and Macroinvertebrate Communities Following Low-Head Dam Removal. *Journal of the North American Benthological Society*, *21*(1), 172–187.

The Climate Reality Project. (2016, March). *A Thirst for Power: The Water-Energy Nexus*. Climate Reality. https://www.climaterealityproject.org/blog/thirst-power-water-energy-nexus

Tilt, B., Braun, Y. A., & He, D. (2009). Social impacts of large dam projects: A comparison of international case studies and implications for best practice. *Journal of Environmental Management*, *90*.

US Department of Energy. (2014). *The Water-Energy Nexus: Challenges and Opportunities*. Water-Energy Tech Team. http://energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf

Vanham, D. (2016). Does the Water Footprint Concept Provide Relevant Information to Address the Water–Food–Energy–Ecosystem Nexus? *Ecosystem Services*, *17*, 298–307.

Walsh, B. P., Murray, S. N., & O'Sullivan, D. T. J. (2015). The Water Energy Nexus, An ISO50001 Water Case Study and the Need for a Water Value System. *Water Resources and Industry*, *10*, 15–28. https://doi.org/10.1016/j.wri.2015.02.001

Wang, P., Lassoie, J. P., Dong, S., & Morreale, S. J. (2013). A framework for social impact analysis of large dams: A case study of cascading dams on the Upper-Mekong River, China. *Journal of Environmental Management*, *117*, 131–140.

Warner, J., Mirumachi, N., Farnum, R. L., Grandi, M., Menga, F., & Zeitoun, M. (2017). Transboundary 'hydro-hegemony': 10 years later: Hydro-hegemony 10 years after. *Wiley Interdisciplinary Reviews: Water*, *4*(6), e1242. https://doi.org/10.1002/wat2.1242

Warner, J., & Wegerich, K. (2010). Is Water Politics? Towards International Water Relations. In K. Wegerich & J. Warner (Eds.), *The Politics of Water: A Survey* (1st edition). Taylor & Francis.

Wei, G., Yang, Z., Cui, B., Li, B., Chen, H., Bai, J., & Dong, S. (2009). Impact of Dam Construction on Water Quality and Water Self-Purification Capacity of the Lancang River, China. *Water Resources Management*, *23*(9), 1763–1780. https://doi.org/10.1007/s11269-008-9351-8

Welsch, M., Hermann, S., Howells, M., Rogner, H. H., Young, C., Ramma, I., Bazilian, M., Fischer, G., Alfstad, T., Gielen, D., Blanc, D. L., Röhrl, A., Steduto, P., & Müller, A. (2014). Adding Value

with CLEWS – Modelling the Energy System and its Interdependencies for Mauritius. *Applied Energy*, *113*, 1434–1445. https://doi.org/10.1016/j.apenergy.2013.08.083

World Bank. (2016). *High and Dry: Climate Change, Water, and the Economy*. License: Creative Commons Attribution CC BY 3.0 IGO.

Wu, M., Mintz, M., Wang, M., & Arora, S. (2008). *Consumptive Water Use in the Production of Bioethanol and Petroleum Gasoline*. Energy Systems Division, Argonne National Laboratory.

Zhao, D., & Liu, J. (2015). A New Approach to Assessing the Water Footprint of Hydroelectric Power Based on Allocation of Water Footprints among Reservoir Ecosystem Services. *Physics and Chemistry of the Earth*, *79–82*, 40–46.

PART II

NATIONAL LEVEL OF ANALYSIS

Chapter 2

Water-Energy-Food Security Nexus in Turkmenistan

Aksulu Kushanova, Batyr Kurbanov, Claire Franco

Introduction

The nexus approach was considered under the former Soviet Union, in which the water-energy infrastructure was developed in such a way that it would benefit from and engage a number of sectors, leading to efficient resource allocation and use. However, after the collapse of the Soviet Union, the Central Asian countries moved toward a more sectoral approach, affecting the existing regional water-energy relationships between the upstream and downstream countries. The European Union project "Nexus Dialogue in Central Asia" (the Project) raise the multisectoral water-energy-food (WEF) approach at the regional and national levels in Central Asia (CA) – assuming multisectoral collaboration and planning, in contrast to the resource allocation under "sector by sector" approach. Understanding that a multisectoral approach involves different sectors, depending on the economic peculiarities and the availability of natural resources in the country and region, the EU project championed specifically a water-energy-food nexus as this sectoral interlinkage is mostly sensitive to CA countries.

Table 1. Nexus principles

Principle 1:	There is no single "nexus", but rather a range of "nexi".
Principle 2:	A nexus is often construed as a response to perceptions of insecurity by the state, civil society and the private sector, and by those responsible for environmental sustainability and productivity.
Principle 3:	Nexus is about compromise.
Principle 4:	Nexus is about trade-offs.
Principle 5:	Nexus is about synergies.
Principle 6:	Water is widely considered the senior nexus element.
Principle 7:	Nexus is not the same as Integrated Water Resources Management (IWRM).
Principle 8:	Nexus may be our last chance to achieve sustainable and equitable investments in water, agricultural and energy infrastructure.
Principle 9:	Nexus makes economic and socio-economic sense.

Source: Meyer, 2019.

During the Project implementation (Phase I: 2016-2019), the new term "Nexus" met resistance from regional and national stakeholders, and the mandate and responsibilities of the sectoral ministries limited to their particular sector exacerbated the discussion on the multisectoral approach. That said, while the stakeholders understand the rationality behind their consideration of the Nexus approach, there is a strong need for quantitative and qualitative data on the application of the Nexus approach to particular policies and/or projects before making a policy decision. The final evaluation of the Project showed that less than 30 percent of all the assessed stakeholders were able to integrate the multisectoral approach into their daily practices due to the lack of the necessary institutional set-up, technical capacity and the availability of instruments. The simulation Nexus Game piloted by the project team among young professionals in Central Asia and Afghanistan at the tenth annual Central Asian Leadership Programme (2019) showed that the practical application of the multisectoral

approach and the handling of the trade-offs between competing sectors and ministries improved the participants' understanding by up to 90 percent, and inclined them to favor the Nexus approach (CAREC, 2019).

An institutional and capacity gap analysis undertaken as part of the Project by the International Union for the Conservation of Nature (IUCN) revealed that the concept of nexus is still new to Central Asia, and key decision-makers lack experience with it. A full buy-in by all states would necessitate an improved understanding of the WEF Nexus approach, as well as a demonstration of its relevance and applicability through concrete actions and best practices in the context of Central Asia (Meyer et al., 2019).

During the three-year introduction of the Nexus concept to Central Asia, both regional and national stakeholders voiced a need for practical and hands-on activities to better understand the benefits of the Nexus approach concerning: i) the implementation of joint (transboundary) Nexus projects; ii) the identification of adequate financing mechanisms for multilateral Nexus projects; iii) the development of institutional frameworks at national and regional levels to support multisectoral regional Nexus dialog, planning and decision-making; and iv) well-structured capacity-building interventions to cultivate WEF Nexus thinking among the expert community.

At this time, the project team identified some major gaps impeding the transition to a WEF Nexus approach at national and regional levels, including:

- The current sector-based planning practice does not allow for complex, cross-sectoral planning and resource efficiencies;
- Different sectors continue to consider themselves as competing agents for the state budget;

- Finance and Economy Ministries are not involved in thematic planning activities;
- The bottom-up approach is still at the initial stage of formation.

To address the needs of the national stakeholders and to showcase the Nexus projects in practice, the Project implemented three small-scale Nexus demonstration projects in Tajikistan, Turkmenistan and Uzbekistan to introduce the Nexus jargon and to review the implementation process from a multisectoral perspective on the ground. After receiving positive feedback from state officials and the rural community the practical application/demonstration of the Nexus approach witnessed an increase in buy-in.

This article is dedicated to the small-scale Nexus demonstration project in Turkmenistan, providing a greater opportunity to analyze the case from a multisectoral approach. This pilot project was proposed for the demonstration and was supported by the Interstate Commission on Sustainable Development under the International Fund for Saving the Aral Sea (IFAS). Following the completion of the pilot project, the Global Nexus Secretariat analyzed the project based on the Nexus criteria and found it to be a good nexus demonstration case. The results of the pilot project were then reviewed and presented to the Nexus Regional Dialogue Programmes[1] in early 2020, who acknowledged and recognized that the needs of such projects are common for other regions around the world.

1 Latin America (LA), Niger Basin Region (NBA), Southern Africa (SA), Middle East and North Africa (MENA) and Central Asia (CA).

Table 2. Nexus principles

Principle 1 – Equitable and balanced weighting
Principle 2 – Leaving no one behind
Principle 3 – Political commitment to international agendas
Principle 4 – Strengthening cross-departmental and multisectoral cooperation
Principle 5 – Enhancing mechanisms for data exchange and modelling
Principle 6 – WEF Nexus Capacity Development
Principle 7 – Inclusive and participatory multi-stakeholder approach
Principle 8 – Financing schemes and investments
Principle 9 – Considering the broader context of the natural resource governance system
Principle 10 – Sustainable and efficient resource use
Principle 11 – Furthering peace and preventing conflict

Source: Global Nexus Secretariat, 2020.

Nexus pilot project implementation

Expanding on the sixth nexus principle in Table 1, water is the most important component of the WEF intersection, in that water, energy and food security all depend on its infrastructure. Recognizing this has led to new initiatives related to water infrastructure and technological solutions, with the vision being optimized through the coordinated planning, development and operation of a portfolio of man-made and natural-based water infrastructures. The proposed solutions will strengthen economic and environmental resilience, while bridging divides between sectors and industries (IUCN, 2015).

The small-scale demonstration project in Turkmenistan was implemented in April–December 2019 with support from the EU-funded "Nexus Dialogue in Central Asia" project and the UNDP/GEF project "Supporting climate-resilient livelihoods in agricultural communities in drought-prone areas of Turkmenistan" (SCRL). The small-scale demonstration project aimed at: i) increasing the adaptation potential of a local livestock farm; ii) supporting water-energy-food security in desert pastures; and iii) supporting rural areas and the vulnerable population. As one of the main characteristics of the demo project, the local

community, represented by shepherds, was actively engaged in the demo project implementation and took over certain tasks.

Specifically, the demonstration project restored the old *sardobs* feeding a remote desert pasture in the Daşoguz Province, Turkmenistan, and arranged livable conditions for the local shepherds. The works included:

- The restoration of two neglected *sardob*s with a volume of 250 m^3 each as a water supply; cleaning both *sardob*s and a sump. The restoration works included the reinforcement and concreting of the ceiling, the installation of floor support, the installation of a waterproof barrier and the concreting of the *sardob* floor;
- Covering the area for the collection of water downhill from the sump with a 4 cm-thick concrete pad;
- Building a shepherd's house and livestock drinking troughs;
- Erecting barbed wire fencing;
- Planting a forest belt 2–2.5 m wide inside the fence;
- Installing a pump for pumping water to the animal drinking troughs;
- Installing solar panels to provide electricity for lighting in the house and to power the pump.

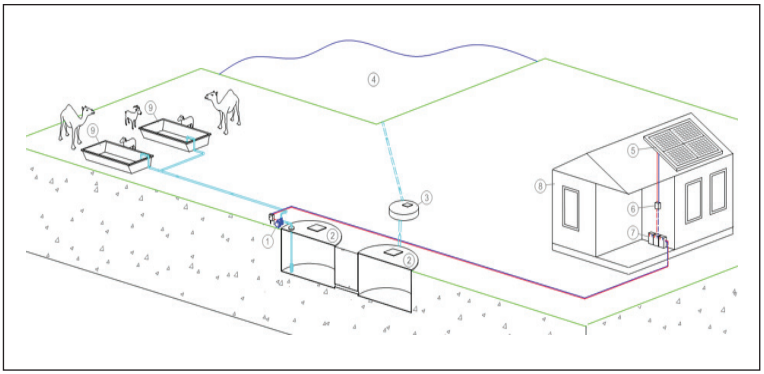


Figure 1. Site of the *sardob* in the desert pasture. 1. *sardob*s (250 m^3 each); 3. sump; 4. water collection area (1 ha); 5. solar panels; 7. pumping station; 8. Shepherd's house; 9. water trough.

*Sardob*s and their significance

A *sardob* is an ancient hydraulic structure for the collection of rainwater in the desert. The name comes from the Persian language, and can be translated as *assard* - "cold" and *âb* - "water". *Sardob*s have been identified dating as far back as the 10th century for the watering of livestock, in locations close to villages, for the satisfaction of social and domestic needs, and even for drinking. In ancient times, *sardob*s were protected by special armies along the Silk Road, ensuring the survival of livestock and people in the hot season. Since that time, they have continued to play an indispensable and strategic role in desert areas. In Turkmenistan, *sardob*s are the second most important source of water after groundwater. Due to the country's downstream location, the groundwater is naturally saline, which by Turkmen state standards means that one liter contains more than one gram of salt. In 2004, UNICEF project officer Arslan Berdiyev reported that the salinity of the Amudarya River can reach 1.6 grams per liter in the dry periods (Blua, 2004). When potable reserves are strained, the population ingests more highly salinized water, which can lead to serious health complications. Berdiyev claims that only around 20 percent of the 1.2 million people living in the Daşoguz Province have access to clean drinking water (Blua, 2004).

In the present day, most *sardob*s have fallen into disuse and disrepair under the influence of the hot climate and the destruction of the existing control system. As a result, water is no longer retained and evaporates during the hot period, leaving none for use. As a result, the territories in their vicinity can no longer be used for animal husbandry and become desolate. Despite the strategic role of *sardob*s as a vital source of drinking water, they are not protected or subject to regular maintenance.

Figure 2. A *sardob* in a desert location

Particularly in desert-dominated countries with large rural populations that are heavily reliant on cattle breeding, *sardob*s have considerable social and economic significance. The volume of the collected water reservoirs varies from 60 to 500 cubic meters. Climate change and external environmental factors interrupted this ancient technique of farming due to very dry periods, a decrease in rainfall and the decay of *sardob*s. Thus, the shepherds stopped grazing their livestock in the remoted pastures, since the *sardob*s were not functioning anymore and water was unavailable for their livestock. As a consequence, farmers, solely let their livestock graze on local pastures which are close to villages, which further speeded up the process of desertification in the area. As water is scarce in the region, restoring and maintaining the *sardob*s is economically more meaningful than the transportation of water, which would overall be four times more expensive.

It is also estimated that one *sardob* allows the prevention of land degradation in the size of 2,700 up to 7,500 ha. For the last decades the contribution of agriculture, forestry and fisheries to the country's GDP has decreased from 33 percent in

1990 to just 9 percent in 2015, which might also be explained by increasing land degradation and deteriorated water-energy access in remote areas.

A comparative analysis of the costs of delivering the same volume of water by water carriers and collecting water in *sardob*s reveals the transportation of water to be four times more expensive than the construction and operation of a *sardob*.

Pilot site

> The farmers are ready to build the wells through collective effort, however, we have no clue about the coordinates of the groundwater. We simply cannot waste resources digging wells in the desert based on guesswork.
>
> *Director of the Garagum livestock farm*

The demo project was conducted at the Esenaman pasture of the Gorogly etrap (district) of the Daşoguz Province in northern Turkmenistan. The Daşoguz Province is mainly covered by the Karakum desert – the third largest desert in Asia, covering an area of approximately 350,000 square kilometers (Britannica, 2013). This region, including the Khoresm Province across the border in southern Uzbekistan, has been deeply affected by the Aral Sea catastrophe, which contributed greatly to water scarcity and salinity. The Daşoguz Province lies 88 meters above sea level and has a desert climate with an average annual rainfall of 100 mm (the lowest in the country).

In this regard, the wellbeing of the mostly rural population and the environmental security of the Daşoguz Province rely heavily and intensively on access to water, and *sardob*s play a significant role under the limited alternatives associated with the geographical peculiarities of the country.

The Esenaman site is managed by the local Garagum livestock farm, which is the largest holder of animals in the Gorogly

etrap and is recognized locally for its scale and efficiency. In 2014, it recorded the highest performance among the other livestock complexes in the region, with the best offspring figures, being 13,662 heads of lambs were obtained from 12,575 ewes. The livestock complex comprises two sheep farms. The total area of desert pasture managed by the Garagum livestock farm is 887,000 thousand hectares, of which 99 hectares are arable land, and the rest are natural pasture.

Figure 3. Map of the pilot site

The Garagum livestock farm is a state cooperative, whose farmers report to the Ministry of Agriculture of Turkmenistan. That said, over the past two decades there has been an ongoing process by which the state livestock alliance will become privatized, and will consequently become an alliance that brings together private farmers.

The population of the Gorogly district as of October 2018 was 942 (Table 3), with children under 17 years making up 31 percent of the total. The entire population of the *gengeshlik* (local council jurisdiction) lives in three villages. Half of the

population are of active economic age, with over 40 percent of the population engaged in livestock farming due to: i) the traditional way of life; ii) their residence in remote areas with poor road access; and iii) that lack of any industrial sites nearby.

Table 3. Demographic information on the Garagum District

	Village names	Total household number	Total population	Out of the total population		0-17 years old		Pensioners	
				Female	Male	Female	Male	Female	Male
1	Damla	96	574	283	264	78	71	13	11
2	Kyrkguyy	21	106	54	52	22	18	5	3
3	Garayanyk	58	289	145	144	65	41	7	8
Total in the local council jurisdiction		**175**	**942**	**482**	**460**	**165**	**190**	**25**	**22**

Source: Garagum District Municipality.

The pasture of the Garagum livestock farm falls under the responsibility of the Garagum Gengeshlik (municipality). The local municipality allocate the pastures to the Garagum livestock farm and the latest allocates/lease the pastures along with its cattle to the local farmers for grazing during the spring and summer seasons.

One peculiarity of economic activity based on pasture animal husbandry in Turkmenistan is that the lease agreement for livestock is concluded between the local livestock farm and the head of the family. Under this agreement, all adult members of the shepherd's family become engaged in the raising and grazing of the livestock with various seasonal roles. The agreement further stipulates that the shepherd receives his salary in the form of the animal yield. For example, for 100 grazed animals, the shepherd should return 100 pastured animals plus a yield of 40 animals. Thus, everything that is produced (the resulting offspring) in excess of the specified remains will belong to the shepherd.

> Our men earn on the livestock farms, but there are no jobs for women in the villages. We use milled products and wool to produce homemade products, which we sell at the cities markets.
>
> *Local woman*

As a rule, the male half of the family is engaged in cattle grazing almost all year round, with fathers, sons and brothers taking turns to graze the livestock. The female half of the family is engaged mainly in housekeeping, but can generate income through handicrafts that can be sold at the market or to intermediaries. Thus, the female portion of some shepherd families is self-employed, and contributes to the household income through their activities.

According to municipality estimates, cattle grazing is the main source of employment for the male population, with the "economically active" population engaged in this type of activity in the surveyed group being above 40 percent. As ascertained during the meetings held with local pasture users, the income from farm work does not fully cover the needs of the local population, and so small-scale livestock and poultry farming is carried out on the household plots of the villagers, as the main livelihood and source of monetary income for the rural population.

The poor transportation infrastructure makes it difficult to find work in nearby areas or to commute to the larger cities for income. This drives some people to leave their rural homes and move to the city where there are more employment opportunities. Those that remain have few options other than engaging in animal husbandry to make a living (due also to the traditional way of life). As can be seen, the local Garagum livestock farm serves as the main source of food and employment for the populations of all three villages of Gorogly etrap, where the livestock activities fully depend on access to water-energy in the desert pastures. This situation related to employment

opportunities and the importance of livestock breeding can be found also in other countries and regions.

Figure 4. Migrated rural population and lack of road infrastructure due to climatic conditions.
Source: Photos provided by local residents.

Esenaman pilot site and the implementation of the demo project

There are two *sardob*s on the Esenaman site, both of which were built in the Soviet times. Over time, and under the influence of the forces of nature, they fell into ruin, and one completely collapsed. There is a 1-hectare site for the collection of water adjacent to the *sardob*s, but without maintenance and use due to consecutive years with seasons of drought since 1995, the water collection area also fell into disrepair. As a result, water stopped being collected in the tanks and the site became unusable. Without this critical water component, the local shepherd population began to move away from Esenaman, and relocated their herds to neighboring pastures in search of more reliable fodder. In short, the cattle stopped grazing when the water source disappeared. According to the shepherds' estimates, the *sardob*s had not been touched in 30 years. The nearby pastures within a 30–35 km radius are overflowing with fodder, but the livestock cannot use it due to the absence of a watering hole.

When better climatic conditions brought a generous amount of rain in 2019, the deteriorated water reservoirs highlighted a new issue of water accumulation. Due to the poor conditions of the *sardob*s, the local shepherds have been unable to utilize the desert pastures for the last 30 years, despite the rich grass yields, and have had to rely instead on only a few pastures over the decades, increasing the deterioration of the land and the rate of desertification in the country, where over 80 percent of the territory is already desert. Adding to the critical need for better resource management is the fact that this part of Turkmenistan is the area that was most affected by the Aral Sea catastrophe.

Water scarcity and the increase in the competition for food over the previous three decades have led to a sharp decrease in the size and quantity of livestock, and the increased pressure on the pastures has expedited desertification in neighboring areas

(UNDP Eurasia, 2020). The revitalization of the catchment area through the restoration of the *sardob*s will allow the movement of the flocks of sheep 30–35 km deeper into the sands, and will support the recovery of previously used pastures amounting to around 105,000 ha within 3–4 years. The restored *sardob*s will open access to an additional 50,000 ha of pasture that is teeming with grass that has not been utilized for the last 30 years. Furthermore, according to shepherds' estimates, the fodder supply of the Esenaman settlement will increase the number of sheep to 5,000–6,000 head, and farmers will gain the opportunity to alternate between two pastures, thus managing the degradation.

Figure 5. A previously extensively used desert pasture "Adzhi Guyi". Source: Photo provided by local residents.

In 2019 two *sardob*s have been restored under the project and equipped with water pumps, providing a total capacity of 500 cubic meters (see *Annex 1*). The project has exceeded its

targeted quantity of solar panels and electricity capacity by 25 percent, which is expected to extend the duration of stay for the shepherds. The third link in the results chain relating to the restored pastures and increased herd sizes will materialize later in 2020.

One *sardob* matters for water-energy-food security

The restoration of even one *sardob* contributes to water-energy-food security in countries like Turkmenistan. On average, only 12 percent of the available pasture is used in Turkmenistan due to insufficient or uneven watering. For example, in the Daşoguz Province, where the pilot project was implemented, pasture productivity is 0.8–0.9 centner per hectare – a unit of measurement reflecting the mass of hundreds of kilograms per area. This means only 36 percent of Daşoguz Province has access to water, which is one of the lowest rates in the country.[2]

Some 30 percent of the pasture of Garagum livestock farm is irrigated land, close to the villages. While there are fodder-rich pastures 70 km from the villages, these rangelands are currently impractical and inaccessible due to their lack of water, although they have the potential to accommodate an additional 150,000 head of livestock. Currently, the Garagum livestock farm has around 40,000 head of livestock, and so there are considerable opportunities to be had in terms of increased breeding output should access to water and energy be provided. In this regard, two restored *sardob*s would provide sufficient water for around four herds, meaning more than 2,400 head of sheep.

Precipitation in the Karakum Desert occurs mainly in the winter and early spring, more than half of it falling between December and April (Owen, 2018). A year in the pasture is divided into three seasons: winter (November-April), summer

2 "Natural pastures and the development of transhumance livestock in Turkmenistan," 2014.

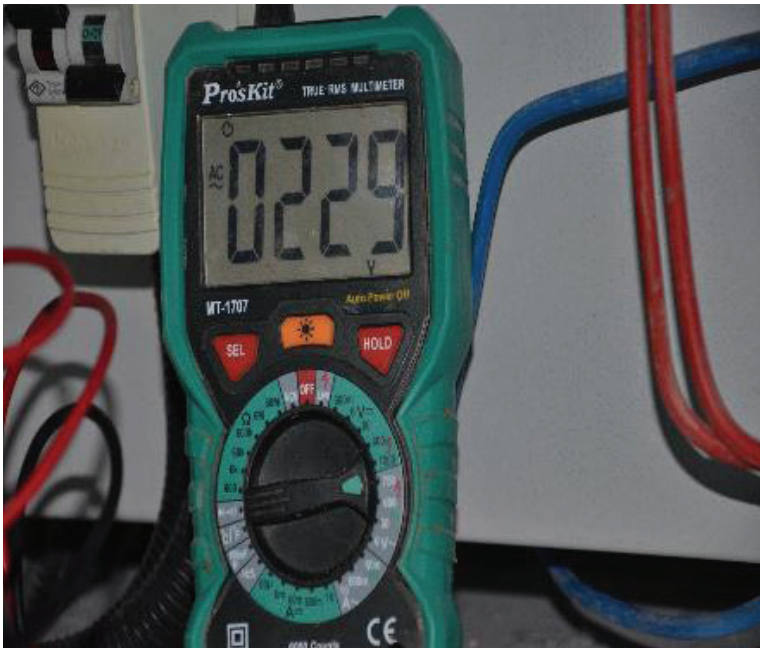
(May-July) and autumn (August-October). The renovation of the shepherds' houses and the provision of solar-powered electricity would allow shepherds with their families to move to these territories and stay there for two seasons, supporting a higher animal yield and greater productivity. Solar-powered water pumps will help free Esenaman from its dependence on the larger electricity grid, access to which is currently almost impossible in the middle of the desert (UNDP Eurasia, 2020). From 2008 to 2018, the energy consumption per capita rose by 8 percent per annum (BP, 2020), indicating that the demand for accessible, affordable energy is increasing, especially in rural areas.

A) Shepherd's house (before the implementation project)

B) Renovated house, allowing shepherds to stay in the pastures for two additional seasons (after project implementation)

C) Old sardobs abandoned for 30 years (before project implementation)

D) Restored sardobs (after project implementation)



E) Solar generated electricity is on

F) Solar panels

G) Local shepherds enjoying their new shepherd house

Figure 6. A) to G): Pilot project results. Source: Project team, local shepherds, UNDP office in Ashgabat, Turkmenistan

Nexus component

The pilot project demonstrates in a practical way how the interlinkages between water, energy and food contribute to the provision of economic and social security, and, if scaled up, can show even more substantial results at a national level. With a budget of around US$25,000, the pilot project not only had a multisectoral dimension, illustrating the Nexus interlinkages, but also served as an example of what could be achieved and replicates at a national level, demonstrating the social and economic importance of *sardob*s for Turkmenistan.

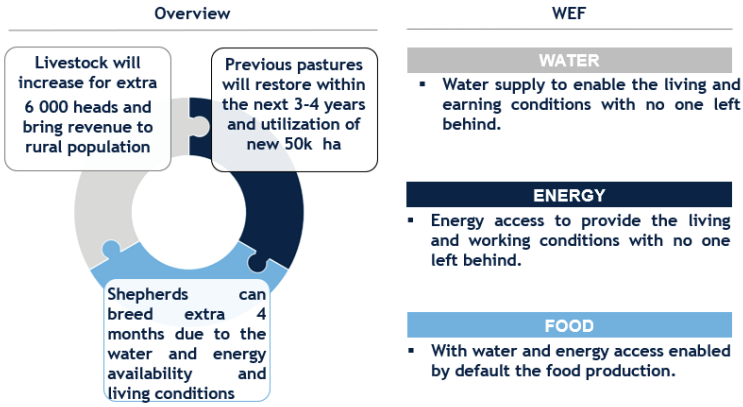


Figure 7. Results of the pilot project in terms of its multisectoral water-energy-food achievements at a livestock level.
Source: Project team, CAREC.

The pilot project employs a multisectoral approach, taking into account water, energy, food security and ecological conservation. As an outcome, the Garagum livestock farm acquires a new water source for the watering of livestock, expands their grazing lands, increases the head of livestock and harnesses solar energy to satisfy household needs in a remote location. The local shepherds, on the other hand, gain a socially well-maintained site for business purposes and play a role in reforestation works. The head of the Garagum livestock farm stated that the top three obstacles they faced were the lack of electricity in remote households, the lack of unpaved access to pasture lands and the lack of water resources for irrigation. Having a local partner that can benefit directly from the work can be considered a valuable input, and increases the likelihood of the attentive maintenance of the facilities (UNDP Eurasia, 2020). The introduction of solar-powered technologies for the management of water and to support the fertility of the land will improve the sustainable growth of the agricultural complex (Embassy of Turkmenistan, Georgia, 2020).

The pilot project provided inputs that would be equally important at local and national levels, as shown in Table 4.

Table 4. Pilot project impact at local and national levels

Local level	National level
Increase of climate adaptation potential; Securing the labor market in a remote area; Prevention of land degradation; Restoration of previously used pastures; Introduction of the RES technology to a rural area; Free up valuable and rare agricultural lands by making distant land areas suitable for cattle-breeding; Improved environment and socio-economic development of the population.	Demonstrating the Nexus WEF approach; Replication of the pilot throughout the country; Development of action programs for agricultural communities, local communities, especially those located in remote areas without access to water or electricity; Restoration of previously used pastures; Promoting RES sources utilizing the country's vast solar potential; Ensuring food security; Revising the traditional way of living.

Water	Energy	Food security
A drainage system for rain and melt water is created, resulting in alternative sources of water for watering and pasture irrigation.	A sustainable system is created in which solar energy is used for lighting and to pump water to the drinking troughs for livestock.	The number of livestock is increasing, and new pastures are being developed.

Preservation of ecosystems
The vegetation cover of currently over-grazed territories is being restored.

Results of the pilot project in terms of its multisectoral water-energy-food achievements at a livestock level. Source: Project team, CAREC.

The decision-making aspect of the pilot project implementation involved the three "water-energy-food" sectors, and the engagement of the vulnerable rural population with limited access to such resources. The pilot project was aligned with Paris Agreement, and advanced the country's goal of SDG fulfillment. Through the Nexus approach, SDGs and other international agendas can be satisfied in a more efficient and cost-effective

manner. The cooperation between the project partners was built on existing structures and capacities at municipal and governmental levels. The pilot project also ensured the inclusion of local practices and knowledge in the sustainable management of the resources of local communities.

Country specifics

> The traditional way of life has not changed. Breeding is still passed down from generation to generation. This is what we can and love to do.
>
> *Local shepherd*

For countries like Turkmenistan, where up to 80 percent of the territory is desert, these kinds of pilot projects help ensure socio-economic and environmental security. Turkmenistan has the lowest precipitation rate in Central Asia (fewer than 200 mm per year, the lowest in Central Asia), and approximately 70 percent of the pasture lands in Turkmenistan have various levels of degradation, due mostly to overgrazing, which strips the land of its vegetative cover and results in the erosion of the topsoil. Furthermore, more than 90 percent of the irrigated areas are subject to salinization (Nepesov & Mamedov, 2016). In a 2016 report, the Economics of Land Degradation Initiative encouraged Turkmenistan to come up with more reliable water and fodder stocks to support the needs of herders and farmers, highlighting "the rehabilitation, reconstruction and maintenance of traditional water sources, including water wells and reservoirs" (Nepesov & Mamedov, 2016).

The limited access to water in the desert pastures forces local shepherds to overutilize the watered pastures, worsening the rate and extent of degradation. One *sardob* will allow the prevention of land degradation of an area of 2,700–7,500 ha. Most water resources originate outside the country, and so in

a country like Turkmenistan, in which over half the population resides in rural areas and is heavily reliant on the breeding of livestock, a *sardob* can make a significant impact.

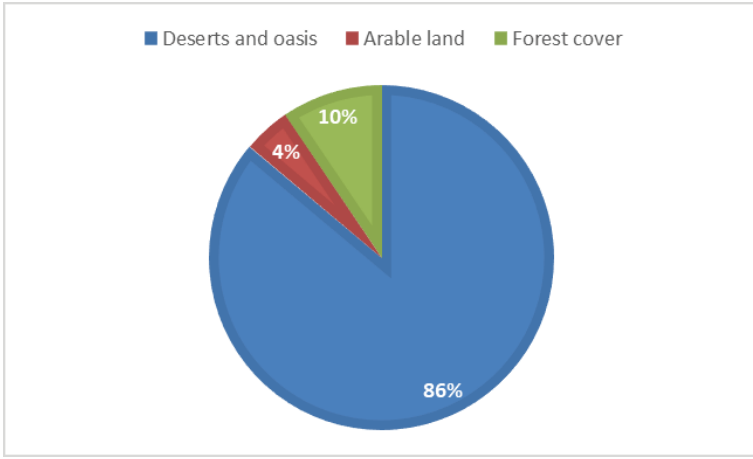


Figure 8. Turkmenistan land type. Source: World Bank.

A pilot project of this nature demonstrates that such an action as restoration of *sardob*s can serve as a climate adaptation measure to collect the resources that will be harnessed under the climate change (World Bank, 2020b). As such, Turkmenistan is projected to experience an increase in average ambient temperature of 6–7°C by 2100, while hydro-meteorological modelling forecasts predict a steadily declining national precipitation of 8–17 percent up to 2100 and beyond (UNDP, 2015). At a regional level, the flow of the Amu Darya and Syrdarya Rivers is expected to decrease by at least 30 percent, severely affecting the availability of water in the region. All of the above will have implications on water management and food security, and will increase the nation's vulnerability to extreme climatic events.

In the presence of climatic and topographic conditions like those experienced in Turkmenistan, climate adaptation measures

are mainly focused around water, and include: i) the construction of new, and the repair of existing wells; ii) the construction of new, and the renovation of existing *kaks*; and iii) the construction of new, and the repair of existing *sardob*s.

The pilot project to support Turkmenistan's public policy

Overall, the pilot project was in line with Turkmenistan's public policy. While no massive restoration of *sardob*s is being undertaken at a national level, the government recognizes the need for water-energy-food security and the application of innovative solutions to ensure the generation and allocation of WEF resources.

As such, Turkmenistan has highlighted food abundance as an area of particular importance and recent achievement. In an address on June 1, 2020, President Berdimuhamedov stressed the priority of improving and expanding the capacity of the domestic energy system, and the application of advanced experience and digital technologies (State Information Agency of Turkmenistan, 2020). Furthermore, the growth of strategic reserves of water was one of the priorities outlined in the "Programs of social and economic development of the country in 2019–2025" (UN, 2019).

The food security landscape is highly vulnerable in Turkmenistan. Self-sufficiency in domestic products by the rural population is vital and highly encouraged, while beyond the rural population, there are numerous business opportunities related to the supply of food, and two-thirds of agricultural production is currently carried out by private entrepreneurs. Currently, experts estimate that domestically produced food in Turkmenistan accounts for around 40 percent of the total, while the remaining 60 percent is imported. This means that a fracture in the import chain, such as the closure of the border with Iran in February 2020 due to the COVID-19 outbreak,

immediately affects food security in Turkmenistan. This particular example had a significant impact on basic food supply, as around 80 percent of all food imports are somehow connected with Iran (Turkmen News, 2020).

Food production is a major employer in rural Turkmenistan, and any steps to limit the impact of local meat production on the environment would support the sustainability of the sector (UNDP Eurasia, 2020). More than half of the Turkmenistan population lives in rural areas and is engaged in animal husbandry and agriculture, although the annual urban population growth rate is around 2 percent (PreventionWeb, 2014). Utilizing the limited amount of arable land, around 30 percent of the population is employed in agriculture, and 19 percent of this figure is female (World Bank, 2021). Each decade, the added value of GDP from agriculture, fisheries and forestry declines by 10–15 percent. Thus, in 1990 the added value was 33 percent, but had fallen to 9 percent by 2015 (World Bank, 2020a), with attributing factors being the increased degradation of land and the limited water resources.

The pilot project demonstrated the efficiency of the electrification of the pastures through solar application in the depth of desert where the electrification is extremely capital expenditure-intensive and not rational. According to the 2020 BP Statistical Review of World Energy, Turkmenistan sourced less than 0.05 percent of its consumed energy from renewable resources in 2018 and 2019, and in 2019, the per annum growth rate of renewable consumption declined by 0.4 percent (BP, 2020). Nevertheless, the country has tremendous potential for solar power, primarily in the Karakum Desert, which covers 80 percent of the country's landmass, due primarily to the availability of vacant land as well as the high silicon content of the sand – a necessary chemical element for the manufacture of solar panels (UNDP, 2014). According to the World Bank's

Global Solar Atlas (2019), the Daşoguz Province, where the pilot project was implemented, has a daily photovoltaic power potential of 4.1–4.5 kWh/kWp. According to Geldi Myradov – a UNDP/GEF project manager working on sustainability initiatives in other parts of the country – "Turkmenistan's climatic conditions are highly favourable for the intensive use of renewable energy sources, particularly solar energy. The introduction of small-sized renewable energy installations in remote and sparsely populated areas is economically beneficial due to high cost of construction of power transmission lines" (UNDP Turkmenistan, 2020).

Conclusion

The Nexus pilot projects, including on *sardob*s, implemented in 2019 under the EU funded project "Nexus Dialogue in Central Asia" (the Project) advanced the narrative of WEF connectivity among stakeholders in the regionally specific context of Central Asia. The projects span borders, industries and sectors in a way that legitimizes the nexus principles as tools for further exploration. In order to optimize the potential for more efficient, cooperative and sustainable development of WEF security, regional actors must acknowledge their interdependence. Developing a robust profile of man-made and nature-based water infrastructure is a fundamental step toward the bolstering of food security and energy access. Solutions should mitigate vulnerability to natural disasters and the changing climate.

The restoration of traditional *sardob* water reservoirs and their increased role within private agricultural communities powered by renewable energy meet several of Turkmenistan's priorities. The success of the project and the momentum it transfers to Phase II to be implemented during June 2020 to June 2023 by CAREC reflect its academic merit and practical application. As the project advances into second phase, there

will be more data and analytical papers produced to communicate where the challenges and successes of the application of the Nexus approach.

In the long term, the pilot project on *sardob*s analyzed above will serve as a practical demonstration of the nexus principles when applied as a solution within a regionally localized landscape. By restoring the capacity to accumulate rainwater, generating cost-efficient renewable electricity and expanding the area of usable grazing pasture, the quality of life of the herding families and their livestock in rural areas will improve at the Esenaman site.

Disclaimer

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The project team will continue monitoring the baseline indicators after the improvement of the pandemic situation in Central Asia and the easing of travel restrictions.

References

Blua, A. (2004, April 28). Archive: Drinking Water Scarce In Northern Turkmenistan. *Radio Free Europe/Radio Liberty*. https://www.rferl.org/a/1052524.html

BP. (2020). *Statistical Review of World Energy 2020*. 68.

Britannica. (2013). *Daşoguz*. https://www.britannica.com/place/Dasoguz

CAREC. (2019). *Report on the 10th Anniversary Central Asian Leadership Programme on Environment for Sustainable Development and the Regional Training Course on Water Diplomacy with a Special Focus on Gender-Sensitive Negotiation and Mediation Skills September 16 – 25, 2019*. https://carececo.org/publications/10th_CALP_Report_en_web.pdf

Embassy of Turkmenistan, Georgia. (2020, August 20). *Agricultural Complex of Turkmenistan: Points of growth and algorithm of diversification*. https://georgia.tmembassy.gov.tm/en/news/41178

Global Solar Atlas. (2019, October 23). *Turkmenistan: Global Photovoltaic Power Potential*. World Bank Group. https://globalsolaratlas.info/download/turkmenistan

IUCN. (2015, September 10). *Nexus Dialogue on Water Infrastructure Solutions*. IUCN. https://www.iucn.org/theme/water/our-work/past-projects/nexus

Meyer, K. (2019). *Building an enabling environment for water, energy and food security dialogue in Central Asia*. IUCN.

Meyer, K., Issakhojayev, R., Kiktenko, L., & Kushanova, A. (2019). *Regional institutional arrangements advancing water, energy and food security in Central Asia*. IUCN. https://portals.iucn.org/library/node/48719

Nepesov, M., & Mamedov, E. (2016). *Turkmenistan Case Study Policy Brief*. The Economics of Land Degradation Initiative and CGIAR Research Program on Dryland Systems. https://www.eld-initiative.org/fileadmin/pdf/Country_Policy_Brief_-_Turkmenistan_WEB.pdf

Owen, L. (2018). *Karakum Desert*. Britannica. https://www.britannica.com/place/Karakum-Desert

PreventionWeb. (2014). *Turkmenistan: Disaster & Risk Profile*. United Nations Office for Disaster Risk Reduction. https://www.preventionweb.net/countries/tkm/data/

State Information Agency of Turkmenistan. (2020, January 1). *Президент Туркменистана провёл рабочее совещание по развитию электроэнергетической отрасли [President of Turkmenistan working meeting on the development of the electric power industry]*. Туркменистан Сегодня [Turkmenistan Today]. http://www.tdh.gov.tm/news/articles.aspx&article22864&cat11

Turkmen News. (2020). *Закрытие границы с Ираном грозит Туркменистану голодом [Closing the border with Iran threatens Turkmenistan with famine]*. https://turkmen.news/news/hunger-turkmenistan/

UN. (2019). *Voluntary National Review of Turkmenistan: Empowering people and ensuring inclusiveness and equality*. United Nations Sustainable Development Goals. https://sustainabledevelopment.un.org/content/documents/24723Voluntary_National_Review_of_Turkmenistan.pdf

UNDP. (2014). *Turkmenistan: Renewable Energy Snapshot*. http://www.undp.org/content/dam/rbec/docs/Turkmenistan.pdf

UNDP. (2015). *National Climate Change Strategy of Turkmenistan*. https://www.tm.undp.org/content/turkmenistan/en/home/library/environment_energy/National-Climate-Change-Strategy-of-Turkmenistan.html?utm_source=EN&utm_medium=GSR&utm_content=US_UNDP_PaidSearch_Brand_English&utm_campaign=CENTRAL&c_src=CENTRAL&c_src2=GSR&gclid=CjwKCAjwoduRBhA4EiwACL5RP7yrQmUg-R3OyzQU3pj-nFLzwCI60wMw93WyLFShRVjvQMYn4VR_6hoCAcsQAvD_BwE

UNDP Eurasia. (2020, February 7). Water breeds life in the Turkmenistan desert. *Medium*. https://undpeurasia.medium.com/water-breeds-life-in-the-turkmenistan-desert-e9912cd599a3

UNDP Turkmenistan. (2020). *Solar Energy to Power Water Supply in the Heart of Karakum Desert*. United Nations Development Programme. https://www.tm.undp.org/content/turkmenistan/en/home/presscenter/pressreleases/2020/Solar-Energy-to-Power-Water-Supply-in-the-Heart-of-Karakum-Desert.html

World Bank. (2020a). *Agriculture, forestry, and fishing, value added (% of GDP)—Turkmenistan | Data* [Database]. World Bank National Accounts Data, and OECD National Accounts Data Files. https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=TM

World Bank. (2020b). *World Bank Climate Change Knowledge Portal*. Country: Turkmenistan. https://climateknowledgeportal.worldbank.org/

World Bank. (2021). *Employment in agriculture, female (% of female employment) (modeled ILO estimate)* [Database]. International Labour Organization, ILOSTAT Database. https://data.worldbank.org/indicator/SL.AGR.EMPL.FE.ZS?contextual=female-employment-by-sector

Annex 1. Baseline indicators on the reconstruction of *sardob*s on the "Esenaman" land plot (as of the end of *Phase I*, December 2019), CAREC

Results chain	Indicator	Baseline	Target	Current value	Source and mean of verification	Remarks
1. Improve access to water for livestock (sheep and camels)	Nr of *sardob*s restored	0	2	Restored	Before and after photographs	Provided
	Nr of water pumps installed	0	1	Done	Before and after photographs	Provided
	Volume (m^3) of drinking water available for livestock at farm-level	0	500 cubic meters (given that each *sardob* is 250 cubic meters)	Done	Before and after photographs	Provided
2. Provide electricity access to remote shepherd houses to allow prolonged stay	Nr of solar panels installed	0	16 pieces of solar (photoelectric) panels with capacity of 250 watts each. In total supply the electricity with the capacity of 4 kilowatt	Installed 20 pieces of solar (photoelectric) panels with a capacity of 250 watts each, reaching a total supply of electricity with a capacity of 5 kilowatts	Before and after photographs	Provided
	Duration (month) of stay on pasture land (2-3 months)	0	How many seasons (4-5 months)	First wintering on this site expected from Nov 2019 – April 2021	Reports and/or indicators/information of «Garagum» farm	Target value can only be measured starting from 2021, after the solar panels have been installed

3. Increase access to pasture to improve food security and income generation potential at farm-level	Increase of head of livestock on «Garagum» farm	32 024	6000	Expected from 2020	Livestock estimates	Target value can only be measured in 2020-2021 after grazing in a new pasture territory.
	Hectares (ha) of pasture land used by «Garagum» farm	880,661 ha. Of which 265,000 is waterlogged	50,000 ha	Expected from 2020	Land area plan	Target value can only be measured starting from 2020, when the «Garagum» farm will begin the reclamation of grazing land.
	Hectares (ha) of pasture land restored, previously used by «Garagum» farm	0	50,000 ha + an additional 105,000 ha saved from degradation	Expected from 2020	Land area plan Google earth	The pasture will be recovered in 3-4 years, measurement of the indicator possible only then
	Nr of workers employed at «Garagum» farm	Total 30 staff. 20 seasonal workers employed.	Not planned	The engagement of additional staff will depend on the yield of the livestock. In perspective, it is expected from 2020.	Financial reports and inquiries of «Garagum» farm	New staff will come with the purchase of additional livestock. Indicator can be measured only after that.
	Revenue of «Garagum» farm	In total: sheep – 39,276, camel – 2,187	«Garagum» farm rents livestock to shepherds, stipulating that the shepherds should return 100% of livestock + 40% of return/ yield.	Expected	Financial reports and enquiries of «Garagum» farm	Changes in revenue will occur as a result of the purchase of additional livestock. Indicator can be measured only after that.

Chapter 3

The Use of Water for Electricity Generation in Turkey

Cemalettin Tüney

Introduction

Hydropower was by far the largest source of renewable electricity in Turkey in 2019. In addition to supplying energy, hydropower offers many other important services to the power grid, and helps to maintain system stability and security of supply by providing frequency regulation, voltage support, contingency reserves, and load following and black start service. Hydropower also plays an increasingly important role in grid-scale energy storage, balancing the services provided by such intermittent renewables as wind and solar power, and water management services through its reservoirs, including flood control, water supply, irrigation and transport. In this chapter we address the use of water for the generation of electricity in Turkey, including its background and the current situation, with due consideration of political and economic policies, as well as its development and the criticisms of the environmentalist block.

The aim of this chapter is to provide the reader with insight into the economic model used for the exploitation of water for the generation of electricity in Turkey, from its earliest beginnings to the present time. In the first part, we detail the water situation in Turkey and its place in the world, while the second part will address the energy profile. The third and

fourth sections will detail the background of hydropower generation in Turkey, and the fifth part will focus on the liberal period, when new promotional models facilitated the realization of the economically viable exploitation of water potential. In the final part, the environmental critics towards rough use of hydropower will be tackled.

Turkey's water potential

Turkey is located primarily in the sub-tropical zone between the humid mid-latitude zone and the dry/hot tropical zone. As a result of its spanning of different geographic regions and climatic zones, from the Mediterranean to continental regimes (Sariş et al., 2010), Turkey experiences varying levels of precipitation, averaging 643mm/m^2/year, corresponding to 501 billion m^3 of water (General Directorate of State Hydraulic Works, 2020). It has 25 river basins, including two that are trans-boundary, the largest being the Tigris and Euphrates rivers that empty into the Persian Gulf, and the Araks River Basin, emptying into the Caspian Sea. However, the annual gross amount of water reserves in Turkey has recently been approximately 1,500 m^3 per capita. Falling within the 3,000–1,000 m^3 range, according to internationally recognized criteria, Turkey is considered a water-poor country, and the picture is worsening due to the rising demand for domestic use, the increasing population, climate change, and the pollution of water reservoirs and flows.

As Table 1 shows, Turkey possesses 1.07 percent of the gross, 1.54 percent of the technical and 1.84 percent of the economically utilizable hydropower potential in the world, and 16 percent of the European economic hydropower potential (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, n.d.)

Table 1. World Hydropower Potential

Region	Gross HP Potential (GWh/year)	Technical HP Potential (GWh/year)	Tech.& Econ. HP Potential (GWh/year)
Africa	4,000,000	1,665,000	1,000,000
Asia	19,000,000	6,800,000	3,600,00
Australia and Oceania	600,000	270,000	105,000
Europa	3,150,000	1,225,000	800,000
N.& Central America	6,000,000	1,500,000	1,100,000
South America	7,400,000	2,600,000	2,300,000
World	40,150,000	14,060,000	8,905,000
Turkey	433,000	216,000	127,820
Turkey/World (%)	**1.07**	**1.54**	**1,84**

Source: Gökdemir et al., 2012.

According to Table 1, Turkey possesses 127,820 GWh/year of economically viable water sources that require the building of 55,000 MW of total installed capacity. This figure, which was 27,000 MW in the 1980s, is subject to increase as the price of electricity increases in the future. By 2020, Turkey has developed 28,494 MW of installed hydropower capacity, and utilizes 51.2 percent of its economic water potential. As of January 2020, installed hydropower capacity accounted for 32 percent of the total installed capacity (91,252 MW). According to the Turkish Energy Exchange report, as of November 2019, 4,492,312 MWh of electricity i.e. 19 percent of the total electricity generation, was produced from hydropower in Turkey (EXIST, 2020).

Figure 1 shows that of the total global installed hydropower capacity of 4,200 TWh in 2018, China ranks first, followed by Brazil, while Turkey occupies sixth place with 28,000 MWh of installed capacity, after Norway.

Energy profile of Turkey in 2019

As an emerging regional economic power, Turkey has recorded the fastest growth in electricity demand among the OECD member countries, with an annual growth rate of 5.5 percent since 2002. Figure 1 shows annual growth in demand for electricity from 2008 to 2018. The main characteristic of Turkey's energy usage is its dependency on imported primary energy sources and its electricity generation from fossil fuels. Turkey, in line with its national strategies and international developments, has been taking the necessary steps to decrease its dependency and to diversify its resources.

Turkey's primary energy resources are coal, natural gas, hydropower, wind and other sources. It consumed 157.7 Mtoe in 2017 – marking a 9.5 percent increase from the previous year, and accounted for 1.2 percent of the global primary energy consumption (BP, 2018). The same report stated a share of renewable energy of 12 percent and a share of hydropower of 8.4 percent. Annual primary energy consumption has almost quintupled between 1990 and 2018, reaching 303 TWh (IEA, n.d.).

The share of renewable resources in electricity generation was 26 percent and the share of hydropower was 20 percent in 2018 (TEİAŞ, n.d.-b).

Table 2. Distribution of Installed Capacity in Turkey by Primary Energy Resource in Nov. 2019

Resource	MW	Percentage
Natural Gas	25,928	28
Dams	20,643	23
Hard Coal and Lignite	10,912	12
Imported Coal	8,967	10
Run of River	7,851	9
Wind	7,554	8
Others	9,398	10
Total	**91,252**	**100**

Source: EXIST, 2020.

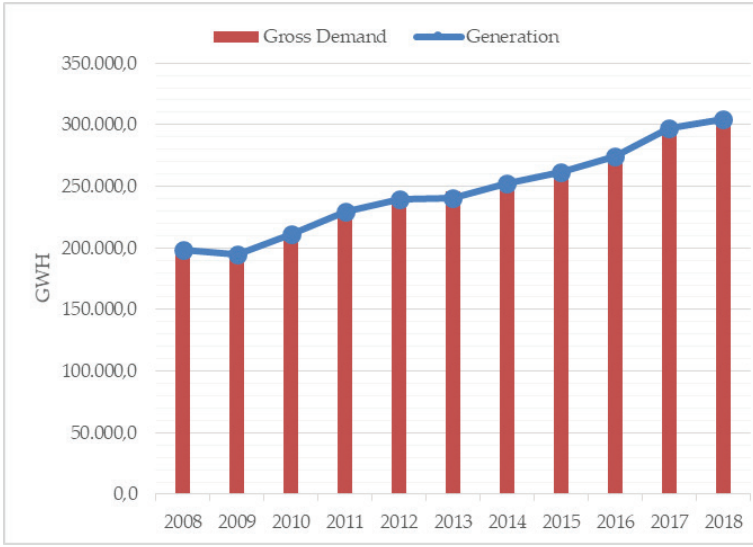

Figure 1. Annual Increase in Gross Electricity Generation and Demand in Turkey (2008-2018).

Table 3. Distribution of Electricity Generation in Turkey by Primary Energy Resource in 2018

Resource	Electricity Generated GWh	Percentage
Natural Gas	92,482.8	30.34
Imported Coal	62,988.5	20.67
Hydropower	59,938,3	19.66
Hard Coal and Lignite	50,260,1	16.49
Wind	19,949,2	6.54
Others	19,182,1	7.22
Total	**304,801.9**	**100**

Source: TEİAŞ, n.d.-b.

Table 4. The Distribution of Electricity Generation in Turkey by Electricity Utilities in 2019

Name of Electricity Utilities	Installed Capacity MW
Independent Power Plants	61,866
State owned Power Plants (EUAS)	19,552
BOT[1]	150
ToOR[2]	3,447
Unlicensed PP's	6,206
Total	**91,252**

Source: EXIST, 2020.

Table 5. Key Statistics of Turkey in 2018

	Total Energy Production Mtoe	Total Primary Energy Supply Mtoe	Electricity Final Consumption TWh
	41	146	303
Increase from 1990 (%)	64	186.27	506

Source: IEA, 2016.

Background to the development of hydropower in Turkey

The Hittites in Anatolia built the first known dam structure some 1300 years ago, and the dams built by the Ottomans are still in the service of the people of İstanbul. The first dams to be built after the foundation of the Republic of Turkey were the Çubuk I and Çubuk II Dams near Ankara, which were solely for the supply of drinking water. The first hydropower unit was a dynamo of 2 kW capacity, connected to a watermill that was later developed into a small HPP dam producing 60 kW, built in 1902 during the Ottoman Period on the Berdan River in Tarsus, southern Turkey (İbiş, 2018; Özdemir, 2016). Up until the

1 Build-Operate-Transfer. See footnote 5 in this Chapter.

2 Transfer of Operating Rights. See footnote 3 in this Chapter.

1930s, it was mainly foreign entrepreneurs, and a few local entrepreneurs and cooperatives who were involved in electricity generation activities in the Republican period. The great recession of 1929 saw most of these enterprises going bankrupt, and the government, which had already adopted a statist economic development model in response to the recession, appropriated all foreign electricity utilities (Özdemir, 2016).

İller Bankası, a state-owned financial institution, was established in 1933 to aid local government in electricity generation, after which, Etibank, a state economic enterprise, was established in 1935 to carry out all electricity generation and distribution works, and all power plant and transmission line construction. Lastly, the Electrical Power Survey and Development Institute (EİE) was established to carry out potential assessment studies related to water. In November 18, 1937, Prime Minister Celal Bayar announced in his first Government Program that the utilization of hydropower was their target, referring to it as white coal, and stated that the EİE would be conducting surveys of the Sakarya River, the waters of the Adana and Kayseri provinces, the Aegean region rivers, and the Euphrates, Tigris and Kızılırmak Rivers (Yurtoğlu, 2018).

The private Antalya Electricity Company, which would later become the Kepez Electricity Company, founded in 1925 (Ünsal, 2020), and the Kayseri and its Vicinities Electricity Company (KCETAŞ, n.d.), founded in 1926, survived the appropriations, and their concessions were renewed by the Democratic Party government after 1950. The generation of electricity in those years relied mainly on thermal energy sources, and was criticized as being the cause of foreign exchange losses during this period.

Table 6. Electricity Generation by Primary Energy Sources in 1938

	Million kWh	%
Hard Coal	232	82.3
Lignite	2	0.7
Fuel Oil	28	10.0
Other fuels	2	0.8
Hydropower	17.5	6.2
TOTAL	**281.5**	**100.0**

Source: Çavdar, 1984, p. 692.

Table 7. Electricity Generation by Primary Energy Sources in 1950

	Million kWh	%
Hard Coal	540.307	68.48
Lignite	137.047	17.37
Fuel Oil	81.533	10.33
Hydropower	29.982	3.8
TOTAL	**789.5**	**100**

Source: Çavdar, 1984.

Installed hydroelectric power capacity was 18 MW in 1950, accounting for only 4.4 percent of total installed capacity. At the end of World War II, when the multiparty system was established, Turkey witnessed dramatic economic change. The Democratic Party (DP), which came to power in 1950, launched numerous development projects including the building of large dams, making use of the financial support provided under the US Marshall Plan. Besides the institutions mentioned above, the General Directorate of State Hydraulic Works (DSİ) was established to build and operate all types of dams and irrigation systems and to manage all of Turkey's water potentials in 1953. In this period, under the DP government, the construction of

the large Seyhan (built in 1956, 54 MW), Sarıyar (1956, 160 MW), Kemer (1958, 48 MW), Hirfanlı (1959, 128 MW) and Demirköprü (1960, 69 MW) HPPs was completed, and ground was broken for other large dam projects. As these large dams entered into operation, the share of installed hydropower capacity increased from 18 MW in 1950 to 431 MW in 1960, in other words, accounting for 35.6 percent of the total 1,272.4 MW total installed capacity, up from 4.4 percent in 1950.

Table 8. Hydropower Installed Capacity Development

Year	HEP (MW)	Percentage of total Installed Capacity	Percentage of HEP Generated	Total Installed Capacity (MW)
1950	18	4.4	3.8	180
1955	38.1	6.22	5.6	611
1960	411	32.3	35.6	1,272.4

Source: TEİAŞ, n.d-a.

At the time of the multi-party system, the building of large dams was seen as a great achievement and they were seen as monuments of national pride, and would emerge as one of the main themes of the political competition among political leaders of the period.

After the Military coup of 1960, Turkey entered an era of planned economic development, for which the State Planning Organization (SPO) was established in 1961, as prescribed in the new Constitution. The First Five Year Development Plan prepared by the SPO in 1963 (Tekeli, 1984) prioritized the full utilization of the hydropower potential of the country and the increased use of electrical energy in every realm in Turkey. During the first years of the plan, 280.4 MW hydropower capacity and 630 MW of thermal power capacity were added to the existing total installed capacity (Çavdar, 1984). As an institutional outcome of the first plan, the Ministry of Energy

and Natural Resources (MENR) was established in 1964, and the DSİ was attached to it. The initial program put forward by Süleyman Demirel's government (1965–1969) was the first of its kind, stating clearly the government's hydropower priority. The politicians and technocrats of that era were enthusiastic about the conquest over water power. The late Süleyman Demirel, who had a civil engineering background and was the first General Director of the DSİ, held the posts of Prime Minister on seven occasions (10.5 years from 1964 to 1993) and the 9th President of the Republic (between 1993–2000), and was the greatest proponent of the conquest of the power of water. He was known as "the Father" by his supporters, but also "the King of Large Dams". In his memoirs, President Demirel recalled his emotions upon paying a visit to the Hoover Dam in Nevada, USA as a young engineer, and pledged to build dams upon his return to Turkey in 1949 (Demirel & Turgut, 2005).

The Turkish Electricity Authority (TEK) – a state-owned economic enterprise – was established in 1970 for the generation, transmission and distribution of electricity, integrating the operation of all electricity-related activities, and the roles of Etibank, İller Bankası, the municipalities and other official institutions in the electricity field were subsequently phased out. The DSİ was made responsible for building dams and HPPs, while TEK was given the responsibility for the operation of the HPPs (Gökdemir et al., 2012). The construction of the large dams of Keban (1975, 1,330 MW), Oymapınar (1984, 540 MW), Karakaya (1987, 1,800 MW), Altınkaya (1988, 700 MW) and Atatürk (1992, 2,400 MW) led this period to be known as the Golden Age of hydropower energy in Turkey.

Table 9. Hydropower Installed Capacity Development 1965–1984

Year	HEP (MW)	Percentage out of total Installed Capacity	Percentage of HEP Generated	Total Installed Capacity (MW)
1965	505.1	33.8	44	1,490.5
1970	725.4	48	35.1	1,509.5
1975	1,779.6	42.5	37.8	4,186.7
1980	2,130.8	41.6	48.7	5,118.5
1984	3,874.8	45.8	43.8	8,461.6

Source: TEİAŞ, n.d-a.

Quest for new economic models for energy in Turkey

Up until 1984, with the exception of the privately operated electricity distribution regions of Çukurova, Antalya and Kayseri, the state had realized all electricity-related activities. In line with the global economic trends and the enactment of a new constitution in 1982 following the 1980 military coup, the government adopted a neo-liberal economic policy involving the downsizing of the government, and the privatization of state assets began. The government hoped to recover after the oil crises of the 1970s and global economic crises of the 1980s, which had culminated in rapid urbanization and a population increase, and ushered in a new liberal development initiative in Turkey. More investments were needed to improve the infrastructure and to meet the energy demands of the emerging economy, however, the government lacked the necessary funds, and so both foreign and Turkish private-sector investments were encouraged and incentivized as a solution to the predicament. Market-oriented policies for renewables started in 1984 with third-party financing, and exemptions on excise and sales tax. Several laws were enacted to attract foreign and Turkish private sector investors to build and operate hydro and thermal power plants. (Erdogdu, 2011) Law No. 3096, which ended the monopoly of TEK, was enacted in 1984, and several

approaches, including those involving the private sector, were introduced, such as privatization, ToOR[3] and BO[4] models in the energy sector. Law no: 3996 enacted in 1994 introduced the BOT[5] model, which aimed at the realization of such large-scale projects as energy plants, highways, airports, seaports, telecoms etc., while Law No. 4047, enacted in 1994, provided further incentives, including long-term purchasing and price level State Treasury guarantees for BOT projects. In the hydropower energy sector, this period was marked by the opening of the large dams of Oymapınar (1984), Karakaya (1987), Altınkaya (1988) and Atatürk (1992) by Turgut Özal, the two-time Prime Minister from 1983 to 1989 and the eighth President of the Republic between 1989–1993.

The fierce political competition between Özal and Demirel – as two center-rightist politicians – focused primarily on the realization of major hydropower projects. Public awareness of the development of water potential was high at the time because of the many debates of the political leaders. In 1993, as part of the structural reforms, the TEK Company was divided into two separate state economic enterprises for privatization purposes, creating TEDAŞ, as the distribution company, and TEAŞ, as the generation and transmission company. Unfortunately, the applied BOT, BO and ToOR models did not produce the expected results, and therefore a fragile balance of power persisted during this period. The failure of the models was attributed to poor planning, the lack of coordination

3 Transfer of Operating Rights (ToOR): The transfer of public service enterprises from the public to the private sector under certain conditions for a certain period, and the exchange of a certain transfer price.

4 Build-Own (BO) is a form of project financing in which a private entity receives a concession from the private or public sector to finance, design, construct, own and operate the facility detailed in the contract.

5 Build-Operate-Transfer (BOT) is a form of project financing in which a private entity receives a concession from the private or public sector to finance, design, construct and operate the facility detailed in the concession contract.

and a common understanding among the government authorities and the Judiciary, and also the complicated legal framework. In addition, the long-term purchase agreements, which deviated from the liberal understanding, placed a heavy burden on public funds through take-or-pay contracts. The BOT and BO financial incentives schemes ended in 2000, with only 4,800 MW of hydro and thermal power plant capacity being built in the 17 years following 1984.

Table 10. Hydropower Installed Capacity Development

Year	HEP (MW)	Percentage out of total Installed Capacity	Percentage of HEP Generated	Total Installed Capacity (MW)
1985	3,874.8	42.5	35	9,121.6
1990	6,764.3	41.4	40	16,317.6
1995	9,862.8	47	41	20,954.3
2000	11,175.2	41	24	27,264.1

Source: TEİAŞ, n.d-a.

Another development witnessed during this period was the rise of eco-political opposition towards the prevailing energy policies, which argued against the dependency on imported fossil fuels, the use of more thermal sources and the disregard of Turkey's renewable energy sources. The opposition groups were also against the privatization of state assets and the liberalization of the energy markets, and these criticisms would soon become the *modus vivendi* of opposition parties, environmentalists, chambers of engineers and mainstream media, energy circles in the government and private-sector, as well as public opinion in Turkey, especially in the 2000s.

Liberal period: From 2001 to the present

A new era in the energy markets began in the 2000s. The economic crisis in 2001 compelled the government at the time to

make some major legal and structural reforms, opting to liberalize the electricity sector and accelerate privatization. At the outset, the main aim was to unbundle and liberalize electricity market activities, to privatize state-owned enterprises and to establish a competitive market, but as the Turkish economy started to grow rapidly, policymakers became increasingly concerned about the security of the country's electricity supply. Therefore a new financial model was put in place within the framework of the Electricity Market Law No. 4628, enacted in 2001 (Erdogdu, 2011), and the Energy Markets Regulatory Authority (EMRA) was founded. This structural adjustment was aimed at limiting the government's involvement in energy sector, including the hydropower, to licensing of the market players, adapting regulations and monitoring of the markets by an independent authority (EMRA). The new model adopted by the Law in line with the European Union acquis stipulated the use of incentives to achieve the green energy targets, to reduce carbon emissions and to promote renewable energy sources.

The first key development for hydropower under the new law was the issuance of By-Law regulating the Water Usage Agreement in 2003 introduced incentives, defined the application procedure for HPP projects, and set the functions of provincial institutions and EMRA. Right after that, the DSİ and EİE announced project portfolios via the Internet to be realized by the private sector under the licensing procedure of EMRA. During this period, existing 20 intergovernmental bilateral HPP projects totaling 5,837 MW and 1 BOT project of 90 MW were also included among the announced projects to be applied for by the private sector. Law No. 4628 also divided the TEAŞ Company, into TEİAŞ, as the system operator and the transmission company; EÜAŞ, as the generation company, and the TETAŞ, as the trading company. All HPPs (12,995 MW

total) that had been built so far and operated by the DSİ were transferred to EÜAŞ. Though, this transfer did not include the high dams of Atatürk, Keban and Karakaya on the transboundary Euphrates River, that is to ensure frequency regulation in electricity (Yılmaz, 2018). In addition to this exemption, the DSİ was assigned the task of constructing four large dam projects of total 2,095 MW capacity that were assumed to be beyond the financial capacity of the private sector. The privatization ToOR for 49 years of HPPs under the EUAŞ umbrella was started, as stipulated by the Law.

The By-Law regulating Water Usage Right Agreement issued in 2003 as secondary legislation of the Law No.4646 stipulates that every HPP project holder should sign an agreement with the DSİ, which has since then, become an expert institution in water management in Turkey. Moreover, the By-Law stipulates that the DSİ may grant a "water usage right" certificate to HPP projects. In the event of multiple applications for the same project, the By-Law also stipulates that the DSİ is to conduct a public tender, and then to inform EMRA of the winners for licensing. The water usage agreement states the volume of water flow and calls for the monitoring of the impact of HPP on the river to protect natural life.

Another milestone development in hydropower usage was the enactment of Renewable Energy Resources Law (RER) No: 5346 dated May 2005, that provided a support system, that is, feed-in tariff (FIT) for electricity generation from renewable energy sources. The RER Law No: 5346 envisioned the FIT with upper and lower limits for a maximum of 10 years of operation, being 5.0 and 5.5-euro cents per kWh, respectively. However, the law failed to attract more investors, after which, the Law No. 5346 was elaborated upon and amended by the Law No. 6094 in 2011 (Gözen, 2015). New law introduced the

operation of the Renewable Support Mechanism (YEKDEM) which began on December 1, 2011. The YEKDEM mechanism provides FIT for hydropower with a lower limit of US$7.3 and an upper limit of US9.6 cent/kWh. The FITs provided by the Law no: 5346 were considered insufficient because the FIT was lower than the per kW electricity price realized in the spot electricity market. The effect of the new law could be seen immediately increase in the number of HPP license applications to EMRA, with 1,024 project applications with an installed capacity of 6500 MW were made by the private sector in a short period of time. In addition, Another Law No. 5784 which was enacted in July 2008, exempted RER projects up to 1,00 kW from the need to obtain a license to generate electricity from renewable energy sources also accelerated the utilization of hydropower potential. The aim of the Law No. 5784 was to promote real or legal persons to invest on generating their own electricity needs. Under this law, the government also provides guaranty to buy any excess electricity from these non-licensed power plants. During this period we witnessed an increase in the construction of mini and micro-hydropower plants (Erdogdu, 2011).

YEKDEM support mechanism introduced and integrated day-ahead market in 2011. Under the new mechanism, which was unique to Turkey, renewable-based electricity was sold on the day ahead market in EXIT which also incentivized the realization of hydropower potential of Turkey.

Table 11. Installed Capacity Development

Year	HEP (MW)	Percentage out of total Installed Capacity	Percentage of HP generated	Total Installed Capacity
2001	11,672.9	44	19	28,332.8
2005	12,906.1	33.2	24.6	38,843.5
2010	15,831.2	32	24.6	49,524.1
2015	25,867.8	35.4	25.6	73,147.6
2017	27,273.1	32.7	19.6	85,200,0
2018	28,111.6	31.7	19.9	88,550.8
2019 Nov.	28,494.0	31.9	20	91,252.0

Source: TEİAŞ, n.d.-a.

As can be seen from Table 11, Turkey was able to install 15,587.9 MW hydropower capacity from 2005 to 2019, amounting to almost 1,113.4 MW per year on average under the new legal and economic model. The impact of the new incentive model could also be seen in the number of HPPs established, as detailed in Table 12, and in the total installed capacity benefiting from the feed-in tariffs, presented in Table 13.

Table 12. Breakdown of the Number of HPPs as of March 2019

Status	Number of HPPs	Capacity (MW)
Operational	659	28,391.4
Under Construction	33	1,739.0
Licensed	84	2,342.0
Pre-licensed	150	4,969.0
Under Consideration	5	110
Total	**931**	**37,394**

Table 13. HPPs Operating under the Renewable Support Mechanism

Run of River	6,330 MW
Reservoir	6,373 MW
Total	21,290 MW

Source: YEKDEM.

Table 14 shows that the pace of the realization of water potential under the new schema increased Turkey's share of the world's total installed capacity.

Table 14. Hydropower Capacity Development in Turkey Vis-à-vis the World

Year	World (MW)	Turkey (MW)	TR/World (%)
2008	960,584	13,829	1.08
2017	1,270,496	27,313.1	2.149

When the percentage of utilization of the total economic water potential is taken into account, especially in the last two decades this development was a considerable success for Turkey, yet Turkey has another potential to be realized for the next years.

Table 15. Utilization of Total Economically Viable HP Potential in Turkey in 2019

HPPs	MW	Percentage
Utilized	28,494	51.80
Economical Potential	55,000	100

According to the Renewable Energy Strategy document, Turkey plans to reach 34,000 MW Hydropower capacity by 2023 (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, n.d.).

Issues with hydropower generation

Hydropower generation plants, and primarily the dams constructed for the hydropower plants, have raised some social and environmental concerns. The environmental implications are different from those of fossil fuels, with the main concerns being related to the impact on the land and water ecosystem associated with the construction and operation of hydro dams. These concerns include the effects of changing river flows on ecosystem regimes, the flooding of extensive land areas, necessitating the relocation of residents and a loss of agricultural land, silt deposition and the impact on certain sensitive species (Erdogdu, 2011). Furthermore, all human interventions into natural life, the course of rivers and their diversions can have a considerable impact on the flora and fauna of the ecosystem and human life.

Increase in the number of the construction of HPPs during past two decades in Turkey with the sole purpose of utilizing the natural resources and profit maximization, while ignoring the impacts of these human activities on river basins, has led the environmental degradation and public contentment. Private entrepreneurs, primarily those operating river-type HPPs, sought the rapid realization of their projects, and disregarded the lengthy hydrological, technical and scientific procedures (Gökdemir et al., 2012). Their hasty and rash style actions were tolerated by the Government authorities who prioritizes energy supply security to the environment. The rough approach to construction on the site and their appropriation of lands have led to environmental degradation of and tension with those living in the vicinity of HPPs. Moreover, the diversion of watercourses, thus reducing the availability of water for the streams and agricultural activities in nearby fields further exacerbated the social and environmental problems. The total installed capacity of such run-of-the-river type HPPs is

almost half of the total hydropower capacity, while the cost to the environment and social life of the areas in focus is said to be high. This can be attributed to the fact that the government considers energy security to be the highest priority, and has thus tended to neglect the adverse effects of hydropower projects (Gökdemir et al., 2012).

Conclusion

To conclude, this chapter demonstrates the importance of hydropower for Turkey's overall energy and environment policies. In fact, hydropower provides cheap, clean and environment-friendly form of electricity compared to other forms of electricity produced from fossil fuels. The chapter also highlights the significance of hydropower in Turkey's overall socio-economic modernization strategy. This turned the construction of large dams into one of the focal points of the political agenda and a target of the economic development plans, being considered a remedy to the increasing demand for electricity resulting from rapid industrialization and urbanization.

On the other hand, Turkey is not a water-rich country. Actually, the per capita freshwater stocks of Turkey continue to decline due to climate change, while the use of water has increased over the years. To achieve its ultimate desire to become an economically and socially modern country, Turkey adopted several development programs and established a number of state entities in order to increase Turkey's energy production, including its hydropower capacity. More recently, Turkey adopted new regulations to encourage the construction of hydropower plants stirring up tensions between the local people and environmentalists on one side and entrepreneurs and official bodies on the other in the 2000s.

References

BP. (2018). *BP Statistical Review of World Energy June 2018* (p. 70). BP. https://www.industry.gov.au/sites/default/files/foi-18-011.pdf

Çavdar, T. (1984). *Türkiye'de Enerji*. "Energy in Turkey" In *Cumhuriyet Dönemi Türkiye Ansiklopedisi* (1st ed., Vol. 3). İletişim.

Demirel, S., & Turgut, H. (2005). *Bir ömür suyun peşinde*. "In the Life Time Pursuit of Water" ABC Medya Ajansı.

Erdogdu, E. (2011). An analysis of Turkish hydropower policy. *Renewable and Sustainable Energy Reviews*, *15*(1), 689–696. https://doi.org/10.1016/j.rser.2010.09.019

EXIST. (2020). *Electricity Market Monthly Reports*. EPİAŞ. https://www.epias.com.tr/en/spot-electricity-market/electricity-market-reports/electricity-market-monthly-reports/

General Directorate of State Hydraulic Works. (2020). *Water Resources*. http://en.dsi.gov.tr/land-water-resources

Gökdemir, M., Kömürcü, M. İ., & Evcimen, T. U. (2012). *Türkiye'de Hidroelektrik Enerji ve HES Uygulamalarına Genel Bakış*. "General Overview of Hydropower and HPPs Practices in Turkey" *Türkiye Mühendis Haberleri*, "Turkish Engineers News" *471*, 18–26.

Gözen, M. (2015). Renewable Energy Support Mechanism in Turkey: Financial Analysis and Recommendations to Policymakers. *International Journal of Energy Economics and Policy, 4*(2), 274-287.

IEA. (2016). *Energy Policies of IEA Countries: Turkey 2016 Review – Analysis*. IEA. https://www.iea.org/reports/energy-policies-of-iea-countries-turkey-2016-review

IEA. (n.d.) *Total Primary Energy Supply (TPES) by source: Turkey*. IEA. https://www.iea.org/statistics/?country=TURKEY&category=Key%20indicators&indicator=TPESbySource&mode=chart&categoryBrowse=-false&dataTable=BALANCES&showDataTable=true

İbiş, M. (2018). *"Türkiye Elektrik Piyasası ve Denetimi*. "Electricity Market and its Monitoring in Turkey" TENVA (Energy Foundation of Turkey).

KCETAŞ. (n.d.). Tarihçe https://www.kcetas.com.tr/tarihce/

Özdemir, N. (2016). *İmparatorluktan Cumhuriyete Türkiye'de Elektriğin Tarihsel Gelişimi.* "Historical Development of Electrical Power in Turkey From Ottoman Era to Republican Era" *Osmanlı Medeniyeti Araştırmaları Dergisi*, "Journal Ottoman Civilization Studies"*2*(3), 17. https://doi.org/10.21021/osmed.89880

Sariş, F., Hannah, D. M., & Eastwood, W. J. (2010). Spatial variability of precipitation regimes over Turkey. *Hydrological Sciences Journal*, *55*(2), 234–249. https://doi.org/10.1080/02626660903546142

T.C. Enerji ve Tabii Kaynaklar Bakanlığı. (n.d.). *Hidrolik*. Enerji.Gov.Tr. http://www.enerji.gov.tr/tr-TR/Sayfalar/Hidrolik

TEİAŞ. (n.d.-a). *Elektrik İstatistikleri, "Electricity Statics | Türkiye Elektrik İletim A.Ş.* http://www.teias.gov.tr/tr/elektrik-istatistikleri

TEİAŞ. (n.d.-b). *III-Electricity Generation -Consumption-Losses | Türkiye Elektrik İletim A.Ş.* http://www.teias.gov.tr/tr/iii-electricity-generation-consumption-losses-0

Tekeli, İ. (1984). *Planlama."Planning"* In *Cumhuriyet Dönemi Türkiye Ansiklopedisi* (1st ed., Vol. 6). İletişim.

Ünsal, A. (2020). *Antalya Elektriğin Tarihçesi.* "History of Electricity in Antalya" http://www.emo.org.tr./ekler/99678a83b8c8066_ek.pdf?dergi

Yılmaz, Ş. (2018.). *10. Türkiye Hidroelektrik Potansiyeli Ve Gelişme Durumu." Hydropower Potential and its Prospects in Turkey"* In *Türkiye'nin Enerji Görünümü "Energy Outlook of Turkey" 2018* (p. 306). https://www.mmo.org.tr/sites/default/files/EnerjiGorunumu2018_2_0.pdf

Yurtoğlu, N. (2018). *Cumhuriyet Türkiyesinde Elektrik Enerjisi Üretimi Ve Enerji Politikalari (1923-1960).* "Electricity Generations and Energy Policy of Republican Era Turkey" *Atatürk Araştırmaları Merkezi Dergisi*, *"Journal of Atatürk Research Center" 34/2*(98), 54.

Chapter 4

Water and Energy Security in the Case of Armenia

Mehmet Çağatay Güler

Introduction

Water security is defined as "the 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). It covers multiple subjects, varying from agriculture, the environment, health, economics, political science, energy, etc., and has been regarded as the most significant topic for a country, as without it, its existence and survival cannot be maintained. In this subject, the main factors that determine water security are the available water resources and accessibility to clean water. The total water resources available in the world are estimated at 45,500 km^3 / year (Oki & Kanae, 2006), although only 2.5 percent is accounted for by clean water resources, among which only a small percentage is accessible, with the remainder being locked in glaciers and in groundwater storage (Shiklomanov, 1993, pp. 13-15).

The major determinants of clean water resources are the rate of precipitation and rivers. Globally, 263 rivers and lakes are transboundary (half the Earth's surface), shared by 145 countries (UN-Water, n.d.). Such conditions endanger the water security of states and their perception of security, and there are numerous examples of cases where states are in conflict with states with

which they share clean water resources. There are conflicts and unidentified rights claims between the upper and lower part of the stakeholders (riparian states) eg. Uzbekistan-Kyrgyzstan, Sudan, Egypt and other riparian countries, Mexico and United States, etc. and these are often regarded as threats to survival, since they have the potential to affect not only the issue of water itself but also energy security, health, food security, etc. Hence, countries ascribe crucial importance to water security, contributing to the importance of hydro-geopolitics as the field that deals specifically which this subject.

The hydro-geopolitical situation in Eurasia resembles the geopolitical situation in Eurasia, but is a more specific topic that puts hydro-politics at the center of analyses. Hydro-geopolitics focuses on water resources, water conflicts and their effects on the geopolitical situation. After the collapse of the Soviet Union, the separation of water resources emerged as a serious problem in the Eurasian geography. During the Soviet era, the agreements and management systems under the Union ensured its harmonious functioning. In the post-Soviet era, however, the share of these resources has emerged as an unsolvable problem, like many other problems, as most of the resources satisfying water demand in the region turned into transboundary rivers (Guler, 2018, pp. 54-60). This gave birth to the need for effective and solution-oriented hydro-politics. Since these countries have failed to achieve cooperation in the water politics area, the need for a concrete pathway has become more crucial. To be more specific, the Southern Caucasus contains eight main rivers (Ubilava, n.d.). Almost 40 percent of the total regional territory is located on transboundary river basins. Given the lack of applicable laws related to this issue and the fact that countries are trying to maximize their shares, resolving the problem has become impossible. The issue of water security in these cases thus becomes directly related to a political problem.

Regarding the Armenian case, conflictual circumstances born out of its transboundary water status, are frequently

seen. There are two main rivers in the region, the Araks and the Kura, whose tributaries account for all of Armenia's renewable water resources (FAO, 2016). While three-quarters of the country is located in the Araks Basin, the remainder falls within the Kura Basin (FAO, 2016). The Kura River is shared by five countries, two of which, Armenia and Azerbaijan, are in a long-standing direct conflict, while Armenia also has historical hostilities with Turkey (FAO, 2009, p. 1). Similar to the Kura River, the Araks River is shared by four countries, and the same duo, Azerbaijan and Turkey, are again among those countries. Only around 16 percent of the basin created by these rivers is located within Armenia's borders, although it covers all parts of the country (FAO, 2016). Since its water demands are dependent on the outflow from these transboundary rivers, its existence and critical sectors are vulnerable and prone to external effects. Transboundary rivers should not necessarily be accepted as a source of conflict however, in the Armenian case the dispute over Nagorno-Karabakh is directly related to water security, and the conflict has been created over the sharing of resources. Additionally, Armenia's hostile relationship with Turkey makes the situation even less manageable, so as the probability of achieving a common regime that lays out the utilization conditions of the shared water resources.

The other significant issue that should be mentioned is Armenia's reliance on hydropower. Hydropower, or hydroelectricity, is relied upon to satisfy over one-third of Armenia's total electricity demand (IAEA, 2019). Natural gas-based thermal power plants satisfy another 1/3, although the country has no natural gas or oil reserves, and this absence of fossil fuels gives it no choice but to rely on imports, mainly from Russia and Iran. The remainder of the electricity demand is generated by nuclear power plants, for which fuel is imported from Russia. Overall, only 30–35 percent of the total energy demand is satisfied from domestic resources, and almost all is from hydroelectric power plants. In short, without the current water flow and precipitation, the Armenian energy sector would be 100

percent dependent on foreign fuel, making it much more vulnerable to external effects. Besides being domestic resources, energy demand in the country is dependent on hydropower, and so the importance of water increases exponentially.

In short, transboundary rivers, water conflicts and the importance of water security for Armenia occupy a pivotal role in both its domestic and foreign policies. These policies are usually related to such crucial sectors as energy, agriculture, industry and healthcare, all of which have a parallel relationship with water security. In the Armenian case, however, the link between energy and water security is more prominent and distinctive. Hence, water security and energy security will be scrutinized in separate chapters, while others will be investigated as intertwined.

Water security in Armenia

At the outset, let's briefly clarify Armenia's clean water resources. The country receives approximately 592 mm of precipitation per year, or in other words, 18 billion m^3 of annual rainfall (FAO, 2016), of which 11 billion m^3 is lost to evaporation (FAO, 2016). Its total renewable water resources amount to around 7.7 billion m^3/year (FAO, 2016), although 1.4 billion m^3 is the overlap between the renewable surface water (3.9 billion m^3) and the renewable groundwater (4.3 billion m^3), meaning that its annual internal renewable water resources actually amount to 6.8 billion m^3 (FAO, 2016), which is equal to the annual flow of the Kura and Araks River Basins. There are 14 major sub-basins created through these two main river basins (See Table 1). The number of rivers within these basins exceeds 10,000, although many are small and short. Almost 3/4 of Armenia's territory lies within transboundary river basins.

The majority of dams in the country are left over from the Soviet era. The stored water is mostly utilized for irrigation and hydropower, and occasionally for fisheries. More than 80 reservoirs are operating in the country with a capacity of more than 1 billion m3 (FAO 2016). The largest of these is on the

Arpacay River, which forms the border with Turkey, and has a joint storage capacity with Turkey of more than 500 million m3 and provides water for the irrigation of around 30,000 ha in Armenia. The rest are small reservoirs (FAO, 2016).

Table 1. River basins in Armenia

River Basin	Area (km^2)	Precipitation (million m^2 per year)	Evaporation (million m^2 per year)	Flow (million m^2 per year)	Flow Volume Module (million m^2 per km^2)	Reservoirs (2004, in operation)
Debet - within Armenia	3895	2726	1457	1203	0.309	1
Aghstay - within Armenia	2480	1569	979	445	0.205	5
Small tributaries of Kura - within Armenia	810	510	354	199	0.106	4
Akhuryan - within Armenia	2784	1653	972	392	0.140	8
Kasakh	1480	979	486	329	0.222	6
Metsamor, without Kasakh	2240	N/A	N/A	711	0.317	25
Hrazdan	2565	1572	876	733	0.286	7
Lake Sevan Basin	4750	N/A	N/A	265	0.056	4
Azat	952	607	306	232	0.244	2
Vedi	998	573	340	110	0.111	1
Arpa - within Armenia	2306	1643	768	764	0.331	11
Vorotan - within Armenia	2476	1828	811	725	0.293	7
Voghji - within Armenia	1341	1097	448	502	0.374	2
Meghri	664	470	241	166	0.250	-

Source: FAO, 2016.

According to Falkenmark indicator, which is accepted by the United Nations for the assessment of the clean water situation in certain countries or regions, if the annual water supply is higher than 1,700 m^3 per capita, then the country is categorized as water-abundant (Falkenmark et al., 1998). Any country with amounts below the 1,700 m^3 per capita threshold is considered water-scarce, and there are several degrees of water scarcity depending on the population and the amount of the water drops per capita (Falkenmark et al., 1998). The water availability in Armenia for its population of 2.9 million is enough for the classification of Armenia as a water-rich country. This richness, however, is a relative concept, as two significant factors make water supply a dependent variable, being the share-based water resources and natural disasters.

Share-based water resources, in other words, transboundary rivers, play a pivotal role in defining a country's water security. In recent history we have witnessed dozens of water-related conflicts related to transboundary issues that could be addressed through proper/recognized regulatory regimes. The disagreements over the Euphrates and Tigris Rivers involving Turkey-Iraq-Syria, the dispute over the Syr Darya river between Uzbekistan and Kyrgyzstan, and Kazakhstan and Uzbekistan (Guler, 2018, pp. 60-63), the clashes over the Nile Basin among Sudan, Egypt and other riparian countries, and the transboundary water issues between Mexico and the United States are all examples of such conflicts (Swain, 2004, pp. 34-35).

The distribution of the water potential of the transboundary Araks and Kura Rivers is not yet subject to legal regulation among the five interested parties, being Turkey, Azerbaijan, Iran, Georgia and Armenia. The lack of any multilateral agreement on what drives the quantity and quality of sub-basin water still prevents consensus from being reached on the benefits of improved and collaborative water management at a

regional level. Prior to the dissolution of the Soviet Union, bilateral agreements existed between Turkey and the Soviet Union (ECC, n.d.), and between Iran and the Soviet Union over the use of the Araks River (FAO, 2009, p. 5). However, since Georgia, Azerbaijan and Armenia gained their independence, there is nothing left but disorganization. Despite the passing of many years since the dissolution of the Soviet Union, there is still no control or management mechanism governing the quantity and quality of the water.

The Water Code was adopted by Armenia in 1992 (updated in 2002), and Azerbaijan and Georgia in 1997 (FAO, 2009, pp. 5-6). In 1998, an environmental protection agreement was signed between Azerbaijan and Georgia, and a year later Georgia signed the same agreement with Armenia (FAO, 2009, pp. 5-6), envisaging cooperation in the specific protection of transboundary ecosystems. In 1999, Armenia developed an integrated water resources management plan that was funded by the World Bank (FAO, 2009, pp. 5-6), being a reform plan regarding the usage of water resources to maintain projection and development. In 2002, Armenia established a Transboundary Water Resources Commission to ensure the protection of its rights and to resolve any problems with the neighboring countries (FAO, 2009, pp. 5-6), and while several cooperation agreements were signed and monitoring issues were addressed, no concrete steps were taken toward the establishment of a multilateral binding regime.

In the post-Soviet era, in the absence of any mutual agreements, several water-based conflicts have broken out that have deeply affected Armenia's water security, and the disharmony between Armenia and Azerbaijan is directly related to the transboundary status of the Araks and Kura Rivers (GPF, n.d.; Shikhali & Safarova, 2016). The Nagorno-Karabakh region, which was under Armenian occupation, has significant water

resources over which both countries claim sovereign rights. For years, as a downstream country, however, Azerbaijan had been negatively affected by Armenia's unilateral actions in this regard. Since this region is regarded as Azerbaijan's territory by the international community and law, the utilization of water resources under or over the soil is under Azerbaijani jurisdiction. Nevertheless, due to its previous de-facto status, the water resources were also under Armenian occupation. On the other side, Armenia claims rights over the region and the water resources attached to it, which are considered to be some of the cleanest and high-quality water resources in the region (GPF, n.d.). The tension and hot clashes between Azerbaijan and Armenia threaten the water structures. E.g. following the border clashes involving the two countries in 2014, Armenians intended to target the dams through the military build-up along the border. The Sarsang Reservoir, within the boundaries of Karabakh, used to provide drinking and irrigation water not only to 17 mountainous regions, but also to six surrounding regions until it was occupied by Armenian and separatist forces (Shikhali & Safarova, 2016). Among these is the mostly Azerbaijani region of Tartar, a land of rolling hills which was situated on the line of contact between Azerbaijani and Armenian forces (Shikhali & Safarova, 2016). Sarsang Reservoir has a capacity of 560 million m3, and was under Armenian control, and the residents of Azerbaijani towns that depend on water from the Tartar River and the Sarsang Reservoir abandoned their homes as their farming and stockbreeding activities, and their residence becomes impossible in the absence of water (Shikhali & Safarova, 2016). These varied humanitarian problems are clear evidence of the importance of water security, and its use as a political tool. Though Armenians was once holding the winning hand, not only the transboundary status but also the disputes over sovereignty rights among the

two countries, place the significant water resources at high risk. As such, following the second Karabakh War, the water reservoirs under de-facto Armenian control liberated by Azerbaijan, and the winds have changed. At the current stage, Azerbaijan liberated most of the water reservoirs located in Karabakh including Sarsang reservoir. This further shows us the extent of fragile water security structure in the region and the extent of its loss in terms of water and energy.

Another water-related transboundary problem of Armenia has a profound effect on its water security, being between Ankara and Yerevan. The situation relates to Arpacay River and the Arpacay/Akhurian Reservoir located on the border of Turkey and Armenia. Arpacay River is 186 km long and is used as an irrigation resource by both countries (Gültekin, 2010), and is part of the Kura-Araks River Basin. In the Soviet era, an agreement was signed with Turkey in 1927 according to which the co-riparian states would have an equal share (Gültekin, 2010). After 6 decades, a joint dam was constructed to manage the quantity of the shared water (ECC, n.d.). Further cooperation and facilitation agreements were signed and remained in effect following the collapse of the Soviet Union (ECC, n.d.). Though the previous agreements addressed the quantity issue, there was no provision related to quality (ECC, n.d.). Furthermore, the ongoing conflict over Nagorno-Karabakh has ensured tense bilateral relations, not to mention historic hostility, as the two countries decreased their diplomatic communications and interactions, and the situation has become more complicated following the second Karabakh War. Aside from the hydro-ecology and quality problems, the countries failed to address this issue, and no legal framework or information sharing existed, resulting in water insecurity. Regardless of how smooth the past water-related initiatives have been, new projects over the river would not only affect the amount

but also the quality of water, as there are no restraints or provisions to prevent it.

In both similar and different manners, Iran and Armenia share the Araks River, and have begun constructing a dam, like in the Arpacay case between Turkey and Soviet Armenia. The water supply from Araks River is of great importance to both countries, if not a matter of security. What makes the difference is that the relations between Iran and Armenia in multiple areas remain unproblematic, and while the achieved cooperation mechanism continues to function, this may not always be the case, and the Iranian side occasionally accuses Armenia of polluting the water of the Araks River (Bakhtiari, 2019). Beyond the water issue, the Iran-Armenia relationship is not built on solid foundations, and is sometimes on thin ice, and the bilateral dialog is pragmatic rather than strategic. Under such circumstances, any steps taken against the interests of either side would result in a deep shock with potential repercussions on water security. Since all Armenian water resources are transboundary, their security should be considered vulnerable and fragile.

Beyond the insecurity related to the transboundary nature of its resources, there is another variable, natural disasters that essentially determines the extent of water security. For instance, in 2000, Armenia suffered a serious drought that was devastating to the subsistence farmers inhabiting the mountainous areas who depend on rain-fed irrigation. The initial losses amounted to $110 million, while the subsequent losses of agriculture products were estimated at $43 million, in a country where agriculture accounts for almost 30 percent of the GDP and half of the employment (World Bank, 2017, p. 14). As a result of low precipitation and high temperatures, rainfall in some areas fell by around 70 percent. Most of the crops were lost, leading also to a seed shortage the following year (World

Bank, 2017, p. 14). In 2006, another drought hit, though not as severe, and the resulting decrease in crops forced Armenia to import cereal to meet its requirements (World Bank, 2017, p. 14). In recent years, extreme weather events, droughts, floods, hot dry winds and hailstorms have become more common, and not only last longer, but also bring greater devastation. The total damage from 1994 to 2014 is estimated to have reached around $1.5 billion (World Bank, 2018), including agricultural damage and losses; damage to property; and medical-sanitary losses. Floods caused by climate change and seasonal flows cripple all activities around rivers, particularly in the Araks River Basin, where people have lost their lives, clean water is scarce, and it has not been possible to cultivate sufficient food products. Furthermore, droughts and floods often leave farmers without access to sufficient irrigation water, which directly affects the economy in terms of national products and food security. Armenia is geographically prone to such disasters, and its water security is frequently threatened.

It can thus be concluded that water security is a multidimensional issue with influence over a broad range of subjects, including agriculture, food security, economy and humanitarian security. During times of disaster or insecurity related to outside countries, not only water is affected, but also all of the above issues. Water insecurity attributable to external variables can have significant consequences for both states and citizens in the form of food insecurity; unsustainable socio-economic development; humanitarian problems, such as inability to maintain protection against water-borne pollution and water-related disasters; unfavorable conditions for ecosystems and human well-being. More specifically in the Armenian case, water security has a direct impact on energy security, given its ability to meet its needs from domestic resources, resulting in a high reliance on hydropower, as a result of which, water

security becomes more important than ever. Energy security is analyzed more comprehensively in the following section.

Energy security in Armenia

The concept of energy security is defined by the International Energy Agency (IEA) as "the uninterrupted availability of energy sources at an affordable price". According to the IEA, energy security has several aspects (IEA, 2019): "Long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. Short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance". More simply (Hettiarachchi & Kshourad, 2019, p. 165), it refers to: "Reliable and affordable energy services for cooking, heating, lighting, communications and other productive uses". Among the dozens of different conceptualizations or terminologies used, these definitions are sufficient to explain what energy security is and deals with. Natural gas, as Armenia's primary source of energy, account for almost 60 percent of the total, while nuclear power provides 22 percent and hydropower around 10 percent (IAEA, 2019). Regarding electricity in Armenia, nearly 40 percent is provided by thermal power plants, 30 percent by hydroelectric power plants and approximately 30 percent by nuclear power plants (IAEA, 2019). In more detail, its thermal power plants have an annual capacity of 2.43-gigawatt electrical (GWe) and produce around 3.4 billion kWh electricity (IAEA, 2019). On the other side, hydropower has a total capacity of 1.33 GWe and supplies nearly 2.4 billion kWh each year (IAEA, 2019). Finally, nuclear reactors have a 0.38 GWe capacity and produce the nearly same amount as hydropower, though with less capacity (IAEA, 2019).

Having looked at Armenia's energy picture, some problematic circumstances have emerged in interdependent aspects, namely supply shortages, reliability of resources and refundable prices (ITA, 2019). With regard to the energy security definition provided above, Armenia faces serious challenges to security. To begin with, its dependence on foreign resources draws primary attention. More specifically, since it lacks any proven oil or natural gas reserves, three-quarters of the total energy demand in the country is met through imports of oil and natural gas (IAEA, 2019). Furthermore, it has very limited coal deposits and has no production. The supply problem related to Armenia's foreign resource dependency often emerges as a problem for Armenia. Electricity generation is on the other side of the coin. Even though nuclear power plants provide a high percentage of the total electricity, the fuel is imported from Russia. Moreover, thermal power plants and the necessary natural resources required to operate also fall under the same foreign resource-dependent and insecure circumstances. Georgia, Iran, Europe, and Russia are Armenia's most prominent energy import partners.

Reliable resources and prices, just like the supply shortage issue, are influenced by the nation's foreign resources dependency. As such, Armenian authorities are keen to close old-generation nuclear power plants rather than extending their lifespan (ITA, 2019), seeking more reliable and affordable electricity, and being unwilling to pay million dollars only for an extension. A significant point that should be underlined here related to thermal power plants is that Armenia is not only dependent on external countries due to its lack of resources, as two out of the three companies operating these plants are of foreign origin or operated with foreign capital. For instance, the Hrazdan Energy Company, owned by the Federal Agency for State Property Management (*Росимущество*, *Rosimushchestvo*)

operates the Hrazdan Thermal Power Plant, which has one of the most significant capacities with 1100 MW (nearly half of the total capacity) in the country (Hrazdan Energy Company, n.d.; ITA, 2019). It operates in smaller numbers than the Yerevan TPC, which also controls the market and electricity transfers, but having foreign capital-based companies in the energy sector of such sizes is a potential threat to energy security (ITA, 2019). Protests in Yerevan in 2015 in which 2000 people took to the streets to demonstrate against the electricity tariffs had a connection with the Russian influence, if not dominance, on the Armenian energy sector (Demytrie, 2015; Avedissian, 2015) which stand as a solid proof of Armenia's foreign resource dependency.

As a result of the above, Armenia's primary goal is to develop its domestic energy resources (particularly renewable energy), followed by the replacement of the existing nuclear reactors. At the same time, it is looking at ways to enhance its energy efficiency as a further means of contributing to energy security. To this end, several laws have been enacted, including the Law on Energy (IEA, 2012), which addresses inter-agency relations in the energy sector, and under the same law, the importance given to renewable energy has been increased. The Law also details a purchase guarantee for all electricity generated from renewable energy sources (ITA, 2019; Energy Community, 2017, p. 24), from which the state's desire to encourage renewable energy production can be clearly understood.

Renewable energy resources, primarily hydropower, may be seen as the most significant and reliable solution for the nation's energy security, although its acknowledgment as the solution is a highly controversial topic. Indeed, the most advanced renewable energy technologies in Armenia can be found in the hydropower sector, which has a total capacity of 1.33 GW (The Ministry of Energy Infrastructures and Natural Resources of

the Republic of Armenia, n.d.). The Hrazdan and Vorotan rivers are hosts to 10 power plants that generate the majority of the country's hydroelectric power (The Ministry of Energy Infrastructures and Natural Resources of the Republic of Armenia, n.d.). The Sevan-Hrazdan cascade comprises seven power plants with a total capacity of 560 MW that are designed to generate 2.3 billion kWh electricity – being the Sevan (34 MW), Hrazdan (81 MW), Argel (224 MW), Arzni (70 MW), Kanaker (102 MW), Yerevan-1 (44 MW) and Yerevan-3 (5 MW) hydropower plants (HPPs). The Vorotan cascade, on the other hand, comprises three power plants, featuring the Spandaryan (76 MW), Shamb (171 MW) and Tatev (157 MW) hydropower plants, with a total capacity of 404 MW. In addition to these, there are 187 smaller hydropower plants with a total capacity of 370 MW.

The country has been supplying more than one-third of its total electricity demands through HPPs, and almost three-quarters of the total renewable energy are produced by hydropower. Armenia's current hydroelectric generation capacity is around 1,325 MW. While the potential water energy resources of Armenia amount to 21.8 billion kWh, the total electricity generation in 2018 was 2 billion kWh (The Ministry of Energy Infrastructures and Natural Resources of the Republic of Armenia, n.d.), indicating that the potential is far beyond the current generation, and so production may be enhanced to close the gap between the potential and actual generation.

This gap is why this topic is controversial in terms of the solution. Armenia's geography and topography prevent the nation from utilizing its full capacity. Furthermore, the annual flow of the rivers, precipitation and weather conditions directly affect the amount of electricity that can be generated, being an inevitable environmental effect. Moreover, natural disasters such as floods and drought can also have unpredictable impacts on

hydroelectric power plants and their production process. Independent from the hydroelectric power plants, these are regarded as the general cons of renewable energy resources, and the picture would not change if there were greater reliance on solar or wind power.

Overall, none of the primary energy or electricity resources of Armenia can be categorized as domestic or national, except hydropower, and the foreign dependency and external influence over the energy sector threaten energy security. Hydropower in this respect stands as the only domestic resource that could reduce the influence of foreign states. However, the water resources that hydropower in Armenia relies on are mostly fed by transboundary rivers, making them prone to the external effects of nature. Nature itself determines the water flow, and consequently, the amount of electricity. In some seasons, due to the effects of precipitation and temperature, these plants may even become inoperable, and so relying on hydropower for energy security can be dangerous considering the increasing demand. Armenia's geography and political relations also prevent a diversification of its energy supply, meaning that it has little opportunity to ensure its energy security.

Conclusion

Water security is considered indispensable due to its multidimensional nature. It is the main determinant of food security, agriculture, sustainable development, energy security, humanitarian security, sanitation, and beyond all, life itself, and all of these aspects are interdependent. An absence of water security can have a fundamental impact on survival, and so is a priority for countries.

With the dissolution of the Soviet Union, the water security issue gained greater prominence, as what were once Soviet resources became transboundary. Just like the other regional

nations, Armenia was left with no laws or regulations related to the sharing of water resources, which thus became an obstacle standing in the way of regional cooperation and the assurance of water security. Looking at Armenia's water resources and the annual flow rates, one may understand that it has no concerns whatsoever regarding water security, although two factors must be taken into account, being the shared status of all of its water resources, and the threat of natural disaster or environmental impacts. The absence of a proper, functioning regime related to water usage clearly makes Armenian water security vulnerable, given the potential for conflicts over the share of water or clashes that have consequences on water security. This issue is exacerbated by the suitability of the geography for natural disasters, which makes the situation even more complex.

For Armenia, beyond its survival, food, humanitarian, developmental and agricultural needs, the energy sector is also heavily dependent on water security, since the majority of its electricity is generated from hydropower. In the event of any decrease or uncertainty in its access to water, the country could find itself in a chaotic situation, with the potential to turn into catastrophes of different extents that could be extremely expensive for Armenia. To conclude, Armenia's water security is extremely vulnerable to threats, and its insecurity in this area makes the topic of energy security even more important. It would thus be fair to say that the global significance of water is double for Armenia.

References

Avedissian, K. (2015). The power of Electric Yerevan. *Opendemocracy*, July 6, 2015. https://www.opendemocracy.net/en/odr/electrified-yerevan/

Bakhtiari, F. (2019). Armenia should be more responsible for polluting Aras River. *Tehran Times*, November 23, 2019.

Demytrie, R. (2015). Armenia energy protests: Electric atmosphere in Yerevan. *BBC News*, June 26, 2015.

ECC. (n.d). Turkey-Armenia: Water Cooperation Despite Tensions. https://library.ecc-platform.org/conflicts/turkey-armenia-water-cooperation-despite-tensions#:~:text=In%20order%20to%20manage%20the,basis%20(FAO%2C%202015).

Energy Community. (2017). Energy Governance in Armenia: Policy Recommendations. https://www.energy-community.org/dam/jcr:9c299341-9f78-4f38-9bee-f78d3c7a1355/ECS_Armenia_072017.pdf

Falkenmark, M, Lundquist, I., & Widstrand, C. (1989). Macro-scale Water Scarcity Requires Micro-scale Approaches: Aspects of Vulnerability in Semi-arid Development, *Natural Resources Forum 13* (4), 258-267.

FAO. (2009). Transboundary River Basin Overview – Kura Araks. Accessed March 3, 2020. http://www.fao.org/3/ca2130en/CA2130EN.pdf

FAO. (2016). Armenia: Water Resources. http://www.fao.org/nr/water/aquastat/countries_regions/Profile_segments/ARM-WR_eng.stm

Güler, M. Ç. (2018). What is the role of Hydro- Politics in the Geopolitics of Central Asia. *International Journal of Russian Studies* 7(1), 53-68.

Gültekin, B. (2010). The Ongoing Official Contacts and Cooperation on the Turkish-Armenian Border: The Impossibility for Neighbours to Elude Geography. https://www.tepav.org.tr/upload/files/1284539365-7.The_On_going_Official_Contacts_and_Cooperation_on_the_Turkish_Armenian_Border.pdf

GPF. (n.d.). Armenian-Azerbaijani Water Politics. https://www.globalpolicy.org/the-dark-side-of-natural-resources-st/water-in-conflict/49597-armenian-azerbaijani-water-politics.html

Hettiarachchi, H. & Kshourad, C. (2019). Promoting Waste-to-Energy: Nexus Thinking, Policy Instruments, and Implications for the Environment. In Sunil Kumar, et al. (eds.) *Current Developments in Biotechnology and Bioengineering: Waste Treatment Processes for Energy Generation*, (pp. 163-184). Oxford: Elsevier.

Hrazdan Energy Company. (n.d.). History of the Company. https://www.raztes.am/eng/history/

IAEA. (2019). Country Nuclear Power Profiles: Armenia. https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2019/countryprofiles/Armenia/Armenia.htm

IEA. (2012). Energy Law of the Republic of Armenia. https://www.iea.org/policies/5255-energy-law-of-the-republic-of-armenia

IEA. (2019). Energy security Ensuring the uninterrupted availability of energy sources at an affordable price. https://www.iea.org/areas-of-work/ensuring-energy-security

ITA. (2019). Armenia - Energy Sector. https://www.export.gov/apex/article2?id=Armenia-energy-sector

Oki, T & Kanae, S. (2006). Global Hydrological Cycles and World Water Resources. *Science 313*(5790), 1068-1072. https://doi.org/10.1126/science.1128845.

Shikhali, I. & Safarova, D. (2016) Azerbaijan: Can a Water Reservoir Help Resolve the Karabakh Conflict?. https://eurasianet.org/azerbaijan-can-a-water-reservoir-help-resolve-the-karabakh-conflict

Shiklomanov, I. (1993). World fresh water resources. In Peter H. Gleick (ed.) *Water in Crisis: A Guide to the World's Fresh Water Resources* (pp. 13-25). New York: Oxford University Press.

Swain, A. (2004). *Managing Water Conflict: Asia, Africa and the Middle East*. London: Routledge.

The Ministry of Energy Infrastructures and Natural Resources of the Republic of Armenia. n.d. Hydroenergy. http://www.minenergy.am/en/page/448

Ubilava, M. (n.d.). Water Management in South Caucasus. http://www.feem-web.it/transcat_conf/conf_papers/Ubilava.pdf

UN-Water. (2013). Water Security & the Global Water Agenda: A UN-Water Analytical Brief. https://www.unwater.org/publications/water-security-global-water-agenda/.

UN-Water. (n.d.). Transboundary Waters. https://www.unwater.org/water-facts/transboundary-waters/.

World Bank. (2017). Disaster Risk Finance Country Note: Armenia. http://documents1.worldbank.org/curated/en/316831526641378244/pdf/Armenia-Disaster-Risk-Finance-Country-Note.pdf

World Bank. (2018). Armenia Takes Important Steps Toward a Disaster Resilient Future. https://www.worldbank.org/en/news/feature/2018/08/08/armenia-takes-important-steps-toward-a-disaster-resilient-future

PART III

REGIONAL LEVEL OF ANALYSIS

Chapter 5

The Review of The Water-Electricity Generation Conflicts in Central Asia: The Case of Rogun Dam

Oktay F. Tanrisever, Halil Burak Sakal

Introduction

This chapter explores the potential contributions of peace science to the hydropolitical conflicts in Central Asia by focusing on the case of the Rogun Dam conflict between Tajikistan and Uzbekistan. More specifically, it seeks to identify the opportunity structures available to the conflicting parties, using a mixed methodology involving quantitative and qualitative data on hydropower and water resources for agricultural use, as well as the relevant countries' policy options and peaceful settlement alternatives.

Existing literature on water conflicts focuses mainly on water scarcity in assessing the risk of water-related conflicts between riparian nations in transboundary river basins. More recently, the number of studies combining physical and human-related indicators in analyses of the potential risks of hydropolitical conflicts has increased. As the anthropogenic impact on natural resources increases, water scarcity has emerged as one of the most severe issues around the world, especially in major transboundary river basins such as Colorado in the southwest of North America, the Nile in Northeast Africa, the Brahmaputra in South Asia, or the Mekong in Southeast Asia. There have also been studies and research projects evaluating water

scarcity in the shared river basins around the globe, although most have ignored the political and economic aspects of the issue. Being based on hydraulic data, these studies often reach a *normative* conclusion that water resources should be shared equally among the riparians to overcome water scarcity.

Existing literature fails to consider the human and political factors in the issue, as these aspects have not been appropriately quantified. Not only water data, but also energy data should be included in the proposed models. As these data on the water-energy nexus are often missing, current literature is unable to contribute to peace science studies. Unlike most of the studies in existing literature, the present study takes a different approach to water-related peace science studies, embracing a scientific and objective approach that takes into consideration quantifiable data on the political and economic aspects of the water and energy nexus. In doing so, this study aims to reach a solution-oriented rather than resource-oriented conclusion.

Transboundary rivers are essential items on the agenda of international politics. Politicians usually see the rivers as objects of sovereignty for nation-states. As a natural resource, water is a means of development, and in most cases, water management and allocation policies impact economic growth (Ho, 2017, p. 98). Previous studies have focused primarily on the relationship between transboundary rivers and interstate conflict, under the influence of political realism, and this is closely related to the Malthusian and neo-Malthusian approaches (Mellos, 1988) to interstate conflict (Furlong, Gleditsch & Hegre, 2006; Gizelis & Wooden, 2010, p. 444; Homer-Dixon, 1991; Selby, 2003). These approaches consider dyadic relationships in shared river basins as competition for scarce resources. Environment, water and climate are among the primary topics of interest in security studies (Gleick, 1993, p. 81; Yoffe et al., 2004, p. 2), and a significant

proportion of this body of literature is focused on water scarcity (Johnson et al., 2010; Johnson et al., 2011).

Water scarcity

"Water scarcity" is defined in technical terms as a situation in which "local precipitation [in a region or a state] is insufficient to meet needs", and in which states must rely on "external water resources, both physical and virtual" (Munia et al., 2017, p. 1). That said, water scarcity is also a politically and socially "constructed" concept (Arsel & Spoor, 2010, p. 9). There have been studies investigating the risk of water scarcity over a wider geography around the world, affecting more than 4 billion people (Mekonnen & Hoekstra, 2016). According to some authors, global water problems may lead to water-induced conflicts, especially in the water-scarce regions of the world (Falkenmark, 1990, pp. 177-179). The scarcity of water may also have impacts on economies, with the potential to exacerbate water-related conflicts (World Bank, 2016), though water conflicts usually take the form of economic or verbal confrontations rather than military campaigns (Petersen-Perlman, Veilleux & Wolf, 2017).

Some researchers contend that water scarcity increases the possibility of conflict in shared river basins (Gleditsch et al., 2006, p. 362; Brochmann & Gleditsch, 2012; Hensel et al., 2008; Hensel, Mitchell & Sowers, 2006), while others have reported that there is an increased risk of military dispute between countries that share a river basin (Toset, 2000; Gleditsch et al., 2006, pp. 362-363). That said, water can also contribute to warfare (Gleick, 1993, pp. 83 and 84). If a river is used for multiple purposes, the interaction between dyads increases, which may lead to an increased likelihood of conflict between them (Brochmann & Gleditsch, 2012, pp. 520). In contrast, some authors argue that "shared water does lead to tensions, threats, and even to some localized violence" (Delli Priscoli &

Wolf, 2009, p. 9). While literature generally links water with disputes, several researchers have rejected the idea of "water wars" (Menga, 2016, p. 409). It can be argued that water alone is never the sole cause of conflict (Warner & Wegerich, 2010, p. 7). Studies have also focused on the relationship between water stress in transboundary river basins and upstream water use, with upstream water use increasing the number of people living in a basin under water stress (Munia et al., 2016, p. 9).

This chapter, drawing upon quantified data related to the water and energy nexus in the Rogun Dam region, suggests that the diverse interests of the Central Asian countries in terms of their use of water resources for electricity production and agriculture set them against each other in a conflictual relationship. Such a situation is clearly apparent in the case of the Rogun Dam conflict between Tajikistan and Uzbekistan. The chapter argues that the changes in Uzbekistan's approach to this conflict, from being conflictual to more conciliatory, can be attributed to the scientific approaches, data analysis and quantitative methodologies.

This chapter contributes to the literature in its approach to the concepts of political science and environmental economics, drawing upon the content of various databases. The chapter derives water scarcity data from the AQUEDUCT database of the World Resources Institute, while the Transboundary Waters Assessment Programme of the Global Environmental Facility is accessed for human water stress, agricultural water stress, ecosystem impacts from dams, economic dependence on water resources, and environmental and legal framework data. Hydropower data is garnered from the International Renewable Energy Agency's Renewable Electricity Capacity and Generation Statistics as well as from the International Energy Agency. Agricultural data are accessed from the Food and Agriculture Organization of the United Nations FAOSTAT database.

More specifically, the International Cotton Advisory Committee's Data Portal will be employed for the cotton agriculture data of Uzbekistan.

The chapter opens with a brief discussion of the Rogun Dam's key characteristics, after which an evaluation is made of the political and economic aspects of the Rogun Dam conflict. The chapter continues with an assessment of quantitative energy and electricity supply data, and demand in the Amu Darya Basin, and evaluates the quantified water stress indicators. The chapter then makes projections about the future of the hydropolitical relationship between Uzbekistan and Tajikistan before presenting its conclusions.

Key characteristics of the Rogun Dam project and its objectives

The Rogun Dam project lies on the Vakhsh tributary of the Amu Darya in Tajikistan, around 110 kilometers east of Dushanbe. The Nurek Dam, which has been in operation since 1980, is the tallest concrete dam globally and is located 70 kilometers downstream of the Rogun Dam site (Pöyry Energy, 2014).

Construction of the Rogun Dam began in the Soviet era, but the process was halted after the dissolution of the Soviet Union in 1991 due to financing problems. The decision to restart the construction of the dam was taken in 2008, but once again, financing was a significant issue. In 2014, the World Bank carried out a feasibility study considering the technical and economic, as well as environmental and social impacts of the project (World Bank, 2014). According to the feasibility report, prepared by Pöyry Energy of Switzerland, the need for winter electricity in Tajikistan was the main driver of the dam project, as electricity demand in the winter exceeds the available supply by 25 percent in the country (Pöyry Energy, 2014). The other goals of the dam project are as follows:

- *Downstream flow regulation*: The additional storage capacity provided by Rogun Dam would resolve the shortage of the water problem at the downstream Nurek Dam.
- *Electricity trade*: The excess electricity produced by the dam can be exported to Pakistan and Afghanistan.
- *Flood protection*: Rogun Dam will protect the Nurek Dam from the effects of floods.
- *Sedimentation*: Rogun Dam will extend the economic life of Nurek Dam by holding back sediment (Pöyry Energy, 2014).

Figure 1. The Vakhsh River Basin and the Rogun Dam.
Source: ENR, 2016.

Rogun Dam is planned for construction on the Vakhsh River, the longest river in Tajikistan and a major tributary of Amu Darya (Figure 1). Amu Darya is the largest river in Central Asia and in the Aral Sea Basin, in which there are two major rivers, Amu Darya and Syr Darya. The Aral Sea Basin covers a total of 1.76 million square kilometers (AQUASTAT, 2012, p. 1), and contains Kyrgyzstan and Tajikistan – the basin's water-rich countries – while Uzbekistan, Kazakhstan and

Turkmenistan are the main consumers of the basin's waters. It is calculated that Kyrgyzstan and Tajikistan "potentially control about 68 percent of the total water flow in the Aral Sea Basin" (Jalilov, DeSutter, & Leitch, 2011, p. 161).

The basin of the Amu Darya covers 1,023,610 square kilometers, of which Uzbekistan holds 364,630 square kilometers (including the Zarafshan Basin) of land, accounting for 81.5 percent of the total surface area of the country (AQUASTAT, 2012, p. 1). Amu Darya is mainly fed from Tajikistan (59.45 cubic kilometers), with 76 percent of the total flow (78.46 cubic kilometers), while Uzbekistan contributes only 5 percent to the total runoff (AQUASTAT, 2012, p. 5). The Vakhsh River is the second biggest tributary of the Amu Darya and contributes about 27 percent to the total runoff of the river (Jalilov, DeSutter, & Leitch, 2011, p. 161). As such, the river and the dam project are of great significance for Uzbekistan.

Figure 2. Aral Sea Basin land use.
Source: FAO, 2012, p. 2.

Political and economic aspects of the conflict over Rogun Dam

The rural population of Central Asia is typically engaged in agricultural activities. Agriculture relies heavily on irrigation, with almost 90 percent of all crops produced being in need (AQUASTAT, 2012, pp. 7-8). In the Aral Sea Basin, about 32.6 million hectares of land are cultivable, of which around 9.76 million hectares are "equipped for irrigation", nearly half of which lies within the borders of Uzbekistan (4.20 million hectares). For the Amu Darya Basin in particular, the total estimated cultivable land is about 6 million hectares, some 1.7–2.3 million hectares of which is in Uzbekistan (Jalilov, DeSutter, & Leitch, 2011, p. 162; AQUASTAT, 2012, p. 8).

Uzbekistan uses about 28 cubic kilometers of Amu Darya water for irrigation annually (Jalilov, DeSutter, & Leitch, 2011, p. 162). Under international agreements, the water of Amu Darya is shared equally by Turkmenistan and Uzbekistan, based on the measured water volume at the Kerki gauging station – the start point of the huge Kara Kum Canal, based on a bilateral agreement signed in January 1996 between the two countries (supplementary to the 1992 agreement signed by the five Central Asian states) (CIS Legislation, 1996, s. art.6). A protocol signed during the Soviet era in 1987 allocated around 48 percent of the total Amu Darya water to Uzbekistan, observed by the basin water organization that was established in 1986 (Menga, 2017). Table 1 shows the water allocation among the Amu Darya Basin countries. As mentioned by Maknoon et al., similar to many other international water allocation agreements, these regulations "do not take into account the hydrologic variability of the river flow" (2012, p. 751), despite the seasonal variability of water flow being a crucial issue for Uzbekistan, since the agriculture sector of Uzbekistan depends on the seasonal water flows from upstream countries.

Table 1. Water allocation (cubic kilometers) by country in the Amu Darya Basin

	Tajikistan	Kyrgyzstan	Uzbekistan	Turkmenistan	Total
Average water allocated under	8.845	0.216	21.378	20.96	51.4
Protocol 566[1]	9.5	0.4	29.6	22	61.5

Source: Ahmad & Wasiq, 2004; Menga, 2017.

In practice, Tajikistan uses around 83 percent of its share on average, while Uzbekistan and Turkmenistan use most of their limits, and often exceed their share of allocated water (Table 2). As can be seen in Figure 3, Tajikistan obtains 6.6 cubic kilometers of water from the Vakhsh River, while 21.69 cubic kilometers are used by Uzbekistan (excluding the Zarafshan waters) for irrigation. Of this amount, 4.19 cubic kilometers is used around Karshi, 5.2 cubic kilometers around Zarafshan, 4.4 cubic kilometers around Horezm, and 7.9 cubic kilometers in Karakalpakstan (Figure 3). This agricultural activity mostly withdraws water during the vegetation season, from April to October (Pöyry Energy, 2014, p. 76).

Table 2. The actual proportion of allocated volumes used by countries (%)

	Tajikistan	Kyrgyzstan	Uzbekistan	Turkmenistan
Minimum	67.6	1.8	68.3	74.8
Average	82.8	51.9	94.7	92.9
Maximum	91.4	100	105.8	101.4

Source: Based on BVO data, excerpt from the report of Pöyry Energy (2014, p. 92).

1 Protocol 566: Improvement of the Scheme on the Complex Use and Protection of Amu Darya Water Resources by the Scientific and Technical Council, Ministry of Land Reclamation and Water Management, USSR, September 10, 1987.

The fact that the upstream dams in Tajikistan hold water in the summer season for the generation of electricity in the winter when it is most needed may impact the agricultural activity in Uzbekistan. The main reason for the political and economic dispute is the conflicting seasonality of water use in the Amu Darya Basin.

Figure 3. Use of water resources in the Aral Sea Basin. Source: Cawater-info.net, 2017.

Energy aspects of the conflict over the Rogun Dam

Another important aspect of the conflict over the Rogun Dam between Uzbekistan and Tajikistan is its potential use for energy and electricity generation. According to the International Renewable Energy Agency (IRENA), the total renewable energy capacity of Tajikistan was 5,632 megawatts as of 2018, all of which come from hydropower sources (IRENA, 2019, p. 10).

The total renewable electricity generating capacity of Tajikistan is three times that of Uzbekistan (Table 3).

Table 3. Total renewable energy capacity of Tajikistan and Uzbekistan

Capacity (MW)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tajikistan	4,803	4,802	4,809	4,811	4,814	5,035	5,033	5,039	5,039	5,632
Uzbekistan	1,630	1,746	1,746	1,746	1,747	1,762	1,762	1,796	1,843	1,858

Source: IRENA, 2019, p. 3.

In terms of electricity generation, Tajikistan generates 100 percent more electricity than Uzbekistan from renewable resources. Tajikistan's renewable energy production increased from 15,900 GWh in 2019 to 17,312 GWh in 2017 (Table 4), all of which came from hydropower resources (IRENA, 2019, p. 11).

Table 4. Total renewable energy production of Tajikistan and Uzbekistan

Production (GWh)	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tajikistan	15,900	16,400	16,200	16,900	17,071	16,312	16,900	16,803	17,312
Uzbekistan	9,330	8,100	8,100	8,100	8,102	8,102	8,102	8,015	8,015

Source: IRENA, 2019, p. 5.

In feasibility studies, three alternative projects have been evaluated with different dam heights and different storage and hydropower generation capacities: the first is 265 meters high and has an active reservoir capacity of 3.93 cubic kilometers; the second is 300 meters high and has a reservoir capacity of 6.45 cubic kilometers; and the third is 335 meters high, with a reservoir capacity of 13.3 cubic kilometers, with filling periods of 10, 12 and 14 years, respectively. The final assessment by the World Bank found all alternatives to be economically viable (Pöyry Energy, 2014, pp. 349-350). The third alternative, the so-called FSL1290, would have an installed capacity

of 3,200 megawatts and features the highest "total system cost savings", and with a "net present value" of US$795 million, it is the most feasible alternative (Pöyry Energy, 2014, p. 350).

The feasibility study found the FSL1290 alternative to have the "potential to reduce the average Vakhsh summer flow to 2.0 [cubic kilometers]" (Pöyry Energy, 2014, p. 357). The effects on the riparian countries with this alternative are highest, having the potential to change "the Vakhsh flow pattern affecting downstream water users" (Pöyry Energy, 2014, p. 360). The study thus confirms the concerns of the government of Uzbekistan on the amount of water Uzbekistan needs during the vegetation period.

Water stress aspect of the conflict over Rogun Dam

Water stress indicators have been calculated by some international projects based on the amount of water in the Amu Darya Basin. The third factor that this chapter addresses is the quantified water stress data related to the transboundary Amu Darya Basin. According to the Global Environmental Facility's Transboundary Waters Assessment Programme (GEF-TWAP) database, the Aral Sea Basin is graded 4/5 in terms of human water stress. The highest human water stress indicator (5 out of 5) is recorded in the downstream countries, Uzbekistan and Turkmenistan.

Human water stress is described by the GEF-TWAP as follows:

> [The human water stress] indicator deals with the quantity of water available per person per year relative to the internal and upstream area water supplies, on the premise that the less water available per person, the greater the impact on human development and well-being, and the less water there is available for other sectors. Water benefits must be defined not only by the locally generated runoff but also by

> remote runoff transported horizontally through river corridors as discharge often across international borders. Along the way the supply can be withdrawn, depleted, redirected, and/or polluted, thus setting-up constraints on the accessible water resource system or potential for human water stress. Two (sub)indicators of human water stress were constructed to address the different facets of water supply and water use/withdrawals: a) Renewable Water Supply; b) Relative Water Use (GEF-TWAP, 2016).

Renewable water supply refers to the ratio of the internal water supplies available to the basin country unit (BCU), which means the proportion of the country within the river basin within the total population in the BCU. If the result of this computation is between 500 and 1,000 cubic meters per person per year, the relative risk is graded high. If the internal water supplies are lower than 500 cubic meters per person per year, then the risk is graded "very high". Uzbekistan and Turkmenistan both fall within the latter category (GEF-TWAP, 2016) (Table 5).

It can thus be understood that the downstream countries rely heavily on the upstream countries for water for domestic use and irrigation. On the other hand, both Tajikistan and Uzbekistan depend on their water resources for their economy, with Tajikistan needing water for hydropower generation and export, while Uzbekistan needs it for its agricultural production, which is heavily dependent on irrigation (Table 5).

Table 5. GEF-TWAP risk assessment for the Aral Sea Basin

	Human water stress	Agricultural water stress	Economic dependence on water resources
Tajikistan	3	3	5
Turkmenistan	5	5	3
Uzbekistan	5	5	5

Source: GEF-TWAP, 2016.

The AQUEDUCT database produces similar results, suggesting that "baseline water stress" is high in Uzbekistan, and extremely high in Turkmenistan, while Tajikistan is given a medium ranking. The WRI defines baseline water stress as follows:

Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and non-consumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users (AQUEDUCT, 2019) (Table 6).

Table 6. AQUEDUCT classification and ranking of baseline water stress for the Amu Darya Basin countries

Country	score	rank	Situation
Turkmenistan	4,04	15	Extremely High (>80%)
Uzbekistan	3.82	25	High (40-80%)
Tajikistan	2.65	51	Medium–High (20-40%)

Source: AQUEDUCT, 2019.

The baseline water stress can be evaluated more in detail using the AQUEDUCT database. Figure 4 shows the baseline water stress scores of the individual regions of Uzbekistan.

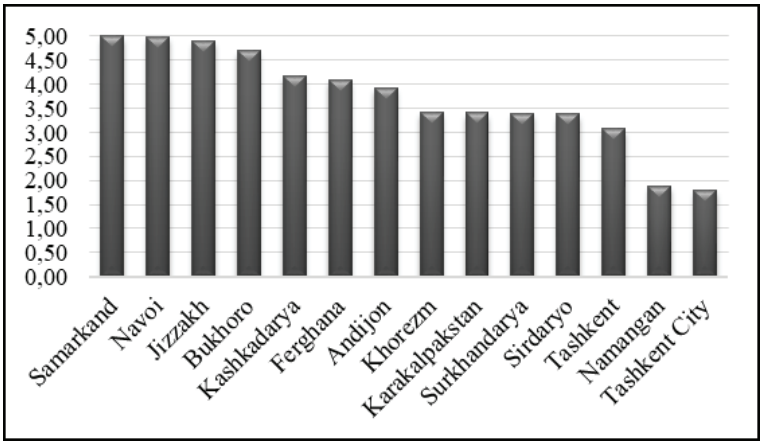

Figure 4. Baseline water stress in the regions of Uzbekistan.
Source: AQUEDUCT, 2019.

Projections of the possible impacts of Rogun Dam

In this section, projections are made of the possible impacts of the Rogun Dam project on the economy, water use and agriculture in the downstream countries. All the projections presented and discussed here are based on official assessments. First, the situation without the construction of Rogun Dam will be assessed. The results of the official calculations and projections are presented in Table 7. According to the data, water consumption in an average year is highest in the downstream countries, namely Uzbekistan and Turkmenistan, which have wide areas of land suitable for irrigated agriculture, and most of their water is used for irrigation. In dry years there is a significant water deficit amounting to around 12.28 cubic kilometers, mostly in Uzbekistan, meaning that the country needs to store large quantities of water for its agricultural activities in the dry years. The area lost due to a lack of irrigation amounts to 342,655 hectares (Table 7) (Pöyry Energy, 2014, p. 326).

In the future, under the impact of the increasing population, the growing economies and the worsening effects of climate change, this situation will change. Water consumption in the Amu Darya Basin will increase from 59.28 cubic kilometers to around 67.50 cubic kilometers per year, and there will also be a slight increase in Uzbekistan's already high water consumption. The dry years will most probably be drier, and the water deficit of Uzbekistan will increase from its current 5.83 cubic kilometers in dry years to 8.99 cubic kilometers, which corresponds to a 54.2 percent increase. This increase will be translated into a loss of even more irrigated areas in the dry years, and it has been estimated that Uzbekistan's loss in dry years will be 528,802 hectares per year in the future (Pöyry Energy, 2014, p. 326).

Table 7. Water consumption and deficit for the Amu Darya countries (without Rogun)

	Water consumption			Irrigation		
	Average year (km³/ year)	**Dry year (km³/ year)**	**Deficit in dry year (km³/ year)**	**Water needed (m³/ha)**	**Area irrigated (ha)**	**Loss in dry year (ha)**
Current situation						
Tajikistan	7.89	6.26	1.63	15,780	500,000	103,576
Afghanistan	2.50	1.98	0.52	13,000	192,308	39,837
Uzbekistan	28.12	22.29	5.83	17,000	1,654,118	342,655
Kyrgyzstan	0.21	0.17	0.04	13,000	16,154	3,346
Turkmenistan	20.56	16.30	4.26	17,000	1,209,412	250,533
Total	59.28	47.00	12.28		3,571,992	739,947
Total flow	75.00	47.00				
Surplus/ deficit	15.72	-12.28				
Percent of total runoff	126.5%	79.3%				**20,7%**
Future projections						
Tajikistan	9.50	6.61	2.89	15,780	602,028	182,838
Afghanistan	6.00	4.18	1.82	13,000	461,538	140,171
Uzbekistan	29.60	20.61	8.99	17,000	1,741,176	528,802
Kyrgyzstan	0.40	0.28	0.12	13,000	30,469	9,345
Turkmenistan	22.00	15.32	6.68	17,000	1,294,118	393,028
Total	67.50	47.00	20.50		4,129,329	1,254,184
Total flow	75.00	47.00				
Surplus/ deficit	7.50	-20.50				
Percent of total runoff	111.1%	69.6%				**30,4%**

Source: Based on Pöyry Energy, 2014, p. 326.

It should be reiterated here that this scenario assumes that Rogun Dam will remain unconstructed on Vakhsh River,

although Rogun Dam would not have a major impact on the already alarming water deficit situation in Central Asia, as shown in the feasibility study (Pöyry Energy, 2014, pp. 328-329).

The main point to be noted here is that Rogun Dam would shift

> additional water from summer to winter, which would reduce water availability for irrigation. […] On the other hand, Rogun has the potential, not for compensating totally the water deficit in an exceptionally dry year, but at least for providing additional water in such a case for minimizing the damage caused otherwise (Pöyry Energy, 2014, p. 328).

There would be a further negative impact on the economic activities of Uzbekistan if Rogun Dam is operated in the same way as Nurek Dam. The Nurek Dam uses its live storage in the winter season and gathers water in the summer, which is the vegetation period for Uzbek agricultural products (Pöyry Energy, 2014, p. 328). There is no evidence, however, that Rogun Dam is intended to be used in a similar way to Nurek Dam. "[I]n compliance with current agreements and practices, the intended mode of operation of Rogun HPP does not entail any change in the summer release pattern" (Pöyry Energy, 2014, p. 328).

Hydropolitics and prospects for the peaceful settlement of the Rogun Dam conflict

In this chapter, we evaluate the Rogun Dam conflict from a hydropolitical perspective, drawing upon the data explored in the previous sections. The government of Uzbekistan clearly opposes the construction of the Rogun Dam, as is evident in official documents published by the Ministry of Foreign Affairs of the Republic of Uzbekistan. A press release dated 3 August, 2015 published on the official website of the Uzbek Ministry of

Foreign Affairs states that "the Rogun Hydropower Plant will cost Uzbekistan US$600 million annually in agriculture alone, reducing the country's GDP by 2 percent and making at least 340,000 of its citizens jobless" (Ministry of Foreign Affairs of Uzbekistan, 2015).

The concerns of Uzbekistan related to Rogun Dam have been detailed in the literature, in which some studies argue that Rogun Dam would reduce the flow in the summer season by 8.6 cubic kilometers, corresponding to a loss of about 506,000 hectares of land per year (Jalilov, DeSutter, & Leitch, 2011) and an 11 percent loss in Uzbekistan's total irrigated landmass (Ministry of Foreign Affairs of Uzbekistan, 2015). Despite the recent change of leadership in Uzbekistan and the more accommodative attitude of the incumbent president towards its neighbors, the abovementioned statement still adorns the website of the Ministry of the Foreign Affairs of Uzbekistan, which means that the government is maintaining its official position on the issue (Sakal, 2015; 2017; Tanrısever & Sakal, 2017).

The feasibility study found further that a loss of 1.2 cubic kilometers of annual water flow will be experienced downstream. Nevertheless, this lost amount of water is part of Tajikistan's annual share, which was mentioned in the abovementioned agreements. Currently, Tajikistan does not make full use of its allocated share, although Tajik water use is likely to increase, and another increase may occur in the future linked to Afghanistan's increasing demand for water (Pöyry Energy, 2014, p. 328).

All these issues related to the management of transboundary water have the potential to lead to interstate conflict in the Aral Sea Basin. However, according to the Transboundary Clean water Dispute Database of Oregon State University, no significant water conflict exists between Uzbekistan and Tajikistan in their history. The database shows only one water event that

scored "-1" on the "Basins at Risk" scale after 2008, the year it was decided the construction of Rogun Dam would be continued. This means that the number and severity of the water-related conflicts between these two countries are not as severe as they may first appear (TFDD, 2019). Another reason for this may be that the dyadic hydropolitical relations are not adequately quantified to help social scientists to interpret hydropolitical issues using relevant data.

Conclusion

Existing literature has emphasized the water scarcity aspect of transboundary water disputes between the riparians in a shared watershed containing important rivers. This scarcity aspect is based on the principle of "equity" and has little to say about the political aspect of the problem, although the present study argues that the political aspect of the bilateral transboundary water issues should be stressed.

To gain a proper understanding of regional hydropolitics, a more detailed quantification may be useful, and future projections are needed to clarify opportunities for conflict resolution in the Aral Sea Basin. The principle of equity is a reflection of the reinterpretation in the literature of the Malthusian scarcity approach to natural resources, and so can be considered as a normative approach to hydropolitical issues. However, as this chapter argues, the objective costs and benefits, as well as opportunities and risks, need to be emphasized to better assess the possibility of conflict and cooperation between the riparians in a shared river basin. It can thus be argued that the data analysis methods of peace science can contribute to the study of water-energy nexus problems.

References

Ahmad, M., & Wasiq, M. (2004). *Water resource development in Northern Afghanistan and its implications for Amu Darya basin*. The World Bank.

AQUASTAT. (2012). *Transboundary River Basin Overview – Aral Sea*. FAO Aquastat. http://www.fao.org/3/ca2139en/CA2139EN.pdf

AQUEDUCT. (2019). *Baseline water stress*. Water Risk Atlas. https://www.wri.org/applications/aqueduct/water-risk-atlas/

Arsel, M., & Spoor, M. (2010). Follow the Water. In M. Arsel & M. Spoor (Eds.), *Water, environmental security and sustainable rural development: Conflict and cooperation in Central Eurasia*. Routledge.

Brochmann, M., & Gleditsch, N. P. (2012). Shared Rivers and Conflict – A Reconsideration. *Political Geography*, *31*(8), 519–527. https://doi.org/10.1016/j.polgeo.2012.11.001

CA Water Info. (2020). *Water resources of the Aral Sea Basin*. Portal of Knowledge for Water and Environmental Issues in Central Asia. http://cawater-info.net/aral/index_e.htm

Agreement between the Republic of Uzbekistan and Turkmenistan on cooperation on water management questions, (1996). http://cis-legislation.com/document.fwx?rgn=25361

ENR. (2016, November 22). *Salini Impregilo Resumes Work on Tall Dam in Tajikistan*. https://www.enr.com/articles/40975-salini-impregilo-resumes-work-on-tall-dam-in-tajikistan

Falkenmark, M. (1990). Global Water Issues Confronting Humanity. *Journal of Peace Research*, *27*(2), 177–90.

FAO. (2012). *Transboundary River Basin Overview – Aral Sea*. FAO Aquastat. http://www.fao.org/3/ca2139en/CA2139EN.pdf

Furlong, K., Gleditsch, N. P., & Hegre, H. (2006). Geographic Opportunity and Neomalthusian Willingness: Boundaries, Shared Rivers, and Conflict. *International Interactions*, *32*(1), 79–108.

GEF/TWAP. (2016b). *Indicator metadata summary* (p. 81). Transboundary Waters Assessment Programme. http://twap-rivers.org/indicators/Report.ashx?type=IndicatorMetadataSummary

GEF/TWAP. (2016). *TWAP Rivers Portal—Indicators application*. http://twap-rivers.org/indicators/

Gizelis, T.-I., & Wooden, A. E. (2010). Water Resources, Institutions, and Intrastate Conflict. *Political Geography*, *29*(8), 444–453. https://doi.org/10.1016/j.polgeo.2010.10.005

Gleditsch, N. P., Furlong, K., Hegre, H., Lacina, B., & Owen, T. (2006). Conflicts Over Shared Rivers: Resource Scarcity or Fuzzy Boundaries? *Political Geography*, *25*(4), 361–382. https://doi.org/10.1016/j.polgeo.2006.02.004

Gleick, P. H. (1993). Water and Conflict: Fresh Water Resources and International Security. *International Security*, *18*(1), 79–112.

Hensel, P. R., Mitchell, S. M., & Sowers, T. E. (2006). Conflict Management of Riparian Disputes. *Political Geography*, *25*(4), 383–411. https://doi.org/10.1016/j.polgeo.2005.11.001

Hensel, P. R., Mitchell, S. M., Sowers, T. E., & Thyne, C. L. (2008). Bones of Contention: Comparing Territirial, Maritime, and River Issues. *The Journal of Conflict Resolution*, *52*(1), 117–143.

Ho, S. (2017). Introduction to 'Transboundary River Cooperation: Actors, Strategies and Impact.' *Water International*, *42*(2), 97–104.

Homer-Dixon, T. F. (1991). On the Threshold: Environmental Changes as Causes of Acute Conflict. *International Security*, *16*(2), 76–116.

IRENA. (2019). *Renewable Energy Statistics*. International Renewable Energy Agency.

Jalilov, S.-M., DeSutter, T. M., & Leitch, J. A. (2011). Impact of Rogun Dam on Downstream Uzbekistan Agriculture. *International Journal of Water Resources and Environmental Engineering*, *3*(8), 161–166.

Johnson, V., Fitzpatrick, I., Floyd, R., & Simms, A. (2011). *What is the evidence that scarcity and shocks in freshwater resources cause conflict instead of promoting collaboration?* New Economics Foundation.

Maknoon, R., Kazem, M., & Hasanzadeh, M. (2012). Inter-Basin Water Transfer Projects and Climate Change: The Role of Allocation Protocols in Economic Efficiency of the Project. Case Study: Dez to Qomrood Inter-Basin Water Transmission Project (Iran). *Journal of Water Resource and Protection*, *04*(09), 750–758. https://doi.org/10.4236/jwarp.2012.49085

Mekonnen, M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. *Science Advances*, *2*(2).

Mellos, K. (1988). Neo-Malthusian Theory. In *Perspectives on Ecology*. Palgrave Macmillan.

Menga, F. (2016). Reconceptualizing Hegemony: The Circle of Hydro-Hegemony. *Water Policy*, *18*(2), 401–418. https://doi.org/10.2166/wp.2015.063

Menga, F. (2017). *Power and Water in Central Asia*. Routledge.

Ministry of Foreign Affairs of Uzbekistan. (2015, March 8). *Press Release of the Ministry of Foreign Affairs of the Republic of Uzbekistan*. https://mfa.uz/en/press/release/2015/08/4992/

Munia, H. A., Guillaume, J., Mirumachi, N., Wada, Y., & Matti, K. (2017). How Downstream Sub-basins Depend on Upstream Inflows to Avoid Scarcity: Typology and Global Analysis of Transboundary Rivers. *Hydrology and Earth System Sciences*.

Munia, H., Guillaume, J. H. A., Mirumachi, N., Porkka, M., Wada, Y., & Kummu, M. (2016). Water Stress in Global Transboundary River Basins: Significance of Upstream Water Use on Downstream Stress. *Environmental Research Letters*, *11*, 1–13.

Petersen-Perlman, J. D., Veilleux, J. C., & Wolf, A. T. (2017). International Water Conflict and Cooperation: Challenges and Opportunities. *Water International*, *42*(2), 105–120.

Pöyry Energy. (2014). *ESIA Report (Final) Volume I: Text*. World Bank. http://pubdocs.worldbank.org/en/219381488268265345/ESIA-Vol-I-Final-eng.pdf

Priscoli, J. D., & Wolf, A. T. (2009). *Managing and Transforming Water Conflicts*. Cambridge University Press.

Sakal, H. B. (2015). Hydroelectricity Aspect of the Uzbek – Kyrgyz Water Dispute in the Syr Darya Basin. *Enerji ve Diplomasi Dergisi / Energy and Diplomacy Journal*, *1*(3), 94–133.

Sakal, H. B. (2017). A Quarter-Century Pursuit of Independence: Politics of Trade, Energy, and Economic Development in Uzbekistan. *Perceptions*, *22*(1), 49–90.

Selby, J. (2003). *Water, Power and Politics in the Middle East The Other Israeli–Palestinian Conflict*. I.B. Tauris.

Tanrısever, O. F., & Sakal, H. B. (2017). *Development of Hydropower Sector and Its Impact on Energy-Environment Nexus in Central Asia*.

Eurasian Research Institute. https://eurasian-research.org/web/publications/Energy-Environment-Nexus-In-Cental-Asia.pdf?1531506495

TFDD. (2019). *International Water Events*. http://gis.nacse.org/tfdd/internationalEvents.php

Toset, H. P. W., Gleditsch, N. P., & Hegre, H. (2000). Shared Rivers and Interstate Conflict. *Political Geography*, *19*(8), 971–996.

Warner, J., & Wegerich, K. (2010). Is Water Politics? Towards International Water Relations. In K. Wegerich & J. Warner (Eds.), *The Politics of Water: A Survey* (1st edition). Taylor & Francis.

World Bank. (2014). *Assessment Studies for Proposed Rogun Hydropower Project in Tajikistan*. https://www.worldbank.org/en/region/eca/brief/rogun-assessment-studies

World Bank. (2016). *High and Dry: Climate Change, Water, and the Economy*. License: Creative Commons Attribution CC BY 3.0 IGO.

Yoffe, S., Fiske, G., Giordano, M., Giordano, M., Larson, K., Stahl, K., & Wolf, A. T. (2004). Geography of international water conflict and cooperation: Data sets and applications. *Water Resources Research*, *40*(W05S04), 1-12. doi: 10.1029/2003WR002530.

Chapter 6

Transboundary Water Management in the Maritsa River Basin

Mayıs Kurt

Introduction

The Maritsa Basin is one of the main river systems in the eastern Balkans, and is shared by Bulgaria, Greece and Turkey. The conflicting needs for water for irrigation and flood control are the main disputed issues in the basin, particularly between Turkey and Bulgaria. In the past, political distrust between the three countries hampered cooperation, although the recent rapprochement between Turkey and Greece and the Bulgaria and Turkey are expected to have a positive influence on the management of transboundary water (Kibaroğlu et al., 2005).

The River Evros (Bulgarian: Марèöа, Greek: Έβρος, Turkish: Meriç), the catchment area of which is shared by Bulgaria, Turkey and Greece, at over 530 km in length, is the longest river on the Balkan Peninsula, forming a natural 240 km frontier between Greece and Turkey. Its origin is in the Rila Mountains in Western Bulgaria, from where it flows in a south-easterly direction between the Balkans and the Rhodope Mountains, turning south when it reaches the border of Greece and Turkey until it joins the Aegean Sea between Enez and Alexandroupolis at a delta with high ecological value. The total drainage area of Evros River is approximately 52,500 km^2, of which 66 percent is in Bulgaria, 27.5 percent is in Turkey and only 6.5 percent is in Greece (Eleftheriadou et al., 2015; Nikolaou et al., 2008).

Regional Characteristic of the Basin

The Meriç Basin has a drainage area of around 52,600 square kilometers, most of which (65 percent) lies in Bulgaria, while Turkey and Greece account for the remaining 28 and 7 percent, respectively (Erkal & Topgül, 2014). Around 218 km of the river is located in Greece (Yannis et al., 2008), and it runs for 16 km along the border in the region where Bulgaria, Greece and Turkey meet, and then forms another boundary between Greece and Turkey that runs for 187 kilometers. In total, the Meriç forms a 203 km border between the European Union and Turkey (Kibaroğlu, 2008).

Table 1. Drainage Area Distribution in terms of Countries

Country	Drainage Area	Percentage
Turkey	14,850 km^2	28 %
Greece	3,685 km^2	7 %
Bulgaria	34,067 km^2	65 %
Total	**52,600 km^2**	**100 %**

Source: Erkal & Topgül, 2014.

Figure 1. Map of Meriç River and its tributaries.
Source: Hidropolitik Akademi, 2014.

Water use in Turkey

The Meriç Basin area in Turkey is located in one of the most developed parts of the country, which is used for both agricultural and industrial activities in Turkey. The main use of water is irrigation, as the Ergene Basin is host to some of the most productive agricultural lands in the country and features the most important agricultural sites for paddy production. Other crops include sugar beet, sunflower, corn, vegetables and fruit. About 95 percent of the drainage area, i.e. 1,239,102 ha of land is arable and 395,194 ha, is irrigable, yet, only 328,039 ha of land is, technically and economically, categorized as irrigable (Kibaroğlu et al., 2005). There are seven dams operating in the Turkish part of the basin, providing irrigation to around 60,000 ha, as well as flood control and some drinking water. As of 2003, the total irrigated area based on surface and groundwater resources was 144,639 ha. During the summer irrigation season, about 436 MCM/year of water is required for pumped irrigation (Ozis et al., 2002).

Plans are in place to increase irrigation agriculture, with irrigation systems under construction for a further 54,879 ha of land, and 328,879 in the project and planning stage. When all the irrigation systems have been completed, 257,493 ha of land will be irrigated with 2.15 billion cubic meters of water per year (Yanik, 1997). Approximately 75 percent of the agricultural production value of the region is derived from plant production and 25 percent from animal production. These numbers show the importance of the Maritsa River for the Turkish agricultural economy (Öziş et al., 2002). On the other hand, flooding is a huge problem in the region, given the frequency, the damage inflicted on the agricultural area and the effect on productivity (Kibaroğlu et al., 2005).

After the 1990s, industry started to move to the Maritsa region in Turkey and, nowadays the region is popular for both industry

and trade due to its location (Trakyaka, 2009). The main urban centers are Edirne and Kırklareli, and the main activities providing income to the region are agriculture and stockbreeding, followed by the textile and garment sectors. The products of the textile and garment sectors account for 13 percent and 10 percent of Turkey's exports, respectively (Eşiyok et al., 2012). The textile and garment sectors require large quantities of water, but unfortunately surface water in the region is limited due to the geographical features of the basin. Despite this, high-density industrial activities develop rapidly, and this has led to an increase in the use of groundwater that has caused the groundwater to drop to -60 m (TUBİTAK, 2013). Industrial activity not only consumes a large amount of water, but also produces wastewater with high pollution load. Industrial pollution is concentrated around the cities of Lüleburgaz, Çorlu and Çerkezköy. The DSİ, followed by the Ministry of Environment, has identified the main sources of pollution in the region as domestic wastewater discharge, the discharge of organized industrial zones (textile, paper and cement factories), waste from slaughterhouses, and drainage waste containing salt and sodium from agricultural activities (Aktas, 1993). The Ergene River is contaminated with discharged untreated industrial wastewater, with high heavy metal concentrations (Hallı et al., 2014).

Figure 2. Development index of Turkey.
Source: Surgun & Zaraci, 2018.

Furthermore, the need for not only water, but also energy, has increased sharply in the region with the development of industry. Over the last 10 years, the energy requirement of the region has increased from 4,300 GWh to 8,000 GWh, being produced from both natural gas and wind, accounting for 4 percent of the total energy in Turkey in 2012. According to researchers, the energy demand is expected to increase by 8 percent each year (Trakyaka, 2012).

Table 2. Energy Production in the Thrace Region by Energy Plants

	Tekirdağ	Kırklareli	Edirne	Total
Solar Energy System	0.00 MW	0.00 MW	0.49 MW	0.49 MW
Wind Power Plant	152.60 MW	116.20 MW	167.20 MW	436.00 MW
Geothermal Energy Plant	0.00 MW	0.00 MW	0.00 MW	0.00 MW
Biogas Power Plant	6.00 MW	22.27 MW	0.00 MW	28.27 MW
Hydro Electric Power Plant	0.00 MW	0.00 MW	0.00 MW	0.00 MW
Natural Gas Power Plant	1.426.66 MW	1.621.21 MW	0.00 MW	3.047.87 MW
Coal-fired Thermal Power Plant	0.00 MW	0.00 MW	0.00 MW	0.00 MW
Others	4.20 MW	5.40 MW	0.00 MW	9.60 MW

Source: Trakyaka, 2009.

Water use in Bulgaria

In Bulgaria, the water resources of the Maritsa Basin are used for agriculture and hydropower production, as well as for domestic and industrial water supplies. There are 21 main dams in operation with a total storage capacity of more than 3,000 MCM (Arsov, 2004). The basin area (about 33,000 km^2) is home to around 2.5 million people (INWEB, 2004), with the main cities being Plovdiv, Stara Zagora, Haskovo, Sliven and Yambol.

The area suffers from water stress resulting from drought and a deterioration in water quality (Kibaroğlu et al., 2005).

The Maritsa region of Bulgaria contains several large water cascades: Cascade Vacha (2 dams with 5 hydropower stations), Cascade Batak (5 dams with 3 hydropower stations), and Cascade Belmeken-sestrimo (1 dam reservoir with 4 hydropower stations). These include those on the Rivers Ardas, Iyra, Provatonas, Ardanio and Komara (GWP-Med, 2012).

Table 3. Reservoirs and their capacities in Bulgaria

Reservoir	**Useful storage (in M m^3)**
Batak	310.0
Golyam Beglik	62.1
Shiroka Polyana	24.0
Pyasachnik	103.0
Vacha	226.12
Krichim	20.3
Belmeken	144.0
Chaira	4.4
Topolnitsa	137.0
Trakiets	90.0
Ovcharitsa	31.0
Domlian	25.0
Garvanovo	25.0
Rozov Kladenets	13.3

There is a lack of available comprehensive data on water use in the Maritsa Basin in Bulgaria, although it is known that the Maritsa Plain contains some of the most fertile agricultural lands in Bulgaria. Agricultural production particularly in the Plovdiv region is very intensive, with the main crops being fruit, vegetables and rice. The use of the Maritsa River for irrigation is, therefore, important for the region. Although the

water used for irrigation decreased drastically during the 1990s in Bulgaria, water use efficiency remains low, with average water losses from the irrigation systems reaching 57 percent, and as much as 75 percent in some regions (Kibaroğlu et al., 2005).

Agricultural and stock-breeding run-off and industrial and urban effluent are the main sources of pollution in the Bulgarian part of the Maritsa Basin. Only around 65 percent of the Bulgarian population are connected to a sewerage system, and only 20 percent to a wastewater treatment plant. The lead and zinc industry that has built up around the mining operations in Bulgaria and the processing operations near Plovdiv may also cause heavy metal pollution in the basin. While the river receives industrial waste from various areas, the quantity of pollutants reduced significantly with the economic decline of the country in the 1990s (Kibaroğlu et al., 2005).

Water use in Greece

The Greek portion of the Maritsa Basin is only 3,700 km^2, and is home to approximately 130,000 people. Alexandroupoli (36,000 inhabitants) is the largest city in the area, which contains almost no industrial activity. The main source of pollution in the region is domestic wastewater, from towns such as Orestiada and Didimoticho (Kibaroğlu et al., 2005).

There is a lack of concise data on water usage and irrigation in Greece, although the Hellenic Ministry of Environment in 1998 declared that clean water was being used increasingly for irrigation and noted that the other land uses in the delta were grazing, commercial fishery and some tourism. For this reason, a dam was built on the Arda River, close to the Bulgarian border, both for the irrigation of 30,000 ha of land and to regulate the discharge from the power plant belonging to the Ivailovgrad Dam in Bulgaria. Around 15,000 ha of land is used for agriculture, close to the river delta, although agricultural

activities are restricted in this location due to unfavorable soil conditions (Kibaroğlu et al., 2005).

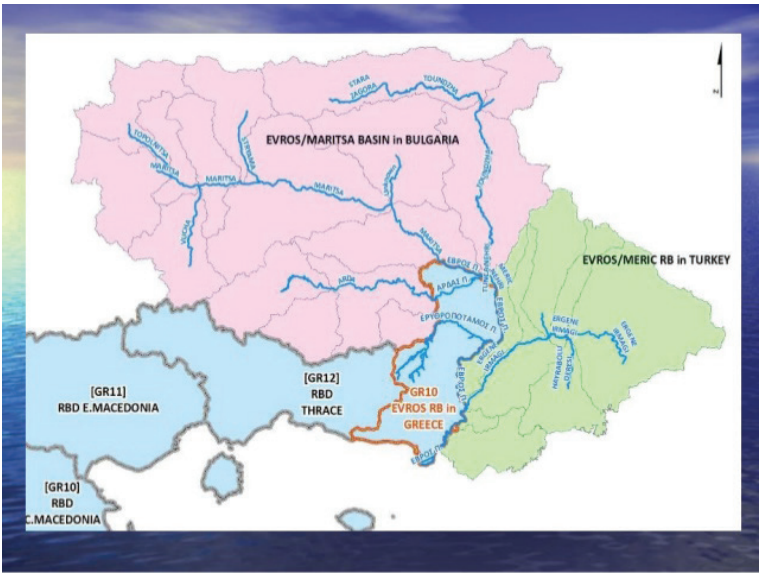

Figure 3. Maritsa River Basin. Source: Legal and practical aspects of bilateral relations between Bulgaria and Greece in the cooperation of transboundary water management - by Vladimir Stratiev.

Water use in the Maritsa Basin

Flood problem

Flooding is a major problem in the Meric Basin for the downstream riparian Turkey and Greece. A series of severe floods were experienced in especially 2005, 2006 and 2007 during which settlements and agricultural areas in Turkey – the Turkish city of Edirne in particular – and Greece were heavily damaged. After the floods, although the main reason for the flooding was generally agreed to be exceptional meteorological conditions, Turkish and Greek downstream experts argued that poor water management in Bulgaria had also been influential. Bulgaria's

reservoirs were said to be inappropriate, and high-water levels in the reservoirs close to the border increase the risk of flooding. Greece and Turkey argue that Bulgaria's release of excess water during heavy rainfall and snowmelt to prevent its dams from breaking leads to floods downstream. In addition, the lack of an appropriate early warning system in the river basin intensifies the impact of the floods (Valvis, 2011).

"The diversion and storage of water for irrigation purposes, mainly in Bulgaria, has resulted in reduced flow downstream. Due to such water shortages, Turkey has on some occasions been deprived of Paddy irrigation" (Ozis et al., 2002). In addition, the low inflow of clean water increases the intrusion of saltwater into the river, with increased salt loads observable up to 35 km upstream of the mouth of the river, making the water inappropriate for irrigation. Furthermore, low clean water inflows lead to siltation problems in the Delta (Samsunlu, 1996).

Figure 4. Edirne, Turkey 2014. Source: Ensonhaber, 2014.

The Turkish media has accused Bulgaria of storing the bulk of the spring and winter flows for summer and early autumn irrigation purposes, which has led to a decline in the availability

of water on the Turkish side. On other occasions when there is excess winter flow, the articles state that Bulgaria did not hesitate to open the dam, leading to severe flooding in the paddy fields downstream in Turkey (Milliyet, 1996).

The Ivaylovgrad Dam, Kırcali Dam and Studen Kladenets Dam cause flooding in Turkey, and especially in the Edirne region. Figure 5 shows the locations of the dams in the Maritsa region in Bulgaria, Number 3 being Ivaylovgrad Dam, number 5 being Kırcali Dam and number 4 being Studen Kaldenets Dam, all of which are close to the Bulgaria-Turkey border. The capacities of these dams are very high, for instance, Ivaylovgrad Dam on the Arda River, which is the closest to the border, has a total reservoir capacity 157,000,000 m^3.

Figure 5. Dam map of Bulgaria. Source: Sunar et al., 2019.

In fact, flooding is a major problem in the Maritsa Basin in both Turkey and Greece. The most recent major flood, which occurred between February 17 and March 24, 2005, inundated

houses and farmland in Greece and caused damage estimated at US$50 million in the area around Edirne (DSİ, 2005a).

Measurements taken at the Kapıkule border quality monitoring stations between 1985 and 2001 reveal the Maritsa and Tundja water bodies in Turkey are heavily polluted, decreased water quality, and threaten the protected basin delta, and this low water quality in the basin is a matter of concern for Turkey (Kole, 2004).

The high sediment loads in the river lead to soil accumulation on the riverbed, especially near Edirne, and generate soil islets on both sides of the river. Many trees grow out of these soil islets and have developed into forests, and this contributes to coastal erosion linked to the increasing roughness coefficient of the riverbed (Yildiz, 1999).

Floods in the spring and summer of 2005 and the spring of 2006 laid waste to much of the low-lying areas in the northeast of the Evros prefecture and the Edirne area (5–10 km inland) – farmlands were flooded, the rail and road infrastructures were damaged, leading to disruptions in transportation, and the inhabitants of villages had to be evacuated. There are also reports that a number of people were killed in Bulgaria as a result of the flooding in the region.

The numerous floods have been linked to above-average rainfall combined with snowmelt, which leads to increased discharges (2000–2500 m^3/s) and the bursting of dikes. The lack of communication and information at an operational level between the three neighboring countries, as well as the inefficient management of the upstream reservoirs in flood-prone areas, contributed to increasing the extent of the damage. To protect the dams, controlled releases were made that increased the damage, and the authorities in Greece and Turkey tried to alleviate the damage through controlled flooding (Nikolaou et al., 2008).

The effects of flooding are not only economic, but also ecological. In 2015 April, many fish spilled onto farmland with the floods, and were stranded after the waters withdrew. Farmers collected them and released them into the Maritsa River (NTV Haber, 2015).

Turkey and Greece

Earlier agreements between Turkey and Greece related to the Maritsa River mainly cover the construction of facilities for flood protection, erosion control and water diversion, and the two countries recently signed a Memorandum of Understanding on Environmental issues. The first agreement on the Maritsa between Greece and Turkey – "The Agreement on the Installation of Hydraulic Systems on both sides of the Meric River" – was signed in 1934 and covered mainly the specifications of the infrastructures that both parties were allowed to build for flood protection and erosion control. The agreement also included provisions for the exchange of topographic data, notifications to the other party prior to construction, and for the settlement of disputes between the two parties (Kibaroğlu et al., 2005).

Another agreement relating to the construction of flood control measures on the Maritsa River was signed between Turkey and Greece in 1955, although the text of the agreement was not published. According to Bilen (2000), the agreement provided for the construction of flood control facilities in accordance with a master plan, and each government was to undertake the construction and financing of the work in its own territory. To determine the joint measures that needed to be taken against flooding of the river, Turkey and Greece awarded a contract to the Harza Engineering Company to prepare a master plan for the Maritsa Basin, although only some of the facilities envisaged by the master plan were realized

(Bilen, 2000). To resolve disputes arising from the master plan and to carry out hydraulic works on both sides of the Maritsa, Turkish-Greek technical teams convened in 1963 and agreed on the "Protocol on the Rehabilitation of the Meric River Basin Forming the Significant Part of Turkish-Greek Border in Thrace". This protocol encompassed articles on the modification of the border between the two parties, as an exchange of land was necessary for the building of infrastructure on the river. Any disputes arising out of this matter were to be dealt with by a General Engineer, appointed by the French Ministry of Agriculture (Kibaroğlu et al., 2005).

Turkey and Bulgaria

In 1968, Turkey and Bulgaria signed the "Agreement between the Republic of Turkey and the People's Republic of Bulgaria on Cooperation in the Use of the Waters in the Rivers Flowing in the Soils of the Two Countries", which refers to the principles of international law and good neighborly relations (Kibaroğlu et al., 2005).

The 1975 "Agreement on Long-Term Economic, Technical, Industrial and Scientific Cooperation" between the Government of the Republic of Turkey and the Government of the People's Republic of Bulgaria" stated that cooperation between the concerned Turkish and Bulgarian enterprises and organizations should be simplified in all fields of the economy, including "energy production and irrigation, including the joint use of the waters whose shores are in both countries, for energy production and irrigation purposes" (Kibaroğlu et al., 2005).

Recognizing the need for cooperation to alleviate the severe consequences of drought suffered by both parties, the Agreement on Assistance and Cooperation in the Field of Water to Reduce the Negative Effects of Drought of 1993 was signed (Kibaroğlu et al., 2005).

The Turkish-Bulgarian Joint Committee for Economic and Technical Cooperation then signed the "Agreement on the Approval of the 15th Term Protocol," in 2002 (Kibaroğlu et al., 2005).

Agreements of Beneficiaries:

- Energy-Electricity
- Water Usage
- Flood protection
- Irrigation
- Water quality and the environment

There are conflicting interests in water resource development in the Maritsa Basin between Bulgaria and Turkey, and Turkey's plans to increase the quantity of irrigated areas in the Maritsa Basin would aggravate the situation. To make more water available for irrigation in Turkey, it has been proposed the Turkey consider the possibility, despite the additional cost, of building off-stream storage facilities to collect the excess winter outflow from the Bulgarian and Greek dams (Ozis et al., 2002). Turkey has proposed joint dam projects with Bulgaria, which would also contribute to flood control, as one of the most urgent fields of action in the basin. Even though agreements are in place for cooperation in flood prevention and control, adherence has been unsatisfactory in the past. Following the severe floods of March 2005, Turkey is reported to have sent Bulgaria a note of protest due to its alleged failure to abide by the bilateral agreement, and Greece has also blamed Bulgaria for floods it has experienced (Kibaroğlu et al., 2005).

Subsequently, Ankara and Sofia agreed to cooperate in the construction of a dam on the river Tundja in order to mitigate Turkey's flooding problems. The two sides agreed to appoint experts to develop the project and to establish a Turkish-Bulgarian joint technical commission for its implementation. The dam is expected to not only provide flood protection, but also to bring

further benefits to the two countries, for example, it could also provide irrigation to the area around Edirne and Kirklareli in Turkey (Kibaroğlu et al., 2005). In April 2005, a technical delegation from Bulgaria paid a visit to the DSİ Regional Directorate in Edirne, leading to consensus being reached regarding the location of the dam and the signing of a protocol. In addition, during a visit of the DSİ Regional Director to Bulgaria in May 2005, the two sides agreed that the project development for the Suakacagi Dam in the Tundja River would be finalized with joint studies in June 2005 (DSİ, 2005b).

Edirne Channel Project

The project was designed by the DSİ (State Hydraulic Works) in Turkey and included a 6,000 m channel with the surrounding area of around 430 decares being developed for recreation. The 7,800-meter-long canal will operate as a tributary of the Meriç River, and the canal will be operated like another river flowing from the entrance of the city after Arda, Maritsa and Tunja.

Even if the flow of the Maritsa River exceeds 2000 m^3/s, the bypass channel will be sufficient to prevent flooding. The project, initiated in November 2015 with a budget of 45 million TL, was completed at the end of 2019.

Environmental and water pollution problems – Ergene River Region

Bilateral relations in the Maritsa Basin have improved over the last decade, providing a political context for negotiations and for the settling of major water-related conflicts. That said, collaboration in flood protection needs to be improved, and the conflicting claims to water by Turkey and Bulgaria for irrigation can be an impediment to the implementation of irrigation projects in Turkey. It remains to be seen whether the planned joint dam projects will be realized and whether they constitute an appropriate solution for conflicting water needs.

No agreements exist yet on water quality in the basin, although upstream water pollution is increasingly perceived as an issue for Turkey and Greece. EU membership of all three riparian countries would provide a good incentive to increase transboundary cooperation. The prospect of joint nature conservation activities and a legal framework for the protection of wetlands provide further incentives for collaboration in water resource management, and such collaborations could also contribute to good neighborly relations between the riparian countries and the communities living in the border regions (Kibaroğlu et al., 2005).

Good water quality brings mutual benefit to all riparian countries as nature protection and conservation in the basin area, especially the protection of the Ramsar Site. The Evros Delta is in need of action, and projects for the Lower Meric Valley Flood Plain – a biosphere reserve – are in place on the Turkish side. Several other initiatives have been taken as the first steps in transboundary conservation activities, although no concrete results have yet been achieved (Kibaroglu et al., 2005):

- The Turkish Ministry of Environment and Forestry, with support from the UNESCO Regional Bureau for Science in Europe, organized an international conference on "Biosphere Reserves and Transboundary Cooperation between Bulgaria, Greece and Turkey" which was planned place in Edirne in July 2005 (Kibaroglu et al., 2005). The conference "Bridging Science and Society" was conducted in 2007 in Antalya.
- In 2001, the Mediterranean Wetlands Initiative (MedWet) developed a project to foster transboundary collaboration in the management and protection of the Maritsa River and its wetlands. Unfortunately, internal reasons prevented the funding of the project from being approved (Kibaroglu et al., 2005).

- The European Green Belt initiative, under the leadership of the German Federal Agency for Nature Conservation (BfN) and IUCN, aims to transform the former Iron Curtain area along the east-west divide of Europe into a protected corridor, thus acting as a symbol of unity between East and West. One stretch of the European Green Belt route follows Bulgaria's borders with Turkey and Greece (Kibaroglu et al., 2005).

The Maritsa Basin has been identified as one of the priority sites for transboundary cooperation (IUCN, 2004). Water quality remains an unresolved issue in the basin, and any solution to the problem, arising, to a significant degree, from insufficient wastewater treatment, would need considerable investment in infrastructure. Ongoing EU-cooperation programs involving accession countries may lead to the partial alleviation of the problem. The high sediment load – a consequence of erosion in the basin – causes siltation problems in the River Delta and leads to the formation of sand islets. Turkey has launched a program to clear the sand islets in order to maintain a regular flow, although the technical cooperation of the other riparians is deemed necessary if the issue is to be fully addressed (Yildiz, 1999).

Data exchange and scientific cooperation

The exchange of hydrological data seems to be insufficient between the riparian countries, and it has been reported that no information is available from the Bulgarian side about the discharge of waste into the river or the retention of water (Mylopoulos et al., 2004). Establishing scientific exchange between the riparian countries may lead to further collaboration. In the Maritsa Basin, exchanges of this nature take place, to some extent, through the International Network of Water-Environment Centres for the Balkans (INWEB) that was established in 2000.

Funded by the UNESCO Regional Bureau for Science in Europe (UNESCOROSTE), INWEB organized an international workshop in 2004 with the objective of sharing the available data on transboundary watercourses in south-eastern Europe and to contribute to the compilation of an inventory in accordance with the UNECE framework document guidelines, and participants from all three riparian countries took part in the workshop and presented data and information on the Maritsa Basin. Furthermore, the World Hydrological Cycle Observing System (WHYCOS) offers a network for the exchange of data and has established a global network of national observatories with the objective of creating a relatively transparent database. Among these, the Mediterranean division (MED-HYCOS) has set up five Data Collection Platforms in the Maritsa Basin: four in Bulgaria and one in Turkey (Kibaroğlu et al., 2005).

Energy use in the Martisa Basin

The gradual increase in industrial activity increased not only water but also energy needs, and existing natural gas power plants and wind turbine power plants remained inadequate. To meet the demand, natural gas and electricity trade is on the agenda of the Maritsa region.

Hydropower plants on Maritsa River

A general analysis of the distribution of hydropower plants on the Maritsa region reveals that 24 of the 25 dams are in the Bulgarian section, indicating that energy production is more important than water for Bulgaria (Kimençe, 2015). The Greek part of the basin contains one dam, which was built to regulate water flow coming from the Ivailovgrad HPP in Bulgaria, and to irrigate 30,000 ha of farmland (Kibaroğlu, 2008).

In 1998, Bulgaria and Turkey signed an agreement to cooperate in the energy and infrastructure sectors, under which

Bulgaria agreed to employ Turkish companies to carry out two major infrastructure projects: The Gorna Arda hydropower project and the construction of a section of the Maritsa highway (Buechsenschuetz, 2003).

In 2000, however, the Turkish Ceylan Holding Company, which was chosen to participate in the two infrastructure projects, experienced financial difficulties and no alternative contractor was commissioned, meaning that the projects did not pass the planning stages. Turkey claimed that this constituted a non-fulfillment of the 1998 agreement and stopped purchasing electricity from Bulgaria in 2003 (Buechsenschuetz, 2003).

The two countries are expected to discuss the 1998 bilateral electricity-for-infrastructure deal that included the building of dams on the Arda River in Bulgaria, as one of the leading electricity exporters in the Balkan region, which is interested in resuming the export of electricity to Turkey. Turkey, on the other hand, is reported to be insisting on compliance with the agreement by Bulgaria to employ Turkish companies for the construction of infrastructure projects (Nenkova, 2005).

Natural gas lines passing through Maritsa Basin

The Maritsa region contains two natural gas lines that connect Europe and Russia, namely the Blue Stream line and TANAP line. Natural gas and electricity, exporting and importing between countries, supply in the region. Some 20 million m^3/year capacity of imported natural gas is stored in Silivri in the Maritsa region.

Although Maritsa region consists of 2 percent of Turkey land, it holds 17 percent of all-natural gas power in Turkey. It can be understood from this that the region is highly dependent on foreign sources for its energy requirements (Enerji Atlası, 2015).

Turkish Electric Grid: This is connected to the Bulgarian Electric Grid via two 400 kV transmission lines, and to the Greek Electric Grid via one 400 kV line. On 18 September, 2010, the synchronization of the Turkish electric grid with that of the European Union was completed, allowing the transmission of electricity between Turkey and other European Countries. Turkey will thus become a bridge between the East and West due to its strategic position, which will support not only the transfer of natural gas, but also electricity (TEİAŞ, 2015).

The trade of electricity between Turkey and Greece was launched on 2 June, 2011 with the signing of an agreement between the EU and Turkey. Under the agreement, 45 companies in Bulgaria and 28 companies in Greece are selling electricity to Turkey, while 11 Turkish companies are selling electricity to Bulgaria, and 23 companies are selling electricity to Greece (TEİAŞ, 2015). Moreover, many wind farms have been built in the Thrace region of Turkey, the total capacity of which has reached approximately 320 MW (Enerji Atlası, 2015). It can thus be understood that the Maritsa region is important not only for water, but also due to its energy potential for all three countries.

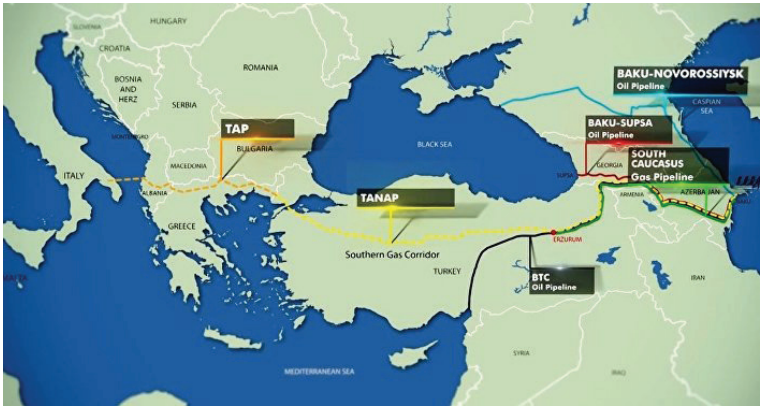

Figure 6. Pipelines passing through the Maritsa Region.
Source: Offlinepost, 2019.

Agreements

Transboundary water and WFD

Transboundary Rivers can be at the heart of potential conflict or political tension, and consequently affect relations between neighboring countries (Sadoff & Grey, 2002). International water relations are certainly complex, being rarely transparent or easily quantifiable. Particularly where water is thought to be scarce, water users and political leaders take strong and often conflicting positions and pursue policies that remedy water scarcity in the political economy beyond the water sector, while sustaining apparent confrontations over water resources (Zeitoun & Allan, 2008).

The EU WFD – until recently a driving force for cooperation in the management of shared water resources in Europe – aside from the difficulties related to geographical location and the existence of different national legislations, had also to address the void of international legislation in regard to the regulation of transboundary waters. Past transboundary cooperative efforts focused on specific water issues (economic, environmental etc.) rather than promoting integrated approaches. The WFD (European Water Framework Directive) 2000/60/EC, establishes a new institutional framework, promoting a common approach, common objectives, principals and definitions, and measures to support the management of waters in Europe. The new Water Framework Directive provides the conditions to support significant reform in European environmental legislation and administrative practice. The new Water Framework Directive calls for the application and implementation of basic principles in support of sustainable water resources management, ensuring specifically effectiveness, efficiency and equity. It is a prominent example of an integrated water policy based on a river basin approach. The WFD partly replaces and partly augments the

existing legislation, providing a comprehensive framework in which the member states must orient their efforts. The Directive integrates all water resources, ecological objectives, water uses and functions, interdisciplinary analyses and expertise within a common policy framework. The EU member states are bound to achieve a "good ecological status" for water bodies. Territorial management based on physical rather than administrative boundaries represents a major innovation in the procedure. Significant emphasis is placed on the joint resolution of transboundary water problems. The need to integrate qualitative and quantitative information and the inclusion of scientifically assessed risk in decision-making imposes planning processes leading to the inclusion of more complex, subjective and complicated choices (Transcat compendium, 2006). The WFD foresees increased public participation in the water resource management process and prescribes the economic assessment of potential measures to achieve good water status. To cope with the increasing complexity of such innovative policy, the traditional state-led approach to decision making is being replaced by new institutions, actors and levels of governance. Thus, the management of transboundary river basins emerges as one of the most challenging issues related to the WFD implementation process (Yannis et al., 2008).

International knowledge of the current status in water cooperation and unresolved disputes related to transboundary rivers in Turkey is lacking. To improve the body of information in preparation for intensified dialogue between Turkey and the EU (Kibaroğlu et al., 2005), the following are required:

- A comprehensive assessment of the current use and management of the Turkish transboundary waters, including, if available, bilateral or multilateral agreements and organizations,

- Identification of existing and/or potential disputes relating to infrastructure development and other forms of intensified water use,
- Identification of key elements of the EU strategy to support Turkey in further developing a cooperative approach to its transboundary waters,
- Identification of proposals for the integration of transboundary water issues into the German-Turkish Environmental Cooperation.

Turkish water policy, legislative, and institutional structures

Turkey, as an EU accession candidate, and a member of the OECD and G-20, has set sustainable development and environmental targets. In recent years, considerable progress has been made toward the conservation of the environment and natural resources, the prevention of pollution, the use of renewable energy, and the expansion of water and wastewater services. Although the full implementation of the legislation will require time and significant funding, many studies have been made and large investments have been carried out to ensure full alignment with the EU acquis and the transposition of the WFD concerning river basin management. The intensive planning activities and the construction of physical structures have been followed by considerable progress in improving the water supply, to achieve the realization of socio-economic development goals since the 1950s (Kibaroğlu, 2007). Policies related to water and natural resources in Turkey have witnessed continuous reforms in the second half of the 20th century, with significant changes occurring especially as part of the EU accession process. The need for a basin unit-based management concept, and coordination between institutions were highlighted in the Sixth Turkish Five-year Development

Plan (1989). Every subsequent development plan has increasingly emphasized the importance of the basin-based management approach for the planning and administration of natural resources, especially water and soil. Turkish environmental policies are directed toward satisfying the increasing demand for water supply and food security, the generation of energy, and conservation of the environment in accordance with international standards. The Turkish water policy has four main dimensions (Delipınar & Karpuzcu, 2017):

1. Improvement of water resources, increasing agricultural production through irrigation, domestic use, flood control power generation,
2. Water transfer from Turkey to water-stressed nations,
3. For EU accession, the adoption of the national environmental strategy and action plan, studies of new water legislation and institutional restructuring,
4. Transboundary water policy and its concepts, as follows: consistent and transparent, equitable and with optimum utilization, efficient use, sharing of benefits, cooperation among riparian states, and sharing of information and data.

In summary, whether to meet the ever-increasing water demand for sustainable management of water resources at basin level, or to adopt the EU Legislation, the IWRM has been gaining importance, and Turkish national and international efforts have been accelerated since 2009 (Delipınar & Karpuzcu, 2017).

Bilateral agreements

Up to now, only bilateral agreements exist related to water-related issues in the basin. Any cooperative initiative in the Maritsa Basin needs to be considered within the broader context of the political relations between the riparian countries. Greece-Turkey relations in particular have been far from friendly over the

years. Since the second Greco-Turkish war (1919–1922), the main issues have been the Cyprus dispute and the conflicting territorial claims in the Aegean Sea, including the 1996 "Kardak Crisis" that emerged over a deserted island in the Eastern Aegean that led to a serious diplomatic confrontation between the two countries. In addition, the Maritsa Basin is situated in Thrace, which is home to diverse communities and Turkish minorities living in both the Greek and Bulgarian parts, as well as Greek minorities living in Turkey. The minority conflict is the oldest issue between Turkey and Greece and has been the main problem affecting Bulgarian-Turkish relations since the end of World War II. Since 1999, however, Turkish-Greek relations have entered a new era of rapprochement, due largely to close co-operation between the Foreign Ministers of the two countries. Turkish-Greek joint committees have been established and several agreements promoting cooperation in fields ranging from the environment to combating terrorism have been reached. The only minor drawback was the European Council's decision of December 2002 to grant EU membership to the Greek part of Cyprus (Kibaroğlu et al., 2005).

Table 4. Bilateral Agreements between the three nations (Turkey, Greece and Bulgaria)

Bilateral Agreements		
Turkey – Bulgaria	Treaty on the Prevention and Treatment of Border Events and the Maintenance of Border Signs	Signed in Ankara on December 28, 1967 and accepted by the TGNA on March 27, 1969.
	Agreement on Cooperation to Benefit from the Waters of the Running Rivers from the Two Country Territories	The agreement, dated October 23, 1968, was accepted by the TGNA on November 25, 1969.
	Friendship Between the Republic of Turkey and the Republic of Bulgaria, Good Neighborly Relations, Cooperation and Security Agreement	The Agreement was signed on May 6, 1992 in Ankara, and was accepted by the TGNA on September 15, 1994.

	Boundary Determination of the Mutluere / Rezovska Deresi Downstream Region and the Agreement on the Restriction of Authority Areas in the Black Sea Between Two Countries	The agreement was signed on December 4, 1997 and was accepted by the Grand National Assembly on May 25, 1998.
	Trade and Economic, Industrial and Technical Cooperation Agreement between the Governments of the Republic of Turkey and the Republic of Bulgaria.	Signed on July 6, 1994 and entered into force on September 22, 1997.
	Economic Cooperation Agreement between the Republic of Turkey and the Republic of Bulgaria	The meeting was held in Sofia on January 24-25, 2007,"Economic Cooperation Agreement between the Republic of Turkey and the Republic of Bulgaria", which was prepared to ensure the continuation of the Turkey-Bulgaria Joint Economic Commission Meeting, was signed on the occasion of the first meeting of the Turkey-Bulgaria High Level Cooperation Council held in Ankara on 20 March 2012.
Turkey-Greece	Agreement regarding the arrangement of the hydraulic plant to be built on both sides of the Meriç-Evros river	Signed in Ankara on June 20, 1934
	Protocol Concerning the Border Allocation Due to the Improvement of the Meriç River Channel That Determines the Significant Part of the Turkish-Greek Thrace Border	Signed on January 19, 1967.
	Economic Cooperation Agreement Between the Republic of Turkey and Greece	Signed on February 4, 2000 in Athens.
	Greek-Turkish Protocol on the Establishment of a Joint Task Force Against Natural Disasters, Involving the Republic of Turkey and Greece	Signed in Athens on November 8, 2001.

	Republic of Turkey and the Hellenic Republic Ministry of Forestry and Water Affairs, Environment, Energy and Climate Change Memorandum of Understanding on Cooperation Between the Ministries in the Energy Field	Within the scope of the first meeting of the Turkey-Greece High Level Cooperation Council held in Athens on 14 May 2010, in order to further develop long-term comprehensive cooperation in the field of energy between the Ministry of Forestry and Water Affairs of the Republic of Turkey and the Ministry of Environment, Energy and Climate Change of the Hellenic Republic in the Field of Environment A Memorandum of Understanding on Cooperation was signed.
Bulgaria - Greece	Agreement on Cooperation in the Utilization of the Waters of the Rivers Between the Two Countries	The two countries signed a cooperation agreement in 1964 on the common use and management of surface water resources.
	Agreement for the Establishment of the Bulgarian-Greek Joint Committee for Cooperation in the Fields of Energy and Water Use, with a view to following the Implementation of the 1964 Treaty	Bulgarian-Greek Joint Committee responsible for energy production and management of joint waters established in 1971.
	Monitoring of the Nestos River and the Establishment of the Commission for the Control of the Implementation of the Agreement and the Resolution of Disputes	Under the "Mesta-Nestos Agreement" signed between the two countries in 1995, the parties reached an agreement that 29 percent of the Mesta River water in Bulgarian territory will be exported to Greece for 35 years (1995-2030)
	Memorandum of Understanding on Cooperation in the Field of Environmental Protection	The agreement entered into force in both states in 2005.

Source: Ministry of Forestry and Water Management (2017).

Turkey and Bulgaria

In 1968, Turkey and Bulgaria signed the "Agreement between the Republic of Turkey and the People's Republic of Bulgaria on Cooperation in the Use of the Waters in the Rivers Flowing in the Soils of the Two Countries", which refers to the principles

of international law and good neighborly relations. The main objective was to regularize the beneficial use of boundary and Transboundary Rivers and to provide for flood protection. The parties committed to cooperation in the research and study of ventures that would be beneficial to both, to not inflict serious damages on each other through the construction or operation of facilities on the rivers, to exchange information on floods and icing as rapidly as possible, and to exchange hydrological and meteorological data. A Turkish-Bulgarian Joint Commission composed of equal numbers of experts from both countries was given the responsibility of settling any disputes that may arise during the implementation of the agreement. The 1975 "Agreement on Long-Term Economic, Technical, Industrial and Scientific Cooperation" between the Government of the Republic of Turkey and the Government of the People's Republic of Bulgaria" states that cooperation between the concerned Turkish and Bulgarian enterprises and organizations shall be simplified in all the fields of the economy, including "energy production and irrigation, including the joint use of the waters with shores in both countries, for energy production and irrigation purposes" (Kibaroğlu et al., 2005).

The 1993 Agreement on Assistance and Cooperation in the Field of Water for Reducing the Negative Effects of Drought was signed in recognition of the requirement for cooperation to reduce the consequences of drought on both parties. According to the agreement, Bulgaria, on a one-off basis and limited to 1993, should supply additional water to Turkey from Tundja River, while Turkey should assign US$0.12 per m^3 for water provided by Bulgaria. Hence, Turkey bought 15,866,000 m^3 of irrigation water from Bulgaria at a cost of US$1,903,904 (Kibaroğlu et al., 2005).

In 1998, Bulgaria and Turkey signed an agreement to cooperate in the energy and infrastructure sectors, in which Bulgaria

agreed to employ Turkish companies to carry out two major infrastructure projects: The Gorna Arda hydropower project and the construction of a stretch of the Maritsa highway. In return, Turkey was to purchase a certain amount of electricity at a fixed price from Bulgaria. The Gorna Arda hydropower project was launched in 1999 and included the rehabilitation of existing dams as well as the construction and operation of three new dams on Arda River close to the Turkish border. (Kibaroğlu et al., 2005).

The Turkish-Bulgarian Joint Committee for Economic and Technical Cooperation signed the "Agreement on the Approval of the 15th Term Protocol" in 2002. Under the "Environment" subheading, both parties agreed to further their environmental cooperation in the protection of surface and groundwater resources and water-related environments. Under the "Energy and Environment" heading, the Turkish side repeated its request to establish a joint technical working group to investigate the conditions for the construction of Suakacagi Dam on Tundja River. The Bulgarian side stated that the issue would be addressed promptly, and both sides agreed further to continue their exchange of hydrological data to prevent flooding, and to exchange data on water levels and releases from the dams on the Maritsa, Arda and Tundja Rivers. They further agreed the Technical Working Group which was created under the 1968 Agreement should continue its regular activities (Kibaroğlu et al., 2005).

A protocol was signed between the DSİ and the National Institute of Meteorology & Hydrology (NIMH) of Bulgaria in 2002 related to the installation, operation and maintenance of a flow observation telemetry station on the Maritsa River in Svilengrad, Bulgaria to ensure improved monitoring of hydrometeorological data in periods of flooding. Joint studies are continuing into the installation of an early warning system for

flood protection on the Turkish-Bulgarian border (Kibaroğlu et al., 2005). The current project name is "Prevention and Minimization of the Risks for the Environment and Vision for Innovative Tools (PREVENT)" with the EU's Instrument for Pre-Accession Assistance (IPA) through the "CBC Bulgaria - Turkey" Operational Programme for the 2014-2020 programming period. The investment falls under the priority "Protecting the environment and promoting climate change adaptation and mitigation, risk prevention and management" (European Commission Projects, 2007).

Turkey and Greece

Earlier agreements between Turkey and Greece on the Maritsa River mainly covered the construction of facilities for flood protection, erosion control and water diversion, and the two countries have recently signed a Memorandum of Understanding related to environmental issues. The first agreement related to the Maritsa River between Greece and Turkey was signed in 1934. "The Agreement on the Installation of Hydraulic Systems on both Sides of the Meric River" covered mainly the specifications for the infrastructure allowed to be built by both parties for flood protection and erosion control. The agreement also included provisions for the exchange of topographic data, notifications to the other party prior to constructions and the approach to the settlement of disputes between the two parties (Kibaroğlu et al., 2005).

A "Memorandum of Understanding Concerning Cooperation in Environmental Protection" was signed between Greece and Turkey in 2001, stipulating that government bodies of the two parties "shall exchange scientific, technical and legal information and shall encourage such exchanges among academic institutions". "Coordination and cooperation in the different fields of activity shall be managed by a Joint Committee comprising

five representatives from each of the two countries." The fields of potential cooperation, however, do not include river management, although the areas mentioned include "combating marine pollution", "Environmental Impact Assessments" and "Land-based sources of pollution", provide options for cooperation relating to the management of the Maritsa River. There are also 26 joint development initiatives that offer opportunities for the fostering of transboundary cooperation in water resource management in the basin. The Community Initiative Programme INTERREG III A / Greece – Turkey is envisaged to support cross-border cooperation projects. The program, envisaged for the 2003–2006 period, seeks to support the maintenance of good neighborly relations and promoting the region as a nexus for consolidating peace and growth in the Eastern Balkan Peninsula and on the Aegean Sea. Under the environmental component of the program, priority will be given to the integrated management of the cross-border waters, in accordance with the WFD, and to the management of ecosystems of exceptional ecological significance (Kibaroğlu et al., 2005).

Outstanding issues and options for win-win solutions

The existing agreements and cooperation in the basin cover issues of flood protection and joint infrastructure projects, as well as general environmental issues, including the conservation of protected areas. Issues of water allocation, on the other hand, remain unsettled, and no legal provisions exist related to water quality standards within the basin. Likewise, arrangements on the exchange of data and information focus mainly on information on floods, while the crossborder availability of data on water quality is reputed to be a problem. In addition, no agreement exists that would provide for a minimum inflow of clean water into the delta to satisfy the water needs

of the ecosystems, and to prevent salt intrusion and siltation (Kibaroğlu et al., 2005).

Water framework directives and applications by countries

"Directive 2000/60/EC of the European Parliament and of the Council dated October 23, 2000" established a framework for Community action in the field of water policy and set the objectives for the prevention of a deterioration in status of all Community waters – both inland and coastal – to ensure the achievement and maintenance of their good status by 2015. The main objectives of the WFD are: to provide an integrated system of water management based on hydrological catchments rather than political or administrative boundaries (Art. 3); to set environmental objectives to ensure that all water bodies – rivers, lakes, coastal waters and groundwaters – achieve a "good status", and to prevent the deterioration of such waters (Art. 4); to introduce a "combined approach" to pollution control (Art. 10); to contribute in mitigating the effects of floods and droughts (Art. 1); and to ensure the involvement of active stakeholders and the public (Art. 14) (Nikolaou et al., 2008).

The WFD 2000/60/EC, establishes a new institutional framework, giving directions for the common approach, the common objectives, principals, definitions and measures for the management of waters in Europe. The new Water Framework Directive provides the conditions for important reform in the European environmental legislation and administrative practice. The objective of the new Water Framework Directive is the application and implementation of basic principles of sustainable water resources management, and specifically effectiveness, efficiency and equity. It is a prominent example of an integrated water policy based on river basin approach. The WFD partly replaces and partly augments existing legislation to provide a

comprehensive framework, in which member states will have to orient their efforts. The Directive integrates all water resources, ecological objectives, water uses and functions, interdisciplinary analyses and expertise within a common policy framework. EU member states are bound to achieve a "good ecological status" for water bodies. Territorial management based upon physical rather than administrative boundaries represents a major innovation in the procedure. Great emphasis is placed on jointly resolving transboundary water problems. The need to integrate qualitative and quantitative information and the inclusion of scientifically assessed risk in decision-making imposes planning processes aimed at including more complex, subjective and complicated choices (Transcat compendium, 2006). The WFD foresees increased public participation in the water resource management process and prescribes the economic assessment of potential measures to achieve good water status. To cope with the increasing complexity of such an innovative policy, the traditional state-led approach to decision making is being replaced by new institutions, actors and levels of governance. Thus the management of transboundary river basins emerges as one of the most challenging issues related to the WFD implementation process" (Yannis et al., 2008).

Transboundary corporation project in the Maritsa region

Comparison of ICPR, ISRBC and IJC Methods[1]

Resolving the transboundary water problems between the riparian nations requires negotiation on the basis of trust and goodwill. When the mutual trust environmental is created, relationships between riparian can improve gradually. On the other hand, agreements signed between riparian countries are

1 ICPR: International Commission for the Protection of the Rhine
ISRBC: International Sava River Basin Commission
IJC: International Joint Commission

in demand in terms of economic, political (acquiring EU membership) and environmental problems.

Both the ICPR and ISRBS methods advise, as a first step, identifying the most crucial problems related to the basin, which for the Maritsa Basin is flooding. The flood problem can be seen as a potential locomotive in the development of cooperation in the basin. First of all, a commission should be established, and common decisions should be taken, which would allow the sharing of experiences and the establishment of mutual trust between the riparian nations. The ISRBC, ICPR and IJC examples show that even in recent examples where the riparian nations are at war with each other, common economic interest can support cooperation in river basin management involving the two sides. For example, after the break-up of Yugoslavia, countries, despite being at war, were compelled to collaborate regarding Sava River and EU membership and led to the establishment of the ISRBC. The same example can be used for the ICPR. The considerable industrial pollution of Ren River forced the riparian countries to collaborate. The North American riparian in different geography signed the IJC agreement in 1909. The authority of the IJC has increased continuously and gradually in line with the changes in population, industry, farming and environmental contamination (Ministry of Forestry and Water Management, 2017).

Flooding, water shortages and water pollution are the main problems in the Maritsa Basin. Even though similar problems were examined for the Sava and Ren River Basins under the ISRBC, ICPR and IJC organizations, not all problems could be resolved. It is necessary, however, to make use of the studies that targeted the resolution of these problems.

The ICPR, ISRBC and IJC carried out several studies and developed action plans aimed at preventing and resolving the flooding problem. The ISBRC, in its action plan, recommended

separate precautionary programs to counter flooding in each riparian nation. It also drew up the Flood Protection Protocol, establishing the legal basis for the resolution of the flooding problem. The ICPR proposed the reactivation and reorganization of the former flood plains, and as a result, the riparian nations put many national precautions in place with a view to fulfilling the ICPR provisions for the enhancement of water quality in the Ren River Basin and ecological variety.

The condition of Sava River is the same as that of the Maritsa River. The countries downstream of Sava River are non-EU, and like Maritsa, suffer from flooding. The Maritsa region can benefit from the experiences of Sava River, and similar studies can be carried out for Maritsa region to resolve or reduce the flood problem. (Özdemir, 2015).

As a result, all three riparian should collaborate and enter into transboundary agreements to resolve the problems of the Maritsa River Basin. All collaborations and agreements take time and move step by step, but applications of agreements must be directed (Özdemir, 2015).

The transboundary water projects between Bulgaria and Greece for the Maritsa Basin

While agreements have been signed between Bulgaria and Turkey, and between Bulgaria and Greece, the exchange of information and the operation of dams in times of flooding have been unsatisfactory. Support could be provided to the three riparian countries to establish a joint flood warning and control program, and the same approach can be applied to the prevention of other hazards. A joint hazard prevention program in support of transboundary cooperation could be established within the scope of, for example, an EU Twinning project, for which the Germany-funded program in the Kura Aras Basin serves as a good example (Kibaroğlu et al., 2005).

Several initiatives touch on the issue of transboundary cooperation in the basin, and building on these initiatives or providing technical or financial support to them could improve the status of ecosystems and biodiversity in the basin area, while also encouraging cooperation between the riparian countries in issues of water management (Kibaroğlu et al., 2005).

Water quality in the basin suffers from the discharge of insufficiently treated domestic wastewater, mainly by Bulgaria and Turkey, and resolving this problem requires major investment. The financial support provided by EC programs and development banks could be supplemented by initiatives promoting cooperative approaches and the exchange of knowledge and know-how between riparian countries (Kibaroğlu et al., 2005).

Water in the basin is mainly employed in irrigated agriculture in both Bulgaria and Turkey. Promoting joint riparian efforts to increase the efficient use of water in irrigation would not only help reduce the pressure on the available water resources but would also foster cooperation in water resource management. The same applies to efforts to reduce the pollution associated with agricultural runoff. EU accession requires all riparian in the Maritsa River Basin to adopt the WFD and the UNECE Water Convention. Using the Maritsa River Basin as a pilot area, Bulgaria and Turkey could be assisted in implementing the relevant legislation, thus providing the grounds for transboundary cooperation, and an initiative could ultimately lead to the establishment of a trilateral river basin commission, similar to those that exist in other European transboundary basins (Kibaroğlu et al., 2005).

In 1991, the Bulgarian and Greece committees came together and signed a protocol related to the measurement and monitoring of quality and quantity values in the Maritsa, Nestos and Surma Rivers, and submitted an application to the EU. This led Bulgaria and Greece to set up hydro-meteorological

monitoring station on the rivers between 2000 and 2006 under the INTERREG program, the main aim of which was to overcome the flooding problems. However, Greece never activated the six monitoring stations under its responsibility and had caused many floods and economic damage since 2003 (Valvis, 2011).

Aside from the INTERREG program, the *"Technical Assistance Project on Water Quality Management in Arda River" (2007), "Flood Management in EVROS2010/2010 with Effective Precaution and Joint Operation Simulation in the European Union in Flood Threatened Regions" (2010) and "Flood Risk in the Cross-Border Region" Project of Establishment of Flood Warning System in Arda River Basin to Minimize" (2014)* are the other transboundary agreements in the Maritsa Basin.

Under the IPA program, Bulgaria and Turkey signed the "INTERREG IPA Cross-border Program Bulgaria and Turkey – CCI 2014TC16I5CB005" in 2015 (Bulgaria-Turkey IPA Cross-border Programme). Moreover, the NIMH (Bulgaria) and DSİ (Turkey) have also developed projects aimed at flood protection, including:

1. Risk Analysis for Flood and Flood Mitigation in the Maritsa River Basin and Sharing of Information with Assessment Project
2. Capacity Enhancement and Flood Control Project for Flood Forecasting

Conclusion

This chapter makes a holistic analysis of three main issues – water quality, agricultural activity and energy – and their influence on the countries of Turkey, Greece and Bulgaria. When these three issues are examined together, all riparian will benefit.

Maritsa Basin is very important for Turkey, in terms of its agricultural and industrial activities. The total area of the

Maritsa-Ergene Basin is 14,560 km^2. According to TUİK data, the population of the Maritsa-Ergene Basin is 1,768,368, and there is 11,357 km^2 of agricultural land, meaning that 80 percent of the area is suitable for agriculture. Furthermore, 75 percent of agricultural production is plant cultivation, while the remaining 25 percent comes from livestock. The agricultural land is used for the cultivation of 12 percent of the total wheat, 61 percent of the total sunflower and 54 percent of the total rice production in Turkey. As such, the irrigation provided by Maritsa River is of vital importance to Turkey (TUBİTAK, 2013). Additionally, there are 2,037 industrial plants in the area, 82 percent of which are in Tekirdağ, 10 percent are in Kırklareli and rest are in Edirne (Sağlam, 2014). The textile and clothing sectors are predominant in the area and are the industries that use the most water for production.

The main problem encountered in the Maritsa region of Turkey is flooding, which in the past has not only destroyed large agricultural areas, but also decreased the water quality in the rivers. Furthermore, floods cause considerable damage to the properties of those living in the Thrace region, at great cost. If these three riparian countries can reach an agreement by addressing the transboundary water problem holistically, everyone will be able to benefit from it.

Turkey can minimize the damage from flooding and will be able to irrigate its agricultural lands during the dry season, and can also benefit from the Maritsa River as a local and cheap source of energy, and these benefits are the same for Greece. As Greece's share of the Maritsa region is lower than that of Turkey, its benefit will be less. The benefit gained by Bulgaria is different to that of the other two countries. If Bulgaria complies with its duty to prevent flooding, it will no longer be under political pressure from Turkey and Greece and will fulfill the requirements of the EU and international agreements.

In addition, bilateral and multilateral agreements should be evaluated holistically, and the applied and non-applied articles should be examined. A solution to the problems should be proposed and evaluated.

References

Aktas, Y. (1993). Meriç Nehri'nde Kimyasal Kirliliğin incelenmesi (Examination of Chemical Pollution in Meric Basin). Unpublished PhD Dissertation, Edirne: Trakya University.

Arsov, R. (2004). Bulgarian Transboundary Rivers. Paper presented at the workshop Development of an Inventory of Internationally Shared Surface Waters in South- Eastern Europe. Thessaloniki, Greece, 18-20 Oct. 2004.

Buechsenschuetz, U. (2003). Turkey's New Energy Policy Hits Bulgaria. Radio Free Europe/Radio Liberty Newsline 19 June 2003. http://www.rferl.org/newsline/2003/06/190603.asp.

Delipınar, Ş., & Karpuzcu, M. (2017). Policy, legislative and institutional assessments for integrated river basin management in Turkey. *Environmental Science & Policy*, *72*, 20–29. https://doi.org/10.1016/j.envsci.2017.02.011.

DSİ. (2005a). Türk Heyeti Bulgaristan'daydi. Basin Bültenleri, DSİ Genel Müdürlügü, Basın Müşavirliği, 1 April 2005. www.dsi.gov.tr/basin/bulgaristan.htm

DSİ. (2005b). Bulgar Heyeti Suakacagi Baraji Icin Türkiye'deydi. Basin Bültenleri, DSİ Genel Müdürlügü, Basın Müşavirliği, 10 May 2005. http://www.dsi.gov.tr/basin/bulgaredirne.htm

Eleftheriadou, E., Giannopoulou, I., & Yannopoulos, S. (2015). The European Flood Directive: Current Implementation and Technical Issues. *European Water*, *52*, 13–22.

Enerji Atlası. (2015). Doğalgaz Santralleri. http://www.enerjiatlasi.com/dogalgaz/.

Ensonhaber. (2014, 6 December). Tunca ve Meriç nehirlerinin suları birleşti. https://www.ensonhaber.com/tunca-ve-meric-nehirlerinin-sulari-birlesti-2014-12-06.html.

Erkal, T., Topgül, İ. (2014). Floods of Meriç River occurred in the last fifteen years and protection projects. TÜCAUM VIII. Coğrafya Sempozyumu.

Eşiyok, B. A., & Sekmen, F. (2012). Türkiye Ekonomisinde Bölgesel Gelişmişlik Farklılıkları, Doğu Anadolunun Bölgesel Gelişimdeki Yeri ve Çözüm Önerileri. Ankara: Türkiye Kalkınma Bankası A.Ş.

GWP-Med. (2012). Transboundary Water Resources Management in Southeastern Europe. http://twrm-med.net/southeastern-europe/transboundary-river-basin-management/shared-surface-water-bodies/new-river-basins/maritsa-evros-meric-river-basin

Hallı, M., Sarı, E., & Kurt, M. A. (2014). Assessment of Arsenic and Heavy Metal Pollution in Surface Sediments of the Ergene River, Turkey. *Polish Journal of Environmental Studies*, *23*(5), 1581-1590.

Hidropolitik Akademi. (2014). Transboundary Floods over Meriç (Maritza/Evros). https://www.hidropolitikakademi.org/uploads/wp/2018/10/Transboundary-Floods-over-Meri%C3%A7-MaritzaEvros.pdf

IUCN. (2004). Conservation without Frontiers - Towards a new Image for the Balkans. A Strategic Plan for the IUCN South-Eastern European Programme. IUCN Regional Office for Europe. http://www.euronatur.org/PDF_Dateien/balkanstrategie_200405.pdf.

Kibaroğlu, A. (2007). *Küresel Havza Yönetimi Yaklaşımları: Türkiye Su Kaynakları Yönetimine Yansımaları*. 113–122.

Kibaroğlu, A. (2008). Meriç Nehir Havzası Sınıraşan Su Politikaları. *Taşkın Konferansı Bildiriler Kitabı*.

Kibaroğlu, A., Klaphake, A., Kramer, A., Scheumann, W., & Carius, A. (2005). *Cooperation on Turkey's transboundary waters* (F+E Project 903 19 226). The German Federal Ministry for Environment.

Kimençe T. (2015). Alt Komite Toplantısı Sunumu – Çevre İklim Değişikliği AB'iyeliği ile İşbirliği Meriç Havzası. Ankara.

Kole, M., (2004). Meriç Nehri Hidropolitiği. Unpublished Paper, Hydropolitical and Strategic Research Center. Ankara: Hacettepe University

Milliyet, (1996, 5 December). Edirne'yi su bastı. http://www.milliyet.com.tr/1996/12/05/yasam/edirne.html .

Mylopoulos, Y. A., Eleftheriadou, E. & Kampragou, E. (2004). The transboundary catchment of River Nestos and the bilateral agreement

between Greece and Bulgaria. Conference on Integrated Water Management of Transboundary Catchments: A Contribution from TRANSCAT. Venice, Italy: 24-26 March 2004.

Nenkova, S. (2005). Turkey Still Wants Gorna Arda, Maritsa Projects. *Bulgarian Economic Review*, *6*, March 28, 2005. http://www.pari.bg/cgi-bin/ber.home.cgi.

Nikolaou, A. D., Meric, S., Lekkas, D. F., Naddeo, V., Belgiorno, V., Groudev, S., & Tanik, A. (2008). Multi-parametric water quality monitoring approach according to the WFD application in Evros trans-boundary river basin: Priority pollutants. *Desalination*, *226*(1–3), 306–320. https://doi.org/10.1016/j.desal.2007.02.113

NTV Haber. (2015). NTV Haber Sitesi. Nisan 28, 2015 http://www.ntv.com.tr/galeri/turkiye/tarlada-balik-tutuyorlar,FNdv88J0XE2oS2g5_H6PVw/gITSAYR1Zk-TGBw9Io34FQ.

Offlinepost (2019, 29 December). EastMed και TANAP: φωνές και ψίθυροι. https://www.offlinepost.gr/2019/12/29/eastmed-%CE%BA%CE%B1%CE%B9-tanap-%CF%86%CF%89%CE%BD%CE%AD%CF%82-%CE%BA%CE%B1%CE%B9-%CF%88%CE%AF%CE%B8%CF%85%CF%81%CE%BF%CE%B9/

Ozis, U., Ozdemir, Y., Baran, T., Turkman, F., Fistikoglu, O. & Dalkilic, Y. (2002). Turkiye'nin sinir asan sularinin su hukuku ve su siyaseti acisindan durumu. In Zekai Sen (ed.) *Sinir Asan Sularimiz.* Istanbul: Su Vakfi Yayini, 36-37.

Öziş, Ü. & Özdemir, Y. (2002). "Firat-Dicle Havzasi ve Türkiye" TMMOB 2. Su Politikaları Kongresi.

Özdemir, 2015. "Boundary Water Policies in The World: Evaluation of The Meriç Basin." Expertise Thesis of Ministry of Forestry and Water Management, 2017.

Surgun, O. & Zaraci, Y. (2018). Ranking of provinces by entrepreneurship, innovativeness, and human capital indicators, using PROMETHEE –The case study of Turkey, Mehmet Akif Ersoy University Department of Economics, Turkey.

Sadoff, C. & Grey, D. (2002). Beyond the river. Benefits of cooperation on international rivers. *Water Policy*, *4*, 389-403.

Sağlam, S. (2014). Meriç Nehir Havzası'nın Avrupa Birliği Su Çerçeve Direktifi Açısından Değerlendirilmesi - Uzmanlık Tezi. Ankara: T.C. Orman ve Su İşleri Bakanliği.

Samsunlu, A., Maktav, D. & Kapdaslii, S. (1996). Transboundary Water Issues Between Greece-Bulgaria and Turkey: The Case of Meriç / Evros River. In Istvan Bogardi (ed.) *Transboundary Water Resources Management. Institutional and Engineering Approaches*. Berlin: Springer.

TEİAŞ, 2015. TEIAS Kapasite İhale Sistemi. www.tcat.teias.gov.tr/companies/registered.

Trakyaka. (2009, 1 May). Trakya Kalkınma Ajansı. http://www.trakyaka.org.tr/content-184-bolge_ekonomisi.html

TUBİTAK., 2013. Havza Koruma Eylem Planlarının Hazırlanması Projesi - Ergene Havzası. Ankara: Orman ve Su İşleri Bakanliği.

Valvis, A. (2011, June). *Environmental security and trans-boundary water management: Political and economic dimensions of ri ver Evros "mis-management."* The 5th Biennial Hellenic Observatory PhD Symposium on Contemporary Greece & Cyprus.

Yanik, B. (1997). Türkiye'deki Sinir asan ve Sinir Olusturan Su Kaynaklari. Unpublished PhD dissertation. Istanbul: Teknik Üniversitesi.

Yildiz, D. (1999). Sinir Olusturan ve Sinir asan Su Kaynaklarımız ve Kiyidas Ulkeler Arasında Teknik Isbirliği Gereksinimi. Cevre ve Mühendis TMMOB Cevre Mühendisleri Odasi Yayini, no. 18: 28-35.

Zeitoun, M., & Allan, J. A. (2008). Applying Hegemony and Power Theory to Transboundary Water Analysis. *Water Policy*, *10* (Supplement 2), 3-12. https://doi.org/10.2166/wp.2008.203.

Chapter 7

Water Security and Climate Change Challenges in the Transition Economies of Central Asia

Iskandar Abdullaev, Shavkat Rakhmatullaev

Introduction

Central Asia is one of the world's oldest water-dependent regions. Often referred to as the Aral Sea Basin, it is fed by two large rivers –Amu Darya and Syr Darya. Water has been a key component in the socio-economic development of the region throughout its history. The high mountains, broad valleys and great deserts of Central Asia have witnessed the construction of ancient cities, and the emergence and disappearance of civilizations due to the lack of water, and the desertification of gardens and irrigated lands (Dukhovny & De Schutter, 2011). The main element in the survival of any civilization in the Aral Sea Basin has been its access to water, and as a result, a vast and interlinked water infrastructure has developed in the region (Abdullaev, 2012).

Water-related infrastructure is both a wealth and a curse for the region. It is projected that by 2040, all Central Asian countries will be experiencing "extremely high" levels of water stress, among the other top 33 countries in the world (WRI, 2020). Moreover, it is reported that renewable water availability per capita declined by 25 percent between 2002 and 2014 across Central Asian countries (UN, 2018). Failure to invest in water management and improve water security may impede economic

growth and job creation, while poor water supply and sanitation will have a direct impact on social stability, health and human capital development (WWAP, 2019; WB, 2019; 2015). Climate change will affect the rural and urban populations differently. Poverty, migration and food insecurity are most prevalent in rural areas. For example, the vulnerability of the rural population to climate-related risks is higher than the urban population due to the existing constraints on the available financial resources, the access to employment opportunities and the fragile physical infrastructure (ADB, 2017).

Related to the economic context, the region may witness a decline of up to 6 percent of its regional GDP (Gross Domestic Product) growth rates by 2050 under a business-as-usual scenario related to inefficient water management regimes (WB, 2016a). The costs of inaction, however, will be far higher, especially under the impacts of climate change. Thus, it is of vital strategic importance to harness the productive potential of water resources and limit their destructive impacts (Strong et al., 2020).

The demand for water, energy and food will increase with the projected population growth in Central Asia, with the 72 million in 2017 projected to increase by 18 million by 2050. Furthermore, the economic outlook for the next 2–3 years is not optimistic for the region, as the traditional sources of export-led growth will be affected due to the low price of mineral commodities (oil, coal, gas and metal) under the coronavirus situation (WB, 2020a). The coronavirus pandemic has led to the most significant negative shock felt since the global financial crisis, and it continues to do severe damage to global activity.

The Central Asian countries remain among the least energy-efficient and most carbon-intensive economies in the world (WB, 2016b). While the governments recognize that the increased use of new renewable energy (e.g., solar and wind)

will reduce the economy's carbon intensity, such sources still account for only a fraction of the generated electricity across the countries. Kazakhstan is the only country that has made practical efforts in the solar and wind energy sector, developing large-scale plants to generate electricity on a large scale, while nascent conditions can be observed in all other countries in the region.

The break-up of the former Soviet Union and the subsequent transformation of the region affected all aspects of governance, policymaking and economic activity, i.e., agriculture, industry and environmental policies, during the statehood building process (Guillaume et al., 2015). And still, some processes remain unfinished and in the fluid phase. During the "construction of statehood" in Central Asia, regional integration has been outpaced by the more autonomous development pathways established by each state.

Water has become a key element in both the enhancement and limitation of economic development in the region. Under the expected impacts of climate change, the region may face severe water shortages, equal to 8–10 percent of the current water use (CAREC Institute, 2020). According to different scenarios, the per capita water availability in the region will drop from 2,500 cubic meters/per capita per annum to 1,400 cubic meters/per capita per annum (Varis, 2014). Moreover, the inefficient use of water and the vast amounts of water lost from the water systems will further deteriorate the water situation in the region. The subsequently increased competition for water between riparian nations, economic sectors and communities may lead to both a slowdown in economic development and a loss of political stability (Bernauer & Siegfried, 2012; Leb et al., 2018).

Since the 2000s, the concept of water security has been widely discussed in research and in international development

spheres, from the household to the global level (GWP, 2000; Abdulloev, 2020; Xenarios et al., 2019). In earlier approaches, physical water availability indices that tracked imbalances between supply and demand were a central part of researches, such as Falkenmark's water stress index, and the ratio of withdrawal to the availability of water; yet they did not account for inadequacies in the water infrastructure (Srinivasan et al., 2017). Later, an economic water security concept was developed by several authors to account for the role played by the water infrastructure (Sadoff et al., 2015). Moreover, the scale of intervention/analysis (household, community, river basin, country and world) emerged as another major factor; i.e., achieving water security at one scale may threaten water security at different scales (Hoekstra et al., 2018). This holds especially true with globalization, as the production and consumption regions are geographically distinct (Mekonnen & Hoekstra, 2014). Sadoff et al. (2015) claims that water security is not a static goal, but rather a dynamic continuum that alters with changing climates, growing economies and asset stocks, as well as resource degradation.

Looking at water security from a risk standpoint, managing risks and reducing vulnerability to shocks from climate variability and water-related disasters is another arena of adaptation and mitigation. In this context, the Sendai Framework for Disaster Risk Reduction of 2015 can be viewed as addressing a broader scope of hazards and risks for the prevention and mitigation of the shocks linked to natural and man-made hazards (UNDRR, 2019). In making the logical connection between reducing risk and building resilience, the Sendai Framework provides the connecting tissue between the 2030 Agenda for Sustainable Development and the Paris Agreement.

ADB (2016) have developed water security quantitative indicators which are the most comprehensive assessment for

the entire Asian region. In nutshell, a region's performance is strongly influenced by its water governance, inefficient resource policies, and its level of dependence on transboundary water resources (Jalilov et al., 2013; Wegerich et al., 2015; Rakhmatullaev et al., 2018). Currently, each country seeks to secure its water, energy, and food resources, but in doing so, compromises the environment. In fact, the current political agendas are borne out of the dominant Soviet self-sufficiency policies that were implemented in response to the Cold War-era realities (Stucki & Sojamo, 2012). Self-sufficiency political modes of production will dominate under the ongoing Coronavirus pandemic, and especially in agriculture. Currently, countries are promoting a highly politicized security approach, compromising:

- Water security: national priorities, climate change adaptation, demand-driven, efficiency improvements, IWRM policies and institutions;
- Energy security: new production, renewable energy sources, energy efficiency policies, transmission systems, energy markets;
- Food security: self-sufficiency, export and markets, distribution, efficiency, crop diversification;
- Environment: protection, rehabilitation, environmental services, eco-tourism, biodiversity.

All nations face the same challenges related to sustainability in the provision of water and energy. Local governments often find themselves in a charge of service delivery, but lack the capacity to fulfill this function (OECD, 2011). Moreover, the engagement of the private sector has proved to be a cumbersome endeavor in water-related sectors, as still most infrastructure is under state jurisdiction.

At an operational level, resilient service delivery requires building and improving the capacity of local water and energy service utilities to assess and identify climate risks and adapt their current practices to sustainable operation and adequately respond to the climate change challenges (WB, 2015). The best international best practices frame three interlinked processes: i) vulnerability assessments of the system; ii) climate-resilient business planning and iii) the development and implementation of an emergency response plan (USAID, 2017). Public utilities are reluctant and unready to interact with outside stakeholders on customer-related matters.

The main goal of this paper is to make a comprehensive assessment of the main issues and perspectives of the irrigation, energy, agriculture and water supply & sanitation sectors in the context of water security, risk management and potential climate change projections. Water footprint assessments of cotton, wheat and rice are presented to understand the current situation in water and land allocation, and their relationship with international trade.

Climate change and GHG emissions

Temperature changes and heat extremes are projected to increase more in the summer months than in cold periods in Central Asia (ADB, 2017). An increase in air temperature will increase the biological water requirements of crops with increased evapotranspiration rates, and as a result, more water will be needed for irrigation (CAREC Institute, 2020). On other hand, a decrease in precipitation is predicted in the summer and fall, while a modest increase or no change in precipitation is expected in the winter months in the region (Rakhmatullaev & Abdullaev, 2014). Moreover, scientific observations and state-of-the-art climate models show an increase in the frequency and intensity of rainfall events in many parts of the

world (WWAP, 2020). Extreme precipitation is a pre-condition for mudflows, flash floods, landslides and accelerated rates of erosion and sedimentation, each of which poses a danger to the normal operation of water-related infrastructures and contributes to service disruptions.

Glaciers recession may occur more rapidly due to the warming, which may reduce river flow significantly and negatively impact long-term water availability in some countries (WB, 2016a). At first, the shrinking of glaciers will supply surpluses for the river runoff, but in the future the reduced glacier volume will eventually result in a decrease in summer runoff, at the peak of the vegetation period (WWAP, 2020). For example, extreme rainfall events will lead to flooding, with impacts of physical assets and an increase in turbidity levels, affecting water quality. Increased surface temperatures can lead to algal bloom, affecting water quality and increasing evapotranspiration, thus reducing water supply (UNICEF and WHO, 2019).

All countries in the region are party to the United Nations Framework on Climate Change Convention (UNFCCC) and are signatories to its annex, the Kyoto Protocol and the updated Paris Agreement (Table 1). The countries have submitted their three editions of the national communications on climate change to the United Nations. In the context of climate change adaptation, both the mandate and role of national water management agencies, and water and energy utilities are only supportive, i.e., providing data and information, and participating in the preparation of national communications with other government agencies.

Table 1. Status of climate agreements in Central Asian nations

Country	UNFCCC	Kyoto Protocol	Paris Agreement	National Communication Submission	NDC Submission
Kazakhstan	June 1992 (signed) May 1995 (ratified)	March 1999 (signed) June 2009 (ratified)	August 2016 (signed) December 2016 (ratified)	NC1- November 1998 NC2-June 2009 NC3-June 2013	December 2016
Kyrgyzstan	May 2000 (ratified)	May 2003 (ratified)	September 2016 (signed)	NC1-March 2003 NC2-December 2008 NC3-January 2017	February 2020
Tajikistan	January 1998 (ratified)	December 2008 (ratified)	April 2016 (signed) March 2017 (ratified)	NC1- October 2002 NC2- December 2008 NC3- December 2014	March 2017
Turkmenistan	June 1995 (ratified)	September 1998 (signed) January 1999 (ratified)	September 2016 (signed) October 2016 (ratified)	NC1- November 2000 NC2- November 2010 NC3- January 2016	October 2016
Uzbekistan	20 June 1993 (ratified)	November 1998 (signed) October1999 (ratified)	April 2017 (signed) November 2018 (ratified)	NC1- October 1999 NC2- December 2008 NC3- February 2017	November 2018

Source: National Communications to Climate Change (www.unfccc.int)

The region's countries are lagging in the preparation of their national action plans on climate change mitigation and adaptation. Due to both the scattered nature of the data and the scarce analytical skills, reporting on climate change is becoming an additional burden on state agencies. The capacitating of the national focal points on climate reporting is a major field of intervention for the international partners in Central Asia. Both vertical and horizontal coordination, and coherence in the governance architecture involving a variety of stakeholders have consequently become vital.

Aside from Kyrgyzstan, all countries have ratified the Paris Agreement, and Nationally Determined Contributions (NDCs)

have been submitted. The NDC reveals the national efforts to reduce GHG emissions, and to increase resilience and reduce vulnerability to climate change within the context of sustainable development (Table 2). Each country is required to provide its NDCs every five years (FAO, 2018). Intended Nationally Determined Contributions under the ratification of the Paris Agreement determines national measures on post-2020 period climate national action plans.

Table 2. Elements of submitted Intended Nationally Determined Contributions (INDC) across Central Asian countries

Country	Target	GHG	Sectors
Kazakhstan	Intending to achieve an economy-wide 15%-25% reduction in GHG emissions by 2030 compared to 1990	Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6)	Energy, Agriculture, Waste, Land Use, Land-Use Change and Forestry
Kyrgyzstan	Intending to reduce GHG emissions in the range of 11.49 - 13.75% below BAU in 2030. Additional mitigation measures could reduce GHG emissions in the range of 29.00 - 30.89% below BAU in 2030 compared to 2010	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulfur hexafluoride (SF_6), Nitrogen trifluoride (NF3)	Energy, Industry, solvents and other product use, Agriculture, Land use, land-use change and forestry, Waste
Tajikistan	The potential to reduce GHG emissions to achieve a target of 65-75% of the 1990 level by 2030	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	Power industry and water resources, Industry and construction, Land use, agriculture and gardening and grazing, Forestry and biodiversity, Transportation and infrastructure
Turkmenistan	Limiting GHG emissions and improving the country's capacity to respond to climate change by 2030 from the 2000 level	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	Energy, Industry, Agriculture, Waste
Uzbekistan	Intending to decrease specific emissions of GHG per unit of GDP by 10% by 2030 from 2010 levels	Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O)	Energy, Agriculture, Industry, Irrigation

Source: UNFCCC (https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx)

Since 1990, all countries have substantially decreased their CO_2 emissions, but are still higher than the global average emission (Figure 1). The analysis indicates that the energy sector is the major emitter of GHG gases, followed by agriculture and industry.

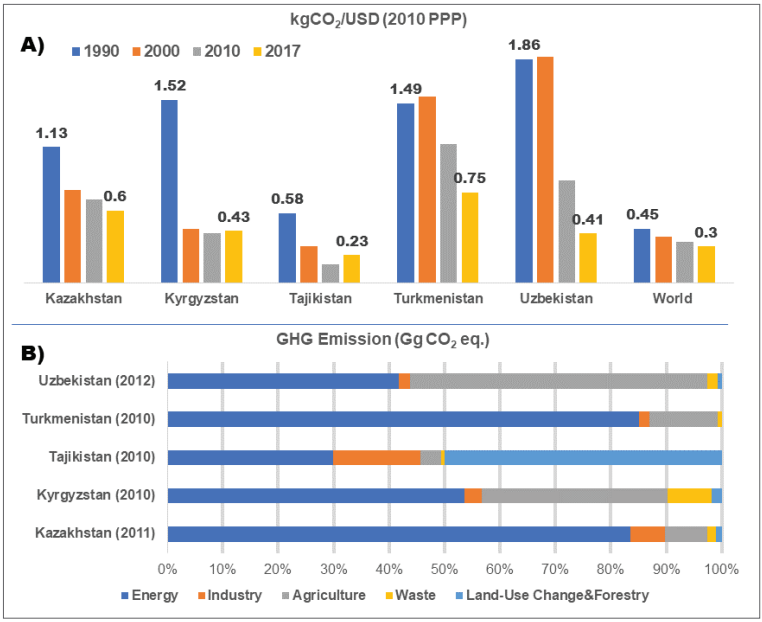

Figure 1. Greenhouse gas emissions A) CO_2 emissions per unit of GDP and B) CO_2 emission by sectors across Central Asian countries. Source: IEA, 2020; National Communications to Climate Change.

Irrigation and drainage

Climate change consequences may transform irrigated agriculture into a restrictively expensive trade (Figure 2). Further temperature increases in the region, where most rivers are fed by snow and glacier melt, will likely lead to changes in river run-off. Long-term projections suggest that the main rivers of

Central Asia will likely experience a reduction in annual run-off (Rakhmatullaev & Abdullaev, 2015; 2016).

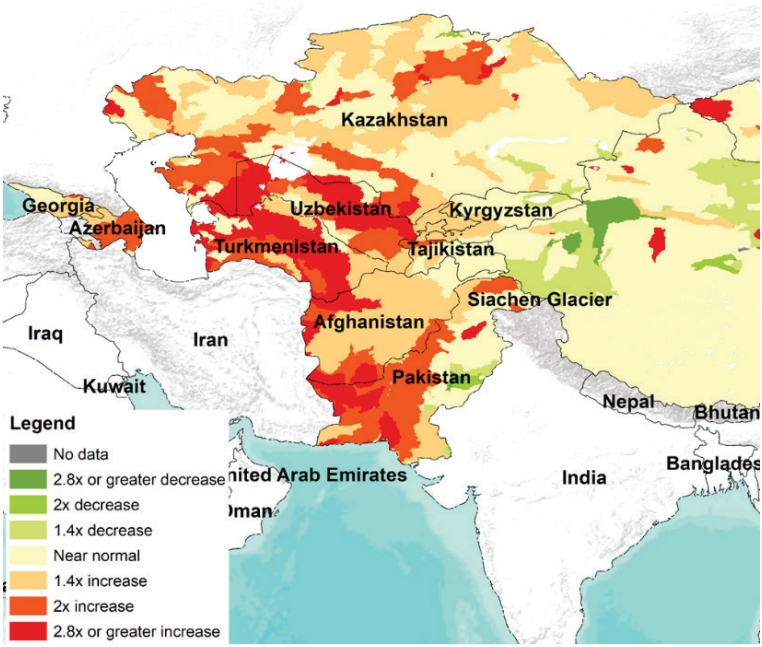

Figure 2. Projected changes in water supply by 2040 under the RCP 8.5 scenario in Central Asia. Adapted from WRI Aqueduct 3.0 (https://www.wri.org/aqueduct).

Currently, the reform of the agriculture, land and water sectors in Central Asia is incomplete. The regulation of agricultural production systems and land ownership is lower than in the Soviet period, although governments still play a significant role in setting production quotas, land distribution and agriculture pricing. The public authorities position themselves as social stabilizers by providing food and water security to the populations, with the downside to this tightly regulated system being the reduced incentive for private financing to the sector, especially infrastructure.

The availability of, and access to water of adequate quantity and quality determines economic performance, social coherence and political stability. All national strategic development programs clearly prioritize an increase in irrigated areas through either new irrigation systems or reclamation efforts (Table 3). This is clear evidence that countries focus on resource extraction rather than productivity gains. All countries claim to have adopted water-saving/conservation measures, yet without practical proof, although water saving could lead to the further expansion of irrigated land, leading to even more water scarcity and a reduction in return flow due to reduced drainage, resulting in a decrease in aquifer recharge and its depletion.

Table 3. Characteristics of irrigated lands in Central Asian nations, and the share of electric power and groundwater sources

Country	Total area equipped for irrigation ('000 ha)	Actual area under irrigation ('000 ha)	Total electric-powered irrigated area ('000ha)	Share of electric-powered irrigated lands (%)	Area equipped for irrigation by groundwater ('000ha)	Share of area irrigated from groundwater (%)
Kazakhstan	2,066	1,265	41	2	2	0.1
Kyrgyzstan	1,023	1,021	51	5	7	1
Tajikistan	742	674	296	40	33	4
Turkmenistan	1,991	1,991	318	16	9	0.5
Uzbekistan	4,199	3,700	1,133	27	274	6
Total	**10,021**	**8,651**	**1,839**		**325**	

Source: FAO AQUASTAT, 2019.

The government of Kazakhstan has an ambitious national program in place to increase its irrigated lands by 1 million ha, and to reclaim 0.5 million ha through the construction of 28 new water reservoirs (with a capacity of 3.8 billion m^3) by 2030 (Government of Kazakhstan, 2020). The government of Uzbekistan plans to reclaim about 0.3 million ha through the construction of seven new water reservoirs with a capacity of

45 million m^3 by 2025 (Ministry of Water Uzbekistan, 2020). Furthermore, all countries, over the next two decades, intend to either reclaim and/or increase their irrigated areas.

Around 1.37 million ha of land equipped for irrigation is reportedly not actually being irrigated in the countries due to various technical and financial reasons. In particular, around 0.8 million ha is not being irrigated in Kazakhstan (FAO, 2019). This shortfall may be attributed to the underfinancing of irrigation schemes, the disrepair of hydraulic infrastructures, the depletion of groundwater resources, and most importantly, the degradation of soil quality and the reduction of ameliorative conditions.

The total electric-powered irrigated area is in the region of 1.83 million ha, accounting for approximately 18 percent of the total irrigated lands, costing governments considerable financial resources from their national budgets. Energy efficiency programs will be thus an integral part of mitigation measures. In addition, approximately 325,000 ha irrigated lands are irrigated from groundwater resources, which requires approximately 30 percent more energy than surface water irrigation, and results in significantly higher greenhouse gas emissions (WB, 2016a).

A 1 percent improvement in efficiency could generate US$10 million of savings annually across the five Central Asia countries, and a 10 percent increase in water pumping efficiency could result in regional public expenditure savings of $188 million per year (WB, 2016b). Annually, billions of cubic meters of water are being lifted, conveyed and transported from surface and groundwater sources via a complex infrastructure system of pumping stations, water intake structures, boreholes and vertical drainage systems, due to the prevailing topographical and hydrogeological environments.

In parallel to the national water policy making, the status of the water agencies at a national level has changed. Previously, independent water ministries have been merged with

those overseeing agriculture, energy or the environment, and thus the decision-making power and prestige of water agencies have been downgraded (Abdullaev & Rakhmatullaev, 2015). The interests of the Central Asian countries on water are different, e.g., downstream countries try to secure water for irrigation and upstream countries using water for hydro-energy production. The countries of the Central Asia have conducted series of the reforms in water sector. Although mergers with other ministries and reductions in funding have taken place, there have been few changes at the operational middle level of water management agencies (Rakhmatullaev et al., 2013).

For example, the irrigation sector (43 large, 1400 medium and 30,000 small sized electrical pumps) consumes around 20 percent of the total electricity use in Uzbekistan (Rakhmatullaev et al., 2010). Annually, some US$425 million is spent on the operation of pump-lifted systems in Uzbekistan alone (cost per kWh = US$0.047 in Uzbekistan 450 UZS/kWh (http://www.uzbekenergo.uz/ru/activities/tariffs-electric-power/).

Material evidence from a 25-year period shows that the arable land (hectares per capita) in all countries has decreased substantially due to population growth, and there are even more dramatic projections for 2050 (Table 4). According to the UNDP (2013), an average of 18 percent of the population is living on degraded lands in individual countries.

Table 4. Arable lands (hectares per capita) for Central Asian countries

Country	1992	2016	Change (decrease)
Kazakhstan	2132	1652	29%
Kyrgyzstan	0.292	0.212	38%
Tajikistan	0.156	0.08	95%
Turkmenistan	0.381	0.343	11%
Uzbekistan	0.209	0.14	49%
World	**0.232**	**0.192**	**21%**

Source: FAO, 2019.

Soil quality degradation is another important factor in population growth projections. The mean figures do not tell the full story of the availability of arable lands. The spatial distribution and quality of arable lands within a country's geographic regions and among its communities play a significant role in decision-making processes. Regretfully, decision-makers do not fully utilize geo-spatial technologies and knowledge products in their selection of agricultural cropping patterns and land allocation, and the same holds true for the design of national water-saving technology programs, and as a result, the expected outcomes are not achieved. Based on geospatial data, specific addressed support programs (financial or technical) should be designed for mitigation activities for most affected communities, as migration may otherwise occur as people go in search of better places to earn a living.

Governments should promote water and land productivities and the diversification of agricultural production, although the practical uptake is rather limited, despite the existence of national programs with subsidy, tax and financial incentive components. The main reason for this is that a large proportion of the benefits are public, while technology adoption costs are private. One potential way forward may be to expand crop insurance instruments and to raise awareness among farmers, encouraging them to change their behavioral and social norms through education programs.

Water footprint of wheat, rice and cotton

The water footprint of a product is the volume of clean water required to produce the product, measured at the place where the product is actually produced (Aldaya et al., 2010; Mekonnen & Hoekstra, 2014). The green water footprint is the volume of rainwater consumed during the growing period of the crop; and the blue water footprint is the volume of surface

and groundwater consumed. The water footprint assessment of crops could inform the production and trade decisions that are most suited to the local environmental conditions. Through such an assessment, a country can strategically treat its domestic water resources through the import of water-intensive products rather than producing them domestically. This paper presents an analysis of three strategic agriculture crops – wheat, rice and cotton – revealing their importance for export revenues and food security.

Wheat is the leading food grain in the human diet, with rice being the second staple food crop across the countries of the region, and the two crops provide 38 percent of the total human calorific intake (FAO, 2019). Wheat is also used as a feed source for the livestock and poultry sectors. On a global scale, wheat and rice have the largest blue water footprints, together accounting for 45 percent of the global total (Mekonnen & Hoekstra, 2014). Around 53 percent of the global cotton fields are irrigated, supporting 73 percent of global cotton production. As would be expected, the largest share of the blue water footprint can be observed in arid and semi-arid regions, where the climatic conditions need to be overcome. In fact, wheat is at the greatest threat from water shortages, as more than half of the irrigated wheat is exposed to extremely high-water stress, and it is projected that by 2040, nearly three-quarters of wheat production will be under threat (WRI, 2020).

The analysis shows that the areas cultivated for the three crops in question range from 22 percent in Kyrgyzstan to 81 percent in Turkmenistan, while Uzbekistan uses around 46 percent of the total water uses in Central Asia for the cultivation of these three crops. This high number can be attributed to the practice of salt leaching in Turkmenistan and Uzbekistan. Briefly, the share of total renewable water resources used across

all countries in question for the production of wheat, cotton and rice is 17 percent, 8 percent and <1 percent, respectively.

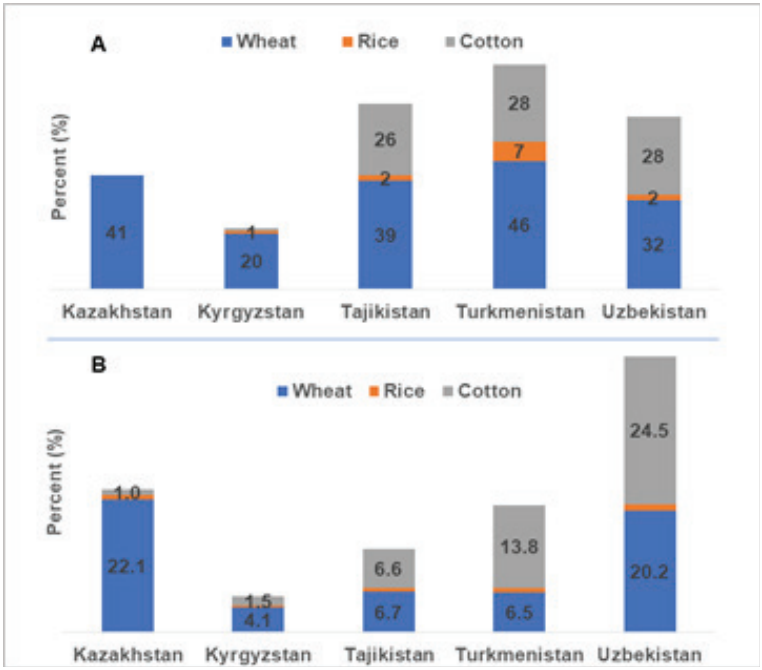

Figure 3. Distribution of A) area sown B) water used for production of wheat, cotton and rice in Central Asian countries. Source: based on FAO data (2020).

Wheat is grown on 39 percent of the total agricultural lands (i.e., ca. 14.7 million ha) in the region, ranging from 20 percent in Kyrgyzstan to 41 percent in Kazakhstan (Figure 3). The wheat basket of the region is Kazakhstan which produces around 63 percent of the total on regional scale (i.e. 23.4 million tons) (FAO, 2019). Winter and spring wheat varieties are cultivated both in rainfed (mostly in Kazakhstan) and irrigated areas. The average global total water footprint for wheat is estimated to be 1,620 m3/ton (Mekonnen & Hoekstra, 2014). The total footprint estimates for crops are different and region-specific. For

conformity purposes, the average global footprint was used. A total of 37.8 billion m^3 of water (both irrigated and rainfed) is needed to grow wheat in the region. For wheat, the water footprint per ton of irrigated and rain-fed agriculture is very similar to the global average.

Cotton is grown on over 2.1 million ha of irrigated lands (8 percent out of total in Central Asia), and Turkmenistan and Uzbekistan are among the top producers in the world. The total cotton production of the region is estimated at 5.1 million tons. The average global total water footprint for cotton is about 3,589 m^3/ton (Mekonnen and Hoekstra, 2010), and a total of 18.3 billion m^3 of clean water is needed to grow cotton in the region. Rice, as the third strategic crop, is sown on 337,000 ha in the region, with Turkmenistan (138,000ha) and Kazakhstan (104,500ha) being the largest producers. On regional scale, the total rice (paddy) production is reported to be 1.1 million tons. The average global total water footprint for rice (paddy) is around 1,486 m^3/ton (Mekonnen and Hoekstra, 2014). A total of 1.7 billion m^3 of clean water is needed to grow rice in the region.

The total water used for both rainfed and irrigated cultivation of the three crops is estimated at 57.8 billion m^3 (around 25 percent of the total renewable water reserves of Central Asian region). The analysis of the water use clearly indicates that the governments of Tajikistan, Turkmenistan and Uzbekistan need to re-think the diversification of their cropping structure and improve water allocation, taking into account the projected climate change impacts.

It is clear that countries still allocate a disproportionate amount of agricultural land and water resources to wheat and cotton, as strategically at least 15–20 percent of land should be used for walnuts, vegetables, fruit and sunflower crops. Such a re-allocation of cash crops does not contribute only to water

savings yet create opportunities for employment in rural areas, increased food security and provides healthier diets with vitamins. International trade becomes distorted when countries in arid areas continue to produce water-intensive goods at an ever-increasing financial and social cost.

As the analysis reveals, the export of the selected agricultural commodities constitutes only, on average up to a quarter of the total export quantities (Table 5). Kazakhstan is the main breadbasket in the region, and supplies most of the flour to all Central Asian countries and Afghanistan. For example, in Tajikistan, cotton exports bring in around 20 percent of all foreign revenues, while cotton, fruit and vegetables account for 25 percent of foreign revenues in Uzbekistan.

Table 5. Exports of the selected agricultural produce by Central Asian countries for 2017

	Wheat (US$)	Rice (US$)	Cotton (US$)	Edible fruits and nuts (US$)	Edible vegetables (US$)
Kazakhstan	965,447,000	25,960,000	101,976,000	14,562,000	126,769,000
Kyrgyzstan	-	335,000	37,611,000	29,169,000	63,162,000
Tajikistan	-	42,000	204,928,000	11,379,000	4,302,000
Turkmenistan	2,535,000	-	309,872,000	3,053,000	8,803,000
Uzbekistan	20,484,000	-	1,029,933,000	543,935,000	307,714,000
Total	**988,466,000**	**26,337,000**	**1,684,320,000**	**602,098,000**	**510,750,000**

Source: International Trade Center, 2020.

The regional countries differ in their approaches to food security. For example, Turkmenistan and Uzbekistan emphasize food self-sufficiency, while others consider a liberal trade regime and activist agricultural development policies to be the path to food security. In the 2016–2021 period, the government of Uzbekistan has been persistently working to transform its cotton- and wheat-growing zones (about 400,000 ha) into horticultural production areas (Ministry of Water Resources of

Uzbekistan, 2020). The high concentration of two crops, combined with the restrictions on exports of other crops, means that farmers have limited means to adapt to the changing yield and price conditions.

The potential of horticulture is enormous in terms of water consumption and higher value-added margins, i.e. the gross margin per hectare is up to five times that of cotton and wheat (WB, 2020b). In addition, research has shown that horticulture requires at least twice as much labor as cereal crops. With the rapid development of agriculture-related e-commerce and digitization, there are opportunities to increase exports to neighboring China and Russia, although access to those markets is constrained by stringent food safety standards.

While the institutional transformation is concerned mostly with the change in governance and management, the ownership, operation and maintenance responsibilities of water-related infrastructures are still under state jurisdiction. Already in Kazakhstan and Kyrgyzstan, the private ownership of some hydraulic infrastructures, such as low-level hydropower facilities, is being introduced, while the state ownership of the hydraulic infrastructure is being maintained in Turkmenistan and Uzbekistan. In Tajikistan, some concession management is in the hands of private entities.

Water supply and sanitation

Before 1990, in the Soviet era, the living standards in the countries in question were at a higher level than those of other Asian countries, including water supply and sanitation (WSS) access and coverage. Across 5 Central Asian countries, 75–95 percent of people have at least basic access to drinking water and sanitation, yet the safely managed potable water and improved sanitation situation are worrisome (UNICEF and WHO, 2019). On one hand, national statistics still report on "high levels of

access" mainly in urban areas. However, these indicators do not reflect current physical conditions of the water/sewerage infrastructures that are outdated, outsized and deteriorated. The situation as regards both sanitation and drinking water is not promising for rural areas. Most importantly, in the quality of service, there is significant inequality between and within provinces, communities and even neighborhoods. At present, public financial/fiscal programs for maintenance have been substantially reduced, along with the degradation of institutional and organizational capacities (WB, 2015).

Paradoxically, governments and utilities continue to focus their limited capital only on the expansion of piped networks. First, a piped water connection on the premises is considered an "improved source" in both Joint Management Programme (JMP) definitions, although there is no assurance that the quality of water delivered to the household is potable (Smita and Kingdom, 2019). A piped connection that delivers unreliable, poor-quality water is still counted as an "improved source".

Access to WSS systems is relevantly better in the capitals and large urban centers of Central Asian countries, while rural areas are generally in a poor condition. Sanitation usually takes the form of latrines and septic tanks. The coverage of sewer connections is declining in countries, both in urban and rural areas, remaining low both in urban and rural areas, with wastewater being collected, but generally not treated as many wastewater treatment plants are functioning only nominally (UNICEF and WHO, 2019). As a result, most wastewater is discharged into water bodies without proper treatment. There is no accurate measurement, registration or monitoring of water production and consumption. Water losses are high, water metering is low in the countries (UN, 2018). Non-revenue water is as high as 50 percent, yet official statistics only report around 30 percent, with the difference being explained

by the fact that water is charged based on consumption norms rather than being based on actual readings from metered networks (WWAP, 2019).

There have been serious reforms focusing on regulatory, financial and institutional factors, yet the overall governance framework is still in transition. As a result, OECD (2011) rightfully points out "continued political interference has prevented water utilities from operating as autonomous institutions on a commercial basis, whether privately or publicly managed". Administrative decentralization should be described as declarative, yet fiscal resources and decision-making have remained at the central level. Tariff levels and collection rates have increased, yet in practice, they barely meet the operational costs. For instance, user charges rarely recover half of operational costs of utilities (OECD, 2011), and the resulting shortage of funding prevents adequate maintenance, rehabilitation and improvement. Another prevailing observation relates to the increasing tariffs. As the population has not seen any improvement in services, there is opposition to further tariff increases.

The new economic reality is reflected in the new laws allowing private ownership of WSS infrastructures. The private management of WSS is only reported in Kazakhstan, while the other four Central Asian countries still maintain the state ownership and management of the WSS networks (WB, 2015). The engagement of the private sector has proven to be a cumbersome endeavor. Service interruptions can be attributed to either technical causes, such as pipe breaks and sewerage clogs, or financial pressure to reduce the cost of electricity used by the operational pumps. Such interruptions can lead to networking contamination by microbiological and other pollutions. In order to enhance sustainability, electricity tariff subsidies, both explicit and implicit, must be reviewed to improve the sector's financial sustainability.

Energy

Approximately 90 percent of the generated global power is water intensive. Energy is required mainly for the provision of water services, just as water resources are required for the production of energy. Economies are still heavily dependent on coal, oil, natural gas and hydropower for electricity generation, contributing to the greenhouse effect (Figure 4A). Hydropower provides more than 90 percent of the electricity in Kyrgyzstan and Tajikistan, while natural gas generates more than 80 percent of electricity in Turkmenistan and Uzbekistan. Coal is the primary source of electricity generation in Kazakhstan. All countries have ambitiously pledged to develop their solar and wind options, yet without any practical proof, with exception of Kazakhstan. The transition from fossil fuels to renewable energy faces two interlinked constraints: i) the underpricing of fossil fuel supported by subsidies, and ii) the risk of stranded assets of state-owned companies with their vested interests (ESCAP, 2020).

Ironically, the effects of climate change on the availability of water may have direct implications on hydropower generation and the cooling of thermal plants, and thus may force countries to increase their dependence on coal and oil further, and in turn, their carbon emissions. For example, energy shortages linked to low reservoir levels already intermittently force the use of coal-fired energy. Governments come under pressure to rebalance fossil fuel subsidies with support for cleaner energy sources in the light of their Paris commitments. In many parts of the world, peak electricity demand is observed during the summer months for air conditioning instead of the winter months for heating, i.e., there has been a seasonal shift. As a result, hydropower operational regimes need to be operated in different modes, against their design parameters.

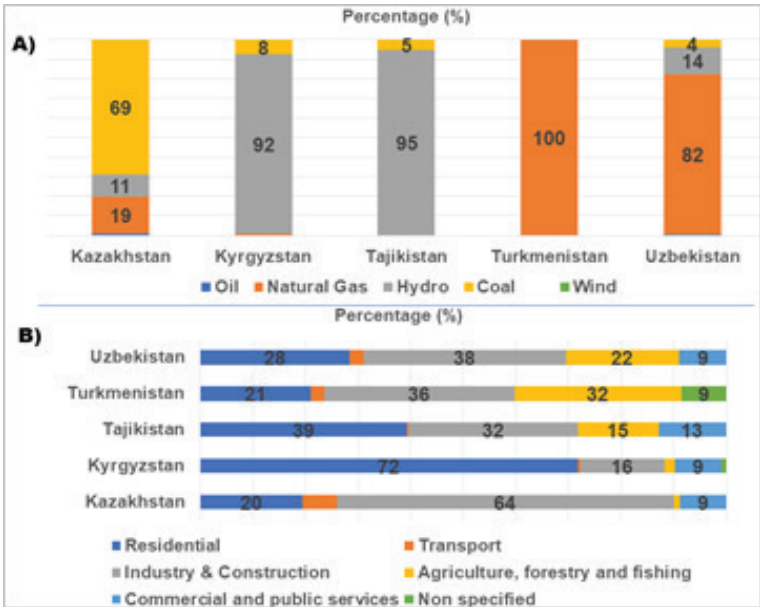

Figure 4. A) Electricity generation by source B) Electricity final consumption by sector in 2017 across Central Asian Countries. Source: IEA, 2020.

An analysis of the electricity use structure shows that that two sectors, industry & construction and residential, on average account for around 37 percent and 36 percent of total electricity usage, respectively across 5 Central Asian countries. It is predicted that the demand from the residential sector will increase due to population growth and the digitization of the economy. Decision-making should, therefore, focus on the design of energy efficiency programs or mitigation and adaptation measures to satisfy the specific needs of these sectors.

At present, in all Central Asian countries, good legislation requires more of practical implementation, in order to increase share of the renewables in energy balance. Unfortunately, solar, wind and biofuels (modern renewables) account for only a very small part of electricity generation all five Central Asian

countries. This means that governments are declaring green economy and resource-efficient economic models as their strategic development milestones in the absence of any practical proof of such a paradigm shift. Electricity power transmission and distribution losses are reported in the range of 10–25 percent, not taking into account unregistered theft. The root cause is an old and inefficient energy infrastructure and industrial machinery, and the equipment assets inherited from the former Soviet Union.

Conclusion

A water footprint assessment indicates that all countries in Central Asia should rethink how to use their limited water and land resources most efficiently for agricultural production. The impact on international trade resulting from the projected climate change impacts, and especially related to water availability, requires more careful approaches. In addition, balanced agricultural cropping systems utilizing climate-smart varieties are prerequisites for the resiliency of countries in terms of food security and foreign revenues. Moreover, under the Coronavirus pandemic, agriculture has emerged as the most promising driver of economic development and employment.

Physical infrastructures are facing numerous problems, such as infrastructure fatigue, biophysical issues, and problems with operation and maintenance on national levels, and this will have an impact on the sustainable functioning and delivery of the intended services. Accordingly, it is of strategic importance that safety assessments and technical audits be carried out for all water- and energy-related facilities, especially infrastructures with shared transboundary aspects. Water pricing is one, albeit often unpopular, mechanism for the promotion of more efficient water use, but now is the time for the reinforcement

of the irrigation service delivery in the region. Regional electricity trade is a proven approach to financial sustainability.

New stakeholders and public actors will become critical in the efforts to meet energy and water-related challenges, while the traditional actors (technocratic bureaucrats) may lose power and influence. The greatest challenge is ensuring the practical implementation of stakeholder participation at the lowest operational utility levels. The increased participation of stakeholders and actors requires open-source, easy-to-access information and user-friendly data management systems to be in place to support decision-making and early warning objectives. Information and communication technologies are essential assets for modeling, early warning systems, streamlining billing and monitoring purposes.

Besides the pursuit of new technical solutions, new political and economic frameworks need to be designed that promote cooperation and integrated planning among sectors. Integrated planning and cross-sector cooperation will leverage possible synergies for the reduction of costs, the assessment of trade-offs, demand-side interventions and the decentralization of services, thus ensuring the sustainability of the infrastructure and sectors. Accordingly, the continuation of the irrigation and water supply & sanitation sector reforms in all countries must be carefully monitored. The provision of support to the national reforms should be based on reform performance, not on requests from the line ministries.

The reduction and insufficiency of financing have been major obstacles standing in the way of sustainable and reliable water supplies to all sectors in almost all countries. Irregular financing also prevents long-term planning in the sector, and leads to serious delays in operation and maintenance. Almost 70 percent of irrigation infrastructure; 50 percent of water supply systems and 50 percent of energy facilities are outdated

and in need of rehabilitation or replacement. Such a scale ensures the irrigation and the supply of water & sanitation remain investment hungry. Governments must therefore introduce incentives within the water sector to make it attractive to private and international investors.

References

AQUASTAT. (2019). Aquastat of Food and Agriculture Organization of the United Nations. https://www.fao.org/aquastat/en/.

ADB. (2017). *A Region at Risk: The Human Dimensions of Climate Change in Asia and The Pacific*. Asian Development Bank (ADB) Mandaluyong City, Philippines. https://dx.doi.org/10.22617/TCS178839-2

ADB. (2016). *Asian water development outlook 2016: Strengthening water security in Asia and the Pacific*. Asian Development Bank (ADB). Mandaluyong City, Philippines.

Abdulloev, A. (2020). Water, Energy, and Food Nexus in the Amu-Darya River Basin: Analysis of Water Demand and Supply Management Infrastructure Development at Transboundary Level. MSc Thesis. Oregon State University.

Abdullaev, I. & Rakhmatullaev, S. (2016). Setting up the agenda for water reforms in Central Asia: does the nexus approach help? *Environ Earth Sci*, *75*(870). https://doi.org/10.1007/s12665-016-5409-8

Abdullaev, I. & Rakhmatullaev, S. (2015). Transformation of water management in Central Asia: from state-centric, hydraulic mission to socio-political control. *Environ Earth Sci*, *73*, 849–861.

Abdullaev, I. (2012). *Socio-technical aspects of water resources management in Central Asia*. Lambert Academic, Saarbucken.

Aldaya, M., Munoz, G. & Hoekstra A. (2010). *Water footprint of cotton, wheat and rice production in Central Asia*. Value of Water Research Report Series No 41. UNESCO-IHE, Delft, The Netherlands.

Bernauer, T. & Siegfried, T. (2012). Climate change and international water conflict in Central Asia. *Journal of Peace Research*, *49*(1), 227–239.

CAREC Institute. (2020). Climate Vulnerability, Infrastructure, Finance and Governance in CAREC Region. Central Asia Regional Economic Cooperation (CAREC) Institute, Urumqi, Xinjiang, China

Dukhovny, V. A. & De Schutter, J. (2011). *Water in Central Asia: past, present, future*. Routledge, New York.

ESCAP. (2020). Economic and Social Survey of Asia and The Pacific 2020: Towards sustainable economies. United Nations Economic and Social Commission for Asia and the Pacific. Bangkok, Thailand.

FAO. (2018). Policy analysis of nationally determined contributions (NDC) in Europe and Central Asia. Food and Agriculture Organization of the United Nations (FAO), Hungary.

Global Water Partnership. (GWP). 2000. Towards Water Security: A Framework for Action. Stockholm: GWP.

Guillaume, J. H. A., Kummu, M., Eisner, S., & Varis, O. (2015). Transferable Principles for Managing the Nexus: Lessons from Historical Global Water Modelling of Central Asia. *Water*, *7*, 4200-4231; doi:10.3390/w7084200

Government of Kazakhstan. (2020). Official Information Website of the Prime Minister of the Republic of Kazakhstan. Eighty-eight thousand jobs to be created during modernization of irrigation infrastructure in Kazakhstan. https://primeminister.kz/en/news/v-hode-modernizacii-irrigacionnoy-infrastruktury-kazahstana-budet-sozdano-88-tys-rabochih-mest-73818

Hoekstra, A., Buurman, J., & Van Ginkel, K. (2018). Urban water security: A review. *Environ. Res. Lett.*, *13*(053002) https://doi.org/10.1088/1748-9326/aaba52

International Energy Agency. (2020). Statistics. https://www.iea.org/statistics/

International Trade Center. (2020). Statistics. http://www.intracen.org/itc/market-info-tools/statistics-export-country-product/

Mekonnen, M. & Hoekstra, A. (2014). Water footprint benchmarks for crop production: A first global assessment. *Ecological Indicators*, *46*, 214–223.

Ministry of Water of Republic of Uzbekistan. (2020). On Approval of the Concept of Development of Water Management Sector of the

Republic of Uzbekistan for 2020-2030. http://www.water.gov.uz/en/posts/1545735855/396

Leb, C., Taylor, H., Nausheen, I., & Irene Rehberger, B. (2018). *Promoting Development in Shared River Basins: Tools for Enhancing Transboundary Basin Management*. Washington, DC, World Bank.

NC of Tajikistan. (2014). Third National Communication of the Republic of Tajikistan to the United Nations Framework Convention on Climate Change (UNFCCC), Dushanbe, Tajikistan.

NC of Turkmenistan. (2015). Third National Communication of the Republic of Turkmenistan to the United Nations Framework Convention on Climate Change (UNFCCC), Ashgabat, Turkmenistan.

NC of Kyrgyzstan. (2016a). Third National Communication of the Kyrgyz Republic to the United Nations Framework Convention on Climate Change (UNFCCC), Bishkek, Kyrgyzstan.

NC of Uzbekistan. (2016b). Third National Communication of the Republic of Uzbekistan to the United Nations Framework Convention on Climate Change (UNFCCC), Tashkent, Uzbekistan.

NC of Kazakhstan. (2017). Seventh National Communication and third Biennial report of the Republic of Kazakhstan to the United Nations Framework Convention on Climate Change (UNFCCC), Astana, Kazakhstan.

Jalilov, S-. M., Amer, S. A., & Ward, F. A. (2013). Water, food, and energy security: an elusive search for balance in Central Asia. *Water Resour Manag*, *27*, 3959–3979. https://doi.org/10.1007/s11269-013-0390-4

OECD. (2011). *Ten Years of Water Sector Reform in Eastern Europe, Caucasus and Central Asia*. OECD Studies on Water, OECD (Organisation for Economic Cooperation and Development) Publishing, Paris, https://doi.org/10.1787/9789264118430-en

Sadoff, C. W., Hall, J. W., Grey, D., Aerts, J. C. J. H, Ait-Kadi, M., Brown, C., Cox, A., Dad son, S., Garrick, D., Kelman, J., McCornick, P., Ringler C., Rosegrant, M., Whittington, D., & Wiberg, D. (2015). Securing Water, Sustaining Growth: Report of the GWP/OECD TaskForce on Water Security and Sustainable Growth, University of Oxford, UK, 180pp.

Smita, M. & Kingdom, B. (2019). *Citywide Inclusive Water Supply: Adopting Off-Grid Solutions to Achieve the SDGs*. World Bank, Washington, DC.

Srinivasan, V., Konar, M., & Sivapalan, M. (2017). A dynamic framework for water security. *Water Security*, *1*, 12-20 https://doi.org/10.1016/j.wasec.2017.03.001

Strong. C., Kuzma, S., Vionnet, S., & Reig, P. (2020). Achieving Abundance: Understanding the Cost of a Sustainable Water Future. Working Paper. Washington, DC: World Resources Institute. Available online at www.wri.org/publication/achieving-abundance

Stucki, V. & Sojamo, S. (2012). Nouns and Numbers of the Water–Energy–Security Nexus in Central Asia. *Water Resources Development*, *28*(3), 399–418.

Rakhmatullaev, S., Abdullaev, I., & Kazbekov, J. (2018). Water-Energy-Food-Environmental Nexus in Central Asia: From Transition to Transformation: pp.103-120. In Zhiltsov, S. S. et al. (eds.), *Water Resources in Central Asia: International Context*, Hdb Env Chem, https://doi.org/10.1007/978-3-030-11205-9

Rakhmatullaev, S. & Abdullaev, I. (2014). Central Asian irrigation sector in a climate change context: some reflections. *J Water Clim Change*, *05*(3), 341–356.

Rakhmatullaev, S., Huneau, F., Le Cousumer, P., & Motelica-Heino, M. (2010). Sustainable irrigated agricultural production of countries in economic transition: challenges and opportunities (a case study of Uzbekistan, Central Asia). In: Wager, F. C. (ed.) *Agricultural production*. Nova Science, New York, pp. 139–161.

Rakhmatullaev, S., Huneau, F., Celle-Jeanton, H., Le Cousumer, P., Motelica-Heino, M., & Bakiev, M. (2013). Water reservoirs, irrigation and sedimentation in Central Asia: a first-cut assessment for Uzbekistan. *Environ Earth Sci*, 68(4), 985–998

UN. (2018). Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation. United Nations. New York.

UNDP. (2013). Human development report 2013. The rise of the South: human progress in a diverse world. United Nations Development Programme.

UNICEF and WHO. (2019). Progress on household drinking water, sanitation and hygiene 2000-2017. Special focus on inequalities. New York: United Nations Children's Fund (UNICEF) and World Health Organization (WHO).

UNDRR. (2019). Global Assessment Report on Disaster Risk Reduction, Geneva, Switzerland, United Nations Office for Disaster Risk Reduction (UNDRR).

USAID. (2017). Toolkit for Climate-Resilient Water Utility Operations at https://www.climatelinks.org/resources/toolkit-climate-resilient-water-utility-operations

Varis, O. (2014). Resources: curb vast water use in central Asia. *Nature*, *514*, 27–29. https://doi.org/10.1038/514027a

Wegerich, K., Van Rooijen, D., & Soliev, I. et al. (2015). Water security in the Syr Darya basin. *Water*, 7, 4657–4684. https://doi.org/10.3390/w7094657

WRI. (2020). Aqueduct Toolkit. World Resources Institute. https://www.wri.org/aqueduct/

WWAP (UNESCO World Water Assessment Programme). (2020). The United Nations World Water Development Report 2020: Water and Climate Change, Paris, UNESCO.

WWAP (UNESCO World Water Assessment Programme). (2019). The United Nations World Water Development Report 2019: Leaving No One Behind. Paris, UNESCO.

WB. (2020a). Fighting COVID-19 Europe and Central Asia Economic Update (Spring), Washington, DC: World Bank. Doi: 10.1596/978-1-4648-1564-5. License: Creative Commons Attribution CC BY 3.0 IGO

WB. (2020b). Central Asia's Horticulture Sector—Capitalizing on New Export Opportunities in Chinese and Russian Markets. Washington, DC: World Bank.

WB. (2019). Damania, R., Sébastien, D., Aude-Sophie, R., Jason, R., & Esha, Z. *Quality Unknown: The Invisible Water Crisis*. Washington, DC: World Bank. doi:10.1596/978-1-4648-1459-4. License: Creative Commons Attribution CC BY 3.0 IGO.

WB. (2016a). High and Dry: Climate Change, Water, and the Economy. World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO.

WB. (2016b). Central Asia: Enhancing Regional Power Trade in Central Asia. World Bank, Washington, DC.

WB. (2015). Social Impact Analysis of Water Supply and Sanitation Services in Central Asia: The Case of Uzbekistan. World Bank, Washington, DC.

Xenarios, S., Sehring, J., Assubayeva, A., Schmidt-Vogt, D., Abdullaev, I., & Araral, E. (2019). Water Security Assessments in Central Asia: Research and Policy Implications: pp.358-378. In Yoshino et al. (eds.), *Water Insecurity and Sanitation in Asia*. Asian Development Bank Institute, Tokyo, Japan.

Chapter 8

Harmonization of Water Quality Legislation in Shared Basins of Central Asia

Tais Reznikova, Shynar Sarikenova, Ruslan Melian

Introduction

Entering the 1990s, the newly independent countries of Central Asia on the whole retained the institutional systems for water resources management that had been developed under the Soviet Union. Since that time, they have continued to develop the legal frameworks for water resources management, including those related to water quality. The agreements "to cooperate in the field of environmental monitoring" and "in the field of hydrometeorology", signed in 1999 within the framework of the Commonwealth of Independent States (CIS), set the legal basis for the interactions of the countries of the region in the joint monitoring of water quality. These agreements aimed to provide the framework for the harmonization of national regulatory, technological and software systems, the regular exchange of information and the consolidation of resources for the implementation of joint programs, as well as other elements of cooperation. To date, however, most of these obligations have not yet been realized, or have been implemented only in part (OSCE, 2019).

Despite the general growing desire to collaborate in the regional management of water supply, each country in Central Asia continues to develop national approaches to the management

and governance of water based on their own interests. Tajikistan and Kyrgyzstan, as upstream countries, are less likely to suffer from water scarcity and water quality problems, and so these countries are more interested in the sustainability of the zones in which water runoff accumulates, the reduction of risks from industrial waste storage facilities, the prevention of mudflows and floods, breakthroughs of high mountain lakes, the development of hydropower and irrigated agriculture. Downstream countries such as Kazakhstan, Turkmenistan and Uzbekistan, in contrast, are experiencing a shortage of clean water, degradation of aquatic ecosystems, and the salinization and desertification of their lands (OSCE, 2019). Access to clean water is of utmost importance for these states, and this should be taken into account when analyzing the leading factors influencing cooperation in water quality issues in the region. The following problems can be drawn from the Soviet legacy and the current situation in the countries:

- The national water quality standardization systems often contain outdated regulations that ignore both the particularities of the current water resources and water use in the region, new monitoring technologies and technical facilities, and the more advanced water quality management practices applied in other regions of the world;
- The current standards are mainly focused on water quality parameters for a limited number of water uses, and overlook the need to set the requirements regarding acceptable environmental impact levels to ensure the sustainability of water ecosystems;
- A substantial proportion of the standards are not being implemented due to deficits in funding and limited human and technical capacities (Petrakov, 2010).

Nevertheless, the Central Asian countries are continuing to develop a national legal framework for water resources management: in Uzbekistan in 2013, the Law "On water and water consumption" was updated, while a new Water Code for the Republic of Tajikistan that takes into account the current trends and requirements was introduced and approved in April 2020. In Kyrgyzstan, plans are in place (as recommended) to introduce the expanded concept of the Integrated Water Resources Management (IWRM) principle into the Water Code, as well as the basin approach, related to the complex use and protection of surface, underground and return waters; to develop a unified water quality classification system for water objects; to elaborate standards for the maximum permissible harmful impacts on water objects, etc. Turkmenistan, on the other hand, developed a new Water Code in 2016 that includes interpretations of the IWRM and hydrographic principle (Melian et al., 2018). Finally, in 2018 Kazakhstan transited to the new Unified System of Classification of Water Quality in water bodies, which is based on the principles of the EU Water Framework Directive WFD 2000/60/EU (European Commission, 2000; Protocol of RWG meeting, November 2019).

The majority of water quality standards currently in use in Central Asia are based on the System of Surface Water Quality Specifications developed in the Soviet Union in the 1960s–1970s (Petrakov, 2010). The Central Asian countries make use of several different water classification approaches that have been developed based on different criteria. For example, all five Central Asian countries traditionally classify water bodies and their parts according to three categories of water use, each of which has special requirements for acceptable water quality indicators: fisheries; household and drinking water; and municipal supply (Petrakov, 2010). Specific water bodies, however, are not distinguished by these categories,

and often the same water body serves or is targeted to satisfy a large spectrum of water consumption (drinking and industrial water supply, irrigation, fishery and recreation and livestock watering, and also for the maintenance of the natural characteristics of the habitats of different water and semi-aquatic organisms, and as a whole for water and water-wetland ecosystems). It is not always clear, therefore, which standards should be applied in each case.

There are a few disadvantages of the system that could limit future cooperation in transboundary basins: 1) the maximum permissible concentrations have been defined based solely on scientific research, without taking into account the technical and economic feasibility or cost of the regulatory measures necessary to fulfill these requirements; 2) the standards have been developed based on a zero-risk concept for human health and aquatic organisms, and are therefore often unreachable for water users; 3) some of the maximum concentration parameters require immediate achievement; in other words, the time frames and the strategies to achieve them are not feasible; 4) the burden on all water users is related to the maximum concentrations, being based on the fishery standard, which makes it impossible for almost all bodies to achieve fishery status; 5) the maximum concentration system is rather difficult to control due to the presence of multiple parameters (OSCE, 2019).

Despite these indicated hurdles preventing the development of multilateral cooperation, there are some successful examples of bilateral cooperation in the region. Kazakhstan and Uzbekistan opened negotiations related to the monitoring of transboundary water quality on the Syrdarya River in 2018 when an Uzbek-Kazakh working group on transboundary water quality monitoring on Syrdarya River was officially established, supported by the governments of the two sides. Among the few regional initiatives existing in Central Asia is a

regional working group on water quality, established as an informal platform that brings together experts from all Central Asian countries. The platform was created within the framework of the UNECE and CAREC (2011) initiative on "Water quality in Central Asia", aimed at promoting the development of efficient and coordinated national policies related to the water quality aspects of integrated water resources management in Central Asia. Since 2018, the Regional working group on water quality in Central Asia has worked as per its mandate, supported by various regional projects. The Regional working group's mission, as mentioned in the mandate, is to come up with effective and coordinated water quality improvement policies for application at national, transboundary and regional levels, thus promoting integrated water resources management in the region (Regional Working Group Mandate, 2018).

The simultaneous use of different classifications, based on different principles and indicators within a region, or even within a country, complicates water quality management and the development of inter-state cooperation in the implementation of water protection activities on transboundary water bodies (Petrakov, 2010). Water quality experts from Central Asia have recognized the need to introduce a unified system for the assessment and classification of water quality, and to positively assess the experience of Kazakhstan in the transition to a new system of classes. During the last meeting of the Regional working group on water quality in Central Asia, held in Tashkent in November 2019, the working group members from the Republic of Kazakhstan presented their experiences in the transition to the new classification. The Regional Working Group members were highly interested in the implementation of such a unified classification approach in the shared basins in the future, using the experience of Kazakhstan as a starting point for the development of transboundary cooperation

(Protocol of the Regional Working Group meeting, 2019). During the meeting, experts from the working group agreed on the importance of transitioning to unified water quality standards for all Central Asian countries in the future (Interviews with experts from Kyrgyzstan, Tajikistan, Uzbekistan). However, the experts also highlighted the current barriers that would make such a transition challenging for the countries to implement soon. The main goal of the present study is to provide an overview and classification of the existing barriers, and to make some recommendations based on expert opinions and a review of literature.

Results

The review was based on data collected during a literature review of studies of water quality management in Central Asia, and on interviews conducted with water quality experts in CA countries. It was understood from a review of relevant scientific papers and publications that a lack of academic knowledge exists on the topic. Water quality management is of greater interest to international development organizations than national scientists in the region. A PESTELS analysis was used to categorize and assess the collected data, and this framework of political, economic, social, technological, environmental, legal and scientific factors helped in the classification of the main barriers in different areas.

Political barriers

In the context of the economic development of the Central Asian countries and population growth in the region, the distribution of the limited water resources between the countries and users within countries remains the most prominent problem on the political agendas of water sector agencies. The main objective of the ministries and committees related to water resources is,

still, to ensure the availability of water for agricultural, industrial and domestic use. After the dissolution of the Soviet Union, the underfunding of the environmental departments, the collapse of the infrastructure for the removal and treatment of wastewater, and the deterioration of waterworks and water conduits led to huge losses of water and the pollution of both the surface and underground waters (Petrakov, 2010). Today, the environmental agencies in the countries are required to ensure the control of water quality at a technical level, although their impact on water policy is limited due to the orientation of the economy toward the more urgent economic sectors to meet the requirements of the growing population for employment. For instance, the most water-polluting sectors, agricultural and industrial production, constitute large shares of the national economies in Central Asia. In Kyrgyzstan, as of 2019, the share of agriculture and industry in the gross domestic product was 39.7 percent (National Statistic Agency of Kyrgyzstan, 2020). These two sectors provide up to 53 percent of employment in the country (World Bank, 2004). One important constraint that hinders the development of a unified strategy for the measurement and improvement of water quality in the countries in question, therefore, is the fact that the environment and water departments often have fundamentally different goals. In all CA countries, aside from Turkmenistan, water committees are directly subordinate to the Ministries of Agriculture, which are the main water consumers (Petrakov, 2010). Thus, the development of a coordinated water quality assessment approach is not yet a priority of national governments.

The experts also confirm that currently, the main political barrier in the way of reforms to the management of water quality in the Central Asian countries is the lack of political will and the low political priority for environmental protection, which leads to a lack of funding and weak intersectoral

policy mechanisms. Environmental issues are thus left in the background of both the national and regional agenda (Interviews with the experts from Kyrgyzstan and Tajikistan). This not only hinders transboundary cooperation related to water quality, but also leads to the further country-wide deterioration of water quality and public health, particularly in rural areas. People living in irrigated areas use the untreated water from the irrigation canals as their primary source of drinking water, and the drainage water is used for further irrigation by downstream water users (Groll et al., 2013).

Another factor that limits the creation of a unified approach to water quality management in the shared basins is the lack of coordination in actions made at a regional level. As mentioned in one of our interviews, a supranational regional center or institution recognized by all CA countries could ensure a smooth transition to a unified assessment and classification approach in the transboundary basins (Interview with the international expert). This is well exemplified in Eastern European countries, where the common regional institutional framework has provided the necessary conditions for the "painless" transition to a unified approach in water quality management. Petrakov (2010) offers the example of the leading regional ecological organization – the International Fund for Saving the Aral Sea (IFAS) – to underline the eternal state of disagreement that exists between ecologists and water workers. IFAS comprises two commissions: one focused on the environment – the Interstate Commission for Sustainable Development (ICSD), and the other focused on water – the Interstate Commission for Water Coordination (ICWC) (Cawater.info, 2020). Even though these two regional organizations technically function under the umbrella of the Aral Fund, cooperation and coordination between them are practically zero.

It is noteworthy to touch upon the lack of institutional structures at national level and the lack of transboundary cooperation among the riparians in Central Asia on water quality. The functions and authorities related to water resources management, as well as the assurance of quality, have been assigned to different ministries and agencies. For instance, surface water resources management (including quality) is usually included within the responsibilities of the Ministries or Committees on water management and agriculture; while environmental matters are dealt with by ministries, committees and agencies involved in environmental protection; underground water management, on the other hand, is managed by a separate agency, as well as the sanitary and epidemiological situation (Melian et al., 2018); the quality of drinking water is under the mandate of the ministries of health, and technogenic accidents and extreme contaminations of water are usually addressed by the ministries of emergencies, the Cabinet of Ministers, and/or local authorities (Melian et al., 2018). This scattered system of management related to water quality is typical to all Central Asian countries, with slight variations. The monitoring of water quality is also carried out by different agencies by their programs that often are not coordinated in terms of the sampling sites, the analyzed parameters and the measurement frequency (Melian et al., 2018). Each agency usually applies its own standards and assessment systems, making the interpretation of data and calculations more complicated. Thus, another factor limiting a smooth transition to a new classification would be the coordination required to enact changes in all related agencies and at all levels (Interview with the expert from Tajikistan).

The expert from Kyrgyzstan highlighted that the main institutional barrier is the current national water management system, which is still based on an administrative-territorial

division, despite all legal efforts to apply a hydrographical principle. The transition to basin-wise management requires the development of comprehensive river basin management plans, containing detailed descriptions of how the target indicators on water quality for each water body in the basin will be achieved, including the ecological state, quantitative parameters, chemical state and established indicators (expert from Kyrgyzstan).

The political aspects of the transition to a unified methodology are considered as a potential driver rather than a constraint (interview with the international expert). The benefits from the common approaches to water quality assessment and management are perceived to be evident by the experts because common approaches and methodologies would eliminate the problem of different interpretations and classifications of data on transboundary water bodies. The development of a common approach would be possible only with support from the highest political level. In order to do this, the leaders of the Central Asian countries could be encouraged to include the issues of water quality management in the list of national priorities and regional agenda.

Economic barriers

Financial problems were identified as the main limiting factor by all of the interviewed experts, with "lack of budget" being mentioned in each category as a key barrier to any reforms (interviews with experts 1 and 2 from Kyrgyzstan; interview with the expert from Uzbekistan; interview with the expert from Tajikistan). There are major costs associated with the establishment of national working groups to review monitoring stations, with budgets required for meetings, round tables and expert consultations, as well as other related expenses. Also, additional budget is needed for the reconsideration/review processes of the main law and the secondary legislation. Resources

are needed for the development of new reporting forms and other documents for daily operations, as well as funding for legislative developments consistent with the innovations, and for the general needs of laboratories to increase their technical capacities (equipment, reagents, etc.).

That said, the review of literature and interviews with external experts have revealed alternative views from the economic perspective that suggest the economic aspects be seen as an opportunity rather than a barrier. In current national water quality management systems, all standards are based on fish, and so require the most stringently clean water. The new classification approach makes it possible to slightly soften the standards and to make the water quality targets for other water users more realistic and achievable (interview with the international expert). The quality of drinking water does not need to be as high as for fish, and even lower quality is required for irrigation. This does not mean that water quality should deteriorate after the introduction of the classes system, but it does provide more realistic conditions for the development of irrigation not tied to fish standards and norms (interview with the international expert). Thus, through the introduction of water classes, a certain amount of the economic burden will be removed from water users, for example, from farmers and industries whose discharge standards today are calculated based on concentrations for fisheries. Often, farmers and industries lack the capabilities and resources to comply with all the requirements and install water treatment systems that can produce the required standards. These are very expensive to purchase and usually costly to maintain, and so as a response, discharges are often made out without any treatment at all. By informing water users of the specific purposes of the water use in the specific section of the river the new system could provide certain economic exemptions for water users, allowing them to invest

an appropriate and affordable amount into water quality improvements in the basin.

In addition to the abovementioned economic incentives for the water users in the new system of classes, there is another motivation for the government. Paying for water pollution remains the main economic mechanism behind the improvement of water quality, and this includes reimbursements of costs for the maintenance and restoration of water sources, the operation of water facilities, water protection and protection from harmful environmental impacts (OSCE, 2019). The main economic mechanisms for the regulation of water quality include payment for wastewater discharge, payment for exceeding discharge standards, waste disposal fees, etc. A new classification system will make the application of these economic mechanisms more efficient, since it paints a more comprehensive picture of the current water class for each water user, and sets the achievable standards and targets with which to comply.

Social barriers

Social barriers are key factors to be considered by water quality managers in all Central Asian countries due to the historical process of water contamination and the poor (or lack of) wastewater treatment systems applied for industrial, agricultural and domestic water use. According to the experts from Kyrgyzstan, one of the main barriers is insufficient awareness of the population on issues of water quality and monitoring (interviews with experts 1 and 2 from Kyrgyzstan and the expert from Uzbekistan). Polluted water resources are responsible for the regular onset of infectious intestinal diseases (dysentery, hepatitis, cholera), and the consumption of products grown with contaminated water (herbicides, toxins, pesticides) in turn regularly lead to bodily dysfunctions, cancer and hereditary diseases (OSCE, 2019). The effect of poor water quality

on public health cannot thus be overstated in the region. More than 2 billion people in Central Asian nations suffer from water-related diseases. One particularly dangerous situation in the region has emerged in rural areas, where only one-third of the residents have access to safe water systems, and only 13 percent are connected to sewerage systems (Ivanov et al., 2017).

The presence of so many historical sources of water pollution and the prevalence of associated diseases in the population makes the transition to the new classification system a highly sensitive issue. It is necessary to understand that the introduction of water classes with different intended uses does not imply a deterioration in water quality standards and an associated negative impact on the population. One expert interviewed raised concerns related to public health. The residents can perceive the introduction of a new classification system as a threat to the public health and thus establish a potential barrier to the transition to a new and common system (interview with the international expert). Thus, full public support for the implementation of the new system will also support the smooth transition to a new system. This requires raising awareness among the general population, which is currently lacking. One of the goals of the new classification, as already noted, is to determine the purpose of use of each water body. This imposes certain water treatment requirements on local water users. The requirements are often more sparing if they are not tied to fishery standards, as in the case of the proposed class system. To understand the system and to gain the support of water users, informational support is needed, which is again perceived as a financial burden in countries (expert 2 from Kyrgyzstan and the expert from Tajikistan).

Weak public participation in policymaking is another significant barrier. Eco-education and level-up public awareness are necessary components in most environmental policy

implementation packages (OSCE, 2019). A society that is well-informed and educated on matters related to water quality creates a demand for open and accessible information about water quality. Currently, there is no such demand on a regular ubiquitous basis (Interview with the international expert).

The third and final barrier is slightly different in nature, but can be still attributed to the social category, and relates to the lack of professional cadres. There are two sides to this problem. The first relates to the lack of personnel and the aging of workers employed in the water sector, which is unattractive to the upcoming generation due to the low wages and social status and the poor working conditions. All this is detrimental to the introduction of innovations, especially those requiring little finance and more employee initiative (Alimbayeva, 2019). On the other side is the issue of the mindset of the water quality specialists, who often oppose any new approaches (interview with the international expert). If the new classification system is to be implemented, it should be made more understandable for all water users, as direct consumers of the information on water classes and the purpose of use. This demonstrates the importance of the awareness-raising component especially in the context of a region where integrated databases containing information on the quantity and quality of water are unavailable to the population and water users (OSCE, 2019).

Technological barriers

The low technical capacity of the water quality-related agencies, and particularly laboratories, is a serious problem in the Central Asian region that causes a deterioration of water quality monitoring systems (Petrakov, 2010). Since the collapse of the Soviet Union, the technical condition of the hydrological and hydrochemical monitoring network on transboundary rivers has declined significantly. The lack of a unified system for

the monitoring of water quality in the region also prevents the reliable assessment of pollution in the transboundary watercourses (Petrakov, 2010).

It is important to understand that various agencies are involved in water quality monitoring in Central Asian countries. The registration of qualitative and quantitative parameters of surface and underground water resources is the responsibility of hydrometeorology and hydrogeology bodies (Melian et al., 2018); the control of the quality indexes of the aquatic medium and pollution sources is carried out by the environmental protection authorities; and health agencies are responsible for the drinking water supply sources, in coordination with local authorities and water services companies; river authorities control the quality of irrigation and drainage waters. In this regard, the proper monitoring of water quality requires not only the coordination of all the relevant state bodies, but also the full technical equipping of each one. This necessitates appropriate financing to address the problem of the lack of laboratories, and the obsolete equipment and technical base of the existing laboratories. Thus, the lack of funding can result in a reduction in the number of water quality parameters for regular control, shortening the periodicity of samples collection, as well as a reduction in the number of hydrometric and hydro-chemical posts and the number of section lines of the water body being controlled (Melian et al., 2018).

All of the interviewed experts identified the lack of technical capacity in water quality institutions as one of the main barriers to the introduction of a unified classification approach. First, a unified monitoring system should be established within the country (expert 1 from Kyrgyzstan). The weak material and technical base (experts from Kyrgyzstan and Tajikistan), for instance, allows only 27 indicators to be monitored regularly in Kyrgyzstan. Such important parameters as heavy metals,

petroleum products, phenols, etc. are not measured due to the lack of resources (expert 2 from Kyrgyzstan), and the same can be said for the hydrobiological indicators in all Central Asian countries (expert 2 from Kyrgyzstan). The lack of a monitoring network among the countries and the large technology gap between the laboratories of neighboring states (as in the case of Kazhydromet and Kyrgyzhydromet) poses a significant constraint to the introduction of a unified system.

An alternative view was presented by the international expert, who shared the experience of the Eastern European group of post-Soviet countries. The situation in these countries is similar and comparable to the Central Asian case in terms of the technical capacities inherited from the Soviet era. The transition in these countries did not require much modernization of the laboratories or updating of the monitoring networks, and a significant increase in the number of regular water samples was also not necessary to support the changes in the water quality regulations. A more significant role here was played by the overall approach or the logic applied in the selection of monitoring points that should be reviewed often in transboundary basins. Currently, the Central Asian Hydromet agencies apply the Soviet methodology to the selection of the location of the monitoring points. In Soviet times, these points were set to assess both the background ecological state and the specific sources of pollution below and above the cities or industrial areas. The new system, in contrast, requires a different approach that takes into account the interests of different water users, including irrigation and drinking water supply, and assesses water quality in coherence with the development plans in the basin and the required water quality. This should underpin the logic applied in the revision of the monitoring network.

In the case of Tajikistan and Kyrgyzstan, the weak network of laboratories in the country requires significant investment if coordinated monitoring and assessment is to be implemented in the Syrdarya and Amu Darya basins. The large technical gap between the laboratories of Kazhydromet and Kyrgyzhydromet poses a significant constraint for bilateral cooperation on water quality (interview with expert 1 from Kyrgyzstan). The lack of equipment prevents the countries from assessing and defining the background physical and chemical pollution (or natural pollution), which is paramount for the successful application of the new classification system, according to the experts from Kyrgyzstan. The lack of funding for water quality laboratories was mentioned as the main limitation to any improvement in the management system (interview with the expert from Tajikistan).

An alternative view is often presented in literature (Melian et al., 2018), suggesting that financial limitations are not an insurmountable barrier, but rather an additional limitation. In Moldova, for example, the switch to the new regulation did not require any additional resources, but mostly a reconsideration of the system of Maximum Allowable Concentrations, which was previously based only on high and sometimes unattainable standards for fish, and is now supplemented with other requirements based on the water use purposes defined for each water body.

Environmental barriers

There is a lack of sufficient studies investigating the large-scale effects of water quality management on the water bodies of different WFD-based (Water Framework Directive) status classes (Destouni et al., 2017) on which to base discussions of the Central Asian region and to compare with the international results.

The protection and restoration of good water quality and ecosystem status in the inland and coastal waters of all EU member states were among the initial goals of the WFD (EU, 2000).

The water ecosystems of Central Asia are known to be sensitive to changes in ambient conditions, which relates to the levels, volumes, and biogeochemical status of the water bodies in endorheic basins (Karthe et al., 2017). The vulnerability of the regional ecosystems to climate change and other human pressures, including agricultural intensification, are noted among the key characteristics of water systems in the region, which also make them sensitive to any fluctuations in water quality. The pressure associated with high water utilization, temperature increases and changes in precipitation patterns aggravate the problems of water quality management and the need for more coordinated approaches in shared basins.

The interviewed experts mostly did not identify the environmental factor as a limitation to the introduction of new classes (experts 1 and 2 from Kyrgyzstan, the expert from Tajikistan). Some highlighted the need to develop a sound scientific basis for the assessment of the ecological impact of the proposed system (interview with the expert from Uzbekistan; interview with the international expert). Currently, the current national water quality standardization systems to some extent take into consideration the requirements for the assurance of natural water quality for water ecosystems (Melian et al., 2018). The permissible values are set to ensure the sustenance of the population, as well as favorable conditions for the water ecosystems. However, responsive management still largely prevails over a proactive approach. If the quality of waters deviates from normative requirements due to some anthropogenic impact, for instance, then certain measures to prevent or reduce the negative influence of the source of pollution are taken (Melian et al., 2018). No strategies or plans, however, have been developed

to prevent pollution and to improve the quality of water in water bodies. Currently, there is a tendency among the Central Asian countries to reduce the number of water quality indicators and to simplify the water quality measurement methodology. By doing this, the authorities in these countries aim at artificially increase the level of water quality. The frequency of sample collection is often reduced, as well as the number of hydrometric and hydro-chemical stations, as well as the number of section lines being controlled (Melian et al., 2018). These policies and applications can prevent a thorough understanding of the ecosystems state being obtained.

Another constraint to the introduction of a new classification was raised by the experts from Kyrgyzstan. A comprehensive assessment of the ecological state of the rivers of the basin requires access to relevant data on not only chemical and physicochemical parameters, but also biological parameters and characteristics, namely, the composition and richness of the aquatic flora and the bottom invertebrate fauna; and also hydromorphological parameters (structure and substrate of the riverbed, coastal zone structure, etc.). Such scientific investigations require additional resources, including funding and scientific expertise, which are often lacking in the countries.

Legal barriers

The legal barriers in both national legislation and in the context of the transboundary basins need to be considered. According to experts, the transition to a new system can be quite time-consuming and difficult to develop at a national level, requiring many legislative amendments in the field of environmental protection, as well as the harmonization of any new law, regulation, etc., and can require considerable resources (interviews with representatives of Kyrgyzstan and Uzbekistan).

In the case of Kazakhstan, the development of the new classification system was supported by private donors and the government. This shows that the issue is not always the lack of financial resources, but also a lack of motivation of the specialists and experts elaborating and implementing the laws and by-laws on water quality management.

Another barrier is the lack of a regional or bilateral (three-lateral) legal framework for the coordinated management of water quality in shared basins. Over the past two decades, the main areas of cooperation among the Central Asian countries have been the distribution of water resources; the harmonization of reservoir regimes, focused mainly on the energy and irrigation needs of states; the prevention of the degradation of the Aral Sea and its adjacent territories; and ensuring the safety of the water infrastructure. Against the background of these priorities, the problems of water quality, although periodically mentioned in the joint declarations of the states and regional agreements, have not been supported by joint actions in practice. Moreover, the quality of water resources is closely interconnected with quantitative parameters and, at the same time, often acts as an integrated indicator of the effectiveness of water resources management in general. International project assessments indicate (OSCE, 2019) that due to the limited potential and resource base of the Central Asian countries, the implementation of large-scale projects aimed at improving the quality of water resources in the coming years is complicated.

Currently, the existing bilateral agreements related to transboundary pollution have to date not produced the necessary practical results required to reduce the level of pollution of transboundary rivers (Petrakov, 2010). The lack of a unified system for the monitoring of water quality in Central Asia highlights the need for a reliable assessment of the current status of transboundary watercourse pollution. The emerging differences in

the standardization approaches to water quality in the region complicate the coordinated assessment of water quality. Based on the above, it can be considered necessary to come up with a unified system for the monitoring of water quality in Central Asia, and to standardize the quality standards. Such a unification requires the transition to the unified regulatory and methodological documentation based on the international water quality requirements (Petrakov, 2010).

Scientific barriers

One of the most important factors influencing the monitoring of water quality in Central Asian countries is the research base, which is currently lacking, according to experts (expert from Uzbekistan, expert 1 from Kyrgyzstan). There is a lack of research institutes that are able, and have the necessary resources, to develop normative and methodological manuals and instructions for the introduction of a unified classification system. For instance, in the Kyrgyz Republic, the State Agency for Environmental Protection and Forestry is mostly engaged in the development of normative documents. The experts highlighted the importance of compiling a research justification for the transition to a new water quality assessment system. There is a need to provide the necessary training to a water quality specialist, to be employed in the related national agencies, but also on-site in the regions where the new system will be implemented (interview with expert 2 from Kyrgyzstan).

The generally outdated educational programs were also highlighted by the experts as a potential barrier to the introduction of a new assessment approach. The dominance of theory over practical implementations was noted among the occurring disadvantages of the current education and training systems. Such methods that prioritize the theoretical approach over practical experience based on the outdated educational

programs were widely practiced before. The water quality-related education and training centers suffer from inadequate funding and the remuneration of university faculties. Switching from the centrally-planned economies to open market has negatively affected the attractiveness of water sector specializations, and higher and secondary special educational institutions often lack the basic resources to properly educate water sector specialists (OSCE, 2019).

The experts stated that the transition to a new system will open up considerable opportunities for the exchange of data and the introduction of more coordinated approaches to the control of water quality in transboundary rivers. However, the qualifications of the personnel in scientific institutes who are involved in this process are another significant limitation. In a move to a new system, it is important to familiarize young specialists with the new classification methodology during their education (interview with representatives of Uzbekistan and Tajikistan).

Conclusion

Water quality issues have traditionally fallen under the shadows of water quantity and distribution, which are associated directly with the economic growth of countries, and thus take the highest priority in the political agenda. The latest studies (Damania et al., 2019) have highlighted the importance of water quality across all economic sectors, illuminating its impacts on nearly all SDGs. The greater impacts on health, agriculture and the environment may lead to significant slowdowns in the economic growth of the Central Asian countries, and the need for more coordinated approaches to avoid this is already recognized at an expert level in Central Asia. The advantages of a unified water quality classification approach are also in the loop of water quality specialists. Such approaches could bring

benefits to both the residents of the basins and regional ecosystems as a result of the more accurate and target-oriented basin-wide planning and management.

A working coordinated water quality management system in the region requires a strong institutional framework, and participatory and transparent governance at the national level. The barriers associated with the transition to a new system identified in the current review can serve as a basis for the development of strategies for improvements to transboundary and regional cooperation on the issue of water quality. The outlined constraining factors in the political, economic, technological, social, environmental, legal and scientific realms can be mostly attributed to the flaws and gaps in the national water management systems. The economic aspect of cooperation in water quality management indicates a need for more intense political efforts in this direction, although it is important to realize that if the reforms to water quality policy are to be implemented in practice, there is a need for governments to facilitate the strengthening of technical, methodological and human capacity in the monitoring and management of water quality.

Recommendations

The following list of recommendations has been developed based on the insights shared by the interviewed experts and the solutions proposed in the reviewed literature.

1) The first recommendation was highlighted by most of the experts and describes an entry point strategy for the introduction of changes in support of better transboundary cooperation in water quality in cases where countries insist on retaining the current national systems. If such progress in joint coordination is to be achieved, a unified system involving the exchange of information can be introduced first for a few transboundary rivers on which the unified system of assessment and

classification can be applied, in addition to the current national systems. This approach was tested by Moldova and Ukraine, which established a working group to carry out monitoring based on a common approach, beginning from the lowest level, i.e., border gauges between the two countries. Ukraine opted to apply the system already developed in Moldova, which was based on the EU Water Framework Directive, in addition to the existing national system in Ukraine. Such a starting point made the transition smoother, and demonstrated the advantages of the new system before the necessary investments and adjustments at a country-wide level.

2) Further promotion of the IWRM – the basin management principle – and basin planning, which are now being implemented in all five Central Asian countries. The harmonization of the general water quality systems based on common principles and parameters will facilitate further cooperation in the regulation of water quality in Central Asia, and its implementation at a cross-border level. One of the main expected outcomes of the unification of the approaches, as highlighted by the experts from Kyrgyzstan, is the introduction of the hydrographic principle in water quality management. If the quality assessment is carried out according to the basin principle, covering the upper, middle and lower streams of the rivers, as well as various climatic zones within the river basins, the landscape features of the catchment area, water management conditions and requirements for the protection of water throughout the river basin, proper joint planning and holistic and proactive management will be achievable in the region.

3) To optimize the use of the resources indicated by the experts, the experiences of neighboring countries (Eastern Europe and Kazakhstan) can be utilized in the region. The developments encountered and the lessons learned can be applied when conducting a research justification for the transition to a

new water quality assessment system; when compiling a general list of water quality indicators for monitoring, especially in the areas at risk of severe pollution; and when developing a common approach to the determination of pollutants at other stages.

4) Another recommendation is to address the lack of funding for the resolution of water quality management problems at both national and transboundary levels through the development of investment programs and infrastructure projects that include the improvement of the water quality component. Transboundary cooperation in water quality issues should take into account not only regulatory, legal and informational issues, but also the potential to attract investment and technology, to bring about infrastructure improvements, and to ensure the more widespread engagement of the private sector in the search for solutions for the countries of the region. The latest World Bank report (Damania et al., 2019) outlines the economic risks and potential losses to the economies resulting from poor water quality. Thus, the economic benefits of coordinated approaches to water quality management should be further explored and presented to decision-makers.

References

Alimbayeva, D. (2009). Practical results on the transition to a unified classification of water quality of water resources of the Republic of Kazakhstan. Presentation during the meeting of the Regional Working Group on water quality in Central Asia (November), Tashkent, Uzbekistan.

Cawater-info. (2020). International Fund for the Aral Sea Saving. http://cawater-info.net/water_world/

Damania, R., Sébastien, D., Aude-Sophie, R., Jason, R., & Esha, Z. (2019). *Quality Unknown: The Invisible Water Crisis*. Washington, DC: World Bank. doi:10.1596/978-1-4648-1459-4.

Destouni, G., Fischer, I., & Prieto, C. (2017). Water quality and ecosystem management: Data-driven reality check of effects in streams and lakes. *Water Resources Research*, *53*(8).

European Commission. (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy. *Official Journal of the European Communities*, L327.

Ivanov, S. V., Fedorova, E. L., & Temirov, E. E. (2017). The water quality impact on public health. *International Journal of Applied and Basic Research*, *3-2*, 186-189.

Karthe, D., Abdullaev, I., Boldgiv, B., Borchardt, D., Chalov, S., Jarsjö, J., Li, L., & Nittrouer, J. A. (2017). Water in Central Asia: an integrated assessment for science-based management. *Environ Earth Sci*, *76*(690). https://doi.org/10.1007/s12665-017-6994-x.

Melian, R. Alimbayeva, D., Bondareva, V., Mamadaliev, B., Aganov, S., Myagkov, S. (2018). Surface water quality monitoring system in Central Asia: needs assessment. https://carececo.org/news/Отчет по качеству воды_ENG_publication.pdf

National Statistic Agency of Kyrgyzstan. (2020). http://stat.kg/ru/news/struktura-valovogo-vnutrennego-produkta-za-2019-god/

Petrakov, I. A. (2010). Legal and institutional framework for water quality management in Central Asian countries. CAREC and UNECE. https://carececo.org/news/Provoviye_i_institucionalniye_osnovy_uprovleniyem_kachestvom_vod_Centralnoy_Azii.pdf

Protocol of the meeting of the Regional Working Group on Water Quality in Central Asia. (2019, November 12).

UNECE and CAREC. (2011). Towards Development of the regional cooperation in ensuring water quality in Central Asia: Diagnostic Report and Cooperation Development Plan. https://carececo.org/upload/02/Diagnostic%20Report.pdf

World Bank. (2004). Analytical research in the field of agricultural policy. Regional working group on water quality in Central Asia. Mandate. CAREC. http://documents1.worldbank.org/curated/en/234381468266964061/pdf/310400REV0RUSS1ltural0Policy0Update.pdf

Conclusion

This edited book brings together the invaluable works of distinguished experts related to various aspects of the nexus of water, energy and the environment in the Eurasian region. Although the individual chapters offer their own conclusions on the specific characteristics of the nexus in the Eurasian region, this Conclusion discusses their significance in a wider regional context and their broader implications for conceptual and empirical studies into the subject.

Nexus studies in the academic literature can be said to have a multidimensional character, with different academic works focusing on the technical, political-economic or societal aspects of the subject. Previous studies of the nexus approach to the interrelated structures of water, energy and environmental issues have argued that the problems arising from these subjects should not be addressed in isolation. As the environmental stresses faced by the world intensify, the need to develop comprehensive, multidimensional, multisectoral and multi-stakeholder policies within the framework of the sustainable development goals set by the United Nations becomes more urgent.

Given the immediacy, diversity and significance of the environmental problems faced by the Eurasian region, the number and quality of studies of the water, energy and environment nexus in Eurasia should be increased in the future. The contributors to this volume evaluate the social, political and

economic dimensions of the nexus from different aspects, scrutinizing the issue in various sub-regions and adjacent areas of Eurasia: Central Asia, the Caucasus and the Balkans with focus either on individual countries, or transboundary and regional settings, and draw some important conclusions.

First of all, the authors in this volume emphasize the interdependence of both the countries in the regional setting, and of the issues of energy, the environment and water. While Abdullaev and Rakhmatullaev discuss the issue of interdependence on a regional scale, Kushanova, Kurbanov and Franco focus on the interdependence of water, energy and agricultural issues on national and sub-national levels, showing clearly the importance of regional and local actors in addressing nexus issues.

Second, the case studies in this volume reveal water, energy and environmental problems to be closely related to infrastructure and financing issues. Reservoirs, irrigation networks, dams, hydropower plants and energy transmission lines are essential components of the infrastructure that warrant attention from a nexus perspective. Reznikova, Sarikenova and Melian, and Abdullaev and Rakhmatullaev show how the physical infrastructures of Central Asia are facing problems of operation, maintenance or underfunding on a national level, which exacerbates the environmental stress caused by water pollution, inefficient water and energy use, power loss, and other related maintenance problems.

New infrastructure projects, especially dams and large hydropower plants in transboundary river basins, have led to transboundary tensions in Central Asia, as indicated by Sakal and Tanrısever, and in the Balkans, as discussed by Kurt. These tensions, the authors argue, should be approached from a holistic perspective with focus on the interconnected nature of water, energy and environmental issues, emphasizing the potential mutual benefits to the regional stakeholders. Regional

politics is key here, in that, as concluded by Reznikova, Sarikenova and Melian, the "lack of political will and the low political priority for environmental protection […] leads to a lack of funding and weak intersectoral policy mechanisms".

Third, the involvement of all stakeholders in efforts to address energy-, environment- and water-related issues is crucial, although stakeholder participation involving both the public and private sectors can be problematic in transboundary settings where legal frameworks are non-existent or inefficient. In transboundary river basins where water is scarce or where water and energy issues are securitized, as emphasized by Güler in the example of the Caucasus, or by Reznikova, Sarikenova and Melian in the example of Central Asia, the lack of multisectoral and transboundary stakeholder involvement in particular poses a significant challenge to the resolution of nexus-related problems.

Fourth, from a nexus perspective, environmental problems are closely linked to water and energy issues, as demonstrated by the authors in this volume. Water quality is a major concern, especially in transboundary river basins and where water is used for energy generation purposes. As emphasized by Tüney, human interventions into natural life have a "considerable impact on the flora and fauna of the ecosystem and human life". The construction of HPPs for the generation of energy and profit maximization ignores their impacts on river basins, climate change and environmental degradation. Reznikova, Sarikenova and Melian found that "The pressure associated with high water utilization, temperature increases and changes in precipitation patterns aggravate the problems of water quality management and the need for more coordinated approaches in shared basins". In the Balkans, as clarified by Kurt, the Water Framework Directive sets the basic principles of sustainable water resource management, effectiveness,

efficiency and equity in water use, although it is only binding for EU member states.

The fifth important conclusion relates to the sharing of information. Here, the need to integrate qualitative and quantitative data and to account for scientifically assessed risks in decision-making processes is crucial, as argued by Kurt, and by Tanrısever and Sakal. Detailed quantifications, and multi-year and multi-stakeholder strategic planning and projections are needed to address nexus-related water, energy and environment problems. As concluded by Abdullaev and Rakhmatullaev, "Integrated planning and cross-sector cooperation will leverage possible synergies for the reduction of costs, the assessment of trade-offs, demand-side interventions and the decentralization of services."

This book discusses the various peculiarities of water, energy and the environment in Eurasia from political, economic and social perspectives. The selected regional cases highlight various problems in Central Asia, the Caucasus and the Balkans that warrant further attention and research. Needless to say, the findings of the individual chapters and the overall conclusions of this book encompass relevant inferences for other regions that extend beyond the Eurasian region. Future studies are needed to address the common properties, problems and issues of not only the broader Eurasian region, including Russia, and its energy connections and transboundary water problems, but also Europe, Asia Africa and Americas. For example, in Eastern Europe, the recent entrants to the European Union (EU) have encountered difficulties in complying with the EU's Green Deal requirements, and its climate change and renewable energy targets. The role of Turkey and the EU's other neighbors; the energy markets and their interconnections; the existing and new natural gas transfer routes; the targets of the Paris Agreement; and the nationally determined contributions

of the individual countries in the Eurasian region from the perspective of the water, energy and environment nexus should be subjected to further comparative and comprehensive study.

The findings of this book demonstrate that there are significant policy challenges facing the Eurasian countries. In fact, renewable energy solutions; reductions in emissions related to the production, transfer and use of energy; efficiency in the use of water and energy; energy-water tradeoffs built on the existing and new schemes; decarbonization; the restoration of environmentally degraded regions and natural resources; improvements to water quality; and smart and effective solutions for the sustainable and equitable use of water for irrigation, domestic purposes and the ecosystem will be hot topics in the near future that will warrant further attention by scholars of various disciplines related to issues of the environment, water and energy in Eurasia.

The findings of the individual chapters of the book suggest a need for further studies on the complex of energy, water and energy in the Eurasian region. Our edited volume has identified the following three major areas for further academic research.

Future studies could explore the unique characteristics of energy, water and energy in the Eurasian region, comparing the region with comparable regions around the world, among which cases in Southeast Asia, the Middle East, Northeast Africa and South America can be considered.

It may also be worthwhile to explore the implication of climate change policies for the nexus of the energy, water and environment complex in the Eurasian region. Given the increasing importance of climate action after the adoption of the Paris Treaty, all countries in the Eurasian region will need to understand the implications of their policies related to energy, water and the environment on the broader success of strategies aimed at mitigating climate change.

Last but not least, the individual chapters of this book indicate a need for further theoretical studies of the nexus approach and the elaboration of the conceptual tools used to explore the complex relationships between water, energy and the environment, as well as climate action, within more sophisticated theoretical frameworks and approaches.

In a nutshell, this edited volume underscores the importance of studying the nexus of water, energy and environment from a holistic perspective that takes the challenges and complexities of the multiple relationships among these closely-related issue-areas into account. We hope that this will not only broaden our perspective of the energy, water and environment complex, but also deepen our understanding of the interactions among water, energy and environment in Eurasia and the rest of the world.

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WATER, ENERGY AND ENVIRONMENT IN EURASIA

Edited by Oktay F. Tanrısever and Halil Burak Sakal

The Eurasian region has been characterized by growing water, energy and environmental challenges. This book intends to provide answers to the following key questions: What are the major conceptual issues with regards to the water, energy and environment nexus in Eurasia? What are the key challenges and drawbacks faced by the countries in the Eurasian region in responding to the nexus issues? How could regional cooperation be developed so as to mitigate nexus-related sustainability problems? What are the future implications of the current challenges for the regional and global environment? This book highlights the analytical benefits of employing the nexus approach in studying the complex dynamics of water, energy and environment in Eurasia. The nexus approach assumes that the inversely-related interdependency between energy and the environment is more evident in water-related issues. The book brings together the original academic contributions of distinguished experts who have been studying various aspects of the nexus of water, energy and the environment in the Eurasian region from technical and socio-economic to diplomatic aspects. The book is composed of three parts which explore these issues systematically in terms of the employed conceptual framework and the levels of analysis: The first part elaborates on the conceptual framework, the second part focuses on the national level of analysis, while the last part deals with the regional level of analysis.

Oktay F. Tanrisever is Professor of International Relations and the Chairperson of the Center for Black Sea and Central Asia (KORA) at the Middle East Technical University (METU), Ankara-Turkey. He has specialized in energy, water and environmental diplomacy; transnational and regional security and peace-building in Eurasia.

Halil Burak Sakal is Associate Professor of International Relations at Cappadocia University, Nevşehir, Turkey. His academic works and research interests include water, energy and environment; sustainable tourism development; and economic and political issues and historiography in Eurasia.

The editors of this book co-authored *Development of Hydropower Sector and Its Impact on Energy-Environment Nexus in Central Asia* published by Akhmet Yassawi University, Eurasian Research Institute in 2017.

Cover image: Dam on Naryn River

CAPPADOCIA UNIVERSITY

Cappadocia Campus:
Mustafapaşa - Uçhisar - Ürgüp / Turkey
Tel: +90 384 353 5009 (pbx) Fax: +90 384 353 5125
Sabiha Gökçen Campus:
Sabiha Gökçen Airport, İstanbul / Turkey
Tel: +90 216 588 0010 (pbx) Fax: +90 216 588 0012
info@kapadokya.edu.tr

www.kapadokya.edu.tr